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| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 12/27/2022 | 11537048 | 5063.08US05 | 5672 |

62274 7590 12/07/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

Stephen T. Meyers, Corvallis, OR;
Jeremy T. Anderson, Corvallis, OR;
Brian J. Cardineau, Corvallis, OR;
Joseph B. Edson, Corvallis, OR;
Kai Jiang, Corvallis, OR;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Inpria Corporation, Corvallis, OR;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

**INFORMATION DISCLOSURE STATEMENT BY APPLICANT**
**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | |
| Filing Date | |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | |
| Examiner Name | Not Yet Assigned |
| Attorney Docket Number | 5063.08US05 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| | 1 | 3385915 | | 1968-05-28 | Hamling | |
| | 2 | 3635883 | | 1972-01-18 | Stamm | |
| | 3 | 4102683 | | 1978-07-25 | DiPiazza | |
| | 4 | 4104292 | | 1978-08-01 | Dworkin et al. | |
| | 5 | 4370405 | | 1983-01-25 | O'Toole et al. | |
| Change(s) applied to document, /J.G./ 11/11/2022 | 6 | 4639208 | A | 01-1987 ~~1983-01-18~~ | Inui et al. ~~Okunaka et al.~~ | |
| | 7 | 4380559 | A | 1983-04-19 | Mandai et al. | |
| | 8 | 4601917 | | 1986-07-22 | Russo et al. | Corresponds to JPS61-000586. |



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

Document Description: Issue Fee Payment (PTO-85B)

# Issue Fee Transmittal Form

| Application Number | Filing Date | First Named Inventor | Atty. Docket No. | Confirmation No. |
|---|---|---|---|---|
| 16987120 | 06-Aug-2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

**TITLE OF INVENTION :**

ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

| Entity Status | Application Type | Art Unit | Class - Subclass | EXAMINER |
|---|---|---|---|---|
| Regular Undiscounted | Utility under 35 USC 111(a) | 1717 | 050000 | BINU THOMAS |

| Issue Fee Due | Publication Due | Total Fee(s) Due | Date Due | Prev. Paid Fee |
|---|---|---|---|---|
| $1200 | $0 | $1200 | 10-Feb-2023 | $0 |

## 1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

| Current Correspondence Address: | Current Indicated Fee Address : |
|---|---|
| 62274<br>CHRISTENSEN, FONDER, DARDI & HERBERT PLLC<br><br>11322 86th Ave. N.<br><br>Maple Grove MN 55369<br>UNITED STATES<br>612 315 4100<br>docket@cfd-ip.com | |
| ☐ Change of correspondence address requested, system generated AIA/122-EFS form attached | ☐ Fee Address indication requested, system generated SB/47-EFS form attached |

## 2.Entity Status

**Change in Entity Status**

○ Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.
Note: Absent a valid certification of micro entity status, issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment. If this box is checked, you will be prompted to choose a micro entity status on the gross income basis (37 CFR 1.29(a)) or the institution of higher education basis (37 CFR 1.29(d)), and make the applicable certification online.

○ Applicant asserting small entity status. See 37 CFR 1.27.
Note: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

◉ Applicant changing to regular undiscounted fee status.
Note: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.



Lam Research Ex. 1002 - Page 3
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

**3.The Following Fee(s) Are Submitted:**

| | |
|---|---|
| ☒ Issue Fee | ☐ I authorize USPTO to apply my previously paid issue fee to the current fees due |
| ☐ Publication Fee | ☐ The Director is hereby authorized to apply my previously paid issue fee to the current fee due and to charge deficient fees to Deposit Account Number _____ |
| ☐ Advance Order - # of copies _____ | ☒ If **in addition to** the payment of the issue fee amount submitted with this form, there are any discrepancies in any amount(s) due, the Director is authorized to charge any deficiency or credit any overpayment, to Deposit Account Number 60-1363 . The **issue fee must be submitted** with this form. **If payment of the issue fee does not accompany this form, checking this box and providing a deposit account number will NOT be effective to satisfy full payment of the fee(s) due.** |

**4.Firm and/or Attorney Names To Be Printed**

**NOTE: If no name is listed, no name will be printed**
For printing on the patent front page, list to be displayed as entered

1. CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
2. DIANE BENNETT, PH.D.
3. PETER DARDI, PH.D.

**5.Assignee Name(s) and Residence Data To Be Printed**

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

| Name | City | State | Country | Category |
|---|---|---|---|---|
| Inpria Corporation | Corvallis | OREGON | UNITED STATES | corporation |

**6.Signature**

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

| | | | |
|---|---|---|---|
| **Signature** | /Peter Dardi/ | **Date** | 11-10-2022 |
| **Name** | Peter S. Dardi | **Registration Number** | 39650 |

WEB IFEE 1.0

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16987120 |
| **Filing Date:** | 06-Aug-2020 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Filer:** | Peter S. Dardi |
| **Attorney Docket Number:** | 5063.08US05 |

Filed as Large Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| UTILITY APPL ISSUE FEE | 1501 | 1 | 1200 | 1200 |
| PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL | 1504 | 1 | 0 | 0 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | **Total in USD ($)** | | **1200** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 47004701 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Peter S. Dardi |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 10-NOV-2022 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 21:12:23 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $1200 |
| RAM confirmation Number | E2022A0L12210999 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Issue Fee Payment (PTO-85B) | Web85b.pdf | 62971<br>508ace47f9770ac0e32f3e826a08aaa54158db34 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 40181<br>3daab9c22ec46b19b4308392ec605c8b9c20ab24 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 103152 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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www.uspto.gov

# NOTICE OF ALLOWANCE AND FEE(S) DUE

62274 7590 11/10/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

| EXAMINER | |
|---|---|
| THOMAS, BINU | |
| ART UNIT | PAPER NUMBER |
| 1717 | |

DATE MAILED: 11/10/2022

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

TITLE OF INVENTION: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | UNDISCOUNTED | $1200 | $0.00 | $0.00 | $1200 | 02/10/2023 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.**



PTOL-85 (Rev. 02/11)

Lam Research Ex. 1002 - Page 9
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62274 7590 11/10/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

| (Typed or printed name) |
|---|
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

TITLE OF INVENTION: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | UNDISCOUNTED | $1200 | $0.00 | $0.00 | $1200 | 02/10/2023 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| THOMAS, BINU | 1717 | 118-050000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 11/10/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

| EXAMINER | |
|---|---|
| THOMAS, BINU | |
| ART UNIT | PAPER NUMBER |
| 1717 | |

DATE MAILED: 11/10/2022

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.



PTOL-85 (Rev. 02/11)

Lam Research Ex. 1002 - Page 11
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

## OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| Notice of Allowability | Application No. 16/987,120 | Applicant(s) Meyers et al. | |
|---|---|---|---|
| | Examiner Binu Thomas | Art Unit 1717 | AIA (FITF) Status Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--*

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 09/15/2022.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are See Continuation Sheet . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   **Certified copies:**

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☑ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/Binu Thomas/
Primary Examiner, Art Unit 1717



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Continuation of 3. The allowed claim(s) is/are: 1-2,4-5,8-21 and 26-27

## DETAILED ACTION

**1.** The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action issued August 12, 2021.

## EXAMINER'S AMENDMENT

**2.** An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Peter Dardi on October 27, 2022.

**3.** The application has been amended as follows:

**4.** Claims 22-25 are canceled.

### *Claim Interpretation*

**5.** This application includes one or more claim limitations that do not use the word "means," but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier.

**6.** Such claim limitation(s) is/are: a configuration providing for selection of the pressure and/or the temperature in the deposition chamber in claim 13.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

Regarding the recitation of configuration providing for selection of the pressure and/or the temperature in the deposition chamber, the recitation is interpreted a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158) which supports the substrate in the deposition chamber (151), as disclosed in figure 16 and amendments to the specification filed April 5, 2021 and January 20, 2021.

Please note, this is not a rejection, but a claim interpretation, as the claim does not recite sufficient structure to perform the claimed function and applicants' responses have not presented a sufficient showing that the claim limitation recite sufficient structure to perform the claimed function so as to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

### *Claim Rejections - 35 USC § 112*

**7.** The claim rejections under 35 U.S.C. 112(d) or 35 U.S.C. 112 (pre-AIA), 4th paragraph, on claim 14 is withdrawn.

### *Claim Rejections*

**8.** The claim rejections under 35 U.S.C. 103 as being unpatentable over Maeng et al. and Kane et al. on claims 1-2, 4-5, 8-21 and 26-27 are withdrawn, and claim rejections under 35 U.S.C. 103 as being unpatentable over Pore et al. on claims 1-2, 8-13, 15-18, 21 and 26-27 are

withdrawn because, while the prior art teaches a system with the structural elements of the deposition chamber, a substrate held within the interior of the deposition, a supply of organic/organotin composition, a structure to deliver flow of a first precursor vapor and a structure to deliver flow of a second precursor vapor of independent claim 1, the prior art does not explicitly teach the claim organotin composition comprising:

a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido (-$NR'R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo (-$OSiR'R^2$ $R^3$, where $R^1$, $R^{2'}$ are independently hydrocarbon groups with 1-10 carbon atoms), silylamido (-$N(SiR^{13})(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido (-$N(SiR^{13})(SiR^{23})$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido (-$N_3$), alkynido (-C-CR, where R is a hydrocarbon group with 1-9 carbon atoms), amidato (-$NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato (- $NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido (-$N(COR')(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof.

### *Reasons for Allowance*

**9.** Claims 1-2, 4-5, 8-21 and 26-27 are allowed.

**10.** The following is an examiner's statement of reasons for allowance:

In regards to independent claim 1, the prior art has been discussed. The prior art teaches the structural elements of the deposition chamber, a substrate held within the interior of the deposition, a supply of organic/organotin composition, a structure to deliver flow of a first precursor vapor and a structure to deliver flow of a second precursor vapor of independent claim 1, the prior art does not explicitly teach the claimed system with the claimed organotin composition comprising:

a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido (-$NR'R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo (-$OSiR'R^2$ $R^3$, where $R^1$, $R^{2'}$ are independently hydrocarbon groups with 1-10 carbon atoms), silylamido (-$N(SiR^{13})(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido (-$N(SiR^{13})(SiR^{23})$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido (-$N_3$), alkynido (-C-CR, where R is a hydrocarbon group with 1-9 carbon atoms), amidato (-$NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato (- $NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido (-$N(COR')(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof, in combination with the other limitations set forth in the independent claim. Further, no other prior art was located that fairly suggested the claimed invention in whole or in part in the time provided for the application, along with the requisite motivation for combination, to anticipate or render the claimed invention obvious.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Binu Thomas/
Primary Examiner, Art Unit 1717

| *Examiner-Initiated Interview Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | | |
|---|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (First Inventor to File) Status** Yes | **Page** **1 of 1** |

| **All Participants** (applicant, applicants representative, PTO personnel) | **Title** | **Type** |
|---|---|---|
| Binu Thomas | Primary Examiner | Telephonic |
| Peter Dardi | | |

**Date of Interview:** 27 October 2022

**Issues Discussed:**

**Proposed Amendment(s)**

The examiner contacted applicants' representative Peter Dardi to approve cancellation of withdrawn method claims.
Applicants' representative agreed to the cancellation, which will be done by examiner's amendment.

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
|---|---|

**Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04**
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

**Applicant recordation instructions:** It is not necessary for applicant to provide a separate record of the substance of interview.

**Examiner recordation instructions:** Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.



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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
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| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
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| US Classification - Searched* | | | |
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| Class | Subclass | Date | Examiner |
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* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |
| Updated search | 01/2021 | BT |
| Updated search | 08/2021 | BT |
| Updated search | 11/2021 | BT |
| Updated search | 06/2022 | BT |
| Updated search | 10/2022 | BT |

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| Interference Search | | | |
|---|---|---|---|
| **US Class/CPC Symbol** | **US Subclass/CPC Group** | **Date** | **Examiner** |
| C23C | 14/all | 10/2022 | BT |
| G03F | 7/167, 7/162 | 10/2022 | BT |

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| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |



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| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/987,120 | Meyers et al. |
| | **Examiner** | **Art Unit** |
| | Binu Thomas | 1717 |

| CPC | | | | | | |
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| **Symbol** | | | | | **Type** | **Version** |
| G03F | / | 7 | / | 168 | F | 2013-01-01 |
| G03F | / | 7 | / | 167 | I | 2013-01-01 |
| G03F | / | 7 | / | 38 | I | 2013-01-01 |
| C23C | / | 16 | / | 407 | I | 2013-01-01 |
| C23C | / | 14 | / | 086 | I | 2013-01-01 |
| G03F | / | 7 | / | 0043 | I | 2013-01-01 |
| C23C | / | 16 | / | 45561 | I | 2013-01-01 |
| G03F | / | 7 | / | 0042 | I | 2013-01-01 |
| G03F | / | 7 | / | 162 | I | 2013-01-01 |
| G03F | / | 7 | / | 2004 | I | 2013-01-01 |
| G03F | / | 7 | / | 325 | I | 2013-01-01 |
| G03F | / | 7 | / | 40 | I | 2013-01-01 |

| CPC Combination Sets | | | | | | | |
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| NONE | | **Total Claims Allowed:** | |
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| (Assistant Examiner) | (Date) | 20 | |
| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | 03 November 2022 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 16 |

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| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/987,120 | Meyers et al. |
| | **Examiner** | **Art Unit** |
| | Binu Thomas | 1717 |

| INTERNATIONAL CLASSIFICATION | | | | | |
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| **CLAIMED** | | | | | |
| G03F7/16 | / | 7 | / | 16 | |
| C23C14/08 | / | 14 | / | 08 | |

| NON-CLAIMED | | | | |
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| US ORIGINAL CLASSIFICATION | |
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| **CLASS** | **SUBCLASS** |
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| CROSS REFERENCES(S) | | | | | | |
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| **CLASS** | **SUBCLASS (ONE SUBCLASS PER BLOCK)** | | | | | |
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| NONE | | **Total Claims Allowed:** | |
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| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | 03 November 2022 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 16 |

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| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
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| NONE | | Total Claims Allowed: | |
|---|---|---|---|
| (Assistant Examiner) | (Date) | 20 | |
| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | 03 November 2022 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 16 |

U.S. Patent and Trademark Office — Part of Paper No.: 20221103



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## PE2E SEARCH - Search History (Prior Art)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | British Equivalents | Time Stamp |
|---|---|---|---|---|---|---|---|
| L1 | 0 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:20 AM |
| L2 | 6 | "15291738" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:21 AM |
| L3 | 1913 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT) | OR | ON | ON | 2020/09/29 09:21 AM |
| L4 | 1851 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:21 AM |
| L5 | 82 | L4 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:29 AM |
| L6 | 6 | "15291738" and deposition near2 chamber | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 11:47 AM |
| L7 | 76 | ("10025179"\|"10228618"\|"10642153"\|"20020076495"\|"20030124457"\|"20040067444"\|"20060088962"\|"20060234138"\|"20080055597"\|"20080286683"\|"20090155546"\|"20090174036"\|"20100044698"\|"20100184259"\|"20110045406"\|"20110135823"\|"20110166268"\|"20110206599"\|"20110244403"\|"20110293888"\|"20120223418"\|"2 | (US-PGPUB; USPAT) | OR | ON | ON | 2020/09/29 01:57 PM |



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| | | | | | | | |
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| | | 0130224652"\|"2013025 3161"\|"20140268062"\|" 20140303283"\|"201500 56542"\|"20150079393"\| "20150221519"\|"20150 253667"\|"20160116839 "\|"20170184960"\|"2017 0184961"\|"2019013787 0"\|"3385915"\|"3635883" \|"4102683"\|"4104292"\|" 4370405"\|"4380559"\|"4 601917"\|"4639208"\|"47 32841"\|"4851481"\|"489 1303"\|"4910122"\|"5025 094"\|"5672243"\|"58919 85"\|"6020269"\|"606038 0"\|"6179922"\|"6183716" \|"6194323"\|"6197896"\|" 6268457"\|"6287951"\|"6 420088"\|"6566276"\|"65 83071"\|"6730454"\|"684 4604"\|"6927108"\|"6946 677"\|"7001821"\|"72083 41"\|"7256129"\|"770905 6"\|"7773365"\|"7799503" \|"8030507"\|"8053370"\|" 8092703"\|"8366967"\|"8 415000"\|"8796483"\|"93 10684").PN. | | | | | |
| L8 | 12 | ("20050266700" \| "20060062916" \| "20070092648" \| "5147688" \| "6061117" \| "6503561" \| "7250083").PN. OR ("7709056").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:09 PM |
| L9 | 107 | ("4059929" \| "5478435" \| "5548159" \| "5558435" \| "5645891" \| "5736425" \| "5747880" \| "5750440" \| "5807607" \| "5814370" \| "5834845" \| "5843602" \| "5847443" \| "5857893" \| "5858457" \| "5858871" \| "5868278" \| "5922299" \| "5948482" \| "5955140" \| "6011123" \| "6015457" \| "6037275" \| "6048256" \| "6066575" \| "6070600" \| "6098843" \| "6107357" \| "6120891" \| "6140252" \| "6159295" \| "6162583" \| "6162838" \| "6163066" \| "6168737" \| "6171645" \| "6171687" \| "6172128" \| "6184260" \| "6187248" \| "6197913" \| "6204202" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:11 PM |

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|---|---|---|---|---|---|---|---|
| | | \| "6208014" \| "6251473" \| "6270846" \| "6277765" \| "6297459").PN. OR ("6583071").URPN. | | | | | |
| L10 | 6 | ("10025179"\|"20100099908"\|"20150221519"\|"4014858"\|"4144222"\|"4174346").PN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L11 | 3 | ("20130253161"\|"4104292"\|"9310684").PN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L12 | 9 | L10 L11 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L13 | 20 | ("20020048770" \| "20030116091" \| "20030118947" \| "20040087184" \| "5456945" \| "5759923" \| "6116184" \| "6231933" \| "6261373" \| "6358559" \| "6365266" \| "6376634" \| "6406794" \| "6428847" \| "6455443" \| "6472076" \| "6576568" \| "6583071" \| "6592980").PN. OR ("7446055").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:21 PM |
| L14 | 6 | ("20020033173" \| "5589300" \| "5894064" \| "6048817" \| "6444763" \| "6583071").PN. OR ("6825131").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:24 PM |
| L15 | 25 | L13 L14 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:29 PM |
| L16 | 59271 | H01L21/02274-02282.cpc. c23c16/$.cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:43 PM |
| L17 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:43 PM |
| L18 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:17 PM |
| L19 | 6 | "15291738" and structure | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:23 PM |
| L20 | 6 | "15291738" and precursor near2 vapor | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:24 PM |
| L21 | 6 | "15291738" and deposition near2 chamber | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:27 PM |
| L22 | 6 | "15291738" and thickness near2 variation | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:28 PM |

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|---|---|---|---|---|---|---|---|
| L23 | 6 | "15291738" and select$4 near5 (temperature pressure) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 04:55 PM |
| L24 | 3 | "20080022896" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 06:07 PM |
| L25 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 11:23 AM |
| L26 | 1873 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 12:02 PM |
| L27 | 84 | L26 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 12:02 PM |
| L28 | 17 | (US-20110293888-$ or US-20040067444-$ or US-20050266700-$ or US-20030118947-$ or US-20120027937-$ or US-20090155535-$ or US-20060211271-$ or US-20040156987-$ or US-20080022896-$).did. or (US-6583071-$ or US-4601917-$ or US-4104292-$ or US-6825131-$ or US-5894064-$ or US-6251473-$ or US-6066575-$ or US-6116184-$).did. | (US-PGPUB; USPAT) | OR | ON | ON | 2021/01/25 12:48 PM |
| L29 | 19 | ("4293594").PN. OR ("4601917").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:44 PM |
| L30 | 1323 | (C23C16/45525).cpc. and carrier near3 gas | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:46 PM |
| L31 | 554 | (C23C16/45525).cpc. and carrier near3 gas near20 inert | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:46 PM |
| L32 | 21 | ("20040209190" \| "20050186339" \| "20060124057" \| "20070194157" \| "20080146011" \| "20090152371" \| "20100300221" \| "20110097507" \| | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:49 PM |

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|---|---|---|---|---|---|---|---|
| | | "20110163062" \| "20110198620" \| "20120074575" \| "20120088315" \| "20130316541" \| "20140262461" \| "20170140920" \| "6146767" \| "6503701" \| "7718011" \| "7954730" \| "8840037" \| "9677984").PN. OR ("10163629").URPN. | | | | | |
| L33 | 141 | (c23c14/$ c23c16/$).cpc. and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:56 PM |
| L34 | 1 | "16987120" and (oxide and hydroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:59 PM |
| L35 | 9 | (c23c14/$ c23c16/$).cpc. and organotin and oxide near10 hydroxide | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:00 PM |
| L36 | 2 | "20170100742" "20160284553" and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:01 PM |
| L37 | 4 | ("20170100742" "20160284553") and carrier near3 gas near20 inert | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:01 PM |
| L39 | 2 | ("20170100742" "20160284553") and carrier near3 gas near20 inert and (argon nitrogen) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:41 PM |
| L40 | 1 | "16987120" and (third near5 vapor) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 05:52 PM |
| L41 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/04/07 09:27 AM |
| L42 | 2 | "20150056542" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/04/07 12:40 PM |
| L43 | 145 | (c23c14/$ c23c16/$).cpc. and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/08/04 10:09 AM |
| L44 | 27 | (c23c14/$ c23c16/$).cpc. and organotin near20 (supply source container) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/08/04 10:10 AM |
| L45 | 1933 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 05:11 PM |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | | | | | |
| L46 | 85 | L45 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 05:11 PM |
| L47 | 68 | ("20040113087" \| "20040175631" \| "20040191423" \| "20040213563" \| "20050208389" \| "20050253077" \| "20060001064" \| "20060068173" \| "20060147818" \| "20060172530" \| "20060175558" \| "20070037410" \| "20070181816" \| "20090208880" \| "20090305174" \| "20090317742" \| "20090321707" \| "20100022078" \| "20100131093" \| "20100197135" \| "20100304027" \| "20110104595" \| "20120068347" \| "20120088193" \| "20120088369" \| "20120126358" \| "20120193762" \| "20120202357" \| "20140120688" \| "20140134827" \| "20140170563" \| "20140170853" \| "20140268082" \| "20150041809" \| "20150077733" \| "20150170957" \| "20150221519" \| "20150332922" \| "20160135274" \| "20160314964" \| "20160379824" \| "20170102612" \| "20170146909" \| "20180004083" \| "20180233349" \| "20180308687" \| "20180337046" \| "20190027357" \| | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 06:23 PM |



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IPR2025-00309 - U.S. Patent No. 11,537,048

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | "20190094685" \| "3513010" \| "3529963" \| "3720515" \| "4241165" \| "4328298" \| "4590149" \| "4845053" \| "5077085" \| "5534312" \| "6162577" \| "6261938" \| "9023731" \| "9551924" \| "9778561" \| "9996004").PN. OR ("10514598").URPN. | | | | | |
| L48 | 1046 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon stannanes ) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 11:40 AM |
| L49 | 1001 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon ) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 11:42 AM |
| L50 | 8 | ("20140099451" "20180004083" "20060228476" ("4590096" "5997639" "4146657" ).pn. ) and (tin organotin) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 04:39 PM |
| L51 | 1940 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:43 AM |
| L52 | 86 | L51 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:43 AM |
| L53 | 60 | (c23c14/$ c23c16/$).cpc. and (organotin organo$1tin) near10 oxide | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:46 AM |
| L54 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 10:08 AM |
| L55 | 81 | L4 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:09 PM |
| L56 | 590 | (c23c14/$ c23c16/$).cpc. AND (organotin tin near5 carbon stannanes ) AND (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:16 PM |
| L57 | 30 | (c23c14/$ | (US-PGPUB; USPAT; | OR | ON | ON | 2022/06/13 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | c23c16/$).cpc. AND (organotin tin near5 carbon stannanes ) near20 (water hydrogen near2 peroxide) | USOCR) | | | | 01:17 PM |
| L58 | 30 | (c23c14/$ c23c16/$).cpc. AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:17 PM |
| L59 | 3 | ("20150170902" "4590096" "4696837" "4788079").pn. AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L60 | 3 | ("20150170902" "4590096" "4696837" "4788079").pn. AND (organotin tin) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L61 | 1 | ("4788079").pn. AND (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L64 | 864 | (coat$3 deposit$3) AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:14 PM |
| L65 | 149 | (coat$3 deposit$3) near20 (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:15 PM |
| L68 | 1 | ("20170100742").pn. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 04:51 PM |
| L69 | 2 | "16987120" AND organotin near10 suppl$3 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/13 09:09 AM |
| L70 | 2 | "16987120" AND organotin near10 structur$3 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/13 09:11 AM |
| L71 | 44 | (Artificial Intelligence) Similar to: 16/987,120 with 0 CPC Selections and 0 Text Selections<br>---<br>Text: (WO-2017066319-A8 OR WO-2017066319-A3 OR KR- | (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, | OR | ON | ON | 2022/10/13 03:54 PM |



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IPR2025-00309 - U.S. Patent No. 11,537,048

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20210135647-A OR US-20200371439-A1 OR EP-3391148-A2 OR WO-2017066319-A2 OR TW-202212344-A OR KR-102346372-B1 OR US-10775696-B2 OR US-20170102612-A1 OR TW-202126668-A OR EP-3896520-A1 OR KR-20210008151-A OR US-20190137870-A1 OR KR-20180054917-A OR TW-201734025-A OR US-10732505-B1 OR EP-3391148-B1 OR CN-108351594-B OR US-20200257196-A1 OR US-10228618-B2 OR TW-202126670-A OR JP-2019500490-A OR TW-I744252-B OR CN-113534609-A OR CN-108351594-A OR TW-I761135-B OR JP-6805244-B2 OR TW-202126669-A OR JP-2021073367-A OR KR-102204773-B1 OR CN-112309837-A OR TW-I743908-B OR KR-20210016274-A OR DE-102020115407-A1 OR US-20210035798-A1 OR KR-20200136138-A OR TW-202109193-A OR KR-20070004177-A OR KR-20170108807-A OR KR-101946701-B1 OR TW-I625817-B OR KR-101080736-B1 OR TW-201735228-A OR JP-6596371-B2 OR JP-2017174855-A OR KR-20060061210-A OR KR-20180075334-A OR EP-1602982-A3 OR KR-100665949-B1).did. | NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN)) | | | | |
| L72 | 41 | (Artificial Intelligence) Similar to: 16/987,120 with 0 CPC Selections and 2 Text Selections<br>Text: (GB-2099600-B OR EP- | (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, | OR | ON | ON | 2022/10/13 03:58 PM |



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IPR2025-00309 - U.S. Patent No. 11,537,048

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0762229-B1 OR AU-616855-B2 OR DE-3804449-A1 OR CN-107111257-B OR JP-2596024-B2 OR JP-S62183468-A OR JP-S62255953-A OR DE-10028223-A1 OR US-4471042-A OR US-6055404-A OR JP-2566914-B2 OR JP-S57122446-A OR JP-S62211663-A OR US-5753936-A OR US-8758971-B2 OR US-4997736-A OR US-6197471-B1 OR EP-0732630-B1 OR WO-8502691-A1 OR EP-2770374-A1 OR US-20210232057-A1 OR US-4798776-A OR US-5658703-A OR US-4430404-A OR US-6861373-B2 OR CA-1298175-C OR DE-3610401-A1 OR DE-3683239-D1 OR JP-S5833257-A OR JP-S6126053-A OR JP-S6242263-B2 OR JP-S632063-A OR US-4587187-A OR GB-2013725-A OR JP-2011133865-A OR JP-H0820743-B2 OR JP-H08320585-A OR JP-H0668635-B2 OR JP-S62196374-A OR JP-S6381468-A OR US-4906542-A OR JP-2789100-B2 OR JP-H0614189-B2 OR JP-H0778637-B2 OR JP-S63113546-A OR NL-161272-C OR FR-2579825-A1 OR JP-H0373858-B2 OR JP-S5875155-A).did. | MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN)) | | | | |
| L73 | 31 | (Artificial Intelligence) More like doc: US-20200371439-A1<br>Text: (KR-20210135647-A OR US-20190137870-A1 OR US-10732505-B1 OR US- | (US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, | OR | ON | ON | 2022/10/13 04:10 PM |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20170102612-A1 OR US-10775696-B2 OR US-20220299878-A1 OR EP-3391148-A2 OR WO-2017066319-A2 OR US-20200257196-A1 OR KR-102346372-B1 OR EP-3896520-A1 OR US-10228618-B2 OR TW-202126670-A OR KR-20180054917-A OR KR-20210008151-A OR TW-202126669-A OR CN-108351594-B OR JP-2019500490-A OR CN-113534609-A OR TW-I761135-B).did. | MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB) | | | | |
| L74 | 1 | "20220269169" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 08:21 AM |
| L75 | 2 | ("20220269169" "5004490").pn. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:05 AM |
| L76 | 113 | fluorin$4 near10 organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:21 AM |
| L77 | 57 | fluorin$4 near10 organotin AND vapor near10 deposit$4 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:22 AM |
| L78 | 0 | fluorin$4 near10 organotin near20 (inert argon) near5 gas AND vapor near10 deposit$4 AND (water hydrogen adj2 peroxide) near10 vapor | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:33 AM |
| L79 | 20 | organotin near20 (inert argon) near5 gas AND vapor near10 deposit$4 AND (water hydrogen adj2 peroxide) near10 vapor | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:33 AM |
| L80 | 1 | ("5417757").pn. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/10/17 10:35 AM |

## PE2E SEARCH - Search History (Interference)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | British Equivalents | Time Stamp |
|---|---|---|---|---|---|---|---|
| N1 | 20 | organotin near20 (inert argon) near5 gas AND vapor near10 deposit$4 AND (water hydrogen adj2 peroxide) near10 vapor | (US-PGPUB; USPAT) | OR | ON | ON | 2022/10/17 10:35 AM |



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IPR2025-00309 - U.S. Patent No. 11,537,048

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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BEFORE THE BOARD OF PATENT TRIAL AND APPEALS BOARD

# BRIEF FOR APPELLANT

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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BEFORE THE BOARD OF PATENT TRIALS AND APPEALS BOARD
APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

## INTRODUCTORY COMMENTS

This is an appeal of the final rejection of claims 1, 2, 4, 5, and 8-27. A Final Rejection was mailed November 26, 2021. A Notice of Appeal was filed on July 15, 2022. This Appeal Brief is thus timely filed.

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

September 15, 2022
Date

/Peter S. Dardi/
Peter S. Dardi, Ph.D., Reg. #39,650

## REAL PARTY IN INTEREST

The real party in interest in the present appeal is the current assignee, Inpria Corporation. Inpria Corporation is a subsidiary of JSR Company of Japan.

## RELATED APPEALS AND INTERFERENCES

The assignee, Inpria Corporation, has no pending appeals that are related to, would directly affect or be directly affected by, or have a bearing on the Board's decision in the present appeal.

## STATUS OF CLAIMS

Claims 1, 2, 4, 5, 8-27 are pending, claims 22-25 are withdrawn, and claims 3, 6 and 7 are cancelled. Claims 1, 2 4, 5, 8-21, 26 and 27 stand rejected.

## STATUS OF AMENDMENTS

All amendments have been entered.

## SUMMARY OF CLAIMED SUBJECT MATTER

The application has a single independent claim, claim 1. The claims are argued together. Claim 1 is summarized in the following. References are made to the specification as filed by page and line numbers. Appellant notes that a paragraph and a figure were added by incorporation by reference in an Amendment dated January 20, 2021. While the support below provides clear support, the added text and figure supplement and provide additional context.

Claim 1 is directed to a system comprising a deposition chamber with an interior isolated from the ambient atmosphere, and various components explicitly recited to be associated with the chamber. See application at page 3, lines 28-31, page 24, lines 20-22 and page 25, lines 5-22. A substrate is within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C. See application at page 25, lines 5-12 and page 27, lines 3-5. The system has an inlet into the deposition chamber. See application at page 25, lines 14-22. Also, the system has structure configured to deliver flow from a supply of an inert gas. See application at page 25, lines 20-22.



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The application generally is directed to the delivery of hydrolysable precursors for the formation of an organotin composition that forms following hydrolysis an oxo-hydroxo network, in which the organotin composition is radiation patternable. While the exemplified processes using solution coating, the application, as originally filed, had a section of text (pages 24-27) specifically devoted to vapor deposition based on the exemplified precursors having suitable vapor pressures for this approach. To this end, the claimed system comprises a supply of an organotin composition comprising a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido ($-NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo ($-OSiR^1R^2R^3$, where $R^1$, $R^2$, are independently hydrocarbon groups with 1-10 carbon atoms), silylamido ($-N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido ($-N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido ($-N_3$), alkynido (-C≡CR, where R is a hydrocarbon group with 1-9 carbon atoms), amidato ($-NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato ($-NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido ($-N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof. See application at page 17, lines 23-14 and page 26, lines 1-8.

To deliver the precursor, the system comprises structure configured to deliver flow of a first precursor vapor from the supply of the organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber. See application at page 25, lines 14-17. To perform the hydroysis, the system also has structure to deliver a second precursor vapor comprising water, hydrogen peroxide or a combination thereof capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising ~~a~~ hydrolysis reaction product with X, wherein the substrate is configured with a surface to receive the non-volatile components of the composition. See application at page 24, lines 26-29, page 25, lines 17-18 and page 27, lines 1-13.



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## GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. The rejection of claims 1, 2, 4, 5, 8-21, 26 and 27 under pre-AIA 35 U.S.C. § 103 as being inpatentable over Maeng et al., J. Vac. Sci. Tech B., 2006, 24, 2276 (hereinafter "Maeng") in view of U.S. patent 3,944,684 to Kane et al. (hereinafter "Kane").

2. The rejection of claims 1, 2, 8-13, 15-18, 21, 26 and 27 under pre-AIA 35 U.S.C. § 103 as being unpatentable over as being unpatentable over published U.S. patent application 2017/0100742 to Pore (hereinafter "Pore").

`Claim 14 was rejected under pre-AIA 35 U.S.C. § 112, 4th paragraph as being an improper dependent claim. This rejection is not appealed, and Appellant intends to cancel claim 14 following completion of the appeal.

## ARGUMENT

## LEGAL AUTHORITY AND LEGAL SYNOPSIS

The Court of Appeals for the Federal Circuit has exclusive appellate jurisdiction for cases arising under the patent law under 28 U.S.C. § 1295 (a)(1). Federal Circuit patent law is subject to review by the U.S. Supreme Court, and the Supreme Court occasionally rules on patent cases that provide ultimate authority for interpreting the patent statutes. "The PTO lacks substantive rulemaking authority." *Koninklijke Philips Electronics N.V. v. Cardiac Science,* 590 F.3d 1326, 1337 (Fed.Cir. 2010). "Judicial precedent is as binding on administrative agencies as are statutes. We remind the district court and the [USPTO] Board that they must follow judicial precedent...."). *Id.* at 1137.

### A. CLAIM CONSTRUCTION

"Claim construction is a legal question, reviewed [by the courts] de novo." *In re Abbott Diabetes Care Inc.*, 696 F.3d 1142, 1148 (2012). It is well settled that during patent examination, claims must be given their "their broadest reasonable construction 'in light of the specification as it would be interpreted by one of ordinary skill in the art.'" *Phillips v. AWH Corp.*, 415 F.3d 1303, 1317 (Fed. Cir. 2005)(*en banc)* (internal citations omitted). "The PTO broadly interprets claims during examination of a patent application since the applicant may 'amend his claims to obtain



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protection commensurate with his actual contribution to the art.'. This approach serves the public interest by reducing the possibility that claims, finally allowed, will be given broader scope than is justified. Applicants' interests are not impaired since they are not foreclosed from obtaining appropriate coverage for their invention with express claim language." *In re Yamamoto*, 740 F.2d 1569, 1572 (Fed. Cir. 1984) (internal citations omitted).

However, "[t]he protocol of giving claims their broadest reasonable interpretation during examination does not include giving claims a legally incorrect interpretation." *In re Skvorecz*, 580 F.3d 1262, 1268 (Fed. Cir. 2009). "This [broadest reasonable interpretation] protocol is solely an examination expedient, not a rule of claim construction. It's purpose is to facilitate exploring the metes and bounds to which the applicant may be entitled, and thus to aid in sharpening and clarifying the claims during the application stage, when claims are readily changed." *Id.* "[T]he broadest-construction rubric coupled with the term 'comprising' does not give the PTO an unfettered license to interpret claims to embrace anything remotely related to the claimed invention. Rather, claims should always be read in light of the specification and teachings in the underlying patent." *In re Suitco Surface, Inc.*, 603 F.3d 1255, 1261 (Fed. Cir. 2010) (emphasis added). "[T]his court has instructed that any such [broadest reasonable] construction be '*consistent with the specification*, ... and that claim language should be read in light of the **specification** as it would be **interpreted by one of ordinary skill in the art**.'" *Id.* at 1260 citing *In re Bond*, 910 F.2d 831, 833 (Fed. Cir. 1990)(quoting *In re Sneed*, 710 F.2d 1544, 1548 (Fed. Cir. 1983))(emphasis added by *In re Suitco Surface, Inc.*).

B. OBVIOUSNESS

"In rejecting claims under 35 U.S.C. §103, the examiner bears the initial burden of presenting a prima facie case of obviousness." *In re Rijckaert*, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993). "The test for obviousness vel non is statutory. It requires that one compare the claim's 'subject matter as a whole' with the prior art 'to which said subject matter pertains.'" *In re Ochiai*, 71 F.3d 1565, 1569 (Fed. Cir. 1995) "[T]he ultimate determination of patentability is made on the entire record." *In re Oetiker,* 977 F.2d 1443, 1445 (Fed. Cir. 1992). "After evidence or argument is submitted by the applicant in response, patentability is determined on the totality of the record, by a preponderance of evidence with due consideration to persuasiveness of argument." *Id.* If the



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Examiner fails to establish a prima facie case of obviousness, the obviousness rejection must be withdrawn as a matter of law. *In re Ochiai*, 37 USPQ at 1131 ("When the references cited by the examiner fail to establish a prima facie case of obviousness, the rejection is improper and will be overturned.").

The objective analysis for applying 35 U.S.C. § 103 requires: (1) determination of the scope and content of the prior art are; (2) ascertaining the differences between the prior art and claims at issue; (3) resolving the level of ordinary skill in the art and (4) against the previous background, determining the obviousness or nonobviousness of the subject matter." *KSR Intern. Co. v. Teleflex Inc.*, 550 U.S. 398, 400 (2007) citing *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17–18, 86 S.Ct. 684, 15 L.Ed.2d 545.

**1. *Claims must be read as a whole***

When determining the scope of the claims for the purpose of 35 U.S.C. § 103, "[e]ach claimed invention must be considered as a whole." *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1548 (Fed. Cir. 1983). The question presented in 35 U.S.C. § 103 is whether the inventions set forth in the individual claims "each as a whole, would have been obvious to one of ordinary skill in the art when they were made," *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1537 (Fed. Cir. 1983). "A patent may not be obtained ... if the differences between the [claimed invention] and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the art." *Ecolochem, Inc. v. Southern California Edison Company*, 227 F.3d 1361, 1371 (Fed. Cir. 2000), citing 35 U.S.C. § 103(a).

As described in detail below, the prior art reference (or references when combined) must teach or suggest the particular combination or modification. The teaching or suggestion to make the claimed combination and reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). "It is impermissible, however, to simply engage in a hindsight reconstruction of the claimed invention, using applicant's structure as a template and selecting elements from references to fill the gaps." In re Gorman, 933 F.2d 982, 987 (Fed. Cir. 1991).



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**2. *There Must Be Some Teaching or Suggestion in the Art to Modify the Teachings of the Cited References.***

"Obviousness is tested by what the combined teachings of the references would have suggested to those of ordinary skill in the art." *In re Fine*, 837 F.2d 1071, 1076 (Fed. Cir. 1988) (internal quotation marks omitted) citing *In re Keller*, 642 F.2d 413, 425 (CCPA 1981). "But it cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination." *In re Fine*, 837 F.2d at 1076 (internal quotation marks omitted) citing *ACS Hosp. Sys., Inc. v. Montefiore Hosp.*, 732 F.2d 1572, 1577 (Fed.Cir.1984). Additionally, "teachings of references can be combined only if there is some suggestion or incentive to do so." *Id.* (emphasis in original) (internal quotation marks omitted). A proposed modification does not support *prima facie* obviousness if the modification would render the modified prior art device modified unsatisfactory for its intended purpose, and the references effectively teach away from the proposed modification. *In re Gordon,* 733 F.2d 900 (Fed. Cir. 1984).

The Supreme Court has recently clarified that the examination of the teachings of the prior art should not be performed rigidly. Specifically, "a court must ask whether the improvement is more than the predictable use of prior art elements according to their established functions." *KSR Int'l Co.*, 550 U.S. at 402. "Often, it will be necessary for a court to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person of ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *Id.* at 402. The Court noted that "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does. This is so because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known." *Id.*, at 402. "Under the correct analysis, any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed." *Id.*, at 403.



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3. References Must be Read as a Whole

When determining whether an invention is obvious over the prior art, "prior art references before the tribunal must be read as a whole and consideration must be given where the references diverge and teach away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock,* 721 F.2d 1540, 1550, 220 USPQ 303, 311 (Fed.Cir.1983), *cert. denied,* 469 U.S. 851, 105 S.Ct. 172, 83 L.Ed.2d 107 (1984). Moreover, appellants cannot pick and choose among individual parts of assorted prior art references 'as a mosaic to recreate a facsimile of the claimed invention.' 721 F.2d at 1552, 220 USPQ at 312." *Akzo N.V. v. U.S. Int'l Trade Comm'n*, 808 F.2d 1471, 1481 (Fed. Cir. 1986). "Thus, Panduit explains that § 103 does not permit a court to stitch together an obviousness finding from discrete portions of prior art references without considering the references as a whole." *In re Enhanced Security Research, LLC*, 739 F.3d 1347 (Fed. Cir. 2014). "[W]hen the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

ANALYSIS

1. Rejection for Obviousness Over Maeng and Kang

The Examiner rejected claims 1, 2, 4, 5, 8-21, 26 and 27 under 35 U.S.C. § 103 as being unpatentable over Maeng in view of Kane. Claims 2, 4, 5, 8-21, 26 and 27 depend from claim 1. Appellant respectfully maintains that the Examiner has failed to establish *prima facie* obviousness and has not met their burden of persuasion of obviousness by a preponderance of the evidence. Based on the following analysis, Appellant requests that the rejection be reversed.

Comments on Claim Construction

Prior to addressing the rejections, Appellant makes a brief note on claim construction issues raised in the Office Action.

First, the Office Action comments on the claim construction of claim 13. While Appellant respectfully does not agree with this claim interpretation, claim 13 is not being separately argued here, so this issue is not presently relevant.

The Office Action makes a further assertion regarding the claimed pump, deposition chamber and block. Claim construction is a matter of law, and Appellant maintains that interpreting these features as means plus function element is contrary to the law. As Appellant



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explained in the file history, pump 155 and pump 156 and thermal block 158 are examples of configurations to provide for selection of the pressure and/or the temperature in the deposition chamber. Respectfully, Applicant has also noted that configurations to control pressure. flow and temperature in a chamber are well-known in the art. Specific embodiments were included in the application based on an incorporation by reference, which was an option contemplated when including the incorporation by reference.

"A patent need not disclose what is well known in the art." *In re Wands*, 858 F.2d 731, 735 (Fed. Cir. 1988). "The test is whether the disclosure 'conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.' This test requires an 'objective inquiry into the four corners of the specification from the perspective of a person of ordinary skill in the art.' Given this perspective, in some instances, a patentee can rely on information that is 'well-known in the art' to satisfy written description." *Streck, Inc. v. Research & Diagnostic Sys., Inc.*, 665 F.3d 1269, 1285 (Fed. Cir. 2012) cert. denied, 132 S. Ct. 2442, 182 L. Ed. 2d 1064 (U.S. 2012) (citing *Ariad,* 598 F.3d at 1351; *Boston Sci. Corp. v. Johnson & Johnson,* 647 F.3d 1353, 1366 (Fed.Cir.2011)) (internal citations omitted). "That which is common and well known is as if it were written out in the patent and delineated in the drawings." *In re Howarth*, 654 F.2d 103, 106 (C.C.P.A. 1981) (citing Webster Loom Co. v. Higgins et al., 105 U.S. 580, 586 (26 L.Ed. 1177) (1881)).

Although Appellant has made this point about the features being well known in the art, the Examiner has failed to date to provide any counter arguments on this point. It is conventional not to burden the weight of a patent by stating what is well known in the art. There are no arguments or evidence on the record that pumps, conduits and heaters are not well known in the art. Thus, the position maintained by the Examiner on claim construction seems to be in error as a matter of law.

Outline of §103 Issues for Claim 1

The fundamental basis for the patentability analysis is the statute and 35 U.S.C. § 103 reads (emphasis added):

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section **102**, if the differences between



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the claimed invention and the prior art are such that **the claimed invention as a whole** would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

The statute is quite clear and explicit that the claimed invention must be considered **as a whole**.

Following a conventional Graham analysis (MPEP 2151II), one compares the claimed subject matter to the cited references. Claim 1 reads as follows:

1. A system comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin composition **comprising a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido ($-NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo ($-OSiR^1R^2\ R^3$, where $R^1$, $R^{2,}$ are independently hydrocarbon groups with 1-10 carbon atoms), silylamido ($-N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido ($-N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido ($-N_3$), alkynido ($-C{\equiv}CR$, where R is a hydrocarbon group with 1-9 carbon atoms), amidato ($-NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato ($-NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido ($-N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof**;



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structure configured to deliver flow of a first precursor vapor from the supply of the organotin compound with the inert gas as a carrier gas to the inlet **to provide for formation of an organotin layer on the substrate surface within the deposition chamber**; and

structure to deliver a second precursor vapor **comprising water, hydrogen peroxide or a combination thereof capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a hydrolysis reaction product with X, wherein the substrate is configured with a surface to receive the non-volatile components of the composition**.

The Office Action cites Maeng for teaching the first four elements of the claim. With respect to the fifth element, the Office Action asserts that Maeng teaches a supply of organometallic compound and refers to the PDMAT bubbler. PDMAT is pentadimethylamine tantalum, which is provided as a powder to supply a precursor. PDMAT is used to make tantalum based films in a reactor. Maeng is the reference referred to by Appellant in their specification as a model for the basic components of the apparatus structure.

Maeng is directed to forming $Ta_2O_5$ using plasma-enhanced atomic layer deposition (PE-ALD). To this end, Maeng employs a water or oxygen plasma. In contrast, Appellant's invention is directed to deposition of a **radiation sensitive** patterning composition based on tin, which is especially useful for EUV photoresist applications. Since Appellant's system is depositing a radiation sensitive composition with an R-Sn bond, it would not be suitable for deposition with a plasma.

The question presented in 35 U.S.C. § 103 is whether the inventions set forth in the individual claims "each as a whole, would have been obvious to one of ordinary skill in the art when they were made," *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1537 (Fed. Cir. 1983). "The test for obviousness vel non is statutory. It requires that one compare the claim's 'subject matter as a whole' with the prior art 'to which said subject matter pertains.'" *In re Ochiai*. 71 F.3d 1565, 1569 (Fed. Cir. 1995).



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Analysis of Legal Issues

As explained in the following, the Office Action bases its rejection on legally wrong analysis that is completely based on ignoring explicitly claimed features of the claimed invention. This analysis is contrary to the statute and correspondingly contrary to well established Federal Circuit law appropriately interpreting the statute and building on guidance from Supreme Court rulings. The legal basis provided in the rejection is clearly flawed. Thus, the rejection is based on clear legal errors.

"The factual predicates underlying an **obviousness** determination include the scope and content of the prior art, the differences between the prior art and the claimed invention, and the level of ordinary skill in the art." *In re Rouffet*, 149 F.3d 1350, 1355 (Fed. Cir. 1998). "If all elements of the claims are found in a combination of prior art references, as is the case here, the factfinder should further consider whether a person of ordinary skill in the art would be motivated to combine those references, and whether in making that combination, a person of ordinary skill would have a reasonable expectation of success." *Merck & Cie v Gnosis S.P.A.*, 808 F.3d 829, 833 (Fed. Cir. 2015).

Respectfully, it seems to go without saying that if all the elements or some obvious variation are not in the references, *prima facie* obviousness is clearly not established under the statute. The sense of this is clear. **If the missing element is completely new, that is a basis itself for patentability. If the missing element is not new, the burden is to provide a reference with the element to allow for proper evaluation of the motivation to combine. Absent a showing of a reference with all of the elements, this is a circumvention of the necessary interrogation of the motivation to combine. Such a shortcoming of a rejection is clear reversible error.**

"We first must determine whether TWi carried its burden to prove that all claimed limitations are disclosed in the prior art. *Medichem, S.A. v. Rolabo, S.L.,* 437 F.3d 1157, 1164 (Fed.Cir.2006) (stating that we consider motivation to combine and reasonable expectation of success only 'if **all** the **elements** of an invention are found in a combination of prior art references')." *Par Pharmaceuticals, Inc. v TWI Pharmaceuticals, Inc.*, 773 F.3d 1186, 1194 (Fed. Cir. 2014).

In the litigation context, the Federal Circuit affirmed a judgement setting aside a jury verdict where the jury verdict did not supply a reference to teach one element of the claimed



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invention. In this case, the court acknowledged that references were of record that could supply the element, and on appeal the Appellant argued that a further reference or knowledge of skill in the art could have supplied the element. These arguments had not been preserved for appeal, so the missing element was sufficient to affirm setting aside a jury verdict of obviousness. *Motorola, Inc., v. Interdigital Technology Corp.,* 121 F.3d 1461, 1466, 1467 (Fed. Cir. 1997). Respectfully, there would not seem to be any support under the law for the idea that elements in a claim can be simply ignored for the purposes of an obviousness analysis, and the statute requires consideration of the invention as a whole.

On page 5 of the Office action it is stated that: "With regards to organotin composition comprising a compound that is described by the formula found in the instant claim 1, the recitation of a particular type of processing materials do not limit an apparatus claim (MPEP2115)." With all due respect, this MPEP section is not on point. As stated in MPEP 2115, "Claim analysis is highly fact-dependent. A claim is only limited by positively recited elements." **In Appellant's claim 1, the organotin compositions are positively recited as a component of the system.** The Examiner's argument based on MPEP 2115 is not on point and is clearly flawed.

MPEP 2115 cited three cases, and none of these support the current rejection, *In re Otto*, *In re Young*, and *In re Casey*. *In re Young* is a CCPA case from 1935, prior to the modern obviousness statute, and will not be considered further. Referring to *In re Otto*, "[a]lthough the structure claims do not recite any means by which the core member could be attached to the hair and thus the manner of its intended use is of no significance, it might be well to note that the Moses pad impregnated with a dry hair curling substance would be operable with a non-liquid solution." 312 F.2d 937, 941 (CCPA 1963). Under *Otto*, even the method of use can be limiting for an apparatus claim if the method of use helps to define structure. Respectfully, the case law is clear that actual words of the claims generally need consideration if they can be construed as defining structure. This is well stated in the context of the following case.

"We are not construing a composition claim that contains a material that in fact protects it from light. No brown bottle appears as part of the claim, nor is there any ingredient in the composition that protects the composition from light. The only apparent distinction between the claimed composition protected from light and that not protected from light is how it is treated; that is not a structural or otherwise meaningful claim limitation." *Research Corp. Technologies, Inc.*



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*v. Gensia Laboratories, Inc.*, 10 Fed.Appx. 856, 861, 862 (Fed. Cir. 2001) (unpublished). This case suggests that the brown bottle would be considered if recited.

With respect to *In re Casey*, the claim at issue for this case is as follows (370 F.2d 576 (CCPA 1967)):

"1. A taping machine comprising a supporting structure, a brush attached to said supporting structure, said brush being formed with projecting bristles which terminate in free ends to collectively define a surface to which adhesive tape will detachably adhere, and means for providing relative motion between said brush and said supporting structure while adhesive tape is adhered to said surface."

With respect to this claim, the adhesive tape is not positively recited, but it only suggests a potential use for a surface.

In *Casey*, the applicant again argued use of the structure and no feature of the structure itself. "The claims in issue call for an apparatus or machine, viz. a tape dispensing machine. The manner or method in which such machine is to be utilized is not germane to the issue of patentability of the machine itself." *Id.* at 580. The holding in Casey follows the principle that carries over from these earlier *In re Otto* apparatus case, and stand for the proposition that how an apparatus is used generally does not limit the apparatus **without positive recitation of the feature**. The point is that if the claim is not limited by the feature from an infringement perspective, the claim cannot use the feature to distinguish the art. This is a reasonable proposition. But this proposition is not relevant for the present claims.

The Office Action further argues: "With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, this recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim (MPEP2111.02/2114)." Respectfully, again the argument is not on point since the analysis is directed to **positively recited** elements in Appellant's claim.

MPEP 2111.02 relates to the **preamble** in the context of claim construction, which is purely a matter of law. The claim preamble is simply, a "system," and it is not clear that this is



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relevant to the present discussion. With all due respect, the feature in question undoubtedly limits the claimed system and is not in the preamble. It is positively recited and would need to be present for there to be infringement. The claim is an article claim to a system, and the article is clearly intended to operate in a particular fashion based on the specifics of the structure. It is appropriate to specify the system to function in an appropriate way. The Examiner has not clearly articulated a claim construction on which the rejection is being based.

MPEP 2114 relates to functional language in Article claims. The context of the citation relates to intended use, but the rejection does not articulate what the supposed intended use is or how the claim is generally being constructed. MPEP 2114I relates to inherent function following from prior art structure, which does not seem relevant under the current claim, and MPEP 2114 IV relates to computer inventions, which is not relevant. So that leaves MPEP 2114II and III, which are somewhat poised in opposite directions.

The heading of MPEP 2114II is "MANNER OF OPERATING THE DEVICE DOES NOT DIFFERENTIATE APPARATUS CLAIM FROM THE PRIOR ART." MPEP 2114II basically refers to two cases, which do not support the rejection. The earlier case is a Board decision, *Ex parte Masham*, 2 U.S.P.Q.2d 1647 (Bd.Pat.App. & Interf.), 1987 WL 123826, which does not seem to be precedential. This case involved a single apparatus claim, which was as follows:

1. An apparatus for mixing flowing developer material, including:

means, defining a chamber, for receiving the flowing developer material therein; and

means for mixing the flowing developer material, said mixing means being stationary and completely submerged in the developer material.

To state the obvious regarding this claim, it is extremely broad being directed to a chamber with a mixer containing a developer material which possibly is defined in the specification. The applicant in this case argued the distinction being that the prior art reference did not show the mixing means being fully submerged under the developer material. In this claim, **the flowing developer material is not positively recited**. Nevertheless, the Board did not dismiss the relevance of the material being worked upon by the Masham apparatus. "The apparatus disclosed by Williams is employed to mix developer material. Accordingly, the disclosed apparatus satisfies the recitations in claim 1 with respect to the identity of the material intended to be worked upon by the claimed apparatus and the general manner in which the claimed apparatus is intended to be



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employed. At any rate, a recitation with respect to the material intended to be worked upon by a claimed apparatus does not impose any structural limitations upon the claimed apparatus which differentiates it from a prior art apparatus satisfying the structural limitations of that claimed." *Id.* **Dicta** in the *Masham* decision suggests potential broader limits on features of apparatus claims, but this aspect was not relied upon in *Masham* since the only aspect of the claim not taught by the reference in that case was the submersion of the mixing element. Again, the flowing developer material was not positively recited. Evidently the prior art in *Masham* taught the flowing developer material.

The second case cited in MPEP 2114II is particularly off point. MPEP 2114II take a fragment of a sentence from *Hewlett-Packard Co. v. Bausch & Lomb Inc.*, 909 F.2d 1464, 1469 (Fed. Cir. 1990); "[A]pparatus claims cover what a device *is,* not what a device *does*." While this statement is plane enough, the actual quote provides a much more textured concept. "Secondly and more importantly, there is no requirement, as B & L implies, that HP show 'operational differences' of the claimed device over the prior art. Claim 1 of LaBarre is an apparatus claim, and apparatus claims cover what a device *is,* not what a device *does.* An invention need not *operate* differently than the prior art to be patentable, but need only *be* different." In this case, the patentee was arguing against invalidity based on an argument that while the prior art showed all of the elements of the claim, a different operation precluded invalidity. This is really a case of attempting to read features from the specification into the claim and not one of ignoring positively recited features that are actually in the claim. So this case is completely off point for the present context, and MPEP 2114II does not support the rejection.

MPEP 2114III actually weighs in Appellant's favor. The heading of this section is "A PRIOR ART DEVICE CAN PERFORM ALL THE FUNCTIONS OF THE APPARATUS CLAIM AND STILL NOT ANTICIPATE THE CLAIM." Under the present facts, the cited art does not perform all of the functions (forming a radiation patternable composition on a substrate surface) and does not teach all of the positively recited features.

Differences Between the Claimed Subject Matter and the Cited Art

The final Office Action asserts that Maeng teaches several of the elements of claim 1, and the remaining elements are noted in bold text in the claim language above, although Maeng is



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asserted later in the office action to teach some related elements as explained below, which could be relevant in the context of motivation to combine. The Office Action cites Kane for teaching an organotin compound.in a closed container with an inlet tube connected to inert carrier gas.

The fifth element of the claimed system refers to "$RSnX_3$," where R and X ligands are specified above in the claim language. The Office Action relies on Kane for this feature. Referring to Kane, column 2, lines 47-60:

"The organotin compounds suitable for use in the present process are compounds that are volatile at temperatures below about 200°C., such as compounds having the formula $(R)_2Sn(OOCR)_2$ or $(R_3Sn)_2O$ wherein R is a lower alkyl group. Suitable compounds include dibutyl tin diacetate, bis(tri-n-propyl) tin oxide. and bis(tri-n-butyl) tin oxide, for example. These organotin compounds may be vaporized by heating to a temperature between about 80° to 150°C., preferably between about 100° to 120°C. They may be vaporized by heating in a boiling water bath, i.e., a temperature about 100°C. Other organotin compounds which may be used to deposit a tin containing oxide film include tetraphenyl tin and tetraisopropyl tin."

While Kane teaches organotin compounds for their purpose, Kane does not teach the claims species of organotin compounds of Appellant's claims. Kane does teach a broad genus of "other organotin compounds." Thus, the Examiner faces the burden of establishing that this broad suggestion in Kane specifically renders obvious the specific compositions in Appellant's claim. The office action does not comment on this issue.

Appellant's claimed system is designed and claimed for deposition of an organotin layer, and to that effect, the substrate temperature is controlled to be not too high. In contrast, Kane is directed to forming a metal oxide coating, specifically a tin oxide doped with indium oxide, which is a transparent conductive ceramic widely used in touch sensors on displays. To achieve that objective in Kane, they need to heat the substrate up to higher temperatures, greater than 350°C. See Kane, column 3 and 4. The formation of an oxide coating is contrary to Appellant's objective of forming a coating with the R-Sn bond intact, as implied by claim 1. Lowering the temperature in the Kane system destroys Kane for its intended purpose, and raising the temperature to the Kane temperatures destroys Appellant's invention for Appellant's intended purpose.

Maeng is also directed to the deposition of a metal oxide coating, specifically tantalum oxide. Maeng does not teach a precursor with an R-Metal bond. As such, the combined teachings



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of Maeng and Kane do not teach a deposition process to form a coating with an R-Sn bond intact. With both references directed to forming oxide coatings, Kane teaches the conditions to form the tin oxide coating, which involves higher temperatures than found in Appellant's claimed invention. While Maeng teaches a range of temperature that can get lower, these temperatures take for granted that a **plasma** is used, which would be inappropriate for the organotin compositions of Applicant's claimed invention since radiation sensitive bonds would be broken by the plasma. Absent hindsight based on Appellant's teachings, there is no motivation to combine Maeng and Kane to provide the claimed temperature range of the present claim 1. To put this another way, the combined teachings of the reference do not teach or suggest "**to provide for formation of an organotin layer on the substrate surface within the deposition chamber**" as specified in Appellant's claim 1. The formation of a metal oxide involves removal of the organic moiety.

The Office Action at page 5 asserts that:

> "Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the supply of organotin compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30)."

With all due respect, Kane teaches higher temperatures relative to the presently claimed invention, and the presently claimed invention is not directed to formation of a tin oxide. On the other hand, Maeng teaches the use of a plasma. Neither Kane nor Maeng teach a system designed to preserve the organic ligands on the metal, which are necessary to provide a radiation sensitive material. Whether or not there is motivation to combine Kane with Maeng, the combination does **not** result in Appellant's claimed invention for several reasons related to the R-Sn structure and appropriate handling of such a structure.

As taught throughout Appellant's specification, hydrolysis of hydrolysable ligands L results in formation of $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ compositions, where $0 < z \leq 2$ and $0 < (z + x) < 4$, and R is a radiation sensitive alkyl ligand. This is an organotin compound and not a tin oxide. The purpose though is relevant only to the extent that the claim is so limited. This is true with respect to the present claim. The present claim positively recites the composition, which is directly on point under the statute.



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Summary

In summary, the cited references alone or combined do not teach vapor deposition of $RSnX_3$, where R and X are defined in claim 1. Thus, the references do not teach a system with a component to deliver this precursor vapor. While Kane teaches use of vapor tin precursors, there is no argument of record that Kane suggests the claimed tin precursor of Appellant's claim 1. Furthermore, the combined teaching of Maeng and Kane do not suggest a system configured to form an organotin coating since the systems of Maeng and Kane are configured to oxidize precursors to form fully oxidized metal oxide coatings. Due to these shortcomings, the rejection does not establish a reasonable expectation of success for modifying the teachings of the cited references to form Appellant's claimed invention.

"The reasonable expectation of success requirement refers to the likelihood of success in combining references **to meet the limitations of the claimed invention**." *Intelligent Bio-Systems, Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367 (Fed. Cir. 2016); *Cumberland Pharmaceuticals Inc. v. Mylan Institutional LLC*, 846 F.3d 1213, 1222 (Fed. Cir. 2017) (*inter partes review*) (emphasis added).

> [A] proper analysis under § 103 requires, inter alia, consideration of two factors: (1) whether the prior art would have suggested to those of ordinary skill in the art that they should make the claimed composition or device, or carry out the claimed process; and (2) whether the prior art would also have revealed that in so making or carrying out, those of ordinary skill would have a reasonable expectation of success. Both the suggestion and the reasonable expectation of success must be founded in the prior art, not in the applicant's disclosure.

*In re Vaeck*, 947 F.2d 488, 493 (Fed. Cir. 1991) (citations omitted; emphasis added); *Velander v. Garner*, 348 F.3d 1359, 1363 (Fed. Cir. 2003) (quoting *In re Vaeck*).

Since the rejection does not establish a teaching in the cited art of all of the claim elements and does not provide a reasonable expectation of success, *prima facie* obviousness is not established. This is reversible error. "If the examiner fails to establish a prima facie case, the rejection is improper and will be overturned." *In re Rijckaert*, 9 F.3d 1531, 1532 (Fed. Cir. 1993).



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Based on the clear reversible errors, the rejection of claims 1, 2, 4, 5, 8-21, 26 and 27 under 35 U.S.C. § 103 as being unpatentable over Maeng in view of Kane should be reversed.

2. Rejection Over Pore

The Examiner rejected claims 1, 2, 8-13, 15-18, 21, 26 and 27 under pre-AIA 35 U.S.C. § 103 as being unpatentable over Pore. Claims 2, 8-13, 15-18, 21, 26 and 27 depend from claim 1. Appellant maintains that *prima facie* obviousness has not been established and that the rejection is based on clear errors of law. Appellant requests reversal of the rejections based on the following description of reversible errors in the rejection.

In the context of this rejection, the Examiner makes no pretense of rejecting the claim as a whole. In the Office Action, the Examiner admits "Pore does not explicitly teach the organotin compounds." The Examiner seems to be rejecting a claim directed to an apparatus for depositing an organotin where the organotin compound is not positively recited in the claim. But that is not the claim. As if to emphasize this position, the Examiner modified the rejection in the last office action to delete Kane from the rejection involving Pore, although it is not immediately clear if this was done based on a clear lack of motivation to combine Pore and Kane or an emphatic statement that the Examiner did not believe that Kane was needed in the rejection. Appellant, of course, maintains that neither rejection (with or without Kane) is effective to establish *prima facie* obviousness, although without Kane, the legal errors are even more stark. .

As noted above, the fundamental basis for the analysis is the statute and 35 U.S.C. § 103 reads (emphasis added):

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section **102**, if the differences between the claimed invention and the prior art are such that **the claimed invention as a whole** would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

The statute is quite clear that the claimed invention must be considered as a whole, and Appellant is aware of no authority providing the PTO the power to ignore the statute and examine claims as



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they desire. This is a fundamental legal error necessitating reversal. Nevertheless, Appellant reviews the justifications in the rejection for ignoring the statute.

Moving to an analysis of the differences between the claimed subject matter and the teachings of the cited art, the following elements are missing from the teachings of Pore:

1) a supply of an organotin composition comprising a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido ($-NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo ($-OSiR^1R^2R^3$, where $R^1$, $R^2$, are independently hydrocarbon groups with 1-10 carbon atoms), silylamido ($-N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido ($-N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido ($-N_3$), alkynido ($-C\equiv CR$, where R is a hydrocarbon group with 1-9 carbon atoms), amidato ($-NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato ($-NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido ($-N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof;

2) structure configured to deliver flow of a first precursor vapor from the supply of the organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber; and

3) to form a composition with non-volatile components and a volatile component comprising ~~a~~ hydrolysis reaction product with X, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

Pore is directed to the formation of a polymer coating. To achieve this, Pore teaches a pulsed process in which a first polymer precursor is deposited followed by the subsequent deposition of a second precursor. A polymerization process occurs on the substrate surface. There is no suggestion or pretense of a suggestion regarding the missing elements from Appellant's claim 1.



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The Examiner justified the absence of the claim elements based on references to the MPEP. In the context of MPEP 2115, the office action asserts that the type of processing materials do not limit the apparatus. Again, MPEP 2115 does not support the rejection. As stated in MPEP 2115, "Claim analysis is highly fact-dependent. A claim is only limited by positively recited elements." In Appellant's claim 1, the organotin compositions are positively recited as a component of the system.

Next, the Office Action refers to MPEP 2111.02 and 2114. The corresponding discussion in the Office Action refer to an intended use. Respectfully, the first two missing elements above are positively recited structural elements of the claimed system. The third missing element noted above arguably relates to an intended use, but this feature also indicated aspects of the reactivity of the precursors that are positively recited, as well as the configuration that provides for their reaction. None of this is taught or suggested by Pore, and the missing features from Appellant's claim are not related to in any way to the teachings of Pore.

Under the statute, the claims must be examined as a whole for the evaluation of obviousness or non-obviousness. The features in Appellant's claim are positively recited and thus cannot be ignored. "The PTO lacks substantive rulemaking authority." *Koninklijke Philips Electronics N.V. v. Cardiac Science,* 590 F.3d 1326, 1337 (Fed.Cir. 2010). Accord, see *Tafas v. Doll*, 559 F.3d 1345 (Fed. Cir. 2009) and *Merck & Co. v. Kessler*, 80 F.3d 1543 (Fed. Cir. 1996). Certainly, the Examiner does not have the authority to disregard the statute. With all due respect, the rejection is based on extreme error of law. The statute simply must be followed.

Since the claimed invention has not been reviewed as a whole, *prima facie* obviousness clearly has not been established or even reasonably asserted. The Examiner has not come close to meeting the burden of persuasion regarding obviousness. Due to these extreme errors, the rejection of claims 1, 2, 8-13, 15-18, 21, 26 and 27 under pre-AIA 35 U.S.C. § 103 as being unpatentable over Pore should be reversed.



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## REQUEST FOR RELIEF

Applicants believe that the Patent Office has failed to meet its burden of persuasion with respect to unpatentability of any of the claims on the present record. Thus, Appellant respectfully requests the reversal of the rejections of claims.

Respectfully submitted,

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## CLAIMS APPENDIX

1. A system comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin composition comprising a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido ($-NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo ($-OSiR^1R^2R^3$, where $R^1$, $R^2$, are independently hydrocarbon groups with 1-10 carbon atoms), silylamido ($-N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido ($-N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido ($-N_3$), alkynido (-C≡CR, where R is a hydrocarbon group with 1-9 carbon atoms), amidato ($-NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato ($-NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido ($-N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof;

structure configured to deliver flow of a first precursor vapor from the supply of the organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber; and

structure to deliver a second precursor vapor comprising water, hydrogen peroxide or a combination thereof capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a



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volatile component comprising ~~a~~ hydrolysis reaction product with X, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

2. The system of claim 1 wherein the substrate comprises a silicon wafer.

3. (Cancelled)

4. The system of claim 1 wherein the inert gas comprises nitrogen or argon.

5. The system of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6-7. (Cancelled)

8. The system of claim 1 wherein the second precursor vapor comprises water vapor.

9. The system of claim 1 further comprising a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. The system of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. The system of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.



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12. The system of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. The system of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. The system of claim 1 wherein the flow comprises a vapor.

15. The system of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. The system of claim 15 wherein the vapor inputting structures provide for control of the flow.

17. The system of claim 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.

18. The system of claim 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. The system of claim 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow, the second vapor flow, and a third vapor flow are sequential.

20. The system of claim 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor



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flow, wherein the first vapor flow and the second vapor flow are at the same time and a third vapor flow is sequential.

21. The system of claim 1 wherein the interior has a temperature from about 45°C to about 200°C.

22. (Withdrawn) A method for forming an organotin layer using the system of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (Withdrawn) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (Withdrawn) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.

25. (Withdrawn) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.

26. The system of claim 1 wherein X is alkylamido or dialkylamido.

27. The system of claim 1 wherein X is alkoxo and aryloxo.



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| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 46625403 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Peter S. Dardi |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 15-SEP-2022 |
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| 1 | Appeal Brief Filed | AppealBrief.pdf | 181042<br>44a9216f773a6b551c19a3f913f9b6198a7bce83 | no | 28 |
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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al. Confirmation No.: 5672

Application No.: 16/987,120 Examiner: Binu Thomas

Filed: August 6, 2020 Group Art Unit: 1717

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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NOTICE OF APPEAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with 37 C.F.R. § 1.191, Applicant hereby appeals to the Patent Trial and Appeal Board from the Office Action mailed June 28, 2022, rejecting claims 1-2, 4-5, 8-21, and 26-27 in the above-identified patent application. A Notice of Appeal fee of **$840.00** was previously paid on February 24, 2022, therefore a fee will not be submitted with this Notice of Appeal. The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 60-1363.

Respectfully submitted,

/Diane Bennett/

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*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No.60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

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July 15, 2022 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 46201094 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
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| **Receipt Date:** | 15-JUL-2022 |
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| **Application Type:** | Utility under 35 USC 111(a) |

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| 1 | Notice of Appeal Filed | NoticeOfAppeal.pdf | 21606<br>30ae23407b2879b2c1303c3049d85054bc9250d9 | no | 1 |

**Warnings:**

| Information: | |
|---|---|
| **Total Files Size (in bytes):** | 21606 |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 06/28/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
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Maple Grove, MN 55369

| EXAMINER |
|---|
| THOMAS, BINU |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 06/28/2022 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket@cfd-ip.com
patents@cfd-ip.com



Lam Research Ex. 1002 - Page 70
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| *Office Action Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 04/20/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-2,4-5 and 8-27 is/are pending in the application.

5a) Of the above claim(s) 22-25 is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-2,4-5,8-21 and 26-27 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



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Lam Research Corp. v. Inpria Corp.
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## DETAILED ACTION

### *Continued Examination Under 37 CFR 1.114*

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on April 20, 2022 has been entered.

2. The Applicant's amendment filed on April 20, 2022 was received. Claims 1-2, 4-5 and 8-21 were amended. Claims 26-27 were added. Claims 22-25 remain withdrawn.

3. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action issued August 12, 2021.

### *Claim Interpretation*

4. This application includes one or more claim limitations that do not use the word "means," but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier.

5. Such claim limitation(s) is/are: a configuration providing for selection of the pressure and/or the temperature in the deposition chamber in claim 13.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the

corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

6. Regarding the recitation of configuration providing for selection of the pressure and/or the temperature in the deposition chamber, the recitation is interpreted a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158) which supports the substrate in the deposition chamber (151), as disclosed in figure 16 and amendments to the specification filed April 5, 2021 and January 20, 2021.

***Claim Rejections - 35 USC § 112***

7. **Claim 14 is rejected under 35 U.S.C. 112(d) or pre-AIA 35 U.S.C. 112, 4th paragraph**, as being of improper dependent form for failing to further limit the subject matter of the claim upon which it depends, or for failing to include all the limitations of the claim upon which it depends.

Claim 14 recites "the flow comprises a vapor", which is found in claim 1 as the possible flows are the first precursor **vapor** or the second precursor **vapor**.

Applicant may cancel the claim(s), amend the claim(s) to place the claim(s) in proper dependent form, rewrite the claim(s) in independent form, or present a sufficient showing that the dependent claim(s) complies with the statutory requirements.

***Claim Rejections - 35 USC § 103***

8. **Claims 1-2, 4-5, 8-21 and 26-27 are rejected under 35 U.S.C. 103 as being unpatentable over Maeng** (as previously provided) **in view of Kane** (**US 3,944,684**).

**In regards to claim 1**, Maeng teaches a PE-ALD system comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate (see 8-inch wafer) within the interior of the deposition chamber, the substrate receives a deposition on a surface of the substrate, where substrate maybe maintained at a temperature of less than 200°C while maintaining a growth rate (fig. 3; pg. 2277);

an inlet (see pipes connected to bubblers) into the deposition chamber;

a structure (see label of Ar gas) delivers flow from a supply of an inert gas; and

a supply of organometallic compound (see label of PDMAT bubbler)

a structure (see pipe between PDMAT bubbler and deposition chamber) delivers a flow from the supply of the organometallic compound with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 1).

Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler (structure which delivers flow of second precursor vapor) provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1).

Maeng does not explicitly teach an organotin composition comprising a compound that is described by the formula found in the instant claim 1, and to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

However, in same field of endeavor of deposition of vapor deposition, Kane teaches an organotin compound (12) is contained in closed container (10, supply of organotin compound) (fig. 1; col. 2, lines 45-60, col. 4, lines 28-35).

Kane teaches an inlet tube (14) supplies a carrier gas to the closed container, where the carrier gas and the organotin vapor is supplied to a tube-18 (structure to deliver flow) which is

connected to a tube-22, so that the carrier gas and the organotin vapor is feed into a reaction chamber (26) (fig. 1; col. 4, lines 28-40). Kane teaches the carrier gas is an inert gas such as neon, argon, krypton, nitrogen and the like (col. 3, lines 20-25).

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the supply of organometallic compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

With regards to organotin composition comprising a compound that is described by the formula found in the instant claim 1, the recitation of a particular type of processing materials do not limit an apparatus claim (MPEP2115).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, this recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim (MPEP2111.02/2114).

Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of using the system to maintain the substrate temperature and use the system to provide the claimed

compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Maeng and Kane as discussed above, where Maeng teaches the substrate is a silicon substrate (pg. 2277). Also, the recitation of a particular type of substrate does not limit an apparatus claim (MPEP2115).

**In regards to claim 4**, Maeng and Kane as discussed above, where Maeng teaches the structure (see label of Ar gas) which provides the inert gas of argon, where argon is used as the carrier gas (pg. 2277).

**In regards to claims 5 and 14**, Maeng and Kane as discussed above, where Maeng teaches the structure which supplies the liquid precursor is a bubbler which bubbles the inert carrier gas through the liquid PDMAT to supply the vapor to the chamber (fig. 1) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

**In regards to claims 8-10, 15-20 and 26-27**, Maeng and Kane as discussed above, where Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1) and Kane teaches the organotin compound is supplied to the reaction chamber (fig. 1; col. 4, lines 30-40).

Maeng and Kane do not explicitly teach the flow from the supply of the organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the material solution and a third precursor vapor as SnL4 as recited in the claim, and with the flow process as recited in the claim.

**In regards to claims 11-12 and 21**, Maeng and Kane as discussed above, where Maeng teaches a pressure of the chamber of 0.1 to 10-mtorr and reactor growth temperature of 150-250°C (pg. 2277-2278).

**In regards to claim 13**, Maeng and Kane as discussed above, where Maeng teaches a selection of the temperature within the deposition chamber (pg. 2278).

9. **Claims 1-2, 8-13, 15-18, 21 and 26-27 are rejected under 35 U.S.C. 103 as being unpatentable over Pore (US 2017/0100742)**.

**In regards to claims 1 and 4**, Pore teaches an apparatus (100, system) comprising:

a deposition chamber having a reaction space (115, interior) isolated from the ambient atmosphere (fig. 2a; para. 46);

a substrate (120) within the interior of the deposition chamber which receives a deposition on a surface of the substrate, where the deposition chamber with the substrate is maintained at a temperature of less than 200°C (fig. 2a; para. 43, 46, 58);

an inlet into the deposition chamber is provide at inlet manifold (135) (fig. 2a; para. 47);

an inert gas source (150, structure) delivers flow from a supply of an inert gas such as argon or nitrogen which is well known (fig. 2a; para. 49); and

a first reactant vessel (105, supply) which supplies an organic reactant (110) (fig. 2a, para. 46)

a gas line (130, structure) delivers flow from the first reactant vessel with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 2a; para. 47).

Pore teaches first reactant vessel vaporizes the first organic reactant and a second reactant vessel (140) (structure for second precursor vapor) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber (fig. 2a; para. 46, 48).

Pore does not explicitly teach the organotin compound.

However, first reactant vessel is a component which is capable of holding and supplying an organotin compound as currently claimed, as the claim does not explicitly require a specific type of vessel material or shape or construction.

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to recognize first reactant vessel as a construction which may supply an organotin composition because the first reactant vessel provide vaporizing

organic reactant. Further, the recitation of a particular type of processing materials do not limit an apparatus claim (MPEP2115).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, this recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim (MPEP2111.02/2114).

Therefore, as Pore teaches the structural limitations of the claim, one would be capable of using the apparatus to maintain the substrate temperature and use the system to provide the claimed compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Pore as discussed above, where Pore teaches the substrate is silicon wafer (para. 17). Also, the recitation of a particular type of substrate does not limit an apparatus claim (MPEP2115).

**In regards to claims 8-10, 15-18 and 26-27**, Pore and Kane as discussed above, where Pore teaches first reactant vessel vaporizes the first organic reactant and a second reactant vessel (140) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber (fig. 2a; para. 46, 48).

Pore does not explicitly teach the flow from the supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114). As Pore teaches the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claims, as the first reactant and the second reactant of SnL4 as recited in the claim, and with the flow process as recited in the claim(s).

**In regards to claims 11-12 and 21**, Pore as discussed above, where Pore teaches a pressure of the chamber of 100-mtorr to 100-torr and a temperature of 100-250°C (para. 43).

**In regards to claim 13**, Pore as discussed above, where Pore teaches a control system (125) which controls a vacuum pump (165) to maintain the pressure in the deposition chamber (fig. 2a; para. 50).

***Response to Arguments***

10. Applicant's arguments filed November 9, 2021 have been fully considered but they are not persuasive.

Applicant's principal arguments are:

a. Maeng and Kane do not reference recites mono-organo tin with three hydrolysable ligands.

b. There is no evidence on record that the precursors of Kane would be suitable for ALD deposition using the apparatus of Maeng. With all due respect, substantial evidence does not support the motivation asserted in the Final Office Action that the use of the Kane precursors would result in tin oxide formation at a lower temperature since ALD involves sequential reaction steps and not a single reaction process of Kane.

c. The systems disclosed by Maeng and Kane are generally optimized for operating at a higher temperature range suitable for forming oxide products. The systems of the cited references are also not suitable for providing sufficient stability of the process conditions to enable deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks.

d. Kane is not teaching or suggesting that the disclosed apparatus would be suitable to maintain a temperature of less than 200°C.

e. Applicant respectfully asserts that there is no teaching in either reference that would suggest processing components suitable for forming an organotin oxide hydroxide layer with intact tin-carbon bonds, and substantial evidence does not indicate the target products could be successfully formed with the apparatus of Maeng or Maeng in view of Kane.

f. The systems of Maeng and Kane fail to provide adequate control of the process conditions. As a result, there is no reasonable expectation of success in achieving conditions in the deposition chambers of Maeng or Kane to produce a radiation sensitive organotin oxide hydroxide coating. Furthermore, neither Maeng nor Kane provide any motivation to modify their systems to have the temperature control features of the presently claimed system.

g. Maeng and Kane are not suitable for deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks.

h. Pore not only does not teach, but does not suggest, motivate in any way or provide any hint that the use of an organotin compound would serve any purpose in the context of their polyimide layer, the temperatures used by the prior arts and there is no hint in Kane that the organotin compound would be desirably deposited onto a substrate of Pore.

i. The substitution of the compositions of Kane into Pore would render Pore nonfunctional for its intended purpose of making a polymer coating.

In response to Applicant's arguments, please consider the following comments:

a. The Applicant's argument is noted, however they directed to the particular type of processing material used by the system. The recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

b. Applicant's argument is not persuasive as neither of the cited prior art discourage the combination. It has held when a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. Also, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Applicant's amendments and arguments focus the chemical composition which do not further structurally limit to provide distinction over the cited prior art combination.

c. Applicant's argument is noted, however Fig. 3 of Maeng clearly shows a temperature of the substrate along the bottom axis which is less than 200°C which achieves a

growth rate. Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus "if the prior art apparatus teaches all the structural limitations of the claim (MPEP 2114).

d. In response to applicant's argument that apparatus would be suitable to maintain a temperature of less than 200°C, the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981).

e. Applicant's arguments is not persuasive as it does not clearly point out the patentable novelty which is found in the claim and not in the prior art. Maeng teaches the structural elements which supplies the organo-tin composition. Maeng teaches the use of a bubbler which represents a structure which that is capable of supplying organo-tin composition.

f. In response to applicant's argument that the prior art do not provide adequate control of the process conditions, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. As Maeng clearly shows a temperature of the substrate along the bottom axis which is less than 200°C and other temperatures, the system has an element which provides for the adjustment of the temperature. Also, the claim is silent to a structural element which provides temperature control and the claim is silent to structural element(s) for control of the process conditions.

g. Applicant's argument is noted but does not feature a structural element found in the claim and not in the cited prior. It has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations (MPEP2114).

h. In response to applicant's argument that the use of an organotin compound would not serve any purpose in the context of their polyimide layer, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim.

i. Pore teach vaporization of organic compounds to form the coating containing organic compounds. It is the examiner's opinion the combination would not result in unsuitable for its intended purpose as neither criticize, discredit, or otherwise discourage the solution. One of ordinary skill in the art will recognize the structural elements taught by the prior art would like be limited to the explicitly taught substrate(s).

## *Conclusion*

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is

encouraged to use the USPTO Automated Interview Request (AIR) at

http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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/Binu Thomas/
Primary Examiner, Art Unit 1717

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
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| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| | | | |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |
| Updated search | 01/2021 | BT |
| Updated search | 08/2021 | BT |
| Updated search | 11/2021 | BT |
| Updated search | 06/2022 | BT |

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
|---|---|



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Lam Research Corp. v. Inpria Corp.
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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| | | | |

| | |
|---|---|
| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |



Lam Research Ex. 1002 - Page 87
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

## PE2E SEARCH - Search History (Prior Art)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | British Equivalents | Time Stamp |
|---|---|---|---|---|---|---|---|
| L1 | 0 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:20 AM |
| L2 | 6 | "15291738" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:21 AM |
| L3 | 1913 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT) | OR | ON | ON | 2020/09/29 09:21 AM |
| L4 | 1851 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:21 AM |
| L5 | 82 | L4 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 09:29 AM |
| L6 | 6 | "15291738" and deposition near2 chamber | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 11:47 AM |
| L7 | 76 | ("10025179"\|"10228618"\|"10642153"\|"20020076495"\|"20030124457"\|"20040067444"\|"20060088962"\|"20060234138"\|"20080055597"\|"20080286683"\|"20090155546"\|"20090174036"\|"20100044698"\|"20100184259"\|"20110045406"\|"20110135823"\|"20110166268"\|"20110206599"\|"20110244403"\|"20110293888"\|"20120223418"\|"2 | (US-PGPUB; USPAT) | OR | ON | ON | 2020/09/29 01:57 PM |



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IPR2025-00309 - U.S. Patent No. 11,537,048

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0130224652"\|"2013025 3161"\|"20140268062"\|" 20140303283"\|"201500 56542"\|"20150079393"\| "20150221519"\|"20150 253667"\|"20160116839 "\|"20170184960"\|"2017 0184961"\|"2019013787 0"\|"3385915"\|"3635883" \|"4102683"\|"4104292"\|" 4370405"\|"4380559"\|"4 601917"\|"4639208"\|"47 32841"\|"4851481"\|"489 1303"\|"4910122"\|"5025 094"\|"5672243"\|"58919 85"\|"6020269"\|"606038 0"\|"6179922"\|"6183716" \|"6194323"\|"6197896"\|" 6268457"\|"6287951"\|"6 420088"\|"6566276"\|"65 83071"\|"6730454"\|"684 4604"\|"6927108"\|"6946 677"\|"7001821"\|"72083 41"\|"7256129"\|"770905 6"\|"7773365"\|"7799503" \|"8030507"\|"8053370"\|" 8092703"\|"8366967"\|"8 415000"\|"8796483"\|"93 10684").PN. | | | | | |
| L8 | 12 | ("20050266700" \| "20060062916" \| "20070092648" \| "5147688" \| "6061117" \| "6503561" \| "7250083").PN. OR ("7709056").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:09 PM |
| L9 | 107 | ("4059929" \| "5478435" \| "5548159" \| "5558435" \| "5645891" \| "5736425" \| "5747880" \| "5750440" \| "5807607" \| "5814370" \| "5834845" \| "5843602" \| "5847443" \| "5857893" \| "5858457" \| "5858871" \| "5868278" \| "5922299" \| "5948482" \| "5955140" \| "6011123" \| "6015457" \| "6037275" \| "6048256" \| "6066575" \| "6070600" \| "6098843" \| "6107357" \| "6120891" \| "6140252" \| "6159295" \| "6162583" \| "6162838" \| "6163066" \| "6168737" \| "6171645" \| "6171687" \| "6172128" \| "6184260" \| "6187248" \| "6197913" \| "6204202" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:11 PM |

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|---|---|---|---|---|---|---|---|
| | | \| "6208014" \| "6251473" \| "6270846" \| "6277765" \| "6297459").PN. OR ("6583071").URPN. | | | | | |
| L10 | 6 | ("10025179"\|"20100099908"\|"20150221519"\|"4014858"\|"4144222"\|"4174346").PN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L11 | 3 | ("20130253161"\|"4104292"\|"9310684").PN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L12 | 9 | L10 L11 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:19 PM |
| L13 | 20 | ("20020048770" \| "20030116091" \| "20030118947" \| "20040087184" \| "5456945" \| "5759923" \| "6116184" \| "6231933" \| "6261373" \| "6358559" \| "6365266" \| "6376634" \| "6406794" \| "6428847" \| "6455443" \| "6472076" \| "6576568" \| "6583071" \| "6592980").PN. OR ("7446055").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:21 PM |
| L14 | 6 | ("20020033173" \| "5589300" \| "5894064" \| "6048817" \| "6444763" \| "6583071").PN. OR ("6825131").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:24 PM |
| L15 | 25 | L13 L14 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:29 PM |
| L16 | 59271 | H01L21/02274-02282.cpc. c23c16/$.cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:43 PM |
| L17 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 02:43 PM |
| L18 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:17 PM |
| L19 | 6 | "15291738" and structure | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:23 PM |
| L20 | 6 | "15291738" and precursor near2 vapor | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:24 PM |
| L21 | 6 | "15291738" and deposition near2 chamber | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:27 PM |
| L22 | 6 | "15291738" and thickness near2 variation | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 03:28 PM |

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|---|---|---|---|---|---|---|---|
| L23 | 6 | "15291738" and select$4 near5 (temperature pressure) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 04:55 PM |
| L24 | 3 | "20080022896" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2020/09/29 06:07 PM |
| L25 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 11:23 AM |
| L26 | 1873 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 12:02 PM |
| L27 | 84 | L26 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 12:02 PM |
| L28 | 17 | (US-20110293888-$ or US-20040067444-$ or US-20050266700-$ or US-20030118947-$ or US-20120027937-$ or US-20090155535-$ or US-20060211271-$ or US-20040156987-$ or US-20080022896-$).did. or (US-6583071-$ or US-4601917-$ or US-4104292-$ or US-6825131-$ or US-5894064-$ or US-6251473-$ or US-6066575-$ or US-6116184-$).did. | (US-PGPUB; USPAT) | OR | ON | ON | 2021/01/25 12:48 PM |
| L29 | 19 | ("4293594").PN. OR ("4601917").URPN. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:44 PM |
| L30 | 1323 | (C23C16/45525).cpc. and carrier near3 gas | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:46 PM |
| L31 | 554 | (C23C16/45525).cpc. and carrier near3 gas near20 inert | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:46 PM |
| L32 | 21 | ("20040209190" \| "20050186339" \| "20060124057" \| "20070194157" \| "20080146011" \| "20090152371" \| "20100300221" \| "20110097507" \| | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:49 PM |

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|---|---|---|---|---|---|---|---|
| | | "20110163062" \| "20110198620" \| "20120074575" \| "20120088315" \| "20130316541" \| "20140262461" \| "20170140920" \| "6146767" \| "6503701" \| "7718011" \| "7954730" \| "8840037" \| "9677984").PN. OR ("10163629").URPN. | | | | | |
| L33 | 141 | (c23c14/$ c23c16/$).cpc. and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:56 PM |
| L34 | 1 | "16987120" and (oxide and hydroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 01:59 PM |
| L35 | 9 | (c23c14/$ c23c16/$).cpc. and organotin and oxide near10 hydroxide | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:00 PM |
| L36 | 2 | "20170100742" "20160284553" and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:01 PM |
| L37 | 4 | ("20170100742" "20160284553") and carrier near3 gas near20 inert | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:01 PM |
| L39 | 2 | ("20170100742" "20160284553") and carrier near3 gas near20 inert and (argon nitrogen) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 02:41 PM |
| L40 | 1 | "16987120" and (third near5 vapor) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/01/25 05:52 PM |
| L41 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/04/07 09:27 AM |
| L42 | 2 | "20150056542" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/04/07 12:40 PM |
| L43 | 145 | (c23c14/$ c23c16/$).cpc. and organotin | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/08/04 10:09 AM |
| L44 | 27 | (c23c14/$ c23c16/$).cpc. and organotin near20 (supply source container) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/08/04 10:10 AM |
| L45 | 1933 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 05:11 PM |

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|---|---|---|---|---|---|---|---|
| | | ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | | | | | |
| L46 | 85 | L45 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 05:11 PM |
| L47 | 68 | ("20040113087" \| "20040175631" \| "20040191423" \| "20040213563" \| "20050208389" \| "20050253077" \| "20060001064" \| "20060068173" \| "20060147818" \| "20060172530" \| "20060175558" \| "20070037410" \| "20070181816" \| "20090208880" \| "20090305174" \| "20090317742" \| "20090321707" \| "20100022078" \| "20100131093" \| "20100197135" \| "20100304027" \| "20110104595" \| "20120068347" \| "20120088193" \| "20120088369" \| "20120126358" \| "20120193762" \| "20120202357" \| "20140120688" \| "20140134827" \| "20140170563" \| "20140170853" \| "20140268082" \| "20150041809" \| "20150077733" \| "20150170957" \| "20150221519" \| "20150332922" \| "20160135274" \| "20160314964" \| "20160379824" \| "20170102612" \| "20170146909" \| "20180004083" \| "20180233349" \| "20180308687" \| "20180337046" \| "20190027357" \| | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/15 06:23 PM |



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|---|---|---|---|---|---|---|---|
| | | "20190094685" \| "3513010" \| "3529963" \| "3720515" \| "4241165" \| "4328298" \| "4590149" \| "4845053" \| "5077085" \| "5534312" \| "6162577" \| "6261938" \| "9023731" \| "9551924" \| "9778561" \| "9996004").PN. OR ("10514598").URPN. | | | | | |
| L48 | 1046 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon stannanes ) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 11:40 AM |
| L49 | 1001 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon ) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 11:42 AM |
| L50 | 8 | ("20140099451" "20180004083" "20060228476" ("4590096" "5997639" "4146657" ).pn. ) and (tin organotin) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2021/11/16 04:39 PM |
| L51 | 1940 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:43 AM |
| L52 | 86 | L51 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:43 AM |
| L53 | 60 | (c23c14/$ c23c16/$).cpc. and (organotin organo$1tin) near10 oxide | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 08:46 AM |
| L54 | 1 | "16987120" | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/01/26 10:08 AM |
| L55 | 81 | L4 and (c23c14/$ c23c16/$).cpc. | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:09 PM |
| L56 | 590 | (c23c14/$ c23c16/$).cpc. AND (organotin tin near5 carbon stannanes ) AND (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:16 PM |
| L57 | 30 | (c23c14/$ | (US-PGPUB; USPAT; | OR | ON | ON | 2022/06/13 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | c23c16/$).cpc. AND (organotin tin near5 carbon stannanes ) near20 (water hydrogen near2 peroxide) | USOCR) | | | | 01:17 PM |
| L58 | 30 | (c23c14/$ c23c16/$).cpc. AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 01:17 PM |
| L59 | 3 | ("20150170902" "4590096" "4696837" "4788079").pn. AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L60 | 3 | ("20150170902" "4590096" "4696837" "4788079").pn. AND (organotin tin) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L61 | 1 | ("4788079").pn. AND (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:04 PM |
| L64 | 864 | (coat$3 deposit$3) AND (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:14 PM |
| L65 | 149 | (coat$3 deposit$3) near20 (organotin tin near5 carbon ) near20 (water hydrogen near2 peroxide) | (US-PGPUB; USPAT; USOCR) | OR | ON | ON | 2022/06/13 02:15 PM |

## PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.



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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| **PATENT APPLICATION FEE DETERMINATION RECORD**<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| AMENDMENT | 04/20/2022 | (Column 1)<br>CLAIMS REMAINING AFTER AMENDMENT | | (Column 2)<br>HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3)<br>PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|
| | Total<br>(37 CFR 1.16(i)) | * 24 | Minus | ** 25 | = 0 | | x $100 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 2 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 0 |

| AMENDMENT | | (Column 1)<br>CLAIMS REMAINING AFTER AMENDMENT | | (Column 2)<br>HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3)<br>PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /TERESA J JACKSON WOODRUFF/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

Customer No. **62274**
Christensen, Fonder, Dardi & Herbert PLLC
11322 86th Avenue N
Maple Grove, MN 55369
Telephone: (404) 949-5730
Facsimile: (612) 315-4321

Attorney Docket No. 5063.08US05

REQUEST FOR CONTINUED EXAMINATION (RCE) TRANSMITTAL

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Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is a Request for Continued Examination (RCE) under 37 C.F.R. § 1.114 of Application No. 16/987,120, filed August 6, 2020 for: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING, by: Stephen T. Meyers, Jeremy T. Anderson, Brian J. Cardineau, Joseph B. Edson, Kai Jiang, Douglas A. Keszler, and Alan J. Telecky.

1. Submission required under 37 C.F.R. § 1.114

a. [ ] Previously submitted

- [ ] Please enter in the present application the unentered Amendment under 37 C.F.R. § 1.116, with any attachments, filed on _____ in said prior application.
- [ ] Consider the arguments in the Appeal Brief or reply Brief previously filed on _____
- [ ] Other _____

b. [X] Enclosed

- [X] An Amendment is enclosed. Claims added by this Amendment are properly numbered consecutively beginning with the number next following the highest numbered claim in the prior application.
- [ ] Affidavit(s)/Declaration(s)
- [ ] Information Disclosure Statement (IDS)
- [ ] Other _____

2. [X] The filing fee is calculated below:

| | Claims Remaining After Amendment | Highest No. Previously Paid For | Present Extra (Equals) | ~~Small Entity Rate~~ | ~~Add'l Fee~~ | OR | **Large Entity Rate** | **Add'l Fee** |
|---|---|---|---|---|---|---|---|---|
| Total | 24 | - 25 | = 0 | ~~x 50~~ | ~~$~~ | | **x 100** | **$0** |
| Indep. | 3 | - 3 | = 0 | ~~x 240~~ | ~~$~~ | | **x 480** | **$0** |
| RCE fee | | | | ~~+ 1000~~ | ~~$~~ | | **+ 2000** | **$2000** |
| Mult. Dep. | | | = 0 | ~~[+ 430]~~ | ~~$~~ | | **[+ 860]** | **$0** |
| | | | | ~~TOTAL~~ | ~~$~~ | OR | **TOTAL** | **$2000.00** |

[ ] First Presentation of Multiple Dependent Claim [MDC]

* If the entry in Column 1 is less than the entry in Column 2, write "0" in Column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space.
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Column 1 of a prior Amendment or the number of claims originally filed.

3. [ ] Applicant(s) is/are entitled to small entity status in accordance with 37 CFR 1.27.

4. [X] The Commissioner is authorized to charge a credit card in the amount of **$2000.00** (The RCE fee under 37 C.F.R. § 1.17(e) is required by 37 C.F.R. § 1.114 when the RCE is filed). The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 60-1363.

Respectfully submitted,

/Peter S. Dardi/

Peter S. Dardi, Ph.D.
Registration No. 39,650

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

April 20, 2022
Date

/Peter S. Dardi/
Peter S. Dardi, Ph.D., Reg. #39,650



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IPR2025-00309 - U.S. Patent No. 11,537,048

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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## AMENDMENT

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

## INTRODUCTORY COMMENTS

Prior to considering the RCE filed with this Amendment, please enter the following amendments and consider the following remarks. Applicant assumes that the Amendment After Final of January 20, 2022 has been entered, and present arguments directed to the pending rejections are presented. This Amendment includes the following:

A. Amendments to the Claims

B. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

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April 20, 2022
Date

/Peter S. Dardi/
Peter S. Dardi, Ph.D., Reg. #39,650

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Currently Amended) ~~An apparatus~~ A system comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin composition ~~compound~~ comprising a compound described by the formula $RSnX_3$, where R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond and wherein X is selected from the group consisting of alkylamido or dialkylamido ($-NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo ($-OSiR^1R^2R^3$, where $R^1$, $R^2$, are independently hydrocarbon groups with 1-10 carbon atoms), silylamido ($-N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido ($-N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido ($-N_3$), alkynido ($-C\equiv CR$, where R is a hydrocarbon group with 1-9 carbon atoms), amidato ($-NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato ($-NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido ($-N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof, or combinations thereof;

structure configured to deliver flow of a first precursor vapor from the supply of [[an]] the organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber~~, the organotin compound~~



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~~comprising a hydrolysable or oxidizable ligand suitable for the formation of an organotin oxide hydroxide layer with a metal-carbon bond that is radiation sensitive~~; and

structure to deliver a second precursor vapor comprising water, hydrogen peroxide or a combination thereof ~~an oxygen-containing compound~~ capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising ~~a~~ hydrolysis reaction product with X ~~a hydrolysable ligand or ligands~~, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

2. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the substrate comprises a silicon wafer.

3. (Cancelled)

4. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the inert gas comprises nitrogen or argon.

5. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6-7. (Cancelled)

8. (Currently Amended) The ~~apparatus~~ system of claim 1 [[6]] wherein the second precursor vapor comprises water vapor.



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9. (Currently Amended) The system ~~apparatus~~ of claim [[6]] 1 further comprising a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. (Currently Amended) The system ~~apparatus~~ of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.

12. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. (Currently Amended) The system ~~apparatus~~ of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the flow comprises a vapor.

15. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. (Currently Amended) The system ~~apparatus~~ of claim 15 wherein the vapor inputting structures provide for control of the flow.

17. (Currently Amended) The system ~~apparatus~~ of claim [[6]] 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.



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18. (Currently Amended) The system ~~apparatus~~ of claim [[6]] 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. (Currently Amended) The system ~~apparatus~~ of claim [[6]] 1 wherein a first vapor inputting structure ~~is~~ is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow, the second vapor flow, and a third vapor flow are sequential.

20. (Currently Amended) The system ~~apparatus~~ of claim [[6]] 1 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are at the same time and a third vapor flow is sequential.

21. (Currently Amended) The system ~~apparatus~~ of claim 1 wherein the interior has a temperature from about 45°C to about 200°C.

22. (Withdrawn, Currently Amended) A method for forming an organotin layer using the system ~~apparatus~~ of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (Withdrawn) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (Withdrawn) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.



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25. (Withdrawn) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.

26. (New) The system of claim 1 wherein X is alkylamido or dialkylamido.

27. (New) The system of claim 1 wherein X is alkoxo and aryloxo.



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REMARKS

Claims 1-2, 4-5 and 8-27 are pending. By this amendment, claims 6 and 7 are cancelled without prejudice, and new claims 26 and 27 are added. Claims 1, 2, 4, 5, and 7-22 are amended. The preamble of claims 1, 2, 4, 5, and 7-21 and the reference to claim 1 in claim 22 are amended to replace apparatus with system, which is believed to be slightly clearer in specifying the nature of the invention. In view of the cancellation of claim 6, the dependency of claims 8, 9 and 17-20 are amended. Claim 1 is amended to specify the precursors more specifically. The amendment of the second precursor in claim 1 is supported by claim 7, now cancelled. The specification supports the amendment of the first precursor in claim 1, for example, at page 15, lines 5-27, page 17, lines 2-14 and page 26, lines 1-8. New claims 26 and 27 correspond to species of claim 1. No new matter is introduced.

Claim Interpretation.

*Claim 13.* The Examiner indicates on page 2, paragraph 5 of the Office Action that the recitation in claim 13 of configuration providing for selection of the pressure and/or the temperature in the deposition chamber is interpreted to be "a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158), as disclosed in figure 16 and amendments to specification filed April 5, 2021 and January 20, 2021." Applicant respectfully asserts that this interpretation is inappropriately narrow.

Applicant incorporates by reference the arguments of the Amendment filed on April 5, 2021 and January 20, 2021. Applicant respectfully maintains that the features of claim 13 are not means plus function limitations. Furthermore, Applicant respectfully asserts that the Examiner's stated interpretation of the features of claim 13 is not consistent with the broadest reasonable interpretation consistent with the specification. As explained in the Amendment filed on January 20, 2021, pump 155 and pump 156 and thermal block 158 are examples of configuration to provide for selection of the pressure and/or the temperature in the deposition chamber. Respectfully, Applicant referred to other non-limiting examples in the specification of disclosure of configurations to control pressure and temperature in a chamber and noted that configurations to control pressure and temperature in a chamber are well-known in the art.



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"A patent need not disclose what is well known in the art." *In re Wands*, 858 F.2d 731, 735 (Fed. Cir. 1988). "The test is whether the disclosure 'conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.' This test requires an 'objective inquiry into the four corners of the specification from the perspective of a person of ordinary skill in the art.' Given this perspective, in some instances, a patentee can rely on information that is 'well-known in the art' to satisfy written description." *Streck, Inc. v. Research & Diagnostic Sys., Inc.*, 665 F.3d 1269, 1285 (Fed. Cir. 2012) cert. denied, 132 S. Ct. 2442, 182 L. Ed. 2d 1064 (U.S. 2012) (citing *Ariad,* 598 F.3d at 1351; *Boston Sci. Corp. v. Johnson & Johnson,* 647 F.3d 1353, 1366 (Fed.Cir.2011)) (internal citations omitted). "That which is common and well known is as if it were written out in the patent and delineated in the drawings." *In re Howarth*, 654 F.2d 103, 106 (C.C.P.A. 1981) (citing Webster Loom Co. v. Higgins et al., 105 U.S. 580, 586 (26 L.Ed. 1177) (1881)).

Rejection Under 35 U.S.C. 103 Over Maeng et al. and Kane et al.

The Examiner rejected claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng et al., J. Vac. Sci. Tech B., 2006, 24, 2276 (hereinafter "Maeng") in view of U.S. patent 3,944,684 to Kane et al. (hereinafter "Kane"). Claim 3 is cancelled. Claims 2 and 4-21 depend from claim 1. Applicant maintains that the combined teachings of Maeng and Kane do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejections based on the following comments.

The Examiner cites Maeng for many of the features of Applicant's claimed invention. The Examiner acknowledges that Maeng does not teach an organotin compound and cites Kane for this feature. Neither reference recites mono-organo tin with three hydrolysable ligands.

The combination of Maeng and Kane then raises the issue regarding the suitability of the combination as well as whether the combination reasonably teaches all of the features of the claim. Maeng is specifically focused on forming thin films of Ta compounds using atomic layer deposition (ALD). In the introduction, Maeng briefly mentions Ti, Zr, Hf oxide formation using ALD. Kane is specifically focused on forming indium tin oxide coatings for forming transparent conductive films, which have been of major commercial importance from the time of Kane until now. ALD had not been invented at the time of Kane, and both references are focused specifically



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on their compounds and techniques of interest. Kane teaches chemical vapor deposition using precursors that react to form an oxide during deposition, and there is no evidence on record that the precursors of Kane would be suitable for ALD deposition using the apparatus of Maeng. With all due respect, substantial evidence does not support the motivation asserted in the Final Office Action that the use of the Kane precursors would result in tin oxide formation at a lower temperature since ALD involves sequential reaction steps and not a single reaction process of Kane.

Furthermore, the instant claims recite a system that is suitable for forming an organotin oxide hydroxide layer having radiation-sensitive metal-carbon bonds. The system of claim 1 provides for the substrate to be maintained at a temperature of less than 200°C. The systems disclosed by Maeng and Kane are generally optimized for operating at a higher temperature range suitable for forming oxide products. The systems of the cited references are also not suitable for providing sufficient stability of the process conditions to enable deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. Both Maeng and Kane are focused specifically on full oxidation to form metal oxides.

The Examiner cites Maeng at Fig. 3, page 2277 for teaching a substrate temperature of less than 200°C while maintaining a growth rate. However, what is growing is a **metal oxide** or a **metal nitride** layer. In other words, the PDMAT or the TDMAT of Maeng are **fully converted** to an oxide ($Ta_2O_5$) or a nitride (TaN), respectively. Maeng described several approaches for their reactions. The plasma reaction approaches (PE-ALD) are clearly too harsh to be relevant for the currently claimed invention. There is no indication that the system of Maeng possesses the process control to form a stable organotin oxide-hydroxide layer, as presently claimed.

The system of Maeng is described as having a PDMAT powder in a bubbler. (See Fig. 1.) The bubbler is heated to generate a "high enough" vapor pressure. (See paragraph bridging pages 2276 and 2277.) However, one of ordinary skill in the art would not expect that the delivery of PDMAT via a bubbler, as described by Maeng, would be a highly controlled process. In contrast, the organotin compounds disclosed in the present application are instrumental in the process control that is achieved by the system. In particular, the carbon tin bonds provide the radiation sensitive ligands. Then, the hydrolysable bonds provide the suitability for vapor deposition while being hydrolysable so that hydrolysis at low temperatures can provide the desired oxo-hydroxo



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network. This design, in turn, enables the vapor phase deposition of radiation patternable organotin oxide hydroxide coatings. Applicant explains in the section entitled "Vapor Based Coating Formation" found on page 24, line 15 to page 27, line 14:

> *The development of precursor compounds comprising of both R-groups with substantially non-hydrolysable bonds to Sn, and X ligands with hydrolysable bonds to Sn has been exploited for the development of vapor phase deposition of radiation patternable organotin oxide hydroxide coatings. In particular, the relatively high vapor pressures and reactivity of many $R_nSnX_{(4-n)}$ compounds such as those listed in Table 1, make possible the use of vapor deposition methods for deposition of organotin oxide hydroxide thin-film photoresists. Through the introduction the hydrolysable precursors in the vapor phase in a reactor closed from the ambient atmosphere, the hydrolysis can be performed as part of the deposition process, i.e., a chemical vapor deposition. (See page 24, line 15-page 25, line 22.)*
>
> *In CVD methods, two or more reactant gases are generally mixed in the chamber in the vicinity of the substrate surface.* ***Therefore, sufficient stability can be designed into the reaction conditions to control undesirable vapor-phase reactions and nucleation.*** *ALD precursors, introduced separately and sequentially to the reaction chamber, typically react with chemisorbed co-precursor or decomposition products saturating the substrate surface.* ***Desirable features of $R_nSnX_{(4-n)}$ precursors include, for example, sufficient volatility for vapor-phase transport in the system, thermal stability to prevent premature decomposition, and appropriate reactivity with co-precursors to produce the target product under prescribed process conditions. The pressure and temperature in the reaction chamber can be selected to control the reaction process****. (See page 25, lines 5-13.)*

Significantly, the instant specification discloses that the substrate **may be heated or may be cooled depending on the precursor properties**. (See page 25, lines 19-20.) Applicant asserts that Maeng fails to teach the feature of a substrate maintained at a temperature of less than 200°C.



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The Examiner recognizes that Maeng does not teach an organotin compound. The Examiner cites Kane for remedying this deficiency of Maeng. Claim 1 is amended to be directed to a specific class of organo tin compounds of particular interest in Applicant's systems. Kane teaches that the substrate temperature should be in the range of 350°C to 550°C for a system with an organotin compound. (See Col. 3, lines 38-41.) Kane is focused on CVD deposition of the oxides, which requires the high temperatures. There is no indication that the system of Kane would provide for control (*maintenance*) of the temperature under 200°C. Moreover, Kane cautions that too low a temperature results in an inefficiently low rate of reaction. With all due respect, Kane is not teaching or suggesting that the disclosed apparatus would be suitable to maintain a temperature of less than 200°C. As with Maeng, Kane also fails to teach or suggest both heating and cooling of the substrate, thus the ability to maintain the temperature of the substrate is limited.

The Examiner asserts that it would have been obvious to incorporate the organotin compound in the closed container of Kane onto the supply of organometallic compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures. With all due respect, the Examiner seems to be misinterpreting Kane's reference to a process for preparing tin oxide coatings that "can be carried out at low temperatures." (See Col. 2, lines 3-7.) In referring to "low temperatures," Applicant asserts that Kane is contrasting with the prior discussion of temperatures on the order of 600-700°C. (See Col. 1, line 52.) In as such, "low temperatures" would be below about 600-700°C. As noted above, "too low a temperature" for the system of Kane refers to temperatures below the range of about 350°C-550°C. Indeed, Kane at Table 1 exemplifies deposition temperatures ranging from 450°C to 555°C. Respectfully, Kane in no way suggests that temperatures below about 200°C would be suitable. Thus, Applicant respectfully asserts that neither Maeng nor Kane motivate the asserted combination of the organotin compound of Kane with the system of Maeng based on the asserted motivation of attaining lower temperatures.

Both Maeng and Kane underscore the important connection between process equipment and precursors/reactants. For example, Maeng discloses that "[o]ne of the critical issues for successful ALD process is the proper selection of precursor and reactant." (See page 2276, second paragraph.) Neither Maeng nor Kane teach an apparatus suitable for the deposition of an organotin compound according to claim 1. Rather, each teaches an apparatus that is specific for the



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generation of a particular metal oxide layer. Maeng is directed to $Ta_2O_5$ layers while Kane is directed to tin-doped indium oxide layers. Applicant respectfully asserts that there is no teaching in either reference that would suggest processing components suitable for forming an organotin oxide hydroxide layer with intact tin-carbon bonds, and substantial evidence does not indicate the target products could be successfully formed with the apparatus of Maeng or Maeng in view of Kane.

With all due respect, the instant system is differentiated from the systems of Maeng and Kane. In particular, the systems of Maeng and Kane fail to provide adequate control of the process conditions. As a result, there is no reasonable expectation of success in achieving conditions in the deposition chambers of Maeng or Kane to produce a radiation sensitive organotin oxide hydroxide coating. Furthermore, neither Maeng nor Kane provide any motivation to modify their systems to have the temperature control features of the presently claimed system.

In summary, the systems of Maeng and Kane are not suitable for deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. Respectfully, the Examiner has failed to establish that Maeng or Maeng in view of Kane render Applicant's claimed invention *prima facie* obvious. Respectfully, the rejection is based on clear error of law. Applicant respectfully requests withdrawal of the rejection of claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng in view of Kane. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.

Rejection Under 35 U.S.C. 103 Over Pore et al. and Kane

The Examiner rejected claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over published U.S. patent application 2017/0100742 to Pore (hereinafter "Pore") in view of Kane. Claims 2, 4-19, and 21 depend from claim 1. Applicant believes that there is no motivation to combine the references as asserted by the Examiner. Applicant asserts that the combined teachings of Pore and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejection based on the following comments.



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As an initial matter, Applicant incorporates by reference the arguments filed on November 9, 2021.

The Examiner recognizes that Pore does not teach the organotin compound. Applicant reiterates that Pore not only does not teach, but does not suggest, motivate in any way or provide any hint that the use of an organotin compound would serve any purpose in the context of their polyimide layer. The Examiner asserts that it would have been obvious to incorporate the organotin compound of Kane onto the first reactant vessel of Pore because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures. Applicant respectfully disagrees with this assessment. Pore teaches a reaction chamber/substrate temperature that is at or below the temperature of the reactant (see Figs. 3A and 3B and paragraph [0046]) and in a range of no more than 250°C (see paragraph [0013]). Referring to the above discussion of the (relatively high) substrate temperatures disclosed by Kane, Applicant asserts that there is no hint in Kane that the organotin compound would be desirably deposited onto a substrate of Pore. With all due respect, the teachings of the references do not support their combination as suggested in the rejection. It would be an understatement to say that substitution of the compositions of Kane into Pore would render Pore nonfunctional for its intended purpose of making a polymer coating.

Respectfully, the rejection is based on clear error of law since the references themselves do not support the asserted combination. The combined teachings of Pore and Kane do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over Pore in view of Kane. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.



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## CONCLUSION

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

/Peter S. Dardi/

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Registration No. 39,650

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16987120 |
| **Filing Date:** | 06-Aug-2020 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Filer:** | Peter S. Dardi/Michelle Douglas |
| **Attorney Docket Number:** | 5063.08US05 |

Filed as Large Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| RCE- 2ND AND SUBSEQUENT REQUEST | 1820 | 1 | 2000 | 2000 |
| | | **Total in USD ($)** | | **2000** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 45515108 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Peter S. Dardi |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 20-APR-2022 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 11:26:19 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $2000 |
| RAM confirmation Number | E20224JB27073916 |
| Deposit Account | 601363 |
| Authorized User | Peter Dardi |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:<br>37 CFR 1.16 (National application filing, search, and examination fees)<br>37 CFR 1.17 (Patent application and reexamination processing fees) | |

37 CFR 1.21 (Miscellaneous fees and charges)

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Request for Continued Examination (RCE) | RCETransmittal-2nd.pdf | 30043<br>77e6d959b137c512a272ea1e3b1be29fc54d40de | no | 2 |
| **Warnings:** | | | | | |
| This is not a USPTO supplied RCE SB30 form. | | | | | |
| **Information:** | | | | | |
| 2 | | AmendmentRCE.pdf | 96469<br>f808654a591fe5117e9057758c244b38a2aed5fb | yes | 14 |
| | **Multipart Description/PDF files in .zip description** | | | | |
| | **Document Description** | | **Start** | **End** | |
| | Amendment Submitted/Entered with Filing of Continued Prosecution Application (CPA)/Request for Continued Examination(RCE) | | 1 | 1 | |
| | Claims | | 2 | 6 | |
| | Applicant Arguments/Remarks Made in an Amendment | | 7 | 14 | |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (SB06) | fee-info.pdf | 38140<br>f1e34f8e9ddb3c10b4efb4be76e29358e7edf21c | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 164652 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

NOTICE OF APPEAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with 37 C.F.R. § 1.191, Applicant hereby appeals to the Patent Trial and Appeal Board from the Office Action mailed November 26, 2021, finally rejecting claims 1-2 and 4-21 in the above-identified patent application. The Commissioner is authorized to charge a credit card payment in the amount of **$840.00** to cover the fee which is submitted herewith.

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

Customer No. **62274**
Christensen, Fonder, Dardi & Herbert PLLC
11322 86th Avenue N
Maple Grove, MN 55369
Telephone: (612) 315-4322

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No.60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

| | |
|---|---|
| February 24, 2022 | /Diane Bennet/ |
| Date | Diane E. Bennett, Ph.D., Reg. #63,240 |

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16987120 |
| **Filing Date:** | 06-Aug-2020 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Filer:** | Diane Elizabeth Bennett/Michelle Douglas |
| **Attorney Docket Number:** | 5063.08US05 |

Filed as Large Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| NOTICE OF APPEAL | 1401 | 1 | 840 | 840 |
| **Post-Allowance-and-Post-Issuance:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | **Total in USD ($)** | | **840** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 45075612 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 24-FEB-2022 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 13:37:17 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $840 |
| RAM confirmation Number | E20222ND37411138 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Notice of Appeal Filed | NoticeOfAppeal.pdf | 20917<br>7ddfa4a8a41aa75914ea6615cf0eb0cd223c74f0 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 38429<br>e3df1ac8f48c86c511fa2dd6e1d02eea4eb9d82d | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 59346 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 01/31/2022

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

| EXAMINER | |
|---|---|
| THOMAS, BINU | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 01/31/2022 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket@cfd-ip.com
patents@cfd-ip.com



Lam Research Ex. 1002 - Page 123
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| ***Advisory Action Before the Filing of an Appeal Brief*** | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

***--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --***

THE REPLY FILED 20 January 2022 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☑ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   - a) ☐ The period for reply expires ____ months from the mailing date of the final rejection.
   - b) ☑ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   - c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection.The current period for reply expires ____ months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.

   *Examiner Note*: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANTS FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37CFR 41.37(a).

AMENDMENTS

3. ☐ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   - a) ☐ They raise new issues that would require further consideration and/or search (see NOTE below);
   - b) ☐ They raise the issue of new matter (see NOTE below);
   - c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   - d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

   NOTE: _____ (See 37CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☑ Applicants reply has overcome the following rejection(s): 35 U.S.C. 112(d) on claim 3
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☑ For purposes of appeal, the proposed amendment(s):(a) ☐ will not be entered, or (b) ☑ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____
9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☑ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: See Continuation Sheet.
13. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
14. ☐ Other: _____.

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:
    Claim(s) allowed:_____.
    Claim(s) objected to:_____.
    Claim(s) rejected:1-2 and 4-21.
    Claim(s) withdrawn from consideration:22-25.

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
|---|---|



Lam Research Ex. 1002 - Page 124
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

Continuation of REQUEST FOR RECONSIDERATION/OTHER 12. The request for reconsideration has been considered but does NOT place the application in condition for allowance because:
Applicant's arguments filed January 20, 2022 have been fully considered but they are not persuasive.
Applicant's principal arguments are:
a. Substantial evidence does not support the motivation asserted in the Final Office Action that the use of the Kane precursors would result in tin oxide formation at a lower temperature since ALD involves sequential reaction steps and not a single reaction process of Kane.
b. The systems of the cited references are also not suitable for providing sufficient stability of the process conditions to enable deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. Both Maeng and Kane are focused specifically on full oxidation to form metal oxides.
c. Maeng describes the approach of the plasma reaction approaches (PE-ALD) are clearly too harsh to be relevant for the currently claimed invention. The thermal ALD deposits in Maeng seem poorly defined, and they anneal all of these thermal deposits at 500°C or 1000°C to form the crystalline oxides. There is no indication that the system of Maeng possesses the process control to form a stable organotin oxide-hydroxide layer, as presently claimed.
d. One of ordinary skill in the art would not expect that the delivery of PDMAT via a bubbler, as described by Maeng, would be a highly controlled process. In contrast, the organotin compounds disclosed in the present application are instrumental in the process control that is achieved by the system.
e. Applicant asserts that Maeng fails to teach the feature of a substrate maintained at a temperature of less than 200°C.
f. Kane teaches that the substrate temperature should be in the range of 350°C to 550°C for a system with an organotin compound. (See Col. 3, lines 38-41.) Kane is focused on CVD deposition of the oxides, which requires the high temperatures. There is no indication that the system of Kane would provide for control (maintenance) of the temperature under 200°C. Moreover, Kane cautions that too low a temperature results in an inefficiently low rate of reaction. With all due respect, Kane is not teaching or suggesting that the disclosed apparatus would be suitable to maintain a temperature of less than 200°C.
g. Applicant respectfully asserts that there is no teaching in either reference that would suggest processing components suitable for forming an organotin oxide hydroxide layer with intact tin-carbon bonds, and substantial evidence does not indicate the target products could be successfully formed with the apparatus of Maeng or Maeng in view of Kane.
h. Applicant respectfully asserts the instant apparatus is differentiated from the systems of Maeng and Kane. In particular, the systems of Maeng and Kane fail to provide adequate control of the process conditions. As a result, there is no reasonable expectation of success in achieving conditions in the deposition chambers of Maeng or Kane to produce a radiation sensitive organotin oxide hydroxide coating . Furthermore, neither Maeng nor Kane provide any motivation to modify their systems to have the temperature control features of the presently claimed apparatus.
i. Applicant asserts that there is no hint in Kane that the organotin compound would be desirably deposited onto a substrate of Pore. With all due respect, the teachings of the references do not support their combination as suggested in the rejection. It would be an understatement to say that substitution of the compositions of Kane into Pore would render Pore nonfunctional for its intended purpose of making a polymer coating

In response to Applicant's arguments, please consider the following comments:
a. Applicant's argument is noted, however the process steps differences between the prior art Maeng and Kane are arguments directed to the intended use which are not persuasive. The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. See In re Keller, 642 F.2d 413, 208 USPQ 871 (CCPA 1981). The apparatus of Maeng and Kane is capable of the process of either single or multiple reaction steps. For the

sake of argument, if multiple steps were involved, then one of ordinary skill in the art would envisage a change in thickness when executing a single process step to a plurality of process steps.

b. Applicant's argument is noted, however they directed to the particular type of processing material used and particular material formed on the substrate. The recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

c. Applicant's argument is noted, however they are directed to process limitations which do not limit the apparatus. A claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations (MPEP2114).

d. In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., process control that is achieved by the system) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See In re Van Geuns, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). The claim merely requires structures to deliver flow, which are taught by the cited prior art.

e. Applicant's argument is noted, however Fig. 3 of Maeng clearly shows a temperature of the substrate along the bottom axis which is less than 200C which achieves a growth rate.

f. Applicant's argument is noted, however Kane was not relied upon to teach the claimed temperature, which is address by Maeng. With regards to low temperature needed, while Kane teaches a preferred temperature range, Kane does teach the lower temperatures achieves a reaction. Even though the reaction maybe low rate, the discussion does not represent a teach away as it does not criticize, discredit, or otherwise discourage the solution claimed.

g. Applicant's arguments is not persuasive as it does not clearly point out the patentable novelty which is found in the claim and not in the prior art. Maeng teaches the structural as claimed which are capable of containing and supplying an organotin layer. With regards to forming an organotin oxide hydroxide layer with intact tin-carbon bonds, this is the results of an intended use of the apparatus, where a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations (MPEP2114).

h. In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies adequate control of the process conditions and the temperature control features) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See In re Van Geuns, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). The claim is silent to a structural element which provides temperature control and the claim is silent to structural element(s) for control of the process conditions. The claimed phrase of structure configured to deliver flow does not represent an structural element which provides control of process conditions.

i. With regards to the temperature, while Kane teaches a preferred temperature range, Kane does teach the lower temperatures achieves a reaction. Even though the reaction maybe at a low rate, the discussion does not represent a teach away as it does not criticize, discredit, or otherwise discourage the solution claimed.

In response to applicants' argument that there is no teaching, suggestion, or motivation to combine the references, the examiner recognizes that obviousness may be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See In re Fine, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988), In re Jones, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992), and KSR International Co. v. Teleflex, Inc., 550 U.S. 398, 82 USPQ2d 1385 (2007).

In this case, Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30) and both Kane and Pore teach vaporization of organic compounds to form the coating containing organic compounds. It is the examiner's opinion the combination would not result in unsuitable for its intended purpose as neither criticize, discredit, or otherwise discourage the solution.

OK TO ENTER: /B.T/

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al. Confirmation No.: 5672

Application No.: 16/987,120 Examiner: Binu Thomas

Filed: August 6, 2020 Group Art Unit: 1717

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

AMENDMENT AFTER FINAL

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action of November 26, 2021, please enter the following amendments and consider the following remarks. This Amendment includes the following:

A. Amendments to the Claims

B. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

January 20, 2022 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| **PATENT APPLICATION FEE DETERMINATION RECORD**<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 01/20/2022 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 24 | Minus | ** 25 | = 0 | | x $100 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 1 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 0 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /TERESA J JACKSON WOODRUFF/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
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This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

AMENDMENT AFTER FINAL

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action of November 26, 2021, please enter the following amendments and consider the following remarks. This Amendment includes the following:

A. Amendments to the Claims

B. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

January 20, 2022
Date

/Diane Bennett/
Diane E. Bennett, Ph.D., Reg. #63,240

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Previously Presented) An apparatus comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin compound;

structure configured to deliver flow of a first precursor vapor from the supply of an organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand suitable for the formation of an organotin oxide hydroxide layer with a metal-carbon bond that is radiation sensitive; and

structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with a hydrolysable ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

2. (Previously Presented) The apparatus of claim 1 wherein the substrate comprises a silicon wafer.

3. (Cancelled)



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4. (Currently Amended) The apparatus of claim [[2]]1 wherein the inert gas comprises nitrogen or argon.

5. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6. (Previously Presented) The apparatus of claim 1 wherein the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ wherein R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond, n = 1 - 3 and X is a ligand having a hydrolysable bond with Sn.

7. (Original) The apparatus of claim 6 wherein the oxygen containing compound comprises water vapor, hydrogen peroxide, ozone, oxygen, an alcohol, or combinations thereof.

8. (Original) The apparatus of claim 6 wherein the second precursor vapor comprises water vapor.

9. (Previously Presented) The apparatus of claim 6 further comprising a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. (Original) The apparatus of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. (Original) The apparatus of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.



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12. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. (Original) The apparatus of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. (Original) The apparatus of claim 1 wherein the flow comprises a vapor.

15. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. (Previously Presented) The apparatus of claim 15 wherein the vapor inputting structures provide for control of the flow.

17. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.

18. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow, the second vapor flow, and a third vapor flow are sequential.

20. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to



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deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are at the same time and a third vapor flow is sequential.

21. (Previously Presented) The apparatus of claim 1 wherein the interior has a temperature from about 45°C to about 200°C.

22. (Withdrawn) A method for forming an organotin layer using the apparatus of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (Withdrawn) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (Withdrawn) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.

25. (Withdrawn) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.



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REMARKS

Claims 1-2 and 4-25 are pending. By this amendment, claim 3 is cancelled and claim 4 is amended. In particular, claim 4 is amended to depend from claim 1. No new matter is introduced.

Claim Interpretation.

*Claim 13.* The Examiner indicates on page 2, paragraph 5 of the Office Action that the recitation in claim 13 of configuration providing for selection of the pressure and/or the temperature in the deposition chamber is interpreted to be "a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158), as disclosed in figure 16 and amendments to specification filed April 5, 2021 and January 20, 2021." Applicant respectfully asserts that this interpretation is inappropriately narrow.

Applicant incorporates by reference the arguments of the Amendment filed on April 5, 2021 and January 20, 2021. Applicant respectfully maintains that the features of claim 13 are not means plus function limitations. Furthermore, Applicant respectfully asserts that the Examiner's stated interpretation of the features of claim 13 is not consistent with the broadest reasonable interpretation consistent with the specification. As explained in the Amendment filed on January 20, 2021, pump 155 and pump 156 and thermal block 158 are examples of configuration to provide for selection of the pressure and/or the temperature in the deposition chamber. Respectfully, Applicant referred to other non-limiting examples in the specification of disclosure of configurations to control pressure and temperature in a chamber and noted that configurations to control pressure and temperature in a chamber are well-known in the art.

Rejection Under 35 U.S.C. 103 Over Maeng et al. and Kane et al.

The Examiner rejected claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng et al., J. Vac. Sci. Tech B., 2006, 24, 2276 (hereinafter "Maeng") in view of U.S. patent 3,944,684 to Kane et al. (hereinafter "Kane"). Claim 3 is cancelled. Claims 2 and 4-21 depend from claim 1. Applicant maintains that the combined teachings of Maeng and Kane do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejections based on the following comments.



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The Examiner cites Maeng for many of the features of Applicant's claimed invention. The Examiner acknowledges that Maeng does not teach an organotin compound and cites Kane for this feature. The combination then raises the issue regarding the suitability of the combination as well as whether the combination reasonably teaches all of the features of the claim. Maeng is specifically focused on forming thin films of Ta compounds using atomic layer deposition (ALD). In the introduction, Maeng briefly mentions Ti, Zr, Hf oxide formation using ALD. Kane is specifically focused on forming indium tin oxide coatings for forming transparent conductive films, which have been of major commercial importance from the time of Kane until now. ALD had not been invented at the time of Kane, and both references are focused specifically on their compounds and techniques of interest. Kane teaches chemical vapor deposition using precursors that react to form an oxide during deposition, and there is no evidence on record that the precursors of Kane would be suitable for ALD deposition using the apparatus of Maeng. With all due respect, substantial evidence does not support the motivation asserted in the Final Office Action that the use of the Kane precursors would result in tin oxide formation at a lower temperature since ALD involves sequential reaction steps and not a single reaction process of Kane.

Furthermore, the instant claims recite an apparatus that is suitable for forming an organotin oxide hydroxide layer having radiation-sensitive metal-carbon bonds. The apparatus of claim 1 provides for the substrate to be maintained at a temperature of less than 200°C. The systems disclosed by Maeng and Kane are not suitable for maintaining this temperature range. The systems of the cited references are also not suitable for providing sufficient stability of the process conditions to enable deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. Both Maeng and Kane are focused specifically on full oxidation to form metal oxides.

The Examiner cites Maeng at Fig. 3, page 2277 for teaching a substrate temperature of less than 200°C while maintaining a growth rate. However, what is growing is a **metal oxide** or a **metal nitride** layer. In other words, the PDMAT or the TDMAT of Maeng are **fully converted** to an oxide ($Ta_2O_5$) or a nitride (TaN), respectively. Maeng described several approaches for their reactions. The plasma reaction approaches (PE-ALD) are clearly too harsh to be relevant for the currently claimed invention. The thermal ALD deposits in Maeng seem poorly defined, and they anneal all of these thermal deposits at 500°C or 1000°C to form the crystalline oxides. There is



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no indication that the system of Maeng possesses the process control to form a stable organotin oxide-hydroxide layer, as presently claimed.

The system of Maeng is described as having a PDMAT powder in a bubbler. (See Fig. 1.) The bubbler is heated to generate a "high enough" vapor pressure. (See paragraph bridging pages 2276 and 2277.) However, one of ordinary skill in the art would not expect that the delivery of PDMAT via a bubbler, as described by Maeng, would be a highly controlled process. In contrast, the organotin compounds disclosed in the present application are instrumental in the process control that is achieved by the system. In particular, the carbon tin bonds provide the radiation sensitive ligands. Then, the hydrolysable bonds provide the suitability for vapor deposition while being hydrolysable so that hydrolysis at low temperatures can provide the desired oxo-hydroxo network. This design, in turn, enables the vapor phase deposition of radiation patternable organotin oxide hydroxide coatings. Applicant explains in the section entitled "Vapor Based Coating Formation" found on page 24, line 15 to page 27, line 14:

> *The development of precursor compounds comprising of both R-groups with substantially non-hydrolysable bonds to Sn, and X ligands with hydrolysable bonds to Sn has been exploited for the development of vapor phase deposition of radiation patternable organotin oxide hydroxide coatings. In particular, the relatively high vapor pressures and reactivity of many $R_nSnX_{(4-n)}$ compounds such as those listed in Table 1, make possible the use of vapor deposition methods for deposition of organotin oxide hydroxide thin-film photoresists. Through the introduction the hydrolysable precursors in the vapor phase in a reactor closed from the ambient atmosphere, the hydrolysis can be performed as part of the deposition process, i.e., a chemical vapor deposition. (See page 24, line 15-page 25, line 22.)*
>
> *In CVD methods, two or more reactant gases are generally mixed in the chamber in the vicinity of the substrate surface.* ***Therefore, sufficient stability can be designed into the reaction conditions to control undesirable vapor-phase reactions and nucleation.*** *ALD precursors, introduced separately and sequentially to the reaction chamber, typically react with chemisorbed co-precursor or decomposition products saturating the substrate*



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> *surface.* ***Desirable features of $R_nSnX_{(4-n)}$ precursors include, for example, sufficient volatility for vapor-phase transport in the system, thermal stability to prevent premature decomposition, and appropriate reactivity with co-precursors to produce the target product under prescribed process conditions. The pressure and temperature in the reaction chamber can be selected to control the reaction process.*** *(See page 25, lines 5-13.)*

Significantly, the instant specification discloses that the substrate **may be heated or may be cooled depending on the precursor properties**. (See page 25, lines 19-20.) Applicant asserts that Maeng fails to teach the feature of a substrate maintained at a temperature of less than 200°C.

The Examiner recognizes that Maeng does not teach an organotin compound. The Examiner cites Kane for remedying this deficiency of Maeng. Yet, Kane teaches that the substrate temperature should be in the range of 350°C to 550°C for a system with an organotin compound. (See Col. 3, lines 38-41.) Kane is focused on CVD deposition of the oxides, which requires the high temperatures. There is no indication that the system of Kane would provide for control (*maintenance*) of the temperature under 200°C. Moreover, Kane cautions that too low a temperature results in an inefficiently low rate of reaction. With all due respect, Kane is not teaching or suggesting that the disclosed apparatus would be suitable to maintain a temperature of less than 200°C. As with Maeng, Kane also fails to teach or suggest both heating and cooling of the substrate, thus the ability to maintain the temperature of the substrate is limited.

The Examiner asserts that it would have been obvious to incorporate the organotin compound in the closed container of Kane onto the supply of organometallic compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures. With all due respect, the Examiner seems to be misinterpreting Kane's reference to a process for preparing tin oxide coatings that "can be carried out at low temperatures." (See Col. 2, lines 3-7.) In referring to "low temperatures," Applicant asserts that Kane is contrasting with the prior discussion of temperatures on the order of 600-700°C. (See Col. 1, line 52.) In as such, "low temperatures" would be below about 600-700°C. As noted above, "too low a temperature" for the system of Kane refers to temperatures below the range of about 350°C-550°C. Indeed, Kane at Table 1 exemplifies deposition temperatures ranging from 450°C to 555°C. Respectfully, Kane



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in no way suggests that temperatures below about 200°C would be suitable. Thus, Applicant respectfully asserts that neither Maeng nor Kane motivate the asserted combination of the organotin compound of Kane with the system of Maeng based on the asserted motivation of attaining lower temperatures.

Both Maeng and Kane underscore the important connection between process equipment and precursors/reactants. For example, Maeng discloses that "[o]ne of the critical issues for successful ALD process is the proper selection of precursor and reactant." (See page 2276, second paragraph.) Neither Maeng nor Kane teach an apparatus suitable for the deposition of an organotin compound according to claim 1. Rather, each teaches an apparatus that is specific for the generation of a particular metal oxide layer. Maeng is directed to $Ta_2O_5$ layers while Kane is directed to tin-doped indium oxide layers. Applicant respectfully asserts that there is no teaching in either reference that would suggest processing components suitable for forming an organotin oxide hydroxide layer with intact tin-carbon bonds, and substantial evidence does not indicate the target products could be successfully formed with the apparatus of Maeng or Maeng in view of Kane.

With all due respect, the instant apparatus is differentiated from the systems of Maeng and Kane. In particular, the systems of Maeng and Kane fail to provide adequate control of the process conditions. As a result, there is no reasonable expectation of success in achieving conditions in the deposition chambers of Maeng or Kane to produce a radiation sensitive organotin oxide hydroxide coating. Furthermore, neither Maeng nor Kane provide any motivation to modify their systems to have the temperature control features of the presently claimed apparatus.

In summary, the systems of Maeng and Kane are not suitable for deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. Respectfully, the Examiner has failed to establish that Maeng or Maeng in view of Kane render Applicant's claimed invention *prima facie* obvious. Respectfully, the rejection is based on clear error of law. Applicant respectfully requests withdrawal of the rejection of claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng in view of Kane. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.



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Rejection Under 35 U.S.C. 103 Over Pore et al. and Kane

The Examiner rejected claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over published U.S. patent application 2017/0100742 to Pore (hereinafter "Pore") in view of Kane. Claims 2, 4-19, and 21 depend from claim 1. Applicant believes that there is no motivation to combine the references as asserted by the Examiner. Applicant asserts that the combined teachings of Pore and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejection based on the following comments.

As an initial matter, Applicant incorporates by reference the arguments filed on November 9, 2021.

The Examiner recognizes that Pore does not teach the organotin compound. Applicant reiterates that Pore not only does not teach, but does not suggest, motivate in any way or provide any hint that the use of an organotin compound would serve any purpose in the context of their polyimide layer. The Examiner asserts that it would have been obvious to incorporate the organotin compound of Kane onto the first reactant vessel of Pore because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures. Applicant respectfully disagrees with this assessment. Pore teaches a reaction chamber/substrate temperature that is at or below the temperature of the reactant (see Figs. 3A and 3B and paragraph [0046]) and in a range of no more than 250°C (see paragraph [0013]). Referring to the above discussion of the (relatively high) substrate temperatures disclosed by Kane, Applicant asserts that there is no hint in Kane that the organotin compound would be desirably deposited onto a substrate of Pore. With all due respect, the teachings of the references do not support their combination as suggested in the rejection. It would be an understatement to say that substitution of the compositions of Kane into Pore would render Pore nonfunctional for its intended purpose of making a polymer coating.

Respectfully, the rejection is based on clear error of law since the references themselves do not support the asserted combination. The combined teachings of Pore and Kane do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over Pore in view of Kane. While Applicant does not acquiesce with respect to the specific assertions in the rejection



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directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.

## CONCLUSION

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

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# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 44790297 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 20-JAN-2022 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 16:05:14 |
| **Application Type:** | Utility under 35 USC 111(a) |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 11/26/2021

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| EXAMINER |
|---|
| THOMAS, BINU |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 11/26/2021 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

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| *Office Action Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 11/09/2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-25 is/are pending in the application.

5a) Of the above claim(s) 22-25 is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-21 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



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## DETAILED ACTION

1. The Applicant's amendment filed on November 9, 2021 was received. Claims 1, 6 and 21 were amended. Claims 22-25 remain withdrawn.

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action issued August 12, 2021.

### *Claim Interpretation*

3. This application includes one or more claim limitations that do not use the word "means," but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier.

4. Such claim limitation(s) is/are: a configuration providing for selection of the pressure and/or the temperature in the deposition chamber in claim 13.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

5. Regarding the recitation of configuration providing for selection of the pressure and/or the temperature in the deposition chamber, the recitation is interpreted a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158) which supports the

substrate in the deposition chamber (151), as disclosed in figure 16 and amendments to the specification filed April 5, 2021 and January 20, 2021.

### *Claim Rejections - 35 USC § 112*

6. The following is a quotation of 35 U.S.C. 112(d):

> (d) REFERENCE IN DEPENDENT FORMS.—Subject to subsection (e), a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.

The following is a quotation of pre-AIA 35 U.S.C. 112, fourth paragraph:

> Subject to the following paragraph [i.e., the fifth paragraph of pre-AIA 35 U.S.C. 112], a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.

7. **Claim 3 is rejected under 35 U.S.C. 112(d) or pre-AIA 35 U.S.C. 112, 4th paragraph**, as being of improper dependent form for failing to further limit the subject matter of the claim upon which it depends, or for failing to include all the limitations of the claim upon which it depends.

Claim 3 recites "structure configured to deliver flow from a supply of an inert gas", which is found in claim 1.

Applicant may cancel the claim(s), amend the claim(s) to place the claim(s) in proper dependent form, rewrite the claim(s) in independent form, or present a sufficient showing that the dependent claim(s) complies with the statutory requirements.

### *Claim Rejections - 35 USC § 103*

8. **Claims 1-21 are rejected under 35 U.S.C. 103 as being unpatentable over Maeng** (as previously provided) **in view of Kane (US 3,944,684)**.

**In regards to claim 1**, Maeng teaches a PE-ALD system (apparatus) comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate (see 8-inch wafer) within the interior of the deposition chamber, the substrate receives a deposition on a surface of the substrate, where substrate maybe maintained at a temperature of less than 200°C while maintaining a growth rate (fig. 3; pg. 2277);

an inlet (see pipes connected to bubblers) into the deposition chamber;

a structure (see label of Ar gas) delivers flow from a supply of an inert gas; and

a supply of organometallic compound (see label of PDMAT bubbler)

a structure (see pipe between PDMAT bubbler and deposition chamber) delivers a flow from the supply of the organometallic compound with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 1).

Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler (structure which delivers flow of second precursor vapor) provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1) and Kane teaches the organotin compound is supplied to the reaction chamber (fig. 1; col. 4, lines 30-40).

Maeng does not explicitly teach the organometallic compound is an organotin compound, to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

However, in same field of endeavor of deposition of vapor deposition, Kane teaches an organotin compound (12) is contained in closed container (10, supply of organotin compound) (fig. 1; col. 2, lines 45-60, col. 4, lines 28-35).

Kane teaches an inlet tube (14) supplies a carrier gas to the closed container, where the carrier gas and the organotin vapor is supplied to a tube-18 (structure to deliver flow) which is connected to a tube-22, so that the carrier gas and the organotin vapor is feed into a reaction chamber (26) (fig. 1; col. 4, lines 28-40). Kane teaches the carrier gas is an inert gas such as neon, argon, krypton, nitrogen and the like (col. 3, lines 20-25).

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the supply of organometallic compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, the recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim (MPEP2111.02/2114).

Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of maintaining the substrate temperature and to provide the claimed compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Maeng and Kane as discussed above, where Maeng teaches the substrate is a silicon substrate (pg. 2277).

**In regards to claims 3-4**, Maeng and Kane as discussed above, where Maeng teaches the structure (see label of Ar gas) which provides the inert gas of argon, where argon is used as the carrier gas (pg. 2277).

**In regards to claims 5 and 14**, Maeng and Kane as discussed above, where Maeng teaches the structure which supplies the liquid precursor is a bubbler which bubbles the inert carrier gas through the liquid PDMAT to supply the vapor to the chamber (fig. 1) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

**In regards to claims 6-10 and 15-20**, Maeng and Kane as discussed above, where Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1) and Kane teaches the organotin compound is supplied to the reaction chamber (fig. 1; col. 4, lines 30-40).

Maeng and Kane do not explicitly teach the flow from the supply of the organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the

formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the material solution and a third precursor vapor as SnL4 as recited in the claim, and with the flow process as recited in the claim.

**In regards to claims 11-12 and 21**, Maeng and Kane as discussed above, where Maeng teaches a pressure of the chamber of 0.1 to 10-mtorr and reactor growth temperature of 150-250°C (pg. 2277-2278).

**In regards to claim 13**, Maeng and Kane as discussed above, where Maeng teaches a selection of the temperature within the deposition chamber (pg. 2278).

9. **Claims 1-18 and 21 are rejected under 35 U.S.C. 103 as being unpatentable over Pore** (US 2017/0100742) **in view of Kane** (**US 3,944,684**).

**In regards to claims 1 and 4**, Pore teaches an apparatus (100) comprising:

a deposition chamber having a reaction space (115, interior) isolated from the ambient atmosphere (fig. 2a; para. 46);

a substrate (120) within the interior of the deposition chamber which receives a deposition on a surface of the substrate, where the deposition chamber with the substrate is maintained at a temperature of less than 200°C (fig. 2a; para. 43, 46, 58);

an inlet into the deposition chamber is provide at inlet manifold (135) (fig. 2a; para. 47);

an inert gas source (150, structure) delivers flow from a supply of an inert gas such as argon or nitrogen which is well known (fig. 2a; para. 49); and

a first reactant vessel (105, supply) which supplies an organic reactant (110) (fig. 2a, para. 46)

a gas line (130, structure) delivers flow from the first reactant vessel with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 2a; para. 47).

Pore teaches first reactant vessel vaporizes the first organic reactant and a second reactant vessel (140) (structure for second precursor vapor) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber (fig. 2a; para. 46, 48).

Pore does not explicitly teaches the organotin compound

However, in the same field of endeavor of thin film deposition, Kane teaches an organotin compound (12) is contained in closed container (10, supply of organotin compound) (fig. 1; col. 2, lines 45-60, col. 4, lines 28-35).

Kane teaches an inlet tube (14) supplies a carrier gas to the closed container, where the carrier gas and the organotin vapor is supplied to a tube-18 (structure to deliver flow) which is

connected to a tube-22, so that the carrier gas and the organotin vapor is feed into a reaction chamber (26) (fig. 1; col. 4, lines 28-40). Kane teaches the carrier gas is an inert gas such as neon, argon, krypton, nitrogen and the like (col. 3, lines 20-25).

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the first reactant vessel of Pore because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, the recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim MPEP2111.02).

Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Pore and Kane teach the structural limitations of the claim, one would be capable of maintaining the substrate temperature and providing the claimed compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, the organotin

compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Pore and Kane as discussed above, where Pore teaches the substrate is silicon wafer (para. 17).

**In regards to claim 3**, Pore and Kane as discussed above, where Pore teaches the inert gas source (150, structure) delivers flow from a supply of an inert gas (fig. 2a; para. 49).

**In regards to claims 5 and 14**, Pore and Kane as discussed above, where Pore teaches the first reactant vessel (105) vaporizes the first organic reactant (110) (fig. 2a; para. 46) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

**In regards to claims 6-10 and 15-18**, Pore and Kane as discussed above, where Pore teaches first reactant vessel vaporizes the first organic reactant and the a second reactant vessel (140) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber(fig. 2a; para. 46, 48) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

Pore and Kane do not explicitly teach the flow from the supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114). As Pore and Kane teach the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the first reactant and the second reactant of SnL4 as recited in the claim, and with the flow process as recited in the claim(s).

**In regards to claims 11-12 and 21**, Pore and Kane as discussed above, where Pore teaches a pressure of the chamber of 100-mtorr to 100-torr and a temperature of 100-250°C (para. 43).

**In regards to claim 13**, Pore and Kane as discussed above, where Pore teaches a control system (125) which controls a vacuum pump (165) to maintain the pressure in the deposition chamber (fig. 2a; para. 50).

***Response to Arguments***

10. Applicant's arguments filed November 9, 2021 have been fully considered but they are not persuasive.

Applicant's principal arguments are:

a. The systems of Maeng and Kang are not suitable for deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. These features of Applicant's claimed invention are accentuated in the amended claims.

b. Pore not only does not teach, but does not suggest, motivate in any way or provide any hint that the use of an organotin compound would serve any purpose in the context of their polyimide layer.

c. Modifications to Pore as discussed in the office action render it unsuitable for its intended purpose.

In response to Applicant's arguments, please consider the following comments:

a. In response to applicant's argument that compositions and temperatures of Maeng and Kang do not render the amended claims obvious, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. Applicants' arguments directed to compositions and temperatures discussed in the prior art do not provide a clear structural difference between the claimed structure and the structure of the prior art needed for patentable distinction.

b. In response to applicant's argument that there is no teaching, suggestion, or motivation to combine the references, the examiner recognizes that obviousness may be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art.

See *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988), *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992), and *KSR International Co. v. Teleflex, Inc.*, 550 U.S. 398, 82 USPQ2d 1385 (2007). In this case, Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

c. Applicant's argument is noted however, both Pore and Kang are directed to an intended purposes of deposition of a thin film using vapor deposition and therefore the combination in the examiner's opinion would not result in unsuitable for its intended purpose. Also, the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981).

***Conclusion***

11. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event,

however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Binu Thomas/
Primary Examiner, Art Unit 1717

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
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| Symbol | Date | Examiner |
| | | |

| CPC Combination Sets - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| | | | |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |
| Updated search | 01/2021 | BT |
| Updated search | 08/2021 | BT |
| Updated search | 11/2021 | BT |

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| | | | |

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| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |



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**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L4 | 8 | ("20140099451" "20180004083" "20060228476" ("4590096" "5997639" "4146657" ).pn. ) and (tin organotin) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/16 16:39 |
| S1 | 0 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:20 |
| S2 | 6 | "15291738" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S3 | 1,913 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT | OR | ON | 2020/09/29 09:21 |
| S4 | 1,851 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S5 | 82 | S4 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:29 |
| S6 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 11:47 |
| S7 | 76 | ("10025179" \| "10228618" \| "10642153" \| "20020076495" \| "20030124457" \| "20040067444" \| "20060088962" \| "20060234138" \| "20080055597" \| "20080286683" \| "20090155546" \| "20090174036" \| "20100044698" \| "20100184259" \| "20110045406" \| "20110135823" \| "20110166268" \| "20110206599" \| "20110244403" \| "20110293888" \| "20120223418" \| "20130224652" \| "20130253161" \| "20140268062" \| "20140303283" \| "20150056542" \| "20150079393" \| "20150221519" \| "20150253667" \| | US-PGPUB; USPAT | OR | ON | 2020/09/29 13:57 |

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|---|---|---|---|---|---|---|
| | | "20160116839" \| "20170184960" \| "20170184961" \| "20190137870" \| "3385915" \| "3635883" \| "4102683" \| "4104292" \| "4370405" \| "4380559" \| "4601917" \| "4639208" \| "4732841" \| "4851481" \| "4891303" \| "4910122" \| "5025094" \| "5672243" \| "5891985" \| "6020269" \| "6060380" \| "6179922" \| "6183716" \| "6194323" \| "6197896" \| "6268457" \| "6287951" \| "6420088" \| "6566276" \| "6583071" \| "6730454" \| "6844604" \| "6927108" \| "6946677" \| "7001821" \| "7208341" \| "7256129" \| "7709056" \| "7773365" \| "7799503" \| "8030507" \| "8053370" \| "8092703" \| "8366967" \| "8415000" \| "8796483" \| "9310684").PN. | | | | |
| S8 | 12 | ("20050266700" \| "20060062916" \| "20070092648" \| "5147688" \| "6061117" \| "6503561" \| "7250083").PN. OR ("7709056").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:09 |
| S9 | 107 | ("4059929" \| "5478435" \| "5548159" \| "5558435" \| "5645891" \| "5736425" \| "5747880" \| "5750440" \| "5807607" \| "5814370" \| "5834845" \| "5843602" \| "5847443" \| "5857893" \| "5858457" \| "5858871" \| "5868278" \| "5922299" \| "5948482" \| "5955140" \| "6011123" \| "6015457" \| "6037275" \| "6048256" \| "6066575" \| "6070600" \| "6098843" \| "6107357" \| "6120891" \| "6140252" \| "6159295" \| "6162583" \| "6162838" \| "6163066" \| "6168737" \| "6171645" \| "6171687" \| "6172128" \| "6184260" \| "6187248" \| "6197913" \| "6204202" \| "6208014" \| "6251473" \| "6270846" \| "6277765" \| "6297459").PN. OR ("6583071").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:11 |
| S10 | 6 | ("10025179" \| "20100099908" \| "20150221519" \| "4014858" \| "4144222" \| "4174346").PN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| S11 | 3 | ("20130253161" \| "4104292" \| "9310684").PN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| S12 | 9 | S10 S11 | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| S13 | 20 | ("20020048770" \| "20030116091" \| "20030118947" \| "20040087184" \| "5456945" \| "5759923" \| "6116184" \| | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | "6231933" \| "6261373" \| "6358559" \| "6365266" \| "6376634" \| "6406794" \| "6428847" \| "6455443" \| "6472076" \| "6576568" \| "6583071" \| "6592980").PN. OR ("7446055").URPN. | | | | |
| S14 | 6 | ("20020033173" \| "5589300" \| "5894064" \| "6048817" \| "6444763" \| "6583071").PN. OR ("6825131").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:24 |
| S15 | 25 | S13 S14 | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:29 |
| S16 | 59,271 | H01L21/02274-02282.cpc. c23c16/$.cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| S17 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| S18 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:17 |
| S19 | 6 | "15291738" and structure | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:23 |
| S20 | 6 | "15291738" and precursor near2 vapor | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:24 |
| S21 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:27 |
| S22 | 6 | "15291738" and thickness near2 variation | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:28 |
| S23 | 6 | "15291738" and select$4 near5 (temperature pressure) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 16:55 |
| S24 | 3 | "20080022896" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 18:07 |
| S25 | 1 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 11:23 |
| S26 | 1,873 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 12:02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | ((“KESZLER”) near3 (“Douglas”)) OR ((“TELECKY”) near3 (“Alan”))).INV. | | | | |
| S27 | 84 | S26 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 12:02 |
| S28 | 17 | (US-20110293888-$ or US-20040067444-$ or US-20050266700-$ or US-20030118947-$ or US-20120027937-$ or US-20090155535-$ or US-20060211271-$ or US-20040156987-$ or US-20080022896-$).did. or (US-6583071-$ or US-4601917-$ or US-4104292-$ or US-6825131-$ or US-5894064-$ or US-6251473-$ or US-6066575-$ or US-6116184-$).did. | US-PGPUB; USPAT | OR | ON | 2021/01/25 12:48 |
| S29 | 19 | (“4293594”).PN. OR (“4601917”).URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:44 |
| S30 | 1,323 | (C23C16/45525).cpc. and carrier near3 gas | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| S31 | 554 | (C23C16/45525).cpc. and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| S32 | 21 | (“20040209190” \| “20050186339” \| “20060124057” \| “20070194157” \| “20080146011” \| “20090152371” \| “20100300221” \| “20110097507” \| “20110163062” \| “20110198620” \| “20120074575” \| “20120088315” \| “20130316541” \| “20140262461” \| “20170140920” \| “6146767” \| “6503701” \| “7718011” \| “7954730” \| “8840037” \| “9677984”).PN. OR (“10163629”).URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:49 |
| S33 | 141 | (c23c14/$ c23c16/$).cpc. and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:56 |
| S34 | 1 | “16987120” and (oxide and hydroxide) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:59 |
| S35 | 9 | (c23c14/$ c23c16/$).cpc. and organotin and oxide near10 hydroxide | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:00 |
| S36 | 2 | “20170100742” “20160284553” and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S37 | 4 | ("20170100742" "20160284553") and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |
| S39 | 2 | ("20170100742" "20160284553") and carrier near3 gas near20 inert and (argon nitrogen) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:41 |
| S40 | 1 | "16987120" and (third near5 vapor) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 17:52 |
| S41 | 1 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/04/07 09:27 |
| S42 | 2 | "20150056542" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/04/07 12:40 |
| S43 | 145 | (c23c14/$ c23c16/$).cpc. and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/08/04 10:09 |
| S44 | 27 | (c23c14/$ c23c16/$).cpc. and organotin near20 (supply source container) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/08/04 10:10 |
| S45 | 1,933 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/15 17:11 |
| S46 | 85 | S45 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/15 17:11 |
| S47 | 68 | ("20040113087" \| "20040175631" \| "20040191423" \| "20040213563" \| "20050208389" \| "20050253077" \| "20060001064" \| "20060068173" \| "20060147818" \| "20060172530" \| "20060175558" \| "20070037410" \| "20070181816" \| "20090208880" \| "20090305174" \| "20090317742" \| "20090321707" \| "20100022078" \| "20100131093" \| "20100197135" \| "20100304027" \| "20110104595" \| "20120068347" \| "20120088193" \| "20120088369" \| "20120126358" \| "20120193762" \| "20120202357" \| "20140120688" \| "20140134827" \| "20140170563" \| "20140170853" \| "20140268082" \| "20150041809" \| "20150077733" \| "20150170957" \| | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/15 18:23 |

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|---|---|---|---|---|---|---|
| | | "20150221519" \| "20150332922" \| "20160135274" \| "20160314964" \| "20160379824" \| "20170102612" \| "20170146909" \| "20180004083" \| "20180233349" \| "20180308687" \| "20180337046" \| "20190027357" \| "20190094685" \| "3513010" \| "3529963" \| "3720515" \| "4241165" \| "4328298" \| "4590149" \| "4845053" \| "5077085" \| "5534312" \| "6162577" \| "6261938" \| "9023731" \| "9551924" \| "9778561" \| "9996004").PN. OR ("10514598").URPN. | | | | |
| S48 | 1,046 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon stannanes ) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/16 11:40 |
| S49 | 1,001 | (c23c14/$ c23c16/$).cpc. and (organotin tin near5 carbon ) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/11/16 11:42 |

**EAST Search History (Interference)**

<This search history is empty>

11/16/2021 4:45:34 PM
C:\Users\bthomas\Documents\EAST\Workspaces\16987120-vapor deposition organotin.wsp

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
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**INFORMATION DISCLOSURE STATEMENT BY APPLICANT**
**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16987120 |
| Filing Date | 2020-08-06 |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | 1717 |
| Examiner Name | Binu Thomas |
| Attorney Docket Number | 5063.08US05 |

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| | 1 | 20120088193 | | 2012-04-12 | Weidman et al. | |

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| | 1 | 0839218 | EP | A1 | 1998-05-06 | Libby Owens Ford Co. et al. | | |
| | 2 | 1379476 | EP | A1 | 2004-01-14 | Plinkington North America, Inc. | | |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
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| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|
| | 1 | DEL RE et al., "Low-LER Tin Carboxylate Photoresists using EUV", Proceedings of SPIE, Vol. 9422, pg. 942221-1 - 942221-10, (March 2016). | |
| | 2 | WARNER et al., "Atomic Layer Deposition of Tin Oxide and Zinc Tin Oxide Using Tetraethyltin and Ozone", Journal of Vacuum Science and Technology, A 33(2), pg. 021517-1 - 021517-7, (February 9, 2015). | |
| | 3 | Supplementary European Search Report from related Application No. 21168191.1 dated September 21, 2021. | |
| | 4 | Office Action from corresponding Korean Patent Application No. 10-2021-7000995 dated October 1, 2021. | X |

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| Examiner Signature | /Binu Thomas/ (11/15/2021) | Date Considered | 11/15/2021 |
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Lam Research Ex. 1002 - Page 168
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
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| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

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**OR**

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A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2021-11-09 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

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Lam Research Ex. 1002 - Page 170
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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| Application Number | 16987120 |
| Filing Date | 2020-08-06 |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | 1717 |
| Examiner Name | Binu Thomas |
| Attorney Docket Number | 5063.08US05 |

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| | 1 | 20120088193 | | 2012-04-12 | Weidman et al. | |

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| | 1 | 0839218 | EP | A1 | 1998-05-06 | Libby Owens Ford Co. et al. | | |
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| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

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|---|---|---|---|
| | 1 | DEL RE et al., "Low-LER Tin Carboxylate Photoresists using EUV", Proceedings of SPIE, Vol. 9422, pg. 942221-1 - 942221-10, (March 2016). | |
| | 2 | WARNER et al., "Atomic Layer Deposition of Tin Oxide and Zinc Tin Oxide Using Tetraethyltin and Ozone", Journal of Vacuum Science and Technology, A 33(2), pg. 021517-1 - 021517-7, (February 9, 2015). | |
| | 3 | Supplementary European Search Report from related Application No. 21168191.1 dated September 21, 2021. | |
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Lam Research Ex. 1002 - Page 172
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
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| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

**CERTIFICATION STATEMENT**

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**OR**

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See attached certification statement.

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A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2021-11-09 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

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# (54) METHOD FOR FORMING TIN OXIDE COATING ON GLASS

VERFAHREN ZUR HERSTELLUNG EINER ZINNOXIDBESCHICHTUNG AUF GLAS

PROCEDE DE FORMATION D'UNE COUCHE D'OXYDE D'ETAIN SUR DU VERRE

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## Description

### FIELD OF THE INVENTION

**[0001]** The present invention relates generally to a method for forming a tin oxide coating on glass, and more particularly, to a process for preparing a tin oxide coating doped with fluorine on a moving ribbon of hot glass by chemical vapor deposition.

### BACKGROUND OF THE INVENTION

**[0002]** Typically, coated glass articles are produced by continuously coating a glass substrate while it is being manufactured in a process known in the art as the "Float Glass Process". This process involves casting glass onto a molten tin bath which is suitably enclosed, then transferring the glass, after it has sufficiently cooled, to take-away rolls which are aligned with the bath, and finally cooling the glass as it advanced across the rolls, initially through a lehr and thereafter while exposed to the ambient atmosphere. A non-oxidizing atmosphere is maintained in the float portion of the process, while the glass is in contact with the molten tin bath, to prevent oxidation. An air atmosphere is maintained in the lehr. The chemical vapor deposition (CVD) of various coatings may be conveniently performed in the bath or the lehr, or even in the transition zone therebetween, by contacting the surface of the hot glass with chemical vapor containing reactants which pyrolytically decompose to form the metal oxide coating. This, of course, requires that the chemical reactants have vaporization temperatures below their thermal decomposition temperatures. Several tin compounds exist which may be vaporized to prepare a tin oxide coating on glass by CVD technology.

**[0003]** The desirable performance characteristics of tin oxide coatings on glass, such as for example low emissivity, low sheet resistance, high light transmittance, high infrared reflectivity, etc., are improved by the incorporation into the tin oxide coating of a dopant. Several materials have been used in the prior art as dopants, but the most effective for tin oxide is the element fluorine. Fluorine may be supplied to the deposition reaction in the form of an organotin fluoride, or as a separate fluorine-containing compound which reacts in conjunction with a tin compound.

**[0004]** The physical form of the reactants employed in glass coating processes is generally a liquid, solid, vaporized liquid or solid, liquid or solid dispersed in a carrier gas mixture, or vaporized liquid or solid dispersed in a carrier gas mixture. The chemical vapor deposition process generally employs a vaporized liquid or solid, which is typically dispersed in a carrier gas mixture.

**[0005]** Both organic and inorganic tin compounds have been used for the deposition by chemical vapor deposition of fluorine doped tin oxide coatings. Thus, for example U.S. Patent No. 4,329,379 discloses a process for forming a fluorine doped tin oxide coating on a hot glass substrate by contacting the glass with the vaporized reactants of a tin tetrachloride, hydrofluoric acid (HF), air and water. Similarly, U.S. Patent No. 4,387,134 teaches that fluorine doped tin oxide films have sheet resistances of 1-10 ohm/square may be produced from a combination of vaporized water, methanol, HF, stannic chloride and $H_2/N_2$ gases.

**[0006]** Alternatively, other generally preferred methods for applying doped tin oxide coatings onto glass involve vaporizing a mixture of an organic tin compound and a fluorine-containing compound, then directing these vaporized reactants onto the surface of a hot glass substrate. Such a method is disclosed in U.S. Patent No. 4,293,594, which additionally suggests the use of an oxygen-containing carrier gas.

**[0007]** Likewise, in U.S. Patent No. 4,590,096, a chemical vapor deposition method of forming fluorine doped tin oxide coatings is disclosed using a mixture of an organotin compound, an organic fluorine dopant, air and water vapor. In the method, the gas stream is said to contain sufficient water vapor such that the relative humidity of the gas stream at 18°C is about 6% to 100%.

**[0008]** In U.S. Patent No. 4,325,987, a CVD method is disclosed in which a gaseous mixture of tin tetrachloride and water vapor in a carrier gas containing at least 30% hydrogen is delivered to the glass surface. A separate gaseous mixture of HF and water vapor may also be delivered to the glass surface. While the preferred tin compound is stated to be tin tetrachloride and this is the only tin compound for which examples are given, mention is made of the possibility of using volatile tin compounds of the type $Sn(Alk)_4$ where Alk denotes a lower alkyl radical and dibutyl-diacetyl tin. As there is a lack of any information on how to practice the method of the invention with the mentioned organic tin compounds, the disclosure does not contribute anything to the advancement of the state of the art in this regard.

**[0009]** It must be noted that the prior art referred to hereinabove has been collected and examined only in light of the present invention as a guide. It is not to be inferred that such diverse art would otherwise be assembled absent the motivation provided by the present invention.

**[0010]** It would be desirable to improve the heretofore known methods for applying a fluorine doped tin oxide coating to a surface of a hot glass substrate by a CVD process, and thereby enhance the low sheet resistance and uniformity of the sheet resistance of the coated glass product. It would also be desirable to provide a method for applying a fluorine doped tin oxide coating to a surface of a hot glass substrate which was less costly than the heretofore known methods.

### SUMMARY OF THE INVENTION

**[0011]** The present invention is directed toward a

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chemical vapor deposition process for applying a fluorine doped tin oxide coating to a surface of a moving ribbon of a hot glass. Surprisingly, it has been discovered that the desirable properties of fluorine doped tin oxide coatings on glass are improved by utilizing a process comprising the steps of: a) providing a hot glass ribbon, including a surface upon which a fluorine doped tin oxide coating is to be deposited; b) pre-mixing an organotin compound, hydrogen fluoride, oxygen and water to form a uniform, vaporized reactant mixture; and c) delivering the vaporized reactant mixture to the surface of the hot glass ribbon; wherein the uniform, vaporized reactant mixture reacts to deposit a coating of fluorine doped tin oxide on the surface of the hot glass ribbon. In a preferred embodiment, a sodium diffusion barrier, preferably a layer of silica, is applied to the surface of the glass substrate prior to the deposition of the fluorine doped tin oxide. The process of the present invention is particularly suitable for the production of glass having a fluorine doped tin oxide coating, useful for energy efficient architectural windows, airplane or automobile windows, and a variety of optical and electronic devices.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0012]** Tin oxide coatings doped with fluorine may be deposited onto the surface of moving a hot glass ribbon by a process generally known in the art as chemical vapor deposition (CVD). In accordance with this process, the reactants are combined so as to form a uniform, vaporized reactant stream which is delivered to the surface of the hot glass ribbon wherein the vaporized reactant stream reacts to deposit a coating of fluorine doped tin oxide on the surface of the hot glass ribbon. In the oxidizing atmosphere, which must exist at the surface of the hot glass, the organotin coating compounds pyrolytically decompose to form the tin oxide coating.

**[0013]** The process is typically conducted during the manufacture of glass by the float glass process, and occurs in the float metal bath, the lehr, or in the transition zone between the bath and the lehr, while the glass is still hot. The glass ribbon is generally provided at a temperature in the range from 384°C (750°F) to 800°C (1500°F. These are typical temperatures for glass during various stages as it is manufactured by the float glass process.

**[0014]** The glass ribbons suitable for use in the process according to the present invention include any of the conventional glass ribbons known in the art for the preparation of coated glass articles. A typical glass used in the manufacture of vehicle windows and plate glass, is commonly referred to as soda-lime-silica glass. Other suitable glasses may be generally designated as alkali-lime-silica glass, boro-silicate glass, alumino-silicate glass, boro-alumino silicate glass, phosphate glass, fused silica, etc., as well as combinations thereof. A preferred glass is soda-lime-silica glass.

**[0015]** The CVD reactant stream of this invention includes an organotin coating compound which is vaporized and conveyed to a point at or near the surface of the advancing glass ribbon. Suitable organotin compounds useful for practicing the invention include, without limitation to those specifically recited, dimethyltin dichloride, diethyltin dichloride, dibutyltin diacetate, tetramethyl tin, methyltin trichloride, triethytin chloride, trimethyltin chloride, ethyltin trichloride, propyltin trichloride, isopropyltin trichloride, sec-butyltin trichloride, t-butyltin trichloride, phenyltin trichloride, carbethoxyethyltin trichloride, and the like, as well as combinations thereof. These compounds are generally well known in the art of CVD technology, as well as commercially available, as precursors for applying a tin oxide coating on hot glass. A preferred organotin compound is dimethyltin dichloride. The organotin compound, and optionally a carrier gas, oxidizer, stabilizer, hydrocarbon, inert gas, and the like, are vaporized to form a gaseous organotin reactant stream. The term gaseous organotin reactant stream, as used herein, typically comprises a vaporized organotin compound, an oxidizer, and an inert carrier gas.

**[0016]** The vaporized organotin compound may be prepared by any of the procedures generally known in the art, such as for example the vaporization of dispersed or fluidized organotin powders or the vaporization of organotin particles in a packed bed a hot carrier gas stream, or the injection of solubilized organotin compound into a hot carrier gas stream, or the bubbling of a carrier gas through a liquid organotin compound. These processes are more fully set forth in U.S. Patents, Nos. 3,852,098; 2,780,553; 4,351,861; 4,571,350; 3,970,037; 4,212,663; and 4,261,722.A preferred method for preparing the reactant stream containing the vaporized organotin compound is to vaporize the compound in a thin film evaporator in the presence of a blend gas, as is disclosed, for example, in U.S. Patent No. 5,090,985, which is also incorporated herein in its entirety by reference thereto. As noted above, this gaseous stream, which generally comprises an inert carrier gas such as helium, nitrogen, or argon, or mixtures thereof, may optionally contain oxidizers such as water or oxygen. Preferred carrier gases are helium and nitrogen, and mixtures thereof, containing oxygen as an oxidizer. The resultant reactant stream containing the vaporized organotin compound is generally heated to a temperature from 107°C (250°F) to 218°C (450°F), then conveyed to the reaction zone at the surface of the hot glass ribbon.

**[0017]** Gaseous hydrogen fluoride or hydrofluoric acid ("HF" is used herein to refer to either hydrogen fluoride gas or hydrofluoric acid) is combined with the vaporized organotin compounds. A separate HF containing reactant stream is formed generally comprised of HF and a carrier, preferably water vapor. The addition of water to the HF-containing reactant stream also lowers the emissivity of the coated glass, while increasing the

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growth rate of the fluorine doped tin oxide deposited. The HF-containing reactant stream may additionally contain conventional adjuvants such as for example helium, nitrogen, or argon, and mixtures thereof, as well as oxidizers such as for example oxygen.

**[0018]** The HF-containing reactant stream is combined with the organotin reactant stream at a point prior to delivery of the reactants to the surface of the hot glass substrate upon which the coating is to be deposited, but preferably in relatively close proximity thereto. The reactant stream containing the HF may be prepared by vaporizing the compound using one of the methods discussed hereinabove relative to the vaporization of the organotin, or by providing the HF as a gas. The vaporized reactant stream containing the HF may be combined with the reactant stream containing the vaporized organotin compound by blending the two gaseous streams prior to delivery to the surface of the hot glass substrate. Alternatively, the HF-containing reactant stream in liquid or solution form may be injected into the hot reactant stream containing the vaporized organotin compound, thereby vaporizing the fluorine-containing solution or liquid compound. After combination, the vaporized reactants of organotin, HF, water and oxygen are delivered to the surface of the hot glass, where they react together to deposit thereon a coating of fluorine doped tin oxide.

**[0019]** In a preferred embodiment, the organotin reactant stream is formed by vaporizing dimethyltin dichloride and an inert carrier gas, such as nitrogen, helium or a mixture thereof in an evaporator such as that described above. The resulting gaseous stream is then combined with gaseous oxygen. At the same time, HF and water are combined in a second evaporator, and the resulting gaseous reactant stream of HF and water vapor is combined with the gaseous organotin reactant stream to form a uniform, gaseous reactant stream. The uniform, gaseous reactant stream is delivered to the surface of the hot glass ribbon, wherein a coating of fluorine doped tin oxide is deposited on the surface of the hot glass ribbon. The uniform, gaseous reactant stream may be delivered to the surface of the glass by any suitable coating device. One preferred coating device is illustrated in U.S. Patent No. 4,504,526.

**[0020]** The uniform, gaseous reactant mixture which is delivered to the surface of the hot glass ribbon in accordance with the invention preferably includes (all percentages being mole %) from about 10 to about 60% oxygen, from about 2 to about 50 % water, and from about 0.2 to about 2% HF, and most preferably includes from about 30 to about 50% oxygen, from about 15 to about 35% water, and from about 0.5 to about 1.5% HF. The uniform, gaseous reactant mixture also includes an organotin compound, the desired concentration of which is a function of the desired thickness of the tin oxide coating and the line speed of the substrate. Thus, as will be appreciated by those skilled in the art, the organotin is provided in the gaseous reactant mixture in an amount sufficient to apply a coating of the desired thickness at the desired line speed of the substrate. For typical commercial operations, the gaseous reactant mixture will generally include from about 0.01 to about 8% of the organotin.

**[0021]** It has also been noted to be preferable, when forming a fluorine doped tin oxide coating in accordance with this invention, to apply a layer of a material which acts as a sodium diffusion barrier between the glass ribbon and the fluorine doped tin oxide coating.

**[0022]** Coated glass articles have been found to exhibit lower emissivity, lower sheet resistance and lower haze when the fluorine doped tin oxide coating deposited in accordance with the invention is applied to the glass with a sodium diffusion layer therebetween, as opposed to directly on the glass. This sodium diffusion layer is preferably formed of silica. The layer of silica is preferably formed using conventional CVD techniques.

**[0023]** In a most preferred embodiment, a thin film of tin oxide is first deposited on the surface of the hot glass ribbon, with the thin film of silica deposited thereover, so that an underlayer structure of tin oxide/ silica is formed intermediate the glass and the subsequently deposited layer of fluorine doped tin oxide. In this embodiment, the silica film not only acts as a sodium diffusion barrier but, in combination with the first (undoped) tin oxide film, helps to suppress iridescence in the resulting coated glass article. The use of such anti-iridescent layers is disclosed in U.S. Patent No. 4,377,613.

**[0024]** It must be noted that the process conditions are not sharply critical for the successful combining and delivering of vaporized reactants according to the present invention. The process conditions described hereinabove are generally disclosed in terms which are conventional to the practice of this invention. Occasionally, however, the process conditions as described may not be precisely applicable for each compound included within the disclosed scope. Those compounds for which this occurs will be readily recognizable by those ordinarily skilled in the art. In all such cases, either the process may be successfully performed by conventional modifications known to those ordinarily skilled in the art, e.g., by increasing or decreasing temperature conditions, by varying the rates of combination of the organotin and HF reactants, by routine modifications of the vaporization process conditions, etc., or other process conditions which are otherwise conventional will be applicable to the practice of the invention.

**[0025]** It will also be noted that the process of the invention may be repeated as desired on a given ribbon so as to form a coating consisting of several successive layers, the composition of each of the layers not necessarily being identical. It is of course obvious that for a given flow rate of the reactants, the thickness of a coating layer depends on the rate of movement of the ribbon. Under these conditions, the reaction stations may if desired be multiplied by juxtaposing two or more coating devices. In this way, successive layers are superim-

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posed before the layers have had time to cool, producing a particularly homogenous overall coating.

**[0026]** The invention is more easily comprehended by reference to specific embodiments which are representative of the invention. It must be understood, however, that the specific embodiments are provided only for the purpose of illustration, and that the invention may be practiced otherwise than as specifically illustrated without departing from its principles and scope.

COMPARATIVE EXAMPLE

**[0027]** Dimethyltin dichloride is melted and then vaporized in a thin film evaporator of the type illustrated in U.S. Patent No. 5,090,985. Helium, as a carrier gas, is simultaneously introduced into the thin film evaporator. The thin film evaporator is equipped with a steam jacket maintained at 162°C (350°F). The resulting mixture of gaseous DMT and helium exits the thin film evaporator and is conveyed along a main reactant line. Gaseous oxygen is introduced into the DMT/He gas stream in the main reactant line. The resultant gas stream continues along the main reactant line.

**[0028]** At the same time, trifluoroacetic acid (TFA) and water are fed into a second thin film evaporator, maintained at 180°C (400°F). The resulting mixture of gaseous TFA and water exits the second thin film evaporator and is fed through a supply line which joins with the main precursor line, combining the TFA/water gas mixture with the DMT/He/$0_2$ gas stream so that the streams are thoroughly mixed to form a uniform, vaporized reactant stream. The final gaseous reactant stream consists of about (all percentages being mole %) 44.2% oxygen, 22.1% water, 30.2% helium, 0.97% TFA, and 2.53% DMT, with the total gas flow of the final gaseous mixture being about 384 standard liters per minute per meter width of the resulting coated glass article.

**[0029]** This vaporized reactant stream is immediately delivered, utilizing the coating device of U.S. Patent No. 4,504,526, to the surface of a ribbon of glass on which a first thin film of tin oxide and a second thin film of silica had been previously deposited by conventional CVD techniques. The ribbon of glass is moving at a line speed of approximately 11,8 meters (466 inches) per minute, and is at a temperature of from 578°C (1,100°F) to 634°C(1,200°F). The reactant stream reacts at the surface of the hot glass to form a coating of fluorine doped tin oxide overlying the silica and tin oxide films. The thickness of the resulting layer of fluorine doped tin oxide is approximately 3,200 Å.

**[0030]** The sheet resistance is measured in 5,08 cm (2 inch) increments across the width of the resulting coated glass article. The sheet resistance ranges from 13.3 to 18.0 ohms per square, with an average sheet resistance of 14.4 ohms per square.

EXAMPLE

**[0031]** Dimethyltin dichloride is melted and then vaporized in a thin film evaporator of the type illustrated in U.S. Patent No. 5,090,985. Helium, as a carrier gas, is simultaneously introduced into the thin film evaporator. The thin film evaporator is equipped with a steam jacket maintained at 162°C (350°F). The resulting mixture of gaseous DMT and helium exits the thin film evaporator and is conveyed along a main reactant line. Gaseous oxygen is introduced into the DMT/He gas stream in the main reactant line. The resultant gas stream continues along the main reactant line.

**[0032]** At the same time, an aqueous solution of HF is fed into a second thin film evaporator, maintained at 180°C (400°F). Additional water is introduced into the second thin film evaporator. The resulting mixture of gaseous HF and water exits the second thin film evaporator and is fed through a supply line which joins with the main precursor line, combining the HF/water gas mixture with the DMT/He/$0_2$ gas stream so that the streams are thoroughly mixed to form a uniform, vaporized reactant stream. The final gaseous mixture consists of about (all percentages being mole %) 42.9% oxygen, 24.6% water, 29.3% helium, 0.70% HF, and 2.5% DMT, with the total gas flow of the final gaseous mixture being about 395 standard liters per minute per meter width of the resulting coated glass article.

**[0033]** This vaporized reactant stream is immediately delivered, utilizing the coating device of U.S. Patent No. 4,504,526, to the surface of a ribbon of glass on which a first thin film of tin oxide and a second thin film of silica had been previously deposited by conventional CVD techniques. The ribbon of glass is moving at a line speed of approximately 11,8 meters (466 inches) per minute, and is at a temperature of from 578°C (1,100°F) to 634°C (1,200°F). The reactant stream reacts at the surface of the hot glass to form a coating of fluorine doped tin oxide overlying the silica and tin oxide films. The thickness of the resulting layer of fluorine doped tin oxide is approximately 3,200 Å.

**[0034]** The sheet resistance is measured in 5,08 cm (2 inch) increments across the width of the resulting coated glass article. The sheet resistance ranges from 13.0 to 15.9 ohms per square, with an average sheet resistance of 14.0 ohms per square.

## Claims

1. A chemical vapor deposition process for applying a fluorine doped tin oxide coating to a surface of a moving ribbon of a hot glass during its manufacture, comprising:

   A) providing a hot glass ribbon including a surface upon which a fluorine doped tin oxide coating is to be deposited,

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B) pre-mixing an organotin compound, hydrogen fluoride, oxygen and water to form a uniform, vaporized reactant mixture; and

C) delivering the vaporized reactant mixture to the surface of the hot glass ribbon;

wherein the uniform, vaporized reactant mixture reacts to deposit a coating of fluorine doped tin oxide on the surface of the hot glass ribbon.

**2.** The process according to Claim 1, wherein the glass is selected from the group consisting of soda-lime-silica glass, alkali-lime-silica glass, boro-silicate glass, alumino-silicate glass, phosphate glass, fused silica glass, and combinations thereof.

**3.** The process according to Claim 1, wherein the glass is soda-lime-silica glass.

**4.** The process according to Claim 1, wherein the organotin compound is selected from the group consisting of dimethyltin dichloride, diethyltin dichloride, dibutyltin diacetate, tetra methyl tin, methyltin trichloride, triethyltin chloride, trimethyltin chloride, ethyltin trichloride, propyltin trichloride, isopropyltin trichloride, sec-butyltin trichloride, t-butyltin trichloride, phenyltin trichloride, carbethoxyethyltin trichloride, and combinations thereof.

**5.** The process according to Claim 1, wherein the organotin compound is dimethyltin dichloride.

**6.** The process according to Claim 1, wherein the glass substrate is provided at a temperature from 384°C (750°F) to 800°C (1,500°F).

**7.** The process according to Claim 1, wherein the uniform, vaporized reactant mixture additionally comprises one or more compounds selected from the group consisting of helium, nitrogen, argon, and nitrous oxide.

**8.** The process according to Claim 1, further comprising the step of depositing on said surface of said hot glass substrate a layer of a material which acts as a sodium diffusion barrier, so that said material is interposed between said surface of said glass substrate and said fluorine doped tin oxide coating.

**9.** The process according to Claim 8, wherein a layer of silica is deposited on the surface of said hot glass substrate prior to the deposition of said fluorine doped tin oxide coating.

**10.** The process according to Claim 9, wherein said layer of silica is deposited on the surface of said hot glass substrate by a chemical vapor deposition process.

**11.** The process according to Claim 9, wherein a layer of tin oxide is deposited on the surface of said hot glass substrate prior to the deposition of said layer of silica.

**12.** The process according to Claim 1, wherein said gaseous reactant mixture includes from 0.2 to 2 mole % hydrogen fluoride.

**13.** The process according to Claim 2, wherein said gaseous reactant mixture includes from 0. 5 to 1.5 mole % hydrogen fluoride.

**14.** The process according to Claim 1, wherein said gaseous reactant mixture includes from 2 to 50 mole % water.

**15.** The process according to Claim 14, wherein said gaseous reactant mixture includes from 15 to to 35 mole % water.

**16.** The process according to Claim 1, wherein said gaseous reactant mixture includes from 10 to 60 mole % oxygen.

**17.** The process according to Claim 16, wherein said gaseous reactant mixture includes from 30 to 50 mole % oxygen.

**18.** A chemical vapor deposition process for applying a fluorine doped tin oxide coating to a surface of a moving ribbon of a hot glass during its manufacture, comprising:

A) providing a hot glass ribbon at a temperature from 384°C (750°F) to 800°C (1,500°F), including a surface upon which a fluorine doped tin oxide coating is to be deposited;

B) pre-mixing an organotin compound, from 0.2 to 2 mole % hydrogen fluoride, from 2 to 50 mole % water, and from 10 to 60 mole % oxygen, to form a uniform, vaporized reactant mixture; and

C) delivering the vaporized reactant mixture to said surface of the hot glass ribbon;

wherein the uniform, vaporized reactant mixture reacts to deposit a coating of fluorine doped tin oxide on the surface of the hot glass ribbon.

**19.** A chemical vapor deposition process for applying a fluorine doped tin oxide coating to a surface of a moving ribbon of a hot glass during its manufacture, comprising:

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A) providing a hot glass ribbon at a temperature from 384°C (750°F) to 800°C (1,500°F), including a surface upon which a fluorine doped tin oxide coating is to be deposited, said surface having a layer of silica applied thereto;

B) pre-mixing an organotin compound, from 0.2 to 2 mole % hydrogen fluoride, from 2 to 50 mole % water, and from 10 to 60 mole % oxygen to form a uniform, vaporized reactant mixture; and

C) delivering the vaporized reactant mixture to said surface of the hot glass ribbon;

wherein the uniform, vaporized reactant mixture reacts to deposit a coating of fluorine doped tin oxide on said layer of silica on the surface of the hot glass ribbon.

**Patentansprüche**

1. Chemisches Gasphasenabscheidungsverfahren zum Aufbringen einer fluordotierten Zinnoxidschicht auf eine Oberfläche eines bewegten Bandes aus heißem Glas während seiner Herstellung, welches aufweist:

   A) Vorsehen eines heißen Glasbandes mit einer Oberfläche, auf welche eine fluordotierte Zinnoxidschicht aufzubringen ist,
   B) Vormischen von einer Organozinnverbindung, Fluorwasserstoff, Sauerstoff und Wasser, um eine gleichförmige, verdampfte Reaktionsmischung zu bilden; und
   C) Führen der verdampften Reaktionsmischung zu der Oberfläche des heißen Glasbandes;

   wobei die gleichförmige, verdampfte Reaktionsmischung reagiert, um eine Schicht aus fluordotiertem Zinnoxid auf der Oberfläche des heißen Glasbandes abzuscheiden.

2. Verfahren nach Anspruch 1, worin das Glas aus der Gruppe bestehend aus Natronkalk-Silikatglas, Alkalikalk-Silikatglas, Borsilikatglas, Aluminosilikatglas, Phosphatglas, geschmolzenem Quarzglas und Kombinationen von diesen ausgewählt ist.

3. Verfahren nach Anspruch 1, worin das Glas ein Natronkalk-Silikatglas ist.

4. Verfahren nach Anspruch 1, worin die Organozinnverbindung aus der Gruppe bestehend aus Dimethylzinn-Dichlorid, Diethylzinn-Dichlorid, Dibutylzinn-Diazetat, Tetramethylzinn, Methylzinn-Trichlorid, Triethylzinn-Chlorid, Trimethylzinn-Chlorid, Ethylzinn-Trichlorid, Propylzinn-Trichlorid, Isopropylzinn-Trichlorid, SEC-Butylzinn-Trichlorid, T-Butylzinn-Trichlorid, Phenylzinn-Trichlorid, Carbethoxyethylzinn-Trichlorid und Kombinationen hiervon ausgewählt ist.

5. Verfahren nach Anspruch 1, worin die Organozinnverbindung Dimethylzinn-Dichlorid ist.

6. Verfahren nach Anspruch 1, worin das Glassubtrat bei einer Temperatur von 384°C (750°F) bis 800°C (1.500°F) vorgesehen ist.

7. Verfahren nach Anspruch 1, worin die gleichförmige, verdampfte Reaktionsmischung zusätzlich eine oder mehrere Verbindungen aufweist, die aus der Gruppe bestehend aus Helium, Stickstoff, Argon und Distickstoffmonoxid ausgewählt sind.

8. Verfahren nach Anspruch 1, weiterhin aufweisend den Schritt des Aufbringens einer Schicht aus einem Material, welches als eine Natriumdiffusionsbarriere wirkt, auf die Oberfläche des heißen Glassubstrats, so daß das Material zwischen der Oberfläche des Glassubstrats und der fluordotierten Zinnoxidschicht angeordnet ist.

9. Verfahren nach Anspruch 8, worin eine Schicht aus Silica auf die Oberfläche des heißen Glassubtrats vor der Abscheidung der fluordotierten Zinnoxidschicht aufgebracht wird.

10. Verfahren nach Anspruch 9, worin die Schicht aus Silica durch ein chemisches Gasphasenabscheidungsverfahren auf die Oberfläche des heißen Glassubtrates aufgebracht wird.

11. Verfahren nach Anspruch 9, worin eine Schicht aus Zinnoxid vor der Aufbringung der Schicht aus Silica auf die Oberfläche des heißen Glassubstrates aufgebracht wird.

12. Verfahren nach Anspruch 1, worin die gasförmige Reaktionsmischung von 0,2 bis 2 Mol % Fluorwasserstoff enthält.

13. Verfahren nach Anspruch 2, worin die gasförmige Reaktionsmischung von 0,5 bis 1,5 Mol % Fluorwasserstoff enthält.

14. Verfahren nach Anspruch 1, worin die gasförmige Reaktionsmischung von 2 bis 50 Mol % Wasser enthält.

15. Verfahren nach Anspruch 14, worin die gasförmige Reaktionsmischung von 15 bis 35 Mol % Wasser enthält.

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16. Verfahren nach Anspruch 1, worin die gasförmige Reaktionsmischung von 10 bis 60 Mol % Sauerstoff enthält.

17. Verfahren nach Anspruch 16, worin die gasförmige Reaktionsmischung von 30 bis 50 Mol % Sauerstoff enthält.

18. Chemisches Gasphasenabscheidungsverfahren zum Aufbringen einer fluordotierten Zinnoxidschicht auf eine Oberfläche eines bewegten Bandes aus heißem Glas während seiner Herstellung, welches aufweist:

A) Vorsehen eines heißen Glasbandes bei einer Temperatur von 384°C (750°F) bis 800°C 1.500°F) mit einer Oberfläche, auf welcher eine fluordotierte Zinnoxidschicht abzuscheiden ist;
B) Vormischen einer Organozinnverbindung aus 0,2 bis 2 Mol % Fluorwasserstoff, 2 bis 50 Mol % Wasser und 10 bis 60 Mol % Sauerstoff, um eine gleichförmige, verdampfte Reaktionsmischung zu bilden; und
C) Führen der verdampften Reaktionsmischung zu der Oberfläche des heißen Glasbandes;

wobei die gleichförmige, verdampfte Reaktionsmischung reagiert, um eine Schicht aus fluordotiertem Zinnoxid auf der Oberfläche des heißen Glasbandes abzuscheiden.

19. Chemisches Gasphasenabscheidungsverfahren zum Aufbringen einer fluordotierten Zinnoxidschicht auf eine Oberfläche eines bewegten Bandes aus heißem Glas während dessen Herstellung, welches aufweist:

A) Vorsehen eines heißen Glasbandes bei einer Temperatur von 384°C (750°F) bis 800°C (1.500°F) mit einer Oberfläche, auf welcher eine fluordotierte Zinnoxidschicht abzuscheiden ist, wobei auf die Oberfläche eine Schicht aus Silica aufgebracht ist,
B) Vormischen einer Organozinnverbindung mit 0,2 bis 2 Mol % Fluorwasserstoff, 2 bis 50 Mol % Wasser und 10 bis 60 Mol % Sauerstoff, um eine gleichförmige, verdampfte Reaktionsmischung zu bilden; und
C) Zuführen der verdampften Reaktionsmischung zu der Oberfläche des heißen Glasbandes;

wobei die gleichförmige, verdampfte Reaktionsmischung reagiert, um eine Schicht aus fluordotiertem Zinnoxid auf der Schicht aus Silica auf der Oberfläche des heißen Glasbandes abzuscheiden.

**Revendications**

1. Procédé de dépôt chimique en phase vapeur servant à appliquer un revêtement d'oxyde d'étain dopé au fluor sur la surface d'un ruban de verre chaud en mouvement pendant sa fabrication, comprenant :

A) la mise à disposition d'un ruban de verre chaud comportant une surface sur laquelle un revêtement d'oxyde d'étain dopé au fluor doit être déposé,
B) le mélange préalable d'un composé organo-étain, de fluorure d'hydrogène, d'oxygène et d'eau pour former un mélange de réactifs vaporisé, uniforme; et
C) le dépôt du mélange de réactifs vaporisé sur la surface du ruban de verre chaud;

dans lequel le mélange de réactifs vaporisé, uniforme réagit pour déposer un revêtement d'oxyde d'étain dopé au fluor sur la surface du ruban de verre chaud.

2. Procédé selon la revendication 1, dans lequel le verre est choisi dans le groupe constitué par du verre de silicate sodocalcique, du verre de silicate alcalicalcique, du verre de borosilicate, du verre d'aluminosilicate, du verre de phosphate, du verre de silice fondue, et leurs combinaisons.

3. Procédé selon la revendication 1, dans lequel le verre est du verre de silicate sodocalcique.

4. Procédé selon la revendication 1, dans lequel le composé organo-étain est choisi dans le groupe constitué par le dichlorure de diméthylétain, le dichlorure de diéthylétain, le diacétate de dibutylétain, le tétraméthylétain, le trichlorure de méthylétain, le chlorure de triéthylétain, le chlorure de triméthylétain, le trichlorure d'éthylétain, le trichlorure de propylétain, le trichlorure d'isopropylétain, le trichlorure de s-butylétain, le trichlorure de t-butylétain, le trichlorure de phénylétain, le trichlorure de carbéthoxyéthylétain, et leurs combinaisons.

5. Procédé selon la revendication 1, dans lequel le composé organo-étain est le dichlorure de diméthylétain.

6. Procédé selon la revendication 1, dans lequel le substrat en verre est amené à une température de 384°C (750°F) à 800°C (1 500°F).

7. Procédé selon la revendication 1, dans lequel le mélange de réactifs vaporisé, uniforme, comprend en outre un ou plusieurs composés choisis dans le groupe constitué par l'hélium, l'azote, l'argon et

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l'oxyde nitreux.

**8.** Procédé selon la revendication 1, comprenant en outre l'étape consistant à déposer sur ladite surface dudit substrat en verre chaud une couche d'un matériau qui joue le rôle de barrière de diffusion du sodium, de manière que ledit matériau soit intercalé entre ladite surface dudit substrat en verre et ledit revêtement d'oxyde d'étain dopé au fluor.

**9.** Procédé selon la revendication 8, dans lequel une couche de silice est déposée sur la surface dudit substrat en verre chaud avant le dépôt dudit revêtement d'oxyde d'étain dopé au fluor.

**10.** Procédé selon la revendication 9, dans lequel ladite couche de silice est déposée sur la surface dudit substrat en verre chaud par un procédé de dépôt chimique en phase vapeur.

**11.** Procédé selon la revendication 9, dans lequel une couche d'oxyde d'étain est déposée sur la surface dudit substrat en verre chaud avant le dépôt de ladite couche de silice.

**12.** Procédé selon la revendication 1, dans lequel ledit mélange de réactifs gazeux comprend de 0,2 à 2% en moles de fluorure d'hydrogène.

**13.** Procédé selon la revendication 2, dans lequel ledit mélange de réactifs gazeux comprend de 0,5 à 1,5% en moles de fluorure d'hydrogène.

**14.** Procédé selon la revendication 1, dans lequel ledit mélange de réactifs gazeux comprend de 2 à 50% en moles d'eau.

**15.** Procédé selon la revendication 14, dans lequel ledit mélange de réactifs gazeux comprend de 15 à 35% en moles d'eau.

**16.** Procédé selon la revendication 1, dans lequel ledit mélange de réactifs gazeux comprend de 10 à 60% en moles d'oxygène.

**17.** Procédé selon la revendication 16, dans lequel ledit mélange de réactifs gazeux comprend de 30 à 50% en moles d'oxygène.

**18.** Procédé de dépôt chimique en phase vapeur servant à appliquer un revêtement d'oxyde d'étain dopé au fluor sur la surface d'un ruban de verre chaud en mouvement pendant sa fabrication, comprenant :

A) la mise à disposition d'un ruban de verre chaud à une température de 384°C (750°F) à 800°C (1 500°F), comportant une surface sur laquelle un revêtement d'oxyde d'étain dopé au fluor doit être déposé;
B) le mélange préalable d'un composé organo-étain, de 0,2 à 2% en moles de fluorure d'hydrogène, de 2 à 50% en moles d'eau et de 10 à 60% en moles d'oxygène, pour former un mélange de réactifs vaporisé, uniforme; et
C) le dépôt du mélange de réactifs vaporisé sur ladite surface du ruban de verre chaud;

dans lequel le mélange de réactifs vaporisé, uniforme, réagit pour déposer un revêtement d'oxyde d'étain dopé au fluor sur la surface du ruban de verre chaud.

**19.** Procédé de dépôt chimique en phase vapeur servant à appliquer un revêtement d'oxyde d'étain dopé au fluor sur la surface d'un ruban de verre chaud en mouvement pendant sa fabrication, comprenant :

A) la mise à disposition d'un ruban de verre chaud à une température de 384°C (750°F) à 800°C (1 500°F), comportant une surface sur laquelle un revêtement d'oxyde d'étain dopé au fluor doit être déposé, une couche de silice ayant été appliquée sur ladite surface;
B) le mélange préalable d'un composé organo-étain, de 0,2 à 2% en moles de fluorure d'hydrogène, de 2 à 50% en moles d'eau et de 10 à 60% en moles d'oxygène, pour former un mélange de réactifs vaporisé, uniforme; et
C) le dépôt du mélange de réactifs vaporisé sur ladite surface du ruban de verre chaud;

dans lequel le mélange de réactifs vaporisé, uniforme réagit pour déposer un revêtement d'oxyde d'étain dopé au fluor sur ladite couche de silice sur la surface du ruban de verre chaud.

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(54) **CHEMICAL VAPOR DEPOSITION OF ANTIMONY-DOPED METAL OXIDE**

CHEMISCHE GASPHASENABSCHEIDUNG VON MIT ANTIMON DOTIERTEM METALLOXID

DEPOT CHIMIQUE EN PHASE VAPEUR D'UN OXYDE METALLIQUE DOPE A L'ANTIMOINE

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## Description

### FIELD OF THE INVENTION

**[0001]** The present invention relates generally to a method for forming a metal oxide coating on glass, and more particularly, to a process for preparing a tin oxide coating doped with antimony on a hot glass substrate by chemical vapor deposition. The invention also relates to a coated glass article manufactured according to this process.

### BACKGROUND OF THE INVENTION

**[0002]** Typically, coated glass articles are produced by continuously coating a glass substrate while it is being manufactured in a process known in the art as the "Float Glass Process". This process involves casting glass onto a molten tin bath which is suitably enclosed, then transferring the glass, after it has sufficiently cooled, to take-away rolls which are aligned with the bath, and finally cooling the glass as it advances across the rolls, initially through a lehr and thereafter while exposed to the ambient atmosphere. A non-oxidizing atmosphere is maintained in the float portion of the process, while the glass is in contact with the molten tin bath, to prevent oxidation. An air atmosphere is maintained in the lehr. The chemical vapor deposition (CVD) of various coatings may be conveniently performed in the bath or the lehr, or even in the transition zone therebetween, by contacting the surface of the hot glass with chemical vapor-containing reactants which pyrolytically decompose to form the metal oxide coating. This, of course, requires that the chemical reactants have vaporization temperatures below their thermal decomposition temperatures. A number of metal-containing compounds exist which may be vaporized to prepare a metal oxide coating on glass by CVD technology. Of particular interest are tin compounds which are vaporized to form tin oxide coatings.

**[0003]** The desirable performance characteristics of certain metal oxide coatings, such as tin oxide coatings, on glass, for example, are low emissivity, low sheet resistance, high light transmittance, high infrared reflectivity, etc., and are improved by the incorporation of a dopant into the metal oxide coating. Among the materials used in the prior art as dopants is antimony. Typically, antimony has been supplied in the form of inorganic antimony compounds, ,such as an antimony halide, for example, $SbCl_3$.

**[0004]** The physical form of the reactants employed in glass coating processes is generally a liquid, solid, vaporized liquid or solid, liquid or solid dispersed in a carrier gas mixture, or vaporized liquid or solid dispersed in a carrier gas mixture. The chemical vapor deposition process generally employs a vaporized liquid or solid, which is typically dispersed in a carrier gas mixture.

**[0005]** U.S. Patent No. 6,005,127 discloses an organoantimony Lewis base adduct which is said to be useful for Sb-ion implantation and formation of antimonide films, by various types of chemical vapor deposition. The present invention does not contain Lewis base adducts, nor does it involve ion implantation or formation of metal antimonides. Further, the 127 patent only discloses the following methods of chemical vapor deposition: chemical vapor deposition, assisted chemical vapour deposition (e.g., laser, light, plasma, ion, etc.).

**[0006]** US 4 293 594 discloses a chemical vapor deposition process for the deposition of antimony doped tin oxide on glass. An organoantimony compound, such as triphenyl antimony dichloride is uses. Although this organoantimony compound contains at least one Sb-C bond, it is subject to undergo premature hydrolysis and/or oxidation at temperature below 288°C because of the antimony chloride groups.

**[0007]** US 6 110 597 discloses triphenyl antimony as a precursor for coating glass with antimony and titanium doped tin oxide. However, in this patent, triphenyl antimony is merely mentioned in a ling list of possible precursors without mentioning the effect that it does not undergo premature hydrolysis and/or oxidation at temperatures less than 288°C. Further, this patent is primarily concerned with solution spray coating processes.

**[0008]** It is the object of the present invention to improve the heretofore known methods for applying an antimony doped tin oxide coating to a surface of a hot glass substrate by a CVD process, and thereby enhance the low sheet resistance and uniformity of the sheet resistance of the coated glass product, while at the same time minimizing the undesirable pre-reaction of precursor materials which occurs with known inorganic antimony dopants. It is also the object of the present invention to provide a method for applying an antimony-doped tin oxide coating to a surface of a hot glass substrate which is less costly than the heretofore known methods.

### SUMMARY OF THE INVENTION

**[0009]** The above object according to the invention is solved by a chemical vapour deposition process comprising the features of claim 1. The present invention is directed toward a chemical vapour deposition process for applying an antimony doped metal oxide coating to a surface of a hot glass substrate. Preferably, the metal is a tin compound. Most preferably, the tin compound is an organotin compound. Surprisingly, it has been discovered that the desirable properties of antimony doped metal oxide coatings, particularly tin oxide coatings, on glass, are improved by utilizing a process

comprising:

A chemical vapour deposition process for applying an antimony doped metal oxide coating to a surface on a hot glass substrate, comprising:

a) providing a hot glass substrate, including a surface upon which an antimony doped metal oxide coating is to be deposited;
b) providing a uniform, vaporized reactant mixture containing a metal compound, an oxygen-containing compound, water, and an organoantimony compound which will not pre-react with said oxygen-containing compound or water at temperatures below 288°C (550°F)., said organoantimony compound being a compound of the form $(R^1)_xSb(R^2)_{3-x}$ where R1 is an aryl group, R2 is an alkyl group, and x=3 or 2;
c) Delivering the vaporized reactant mixture to the surface of the hot glass substrate, and reacting the mixture to deposit a coating of antimony doped metal oxide on the surface of the hot glass substrate; and
d) cooling the coated glass substrate to ambient temperature.

**[0010]** A source of oxygen is necessary for the process of the invention, and is preferably chosen from among air, gaseous oxygen and molecular oxygen.

**[0011]** In a preferred embodiment, a sodium diffusion barrier, preferably a layer of silica, is applied to the surface of the glass substrate prior to the deposition of the antimony doped metal oxide. The process of the present invention is particularly suitable for the production of glass having an antimony doped metal oxide coating, and is useful for energy efficient architectural windows, airplane or automobile windows, and a variety of optical and electronic devices.

**[0012]** Wo 01/10790 Al discloses an antimony doped tin oxide film deposited on, and adhering to a glass substrate, and a coating of fluorine doped tin oxide deposited on and adhering to the coating of antimony doped tin oxide. The resulting coated glass article has a high solar selectivity.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0013]** Metal oxide coatings, particularly tin oxide coatings doped with antimony, may be deposited onto the surface of a hot glass substrate by a process generally known in the art as chemical vapor deposition (CVD). In accordance with the process of the invention, the reactants are combined so as to form a uniform, vaporized reactant stream which is delivered to the surface of the hot glass substrate, wherein the vaporized reactant stream reacts to deposit a coating of antimony doped metal oxide on the surface of the hot glass substrate. In the oxidizing atmosphere, which must exist at the surface of the hot glass, organometallic compounds, preferably organotin coating compounds, pyrolytically decompose to form a metal/tin oxide coating.

**[0014]** The process is typically conducted during the manufacture of glass by the float glass process, and occurs in the float bath, the lehr, or in the transition zone between the bath and the lehr, while the glass is still hot. The glass substrate is generally provided at a temperature in the range from about 399°C (750°F) to about 816°C (1500°F). These are typical.temperatures for glass during various stages as it is manufactured by the float glass process. More specifically, the coating process is conducted at temperature in the range of 482-732°C (900-1350°F), preferably in the range of 593-693°C (1100-1280°F).

**[0015]** The glass substrates suitable for use in the process according to the present invention include any of the conventional glass substrates known in the art for the preparation of coated glass articles. A typical glass substrate, used in the manufacture of vehicle windows and plate glass, is commonly referred to as

**[0016]** soda-lime-silica glass. Other suitable glasses may be generally designated as alkali-lime-silica glass, borosilicate glass, alumino-silicate glass, boro-alumino silicate glass, phosphate glass, fused silica, etc., as well as combinations thereof. A preferred glass is soda-lime-silica glass.

**[0017]** The CVD reactant stream of this invention preferably includes an organotin coating compound which is vaporized and conveyed to a point at or near the surface of the advancing glass ribbon. Suitable organotin compounds useful for practicing the invention include, without limitation to those specifically recited, dimethyltin dichloride, diethyltin dichloride, dibutyltin diacetate, tetramethyl tin, methyltin trichloride, triethyltin chloride, trimethyltin chloride, ethyltin trichloride, propyltin trichloride, isopropyltin trichloride, sec-butyltin trichloride, t-butyltin trichloride, phenyltin trichloride, carbethoxyethyltin trichloride, and the like, as well as combinations thereof. These compounds are generally well known in the art of CVD technology, as well as commercially available, as precursors for applying a tin oxide coating on hot glass. A preferred organotin compound is dimethyltin dichloride. The organotin compound, and optionally a carrier gas, oxidizer, stabilizer, hydrocarbon, inert gas, and the like, are vaporized to form a gaseous organotin reactant stream. The term gaseous organotin reactant stream, as used herein, typically comprises a vaporized organotin compound, an oxidizer, and an inert carrier gas.

**[0018]** The vaporized organotin compound may be prepared by any of the procedures generally known in the art, such

as, for example, the vaporization of dispersed or fluidized, organotin powders, or the vaporization of organotin particles in a packed bed.by a hot carrier gas stream, or the injection of a solubilized organotin compound into a hot carrier gas stream, or the bubbling of a carrier gas through a liquid organotin compound. A preferred method for preparing the reactant streams containing the vaporized organotin compounds is to vaporize the compound in a thin film evaporator in the presence of a blend gas, as is disclosed, for example, in U.S. Patent No. 5,090,985, which is incorporated herein in its entirety by reference thereto. As noted above, this gaseous stream, which generally comprises an inert carrier gas such as helium, nitrogen, or argon, or mixtures thereof, may optionally contain oxidizers such as water or oxygen. Preferred carrier gases are helium and nitrogen, and mixtures thereof, containing oxygen as an oxidizer. The resultant reactant stream containing the vaporized organotin compound is generally heated to a temperature from about 121°C (250°F) to about 232°C (450°F), then conveyed to the reaction zone at the surface of the hot glass substrate, where temperatures at the face of the coater nearest the glass surface are less than.or equal to approximately 288°C (550°F).

**[0019]** A separate reactant stream containing an organoantimony compound, an oxidizer, and an inert carrier gas is another component of the coating system of the invention.

**[0020]** The organoantimony compounds useful in the invention can be generally described by the formula:

$(R^1)_xSb(R^2)_{3-x}$ where $R^1$ is an aryl group, $R^2$ is an alkyl group, and x = 3 or 2

when, in the above formula, x = 2, the family of compounds referred to are known as diaryl alkyl antimony compounds, which while suitable for use in the present invention are more likely to pre-react with oxygen, as will hereinafter be described in greater detail.

**[0021]** When, in the above formula, x = 3, a preferred family of compounds, triaryl antimony compounds, are formed. Examples of such compounds are $(Mes)_3Sb$, where Mes is mesityl or 1, 3, 5 trimethylphenyl, $(Tolyl)_3Sb$, $Ph_3Sb$, and $(R_xC_6H_{5-x})_3Sb$ where R is a small chain organic group, having one to four carbon atoms, (i.e., $C_1$-$C_4$) and x = 1-5. Of these, $Ph_3Sb$ is particularly preferred, for reasons which will hereinafter be discussed.

**[0022]** It has been found that few antimony compounds meet the requisite requirements of being highly reactive at deposition temperatures, but of not pre-reacting with water or oxygen, or being corrosive. The above-described triaryl antimony compounds have been found to meet these criteria and thus are preferred compounds in connection with the present invention. $Ph_3Sb$ is particularly preferred, because in addition to being a triaryl antimony compound having the desired properties described above, it is available in commercial quantities.

**[0023]** Unlike conventional inorganic antimony precursor materials such as $SbCl_3$, when $Ph_3Sb$ is used in conjunction with organotin reagents, water and oxygen, it remains stable, and does not pre-react, so detrimental Sb/O/Cl solid-state compounds are produced in negligible quantities. Materials such as $SbCl_3$ are known to be water-sensitive, and in addition to reacting with water to form the undesirable, non-volatile, solid-state compounds noted above, they are corrosive.

**[0024]** Such solid materials build up on the primary coating device, reducing coating efficiency, or in the worst case, actually causing the coating operation to be shut down completely. Using the air- and water-stable organoantimony precursors of the present invention will reduce operational downtime due to less frequent shutdowns for maintenance because of a build-up of Sb/O/Cl solids.

**[0025]** The organoantimony-containing reactant stream is combined with the organotin reactant stream at a point prior to delivery of the reactants to the surface of the hot glass substrate upon which the coating is to be deposited, but preferably in relatively close proximity thereto. The reactant stream containing the organoantimony may be prepared by vaporizing the compound using any suitable method, such as the methods discussed hereinabove relative to the vaporization of the organotin. The vaporized reactant stream containing the organoantimony may be combined with the reactant stream containing the vaporized organotin compound by blending the two gaseous streams prior to delivery to the surface of the hot glass substrate. Alternatively, the organoantimony-containing reactant stream in liquid or solution form may be injected into the hot reactant stream containing the vaporized organotin compound, thereby vaporizing the antimony-containing solution or liquid compound. After combination, the vaporized reactants of organotin, organoantimony, water and an oxygen-containing compound are delivered to the surface of the hot glass, where they react together to deposit thereon a coating of antimony doped tin oxide.

**[0026]** In a preferred embodiment, the organotin reactant stream is formed by vaporizing dimethyltin dichloride and an inert carrier gas, such as nitrogen, helium or a mixture thereof in an evaporator such as that described above. The resulting gaseous stream is then combined with gaseous oxygen. At the same time, $Ph_3Sb$ and water are vaporized, and the resulting gaseous reactant stream of organoantimony and water vapor is combined with the gaseous organotin reactant stream to form a uniform, gaseous reactant stream. The uniform, gaseous reactant stream is delivered to the surface of the hot glass substrate, wherein a coating of antimony doped tin oxide is deposited on the surface of the hot glass substrate. The uniform, gaseous reactant stream may be delivered to the surface of the glass by any suitable coating device. One preferred coating device is illustrated in U.S. Patent No. 4,504,526, which is incorporated herein in its entirety by reference thereto.

**[0027]** The uniform, gaseous reactant mixture which is delivered to the surface of the hot glass substrate in accordance with the invention preferably includes (all percentages being mole %) from about 10 to about 60% oxygen, from about 2 to about 50% water, and from about 0.01% to about 4% organoantimony, and most preferably includes from about 10 to about 50% oxygen, from about 15 to about 35% water, and from about 0.01% to about 0.05% organoantimony. The uniform, gaseous reactant mixture also includes an organotin compound, the desired concentration of which is a function of the desired thickness of the tin oxide coating and the line speed of the substrate. Thus, as will be appreciated by those skilled in the art, the organotin is provided in the gaseous reactant mixture in an amount sufficient to apply a coating of the desired thickness at the desired line speed of the substrate. For typical commercial operations, the gaseous reactant mixture will generally include from about 0.01% to about 8% of the organotin.

**[0028]** It has also been noted to be preferable, when forming an antimony doped tin oxide coating in accordance with this invention, to apply a layer of a material which acts as a sodium diffusion barrier between the glass substrate and the antimony doped tin oxide coating. Coated glass articles have been found to exhibit lower emissivity, lower sheet resistance and lower haze when the antimony doped tin oxide coating deposited in accordance with the invention is applied to the glass with a sodium diffusion layer therebetween, as opposed to directly on the glass. This sodium diffusion layer is preferably formed of silica. The layer of silica is preferably formed using conventional CVD techniques.

**[0029]** In a more preferred embodiment, a thin film of tin oxide is first deposited on the surface of the hot glass substrate, with a thin film of silica deposited thereover, so that an underlayer structure of tin oxide/silica is formed intermediate the glass and the subsequently deposited layer of antimony doped tin oxide. In this embodiment, the silica film not only acts as a sodium diffusion barrier but, in combination with the first (undoped) tin oxide film, helps to suppress iridescence in the resulting coated glass article. The use of such anti-iridescent layers is disclosed in U.S. Patent No. 4,377,613, which is incorporated herein in its entirety by reference thereto.

**[0030]** It must be noted that the process conditions are not sharply critical for the successful combining and delivering of vaporized reactants according to the present invention. The process conditions described hereinabove are generally disclosed in terms which are conventional to the practice of this invention. Occasionally, however, the process conditions as described may not be precisely applicable for each compound included within the disclosed scope. Those compounds for which this occurs will be readily recognizable by those ordinarily skilled in the art. In all such cases, either the process may be successfully performed by conventional modifications known to those ordinarily skilled in the art, e.g., by increasing or decreasing temperature conditions, by varying the rates of combination of the organotin and organoantimony reactants, by routine modifications of the vaporization process conditions, etc., or other process conditions which are otherwise conventional will be applicable to the practice of the invention.

**[0031]** It will also be noted that the process of the invention may be repeated as desired on a given substrate so as to form a coating consisting of several successive layers, the composition of each of the layers not necessarily being identical. It is, of course, obvious that for a given flow rate of the reactants, the thickness of a coating layer depends on the rate of movement of the substrate. Under these conditions, the reaction stations may, if desired, be multiplied by juxtaposing two or more coating devices. In this way, successive layers are superimposed before the layers have had time to cool, producing a particularly homogenous overall coating.

**[0032]** The invention is more easily comprehended by reference to specific embodiments which are representative of the invention. It must be understood, however, that the specific embodiments are provided only for the purpose of illustration, and that the invention may be practiced otherwise than as specifically illustrated without departing from its scope.

EXAMPLES

Examples 1 and 2

**[0033]** The following experimental conditions are applicable to Examples 1 and 2.

**[0034]** A laboratory furnace having a moving conveyor to move a glass sheet, or sheets, through said furnace at a rate of 508cm (200 inches)/minute, also contains a single, 25.4cm (10-inch) wide, bi-directional coater, the coater being suitable for conveying vaporized reactants to the surface of the glass sheets in order to form a film or film stack by chemical vapor deposition.

**[0035]** The glass sheets are heated to approximately 632°C (1170°F), while the coater, at the reactor face, i.e., the portion nearest the glass surface is at a temperature of approximately 260°C (500°F).

**[0036]** Preparation of the various precursor materials is accomplished by utilizing multiple source chambers known as "bubblers" there being a bubbler for each of ethyl acetate (EtOAc), triphenyl antimony ($Ph_3Sb$), and dimethyltin dichloride ($Me_2SnCl_2$), which are maintained at specific temperatures. Helium gas is introduced into the bubbler, at a particular flow rate.

**[0037]** The specific source or bubbler temperatures and the flow rates are as follows:

| Bubbler | EtOAc | $Ph_3Sb$ | $Me_2SnCl_2$ |
|---|---|---|---|
| Temperature | 36°C (97°F) | 241°C (465°F) | 179°C (355°F) |
| He Flow | 0.5-0.75 slm | 1.0 slm | 1.2 slm |

**[0038]** The prepared reactants are introduced into the laboratory coater along with oxygen ($O_2$) at a flow rate of 5.25 slm, and water ($H_2O$) at a flow rate of 12.4 slm.

**[0039]** The various reactants described above are combined in the coater to deposit an antimony-doped tin oxide coating on, in this case, a clear soda-lime-silica glass sheet whereon a $SiO_2$ layer 20nm (200Å) thick had previously been deposited.

| | Film Thickness | Sheet Resistance | $T_{vis}$ | $T_{sol}$ |
|---|---|---|---|---|
| Example 1 | 195 nm (1951Å) | 142 ohm/square | 63% | 48% |
| Example 2 | 216 nm (2158Å) | 119 ohms/square | 67% | 55% |

**[0040]** Film thicknesses were determined by profilometry.

**[0041]** $T_{vis}$ is the transmission of light in the visible portion of the spectrum (400 nm to 800 nm) through the coated glass.

**[0042]** $T_{sol}$ is the transmission of total solar radiation through the coated glass.

**[0043]** It should also be noted that He flow through the $EtOA_c$ bubbler was 0.75 slm in Example 1, and 0.50 slm in Example 2. Other parameters were as previously described for both examples.

**[0044]** The films produced by these tests are uniform in thickness and conductivity, exhibit low haze and good, selective solar absorption.

Example 3

**[0045]** It has also been found that acceptable antimony-doped tin oxide films may be produced by utilizing a solution of an aryl antimony compound, such as triphenyl antimony ($Ph_3Sb$), dissolved in ethyl acetate (EtOAc). Other suitable solvents include, but are not limited to, hexane, Toluene, dichloromethane, and acetonitrile. An inert gas is bubbled through gaseous dimethyltin dichloride ("$Me_2SnCl_2$), as in Examples 1 and 2. Both reactant streams are combined with oxygen and water, as in Examples 1 and 2.

**[0046]** Laboratory furnace conditions and the coating device utilized for Example 3 are the same as for Examples 1 and 2.

**[0047]** Flow of the $Ph_3Sb$/EtOAc reactant stream, comprising 18% by weight, $Ph_3Sb$, at a flow rate of 11 cubic centimeters per minute, is combined with the reactant stream of $Me_2SnCl_2$ created by bubbling the gas at a flow rate of 1.2 slm through the gaseous $Me_2SnCl_2$, along with oxygen at a flow rate of 5.25 slm and water at a flow rate of 12.4 slm to produce a film on a soda-lime-silica substrate, having a pre-deposited 20nm (200Å) silica barrier layer thereon, the deposited film, having the following properties:

| | Film Thickness | Sheet Resistance | $T_{vis}$ | $T_{sol}$ |
|---|---|---|---|---|
| Example 3 | ≈200nm (2000Å) | 135 ohms/square | 74% | 58% |

**[0048]** The invention has been disclosed in what is considered to be its preferred embodiment. It must be understood, however, that the specific embodiments are provided only for the purpose of illustration, and that the invention may be practiced otherwise than as specifically illustrated without departing from its scope.

## Claims

1. A chemical vapour deposition process for applying an antimony doped metal oxide coating to a surface on a hot glass substrate, comprising:

   a) providing a hot glass substrate, including a surface upon which an antimony doped metal oxide coating is to be deposited;

   b) providing a uniform, vaporized reactant mixture containing a metal compound, an oxygen-containing compound, water, and an organoantimony compound;

c) delivering the vaporized reactant mixture to the surface of the hot glass substrate, and reacting the mixture to deposit a coating of antimony doped metal oxide on the surface of the hot glass substrate; and
d) cooling the coated glass substrate to ambient temperature;

**characterized in that** the organoantimony compound will not pre-react with said oxygen-containing compound or water at temperatures below 288°C (550°F), said organoantimony compound being a compound of the form $(R^1)_xSb(R^2)_{3-x}$ where R1 is an aryl group, R2 is an alkyl group, and x=3 or 2.

2. The process of claim 1, wherein said organoantimony compound is a diaryl alkyl antimony compound.

3. The process of claim 1, wherein said organoantimony compound is a triaryl antimony compound chosen from the group consisting of: $(Mes)_3Sb$, $Ph_3Sb$, $(Tolyl)_3Sb$, and $(R_xC_6H_{5-x})_3Sb$ (where R is a small chain organic group having one to four carbon atoms), and x = 1-5.

4. The process of claim 1, wherein said organoantimony compound is $Ph_3Sb$.

5. The process of claim 1, wherein said vaporized reactant mixture contains said metal compound which is a tin compound and said oxygen-containing compound is oxygen.

6. The process of claim 5, wherein said tin compound is an organotin compound.

7. The process of claim 5, wherein said tin compound is dimethyltin dichloride.

8. The process of claim 5, wherein said coating process takes place as part of a float glass production process.

9. The process of claim 8, wherein said coating process takes place in, or adjacent to, the float bath.

10. The process of claim 9, wherein said coating process occurs at a temperature of from 482-732°C (900-1350°F).

11. The process of claim 10, wherein said coating process occurs at a temperature from 593-693°C (1100-1280°F).

12. The process of claim 10, wherein said coating is deposited at a thickness of 100,0 nm (1000Å) to 500,0 nm nm (5000Å).

13. The process of claim 11, wherein said coating is deposited at a thickness of 100,0 nm (1000Å) to 350,0 nm (3500Å).

14. The process of claim 1, wherein a color suppressing coating is applied to the substrate upon which the antimony-containing coating is deposited prior to the deposition of said antimony-containing coating.

15. The process of claim 1, wherein said organoantimony compound is essentially non-reactive with water and oxygen.

16. The process of claim 1, further comprising providing a sodium diffusion barrier layer and depositing same directly on said hot glass substrate.

17. The process of claim 16, wherein the sodium diffusion barrier layer comprises silica.

**Patentansprüche**

1. Chemischer Dampfabscheidungsprozess zum Aufbringen einer antimondotierten Metalloxidbeschichtung auf eine Oberfläche eines heißen Glassubstrats, welcher aufweist:

a) Bereitstellen eines heißen Glassubstrats, enthaltend eine Oberfläche, auf der eine antimondotierte Metalloxidbeschichtung abzuscheiden ist;
b) Bereitstellen einer gleichförmigen dampfförmigen Reaktandmischung enthaltend eine Metallverbindung, eine Sauerstoff enthaltende Verbindung, Wasser und eine Organoantimonverbindung;
c) Liefern der dampfförmigen Reaktandmischung zu der Oberfläche des heißen Glassubstrats, und Reagieren der Mischung, um eine Beschichtung aus antimondotiertem Metalloxid auf der Oberfläche des heißen Glassubstrats abzuscheiden; und

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d) Kühlen des beschichteten Glassubstrats auf Umgebungstemperatur;

**dadurch gekennzeichnet, dass** die Organoantimonverbindung nicht vorher mit der sauerstoffhaltigen Verbindung oder Wasser bei Temperaturen unterhalb 288°C (550 °F) reagiert, die Organoantimonverbindung eine Verbindung in der Form $(R^1)_xSb(R^2)_{3-x}$ ist, wobei R1 eine Arylgruppe ist, R2 eine Alkylgruppe ist und x = 3 oder 2 ist.

2. Prozess nach Anspruch 1, bei dem die Organoantimonverbindung eine Diaryl-Alkyl-Antimonverbindung ist.

3. Prozess nach Anspruch 1, bei dem die Organoantimonverbindung eine Triarylantimonverbindung ist, die ausgewählt ist aus der Gruppe bestehend aus: $(Mes)_3Sb$, $Ph_3Sb$, $(Tolyl)_3Sb$ und $(R_xC_6H_{5-x})_3Sb$ (wobei R eine kurzkettige organische Gruppe mit einem bis vier Kohlenstoffatomen ist), und x = 1-5.

4. Prozess nach Anspruch 1, bei dem die Organoantimonverbindung $Ph_3Sb$ ist.

5. Prozess nach Anspruch 1, bei dem die dampfförmige Reaktandmischung die Metallverbindung enthält, die eine Zinnverbindung ist, und die Sauerstoff enthaltende Verbindung Sauerstoff ist.

6. Prozess nach Anspruch 5, bei dem die Zinnverbindung eine Organozinnverbindung ist.

7. Prozess nach Anspruch 5, bei dem die Zinnverbindung Dimethylzinn-Dichlorid ist.

8. Prozess nach Anspruch 1, bei dem der Beschichtungsprozess als Teil eines Floatglas-Herstellungsprozesses stattfindet.

9. Prozess nach Anspruch 8, bei dem der Beschichtungsprozess in oder benachbart dem Floatbad stattfindet.

10. Prozess nach Anspruch 9, bei dem der Beschichtungsprozess bei einer Temperatur von 482 bis 732°C (900 - 1350°F) stattfindet.

11. Prozess nach Anspruch 10, bei dem der Beschichtungsprozess bei einer Temperatur von 593 - 693°C (1100-1280°F) stattfindet.

12. Prozess nach Anspruch 10, bei dem die Beschichtung in einer Dicke von 100,0 nm (1000 Å) bis 500,0 nm (5000 Ä) abgeschieden wird.

13. Prozess nach Anspruch 11, bei dem die Beschichtung in einer Dicke von 100,0 nm (1000 Ä) bis 350,0 nm (3500 Å) abgeschieden wird.

14. Prozess nach Anspruch 1, bei dem eine Farbunterdrückungsbeschichtung auf das Substrat, auf dem die Antimon enthaltende Beschichtung abgeschieden wird, vor der Abscheidung der Antimon enthaltenden Beschichtung aufgebracht wird.

15. Prozess nach Anspruch 1, bei dem die Organoantimonverbindung im Wesentlichen mit Wasser und Sauerstoff nicht reagiert.

16. Prozess nach Anspruch 1, weiterhin aufweisend das Vorsehen einer Natriumdiffusions-Barriereschicht und das Aufbringen von dieser direkt auf das heiße Glassubstrat.

17. Prozess nach Anspruch 16, bei dem die Natriumdiffusions-Barriereschicht Silica aufweist.

**Revendications**

1. Procédé de dépôt chimique en phase vapeur pour appliquer un revêtement d'oxyde métallique dopé à l'antimoine sur une surface d'un substrat en verre chaud, comprenant :

a) la fourniture d'un substrat en verre chaud, incluant une surface sur laquelle un revêtement d'oxyde métallique dopé à l'antimoine est destiné à être déposé ;

b) la fourniture d'un mélange de réactants vaporisé uniforme qui contient un composé métallique, un composé contenant de l'oxygène, de l'eau et un composé d'organo-antimoine ;
c) la délivrance du mélange de réactants vaporisé sur la surface du substrat en verre chaud et le fait de faire réagir le mélange de manière à déposer un revêtement d'oxyde métallique dopé à l'antimoine sur la surface du substrat en verre chaud ; et
d) le refroidissement du substrat en verre revêtu jusqu'à température ambiante,

**caractérisé en ce que** le composé d'organo-antimoine ne pré-réagira pas avec ledit composé contenant de l'oxygène ou l'eau à des températures au-dessous de 288° C (550° F), ledit composé d'organo-antimoine étant un composé de la forme $(R^1)_xSb(R^2)_{3-x}$ dans lequel $R^1$ est un groupe aryle, $R^2$ est un groupe alkyle et x = 3 ou 2.

2. Procédé selon la revendication 1, dans lequel ledit composé d'organo-antimoine est un composé de diarylalkylantimoine.

3. Procédé selon la revendication 1, dans lequel ledit composé d'organo-antimoine est un composé de triarylantimoine qui est choisi parmi le groupe qui est constitué par : $(Mes)_3Sb$, $Ph_3Sb$, $(tolyl)_3Sb$ et $(R_xC_6H_{5-x})_3Sb$ (où R est un groupe organique à petite chaîne qui comporte un à quatre atome(s) de carbone), et x = 1 à 5.

4. Procédé selon la revendication 1, dans lequel ledit composé d'organo-antimoine est $Ph_3Sb$.

5. Procédé selon la revendication 1, dans lequel ledit mélange de réactants vaporisé contient ledit composé métallique qui est un composé d'étain et ledit composé contenant de l'oxygène est de l'oxygène.

6. Procédé selon la revendication 5, dans lequel ledit composé d'étain est un composé d'organo-étain.

7. Procédé selon la revendication 5, dans lequel ledit composé d'étain est du dichlorure de diméthylétain.

8. Procédé selon la revendication 5, dans lequel ledit procédé de revêtement est effectué en tant que partie d'un procédé de fabrication de verre flotté.

9. Procédé selon la revendication 8, dans lequel ledit procédé de revêtement est effectué dans le bain de flottage ou de manière adjacente à celui-ci.

10. Procédé selon la revendication 9, dans lequel ledit procédé de revêtement est réalisé à une température qui va de 482° C à 732° C (de 900° F à 1350° F).

11. Procédé selon la revendication 10, dans lequel ledit procédé de revêtement est réalisé à une température qui va de 593° C à 693° C (de 1100° F à 1280° F).

12. Procédé selon la revendication 10, dans lequel ledit revêtement est déposé selon une épaisseur de 100,0 nm (1 000 A) à 500,0 nm (5 000 A).

13. Procédé selon la revendication 11, dans lequel ledit revêtement est déposé selon une épaisseur de 100,0 nm (1 000 A) à 350,0 nm (3 500 Å).

14. Procédé selon la revendication 1, dans lequel un revêtement de suppression de couleur est appliqué sur le substrat sur lequel le revêtement contenant de l'antimoine est déposé avant le dépôt dudit revêtement contenant de l'antimoine.

15. Procédé selon la revendication 1, dans lequel ledit composé d'organo-antimoine est essentiellement non réactif avec l'eau et l'oxygène

16. Procédé selon la revendication 1, comprenant en outre la constitution d'une couche barrière de diffusion de sodium et le dépôt de celle-ci directement sur ledit substrat en verre chaud.

17. Procédé selon la revendication 16, dans lequel la couche barrière de diffusion de sodium comprend de la silice.

## REFERENCES CITED IN THE DESCRIPTION

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| **EFS ID:** | 44238112 |
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| 1 | | Amendment.pdf | 58148<br>bcbd394a8f2ea89e0aee9520b3ddf65ff1d797fe | yes | 8 |

| | Multipart Description/PDF files in .zip description | | | | |
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| | Document Description | | Start | End | |
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| | Claims | | 2 | 5 | |
| | Applicant Arguments/Remarks Made in an Amendment | | 6 | 8 | |
| **Warnings:** | | | | | |
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| 2 | Information Disclosure Statement (IDS) Form (SB08) | IDS_Form_SB_08a-signed.pdf | 1035551<br>6025587c0d607778b35d5f4a7134e5e22a24a0ae | no | 4 |
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**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**<u>National Stage of an International Application under 35 U.S.C. 371</u>**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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## AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

## INTRODUCTORY COMMENTS

In response to the Office Action of August 12, 2021, please enter the following amendments and consider the following remarks. This Amendment includes the following:

A. Amendments to the Claims

B. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

November 9, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Currently Amended) An apparatus comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate, wherein the substrate is maintained at a temperature of less than 200°C;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin compound; [[and]]

structure configured to deliver flow of a first precursor vapor from the supply of an organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand ~~and a metal-carbon bond~~ suitable for the formation of an organotin oxide hydroxide layer with a metal-carbon bond that is radiation sensitive; and

structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with a hydrolysable ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

2. (Previously Presented) The apparatus of claim 1 wherein the substrate comprises a silicon wafer.

3. (Original) The apparatus of claim 1 further comprising structure configured to deliver flow from a supply of an inert gas.



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4. (Original) The apparatus of claim 2 wherein the inert gas comprises nitrogen or argon.

5. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6. (Currently Amended) The apparatus of claim 1 wherein the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ wherein R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond, n = 1 - 3 and X is a ligand having a hydrolysable bond with Sn~~; and the apparatus further comprising structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with X ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition~~.

7. (Original) The apparatus of claim 6 wherein the oxygen containing compound comprises water vapor, hydrogen peroxide, ozone, oxygen, an alcohol, or combinations thereof.

8. (Original) The apparatus of claim 6 wherein the second precursor vapor comprises water vapor.

9. (Previously Presented) The apparatus of claim 6 further comprising a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.



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10. (Original) The apparatus of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. (Original) The apparatus of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.

12. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. (Original) The apparatus of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. (Original) The apparatus of claim 1 wherein the flow comprises a vapor.

15. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. (Previously Presented) The apparatus of claim 15 wherein the vapor inputting structures provide for control of the flow.

17. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.

18. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to



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deliver a second vapor flow, wherein the first vapor flow, the second vapor flow, and a third vapor flow are sequential.

20. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are at the same time and a third vapor flow is sequential.

21. (Currently Amended) The apparatus of claim 1 wherein the interior has a temperature from about 45°C to about [[250]]200°C.

22. (Withdrawn) A method for forming an organotin layer using the apparatus of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (Withdrawn) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (Withdrawn) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.

25. (Withdrawn) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.



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REMARKS

Claims 1-25 are pending. Claims 22-25 are withdrawn pending rejoining. By this Amendment, claims 1, 6 and 21 are amended. The specification supports the amendment of claim 1 and 21 with respect to temperature at page 27, lines 3-5. Claim 1 is also amended for clarity and to introduce a feature from claim 6, which is cancelled from claim 6. No new matter is introduced.

The Examiner has indicated that claim 13 is being interpreted under 35 U.S.C. 112(f) as a means plus function limitation. Applicant notes this and believes that the claim does not presently stand rejected. The Office Action is somewhat ambiguous on this point. Clarification is respectfully requested.

Rejection Under 35 U.S.C. 103 Over Maeng et al. and Kang et al.

The Examiner rejected claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng et al., J. Vac. Sci. Tech B., 2006, 24, 2276 (hereinafter "Maeng") in view of U.S. patent 3,944,684 to Kang et al. (hereinafter :Kang"). Claims 2-20 depend from claim 1. In view of Applicant's previous amendments, the rejection was modified to include Kang. To advance prosecution, Applicant has further amended claim 1 for clarity and to include a limit on the substrate temperature and a feature from claim 6. Applicant maintains that the combined teachings of Maeng and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejections based on the following comments.

Maeng is directed to forming a tantalum oxide (or TaN) film using tantalum alkylamide precursors in an atomic layer deposition approach. Maeng does not teach including a radiation sensitive metal carbon bond that is preserved in the processing or forming an oxo-hydroxo network. Maeng teaches a solid reactant (PDMAT, en.wikipedia.org/wiki/ Pentakis(dimethylamido)tantalum) that is heated to generate sufficient vapor pressure. The process conditions in Maeng are specific for the generation of a metal oxide and are not suitable for maintenance of carbon tin bonds or oxo-hydroxo networks. In particular, they use high heating of the substrate to form the oxide.

Kang is similarly directed to formation of metal oxide coatings, specifically electrically conductive indium tin oxides. To this end, Kang teaches deposition in an oxygen environment with substrate temperatures in the range of 350°C to 550°C, see column 3, lines 39-45.



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The systems of Maeng and Kang are not suitable for deposition of tin compositions with radiation sensitive tin-carbon bonds or for forming oxo-hydroxo networks. These features of Applicant's claimed invention are accentuated in the amended claims. In view of the clarified scope of Applicant's claimed invention, Applicant believes that it is clear that the combined teachings of Maeng and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng in view of Kang. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.

Rejection Under 35 U.S.C. 103 Over Pore et al. and Kang

The Examiner rejected claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over published U.S. patent application 2017/0100742 to Pore (hereinafter "Pore") in view of Kang. Claims 2- 19 and 21 depend from claim 1. Applicant believes that there is no motivation to combine the references as asserted by the Examiner. Applicant asserts that the combined teachings of Pore and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejection based on the following comments.

On page 10 of the Office Action, the Examiner states that "Pore does not explicitly teach[es] the organotin compound." With all due respect, Pore does not teach any metal containing compounds. Pore is directed to deposition of an organic film, such as polyamic acid for conversion to a polyimide layer. Therefore, Pore not only does not teach, but does not suggest, motivate in any way or provide any hint that the use of an organotin compound would serve any purpose in the context of their polyimide layer.

Applicant previously noted that suggested modifications to Pore as rendering it unsuitable for its intended purpose. See MPEP 2145 X.D. In the Examiner's response, the Examiner asserts that as long as the apparatus can perform Applicant's intended purpose, then the rejection is supported. With all due respect, that is clear error of law. The references themselves must support the asserted modification. The law is clear that if the cited reference becomes unsuitable for ITS intended purpose, then the references teach away from the proposed modification. The motivation to modify the teachings of the references cannot come from Applicant's own teachings.



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Kang does not alter this analysis. Kang teaches the introduction of an organotin compound to dope an indium oxide coating. There is no hint in Kang that the organotin compound would be desirable in the context of depositing a polyimide film. With all due respect, the teachings of the references do not support their combination as suggested in the rejection.

Respectfully, the rejection is based on clear error of law. The combined teachings of Pore and Kang do not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over Pore in view of Kang. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these due to the arguments directed to claim 1 that are dispositive.

## CONCLUSION

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| **PATENT APPLICATION FEE DETERMINATION RECORD**<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 11/09/2021 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 25 | Minus | ** 25 | = 0 | | x $100 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 1 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 0 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /DIANE FLOYD/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 08/12/2021

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| EXAMINER | |
|---|---|
| THOMAS, BINU | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 08/12/2021 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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| *Office Action Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 04/13/201.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-25 is/are pending in the application.

5a) Of the above claim(s) 22-25 is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-21 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 04/05/2021 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



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## DETAILED ACTION

### *Continued Examination Under 37 CFR 1.114*

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on April 13, 2021 has been entered.

2. The Applicant's amendment filed on April 13, 2021 was received. Claims 1-2 were amended. Claims 22-25 remain withdrawn.

3. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action issued October 8, 2020.

### *Drawings*

4. The drawings were received on April 13, 2021. These drawings are acceptable.

### *Claim Interpretation*

5. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

6. The claims in this application are given their broadest reasonable interpretation using the plain meaning of the claim language in light of the specification as it would be understood by one of ordinary skill in the art. The broadest reasonable interpretation of a claim element (also commonly referred to as a claim limitation) is limited by the description in the specification when 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is invoked.

As explained in MPEP § 2181, subsection I, claim limitations that meet the following three-prong test will be interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph:

(A) the claim limitation uses the term "means" or "step" or a term used as a substitute for "means" that is a generic placeholder (also called a nonce term or a non-structural term having no specific structural meaning) for performing the claimed function;

(B) the term "means" or "step" or the generic placeholder is modified by functional language, typically, but not always linked by the transition word "for" (e.g., "means for") or another linking word or phrase, such as "configured to" or "so that"; and

(C) the term "means" or "step" or the generic placeholder is not modified by sufficient structure, material, or acts for performing the claimed function.

Use of the word "means" (or "step") in a claim with functional language creates a rebuttable presumption that the claim limitation is to be treated in accordance with 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites sufficient structure, material, or acts to entirely perform the recited function.

Absence of the word "means" (or "step") in a claim creates a rebuttable presumption that the claim limitation is not to be treated in accordance with 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is not interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites function without reciting sufficient structure, material or acts to entirely perform the recited function.

Claim limitations in this application that use the word "means" (or "step") are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action. Conversely, claim limitations in this application that do not use the word "means" (or "step") are not being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action.

7. This application includes one or more claim limitations that do not use the word "means," but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier.

8. Such claim limitation(s) is/are: a configuration providing for selection of the pressure and/or the temperature in the deposition chamber in claim 13.

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

Regarding the recitation of configuration providing for selection of the pressure and/or the temperature in the deposition chamber, is interpreted a pump (155/156) connected to the deposition chamber (151) and/or a thermal block (158) which supports the substrate in the deposition chamber (151), as disclosed in figure 16 and amendments to the specification filed April 5, 2021 and January 20, 2021.

If applicant does not intend to have this/these limitation(s) interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, applicant may: (1) amend the claim limitation(s) to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph (e.g., by reciting sufficient structure to perform the claimed function); or (2) present a sufficient showing that the claim limitation(s) recite(s) sufficient structure to perform the claimed function so as to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

***Claim Rejections - 35 USC § 112***

9. The claim rejection on claim 13 under 35 U.S.C. 112(b) or pre-AIA 35 U.S.C. 112, second paragraph because applicants response filed April 5, 2021 highlighted the areas for the corresponding structure, material, or acts for performing the entire claimed functions and to clearly link the structure, material, or acts to the functions.

***Claim Rejections - 35 USC § 103***

10. The claim rejections under 35 U.S.C. 103 as being unpatentable over Maeng et al. on claims 1-21 are withdrawn because independent claim 1 has been amended.

11. The claim rejections under 35 U.S.C. 103 as being unpatentable over Pore et al. on claims 1-18 and 21 are withdrawn because independent claim 1 has been amended.

Please consider the following.

12. **Claims 1-21 are rejected under 35 U.S.C. 103 as being unpatentable over Maeng** (as previously provided) **in view of Kane (US 3,944,684)**.

**In regards to claim 1**, Maeng teaches a PE-ALD system (apparatus) comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate (see 8-inch wafer) within the interior of the deposition chamber, the substrate receives a deposition on a surface of the substrate;

an inlet (see pipes connected to bubblers) into the deposition chamber;

structure (see label of Ar gas) delivers flow from a supply of an inert gas; and

a supply of organometallic compound (see label of PDMAT bubbler)

a structure (see pipe between PDMAT bubbler and deposition chamber) delivers a flow from the supply of the organometallic compound with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 1).

Maeng does not explicitly teach the organometallic compound is an organotin compound, to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

However, Kane teaches an organotin compound (12) is contained in closed container (10, supply of organotin compound) (fig. 1; col. 2, lines 45-60, col. 4, lines 28-35). Kane teaches an inlet tube (14) supplies a carrier gas to the closed container, where the carrier gas and the organotin vapor is supplied to a tube-18 (structure to deliver flow) which is connected to a tube-

22, so that the carrier gas and the organotin vapor is feed into a reaction chamber (26) (fig. 1; col. 4, lines 28-40). Kane teaches the carrier gas is an inert gas such as neon, argon, krypton, nitrogen and the like (col. 3, lines 20-25).

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the supply of organometallic compound of Maeng because Kane teaches it will provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, the recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim (MPEP2111.02/2114).

Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of providing the claimed compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable

ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Maeng and Kane as discussed above, where Maeng teaches the substrate is a silicon substrate (pg. 2277).

**In regards to claims 3-4**, Maeng and Kane as discussed above, where Maeng teaches the structure (see label of Ar gas) which provides the inert gas of argon, where argon is used as the carrier gas (pg. 2277).

**In regards to claims 5 and 14**, Maeng and Kane as discussed above, where Maeng teaches the structure which supplies the liquid precursor is a bubbler which bubbles the inert carrier gas through the liquid PDMAT to supply the vapor to the chamber (fig. 1) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

**In regards to claims 6-10 and 15-20**, Maeng and Kane as discussed above, where Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1) and Kane teaches the organotin compound is supplied to the reaction chamber (fig. 1; col. 4, lines 30-40).

Maeng and Kane do not explicitly teach the flow from the supply of the organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Maeng and Kane teach the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the material solution and a third precursor vapor as SnL4 as recited in the claim, and with the flow process as recited in the claim.

**In regards to claims 11-12 and 21**, Maeng and Kane as discussed above, where Maeng teaches a pressure of the chamber of 0.1 to 10-mtorr and reactor growth temperature of 150-250°C (pg. 2277-2278).

**In regards to claim 13**, Maeng and Kane as discussed above, where Maeng teaches a selection of the temperature within the deposition chamber (pg. 2278).

13. **Claims 1-18 and 21 are rejected under 35 U.S.C. 103 as being unpatentable over Pore** (US 2017/0100742) **in view of Kane** (**US 3,944,684**).

**In regards to claims 1 and 4**, Pore teaches an apparatus (100) comprising:

a deposition chamber having a reaction space (115, interior) isolated from the ambient atmosphere (fig. 2a; para. 46);

a substrate (120) within the interior of the deposition chamber which receives a deposition on a surface of the substrate (fig. 2a; para. 46);

an inlet into the deposition chamber is provide at inlet manifold (135) (fig. 2a; para. 47);

an inert gas source (150, structure) delivers flow from a supply of an inert gas such as argon or nitrogen which is well known (fig. 2a; para. 49); and

a first reactant vessel (105, supply) which supplies an organic reactant (110) (fig. 2a, para. 46)

a gas line (130, structure) delivers flow from the first reactant vessel with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 2a; para. 47).

Pore does not explicitly teaches the organotin compound

However, Kane teaches an organotin compound (12) is contained in closed container (10, supply of organotin compound) (fig. 1; col. 2, lines 45-60, col. 4, lines 28-35). Kane teaches an inlet tube (14) supplies a carrier gas to the closed container, where the carrier gas and the organotin vapor is supplied to a tube-18 (structure to deliver flow) which is connected to a tube-22, so that the carrier gas and the organotin vapor is feed into a reaction chamber (26) (fig. 1; col. 4, lines 28-40). Kane teaches the carrier gas is an inert gas such as neon, argon, krypton, nitrogen and the like (col. 3, lines 20-25).

Therefore, it would have been obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to incorporate the organotin compound in the closed container of Kane onto the first reactant vessel of Pore because Kane teaches it will

provide for a thin deposition of a film comprising tin oxide at lower temperatures (col. 2, lines 3-20, col. 6, lines 24-30).

With regards to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, the recitation does not further limit the claimed apparatus and appears to be a result of the intended use of apparatus. In apparatus claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim MPEP2111.02).

Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim (MPEP2114).

As Pore and Kane teach the structural limitations of the claim, one would be capable of providing the claimed compounds for the formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, thus fulfilling the limitations of the claim.

**In regards to claim 2**, Pore and Kane as discussed above, where Pore teaches the substrate is silicon wafer (para. 17).

**In regards to claim 3**, Pore and Kane as discussed above, where Pore teaches the inert gas source (150, structure) delivers flow from a supply of an inert gas (fig. 2a; para. 49).

**In regards to claims 5 and 14**, Pore and Kane as discussed above, where Pore teaches the first reactant vessel (105) vaporizes the first organic reactant (110) (fig. 2a; para. 46) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

**In regards to claims 6-10 and 15-18**, Pore and Kane as discussed above, where Pore teaches first reactant vessel vaporizes the first organic reactant and the a second reactant vessel (140) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber(fig. 2a; para. 46, 48) and Kane teaches the organotin compound is contained in closed container which is heated by a boiling water bath (flash evaporator) (fig. 1; col. 4, lines 28-35).

Pore and Kane do not explicitly teach the flow from the supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim (MPEP2115).

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim

(MPEP2114). As Pore and Kane teach the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the first reactant and the second reactant of SnL4 as recited in the claim, and with the flow process as recited in the claim(s).

**In regards to claims 11-12 and 21**, Pore and Kane as discussed above, where Pore teaches a pressure of the chamber of 100-mtorr to 100-torr and a temperature of 100-250ºC (para. 43).

**In regards to claim 13**, Pore and Kane as discussed above, where Pore teaches a control system (125) which controls a vacuum pump (165) to maintain the pressure in the deposition chamber (fig. 2a; para. 50).

***Response to Arguments***

14. Applicant's arguments filed April 13, 2021 have been fully considered but they are not persuasive.

Applicant's principal arguments are:

a. Applicants argue the examiners use of legal issues.

b. Applicants argues the use of an organotin compound with the apparatus of Maeng.

c. Applicants argues the use of an organotin compound would render Maeng unsuitable for its intended purpose of making tantalum based thin films.

d. Pore being generally more specifically directed to forming organic polymer films. Pore does not mention tin or organotin compounds or any apparatus for use with such compounds to make films.

e. Pore does not teach the use of an organotin compound, and such processing would render Pore unsuitable for its intended purpose of making organic films.

In response to Applicant's arguments, please consider the following comments:

a. The examiner appreciates the time and careful detail provided by the applicants, however, as expressed above, the prior art teaches structural limitations of the claim and applicants response do not highlight how the material provided and the intended function of the claimed apparatus provides a structural distinction over the prior art.

b. Applicant's argument is not persuasive as the arguments do not highlight how the bubbler of Maeng is not capable of supplying organotin compound. As expressed above, Maeng teaches the structural elements of the instant claim, where the bubbler of Maeng represents a structural element which capable of supplying an organotin compound. The organotin compound represents a material in its intended use, where the inclusion of the material or article worked upon by a structure being claimed does not impart patentability to the claims (MPEP2115).

c. Applicant's argument with regards to the use of organotin compound to form the intended purpose of making tantalum based thin film, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. As expressed above, Maeng teaches the structural elements of the instant claim, where the bubbler of Maeng represents a structural element which capable of supplying an organotin compound. With regards to rendering Maeng unsuitable for its intended purpose, Maeng is in the field of endeavor

of forming thin films using thin film deposition techniques (pg. 2276), where one of ordinary skill in the art will recognize using the structural elements of Maeng with different compound will results in forming different films. Further, Maeng does not constitute a teaching away reference as it does not criticize, discredit, or otherwise discourage the solution claimed (MPEP2145.02-X-D).

d. In response to applicant's argument that Pore is nonanalogous art, it has been held that a prior art reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the applicant was concerned, in order to be relied upon as a basis for rejection of the claimed invention. See *In re Oetiker*, 977 F.2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992). In this case, Pore is in the same in the field of applicant's endeavor of forming thin film using vapor deposition, which will include CVD and ALD (para. 4, 7), which are comparable to techniques as disclosed in page 25 of applicants specification as originally filed.

e. In response to applicant's argument that Pore does not teach the use of an organotin compound, a recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. As Pore does not state the first reactant vessel cannot supply or is not capable to supply an organotin compound, Pore does not constitute a teaching away reference as it does not criticize, discredit, or otherwise discourage the solution claimed (MPEP2145.02-X-D).

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached on Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Binu Thomas/
Primary Examiner, Art Unit 1717

| Notice of References Cited | Application/Control No. 16/987,120 | Applicant(s)/Patent Under Reexamination Meyers et al. | |
|---|---|---|---|
| | Examiner Binu Thomas | Art Unit 1717 | Page 1 of 1 |

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| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | CPC Classification | US Classification |
|---|---|---|---|---|---|---|
| * | A | US-3944684-A | 03-1976 | Kane; James | C23C16/407 | 427/109 |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
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| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
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| Symbol | Date | Examiner |
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| US Classification - Searched* | | | |
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| Class | Subclass | Date | Examiner |
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* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
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| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |
| Updated search | 01/2021 | BT |
| Updated search | 08/2021 | BT |

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
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IPR2025-00309 - U.S. Patent No. 11,537,048

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| Interference Search | | | |
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| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
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| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |



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**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| S1 | 0 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:20 |
| S2 | 6 | "15291738" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S3 | 1,913 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT | OR | ON | 2020/09/29 09:21 |
| S4 | 1,851 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S5 | 82 | S4 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:29 |
| S6 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 11:47 |
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| S9 | 107 | ("4059929" \| "5478435" \| "5548159" \| "5558435" \| "5645891" \| "5736425" \| "5747880" \| "5750440" \| "5807607" \| "5814370" \| "5834845" \| "5843602" \| "5847443" \| "5857893" \| "5858457" \| "5858871" \| "5868278" \| "5922299" \| "5948482" \| "5955140" \| "6011123" \| "6015457" \| "6037275" \| "6048256" \| "6066575" \| "6070600" \| "6098843" \| "6107357" \| "6120891" \| "6140252" \| "6159295" \| "6162583" \| "6162838" \| "6163066" \| "6168737" \| "6171645" \| "6171687" \| "6172128" \| "6184260" \| "6187248" \| "6197913" \| "6204202" \| "6208014" \| "6251473" \| "6270846" \| "6277765" \| "6297459").PN. OR ("6583071").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:11 |
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| S17 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| S18 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:17 |
| S19 | 6 | "15291738" and structure | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:23 |
| S20 | 6 | "15291738" and precursor near2 vapor | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:24 |
| S21 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:27 |
| S22 | 6 | "15291738" and thickness near2 variation | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:28 |
| S23 | 6 | "15291738" and select$4 near5 (temperature pressure) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 16:55 |
| S24 | 3 | "20080022896" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 18:07 |
| S25 | 1 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 11:23 |
| S26 | 1,873 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 12:02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S27 | 84 | S26 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 12:02 |
| S28 | 17 | (US-20110293888-$ or US-20040067444-$ or US-20050266700-$ or US-20030118947-$ or US-20120027937-$ or US-20090155535-$ or US-20060211271-$ or US-20040156987-$ or US-20080022896-$).did. or (US-6583071-$ or US-4601917-$ or US-4104292-$ or US-6825131-$ or US-5894064-$ or US-6251473-$ or US-6066575-$ or US-6116184-$).did. | US-PGPUB; USPAT | OR | ON | 2021/01/25 12:48 |
| S29 | 19 | ("4293594").PN. OR ("4601917").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:44 |
| S30 | 1,323 | (C23C16/45525).cpc. and carrier near3 gas | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| S31 | 554 | (C23C16/45525).cpc. and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| S32 | 21 | ("20040209190" \| "20050186339" \| "20060124057" \| "20070194157" \| "20080146011" \| "20090152371" \| "20100300221" \| "20110097507" \| "20110163062" \| "20110198620" \| "20120074575" \| "20120088315" \| "20130316541" \| "20140262461" \| "20170140920" \| "6146767" \| "6503701" \| "7718011" \| "7954730" \| "8840037" \| "9677984").PN. OR ("10163629").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:49 |
| S33 | 141 | (c23c14/$ c23c16/$).cpc. and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:56 |
| S34 | 1 | "16987120" and (oxide and hydroxide) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:59 |
| S35 | 9 | (c23c14/$ c23c16/$).cpc. and organotin and oxide near10 hydroxide | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:00 |
| S36 | 2 | "20170100742" "20160284553" and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |
| S37 | 4 | ("20170100742" "20160284553") and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S39 | 2 | ("20170100742" "20160284553") and carrier near3 gas near20 inert and (argon nitrogen) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:41 |
| S40 | 1 | "16987120" and (third near5 vapor) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 17:52 |
| S41 | 1 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/04/07 09:27 |
| S42 | 2 | "20150056542" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/04/07 12:40 |
| S43 | 145 | (c23c14/$ c23c16/$).cpc. and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/08/04 10:09 |
| S44 | 27 | (c23c14/$ c23c16/$).cpc. and organotin near20 (supply source container) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/08/04 10:10 |

**EAST Search History (Interference)**

<This search history is empty>

8/4/2021 5:37:11 PM
C:\Users\bthomas\Documents\EAST\Workspaces\16987120-vapor deposition organotin.wsp

Customer No. **62274**
Christensen, Fonder, Dardi & Herbert PLLC
11322 86th Avenue N.
Maple Grove, MN 55369
Telephone: (612) 315-4322
Facsimile: (612) 315-4321

Attorney Docket No.: 5063.08US05

REQUEST FOR CONTINUED EXAMINATION
(RCE) TRANSMITTAL

---

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is a Request for Continued Examination (RCE) under 37 C.F.R. § 1.114 of Application No. 16/987,120, filed August 6, 2020 for: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING, by: Stephen T. Meyers, Jeremy T. Anderson, Brian J. Cardineau, Joseph B. Edson, Kai Jiang, Douglas A. Keszler, and Alan J. Telecky.

1. Submission required under 37 C.F.R. § 1.114

   a. [X] Previously submitted

      [X] Please enter in the present application the unentered Amendment under 37 C.F.R. § 1.116, with any attachments, filed on April 5, 2021 in said prior application.

      [ ] Consider the arguments in the Appeal Brief or reply Brief previously filed on _____

      [ ] Other _____

   b. [ ] Enclosed

      [ ] An Amendment is enclosed. Claims added by this Amendment are properly numbered consecutively beginning with the number next following the highest numbered claim in the prior application.

      [ ] Affidavit(s)/Declaration(s)

      [ ] Information Disclosure Statement (IDS)

      [ ] Other _____

2. [X] The filing fee is calculated below:

| | Claims Remaining After Amendment | Highest No. Previously Paid For | Present Extra (Equals) | ~~Small Entity Rate~~ | ~~Add'l Fee~~ | OR | **Large Entity Rate** | **Add'l Fee** |
|---|---|---|---|---|---|---|---|---|
| Total | 25 | - 25 | = 0 | ~~x 50~~ | ~~$~~ | | **x 100** | **$0** |
| Indep. | 1 | - 3 | = 0 | ~~x 240~~ | ~~$~~ | | **x 480** | **$0** |
| RCE fee | | | | ~~+ 680~~ | ~~$~~ | | **+ 1360** | **$1360** |
| Mult. Dep. | | | = 0 | ~~[+ 430]~~ | ~~$~~ | | **[+ 860]** | **$0** |
| | | | | ~~TOTAL~~ | ~~$~~ | OR | **TOTAL** | **$1360.00** |

[ ] First Presentation of Multiple Dependent Claim [MDC]

* If the entry in Column 1 is less than the entry in Column 2, write "0" in Column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space.
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Column 1 of a prior Amendment or the number of claims originally filed.

3. [ ] Applicants are entitled to small entity status in accordance with 37 CFR 1.27.

4. [X] The Commissioner is authorized to charge a credit card in the amount of **$1360.00** (The RCE fee under 37 C.F.R. § 1.17(e) is required by 37 C.F.R. § 1.114 when the RCE is filed). The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 60-1363.

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

April 13, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240



Lam Research Ex. 1002 - Page 232
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16987120 |
| **Filing Date:** | 06-Aug-2020 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Filer:** | Diane Elizabeth Bennett/Michelle Douglas |
| **Attorney Docket Number:** | 5063.08US05 |

Filed as Large Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| RCE- 1ST REQUEST | 1801 | 1 | 1360 | 1360 |
| | | **Total in USD ($)** | | **1360** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 42443475 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 13-APR-2021 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 17:00:43 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $1360 |
| RAM confirmation Number | E20214CH01034802 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Request for Continued Examination (RCE) | RCETransmittal-1st.pdf | 30206<br>d4bf551e5b42043309b1017d52ad677dd40d91f1 | no | 2 |
| **Warnings:** | | | | | |
| This is not a USPTO supplied RCE SB30 form. | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 30819<br>fbcd4dc8aa01cde79a20699972254b4ea2456a79 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 61025 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| PATENT APPLICATION FEE DETERMINATION RECORD<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 04/13/2021 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 25 | Minus | ** 25 | = 0 | | x $100 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 1 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 0 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /BRENDA MURPHY/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 04/12/2021

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

| EXAMINER | |
|---|---|
| THOMAS, BINU | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 04/12/2021 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket@cfd-ip.com
patents@cfd-ip.com



Lam Research Ex. 1002 - Page 238
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| ***Advisory Action Before the Filing of an Appeal Brief*** | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

***--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --***

THE REPLY FILED 05 April 2021 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☑ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   a) ☐ The period for reply expires ____ months from the mailing date of the final rejection.
   b) ☑ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection.The current period for reply expires ____ months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.

   *Examiner Note*: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANTS FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37CFR 41.37(a).

AMENDMENTS

3. ☑ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   a) ☑ They raise new issues that would require further consideration and/or search (see NOTE below);
   b) ☐ They raise the issue of new matter (see NOTE below);
   c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

   NOTE: See Continuation Sheet (See 37CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☑ Applicants reply has overcome the following rejection(s): 112(b) on claim 13
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☑ For purposes of appeal, the proposed amendment(s):(a) ☑ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____
9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☐ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: _____.
13. ☑ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
14. ☐ Other: _____.

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:
    Claim(s) allowed:_____.
    Claim(s) objected to:_____.
    Claim(s) rejected:1-21.
    Claim(s) withdrawn from consideration:22-25.

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
|---|---|



Lam Research Ex. 1002 - Page 239
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

Continuation of 3. NOTE: The response submitted April 5, 2021, overcome the 112(b) rejection, but require further consideration of the drawings, specification and if the claims filed overcome the prior art on the record.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16987120 |
| Filing Date | 2020-08-06 |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | 1717 |
| Examiner Name | Binu Thomas |
| Attorney Docket Number | 5063.08US05 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| | 1 | | | | | |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

| | | | |
|---|---|---|---|
| | 1 | Preliminary Rejection from co-pending Korean Application No. 10-2021-7000995 dated April 1, 2021. (Google Translation) | X |

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**EXAMINER SIGNATURE**

| Examiner Signature | /Binu Thomas/ (04/07/2021) | Date Considered | 04/07/2021 |
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.



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| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2021-04-06 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**



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## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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Lam Research Ex. 1002 - Page 244
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

DO NOT ENTER: /B.T/

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al. Confirmation No.: 5672

Application No.: 16/987,120 Examiner: Binu Thomas

Filed: August 6, 2020 Group Art Unit: 1717

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

AMENDMENT AFTER FINAL

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action of February 5, 2021, please enter the following amendments and consider the following remarks. This Amendment After Final includes the following:

A. Amendments to the Specification
B. Amendments to the Claims
C. Amendments to the Drawings
D. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

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April 5, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)
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| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (**Not for submission under 37 CFR 1.99**) | | |
|---|---|---|
| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

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Lam Research Ex. 1002 - Page 246
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
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| | 1 | Preliminary Rejection from co-pending Korean Application No. 10-2021-7000995 dated April 1, 2021. (Google Translation) | X |

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Lam Research Ex. 1002 - Page 247
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

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|---|---|---|
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| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
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**OR**

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See attached certification statement.

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A certification statement is not submitted herewith.

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| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2021-04-06 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

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Lam Research Ex. 1002 - Page 249
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 42375628 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 06-APR-2021 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 15:22:34 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

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## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Information Disclosure Statement (IDS) Form (SB08) | IDS_Form_SB_08a-signed.pdf | 1035043<br>06d6c3c9e245a374f77bebb23b0f9c265b42d454 | no | 4 |

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| 2 | Other Reference-Patent/App/Search documents | KR_PreliminaryRejection_4-1-21.pdf | 2365477<br>672780d56dcae046bdd89084f0dd6a93a7761782 | no | 14 |
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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

AMENDMENT AFTER FINAL

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action of February 5, 2021, please enter the following amendments and consider the following remarks. This Amendment After Final includes the following:

A. Amendments to the Specification
B. Amendments to the Claims
C. Amendments to the Drawings
D. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

April 5, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

AMENDMENTS TO THE SPECIFICATION

In the Specification

Please substitute the following amended paragraph(s) and/or section(s) (deleted matter is shown by strikethrough and added matter is shown by underlining):

At page 25, after line 22, please substitute the following amended paragraph:

Fig. 16 illustrates apparatus 150 for the formation of an organotin oxide hydroxide layer on a substrate. Deposition chamber 151 interfaces with inlet 152, separate inlet 154 and outlet 153 connected with pump 155 and pump 156. Substrate 157 is mounted within the interior of deposition chamber 151 on thermal block 158. In this embodiment, vessel 168 is depicted as a bubbler connected to supply of inert gas 170. Structure 160 is configured to supply organotin compound 164 to deposition chamber 151 through inlet 152. Apparatus 150 also depicts structure 174, configured to deliver a second precursor vapor to deposition chamber 151 through separate inlet 154. Apparatus 150 also depicts structure 180, configured to supply third precursor vapor 178 to deposition chamber 151 through inlet 176.



Lam Research Ex. 1002 - Page 253
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Currently Amended) An apparatus comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas;

a supply of an organotin compound; and

structure configured to deliver flow from [[a]]the supply of an organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

2. (Currently Amended) The apparatus of claim 1 wherein the substrate comprises a silicon wafer.

3. (Original) The apparatus of claim 1 further comprising structure configured to deliver flow from a supply of an inert gas.

4. (Original) The apparatus of claim 2 wherein the inert gas comprises nitrogen or argon.

5. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin



Lam Research Ex. 1002 - Page 254
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6. (Previously Presented) The apparatus of claim 1 wherein the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ wherein R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond, n = 1 - 3 and X is a ligand having a hydrolysable bond with Sn; and the apparatus further comprising structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with X ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

7. (Original) The apparatus of claim 6 wherein the oxygen containing compound comprises water vapor, hydrogen peroxide, ozone, oxygen, an alcohol, or combinations thereof.

8. (Original) The apparatus of claim 6 wherein the second precursor vapor comprises water vapor.

9. (Previously Presented) The apparatus of claim 6 further comprising a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. (Original) The apparatus of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. (Original) The apparatus of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.



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12. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. (Original) The apparatus of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. (Original) The apparatus of claim 1 wherein the flow comprises a vapor.

15. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. (Previously Presented) The apparatus of claim 15 wherein the vapor inputting structures provide for control of the flow.

17. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.

18. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow, the second vapor flow, and a third vapor flow are sequential.

20. (Previously Presented) The apparatus of claim 6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to



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deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are at the same time and a third vapor flow is sequential.

21. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 45°C to about 250°C.

22. (Withdrawn) A method for forming an organotin layer using the apparatus of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (Withdrawn) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (Withdrawn) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.

25. (Withdrawn) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.



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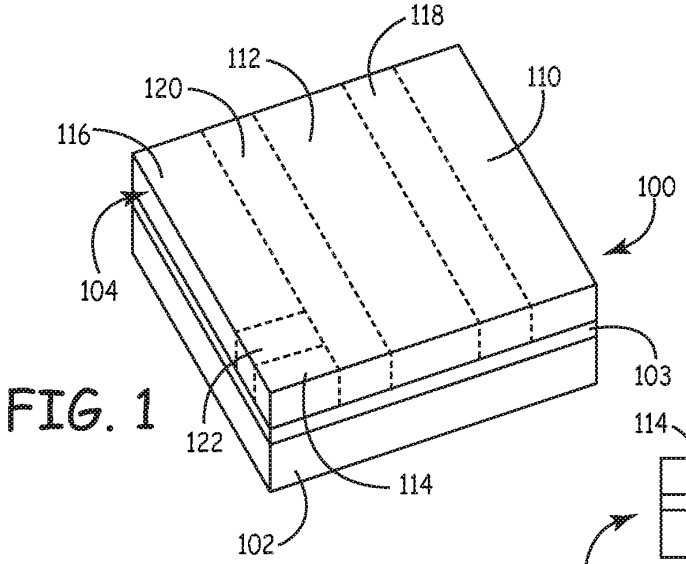



FIG. 1

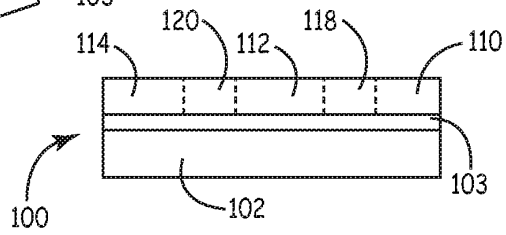



FIG. 2

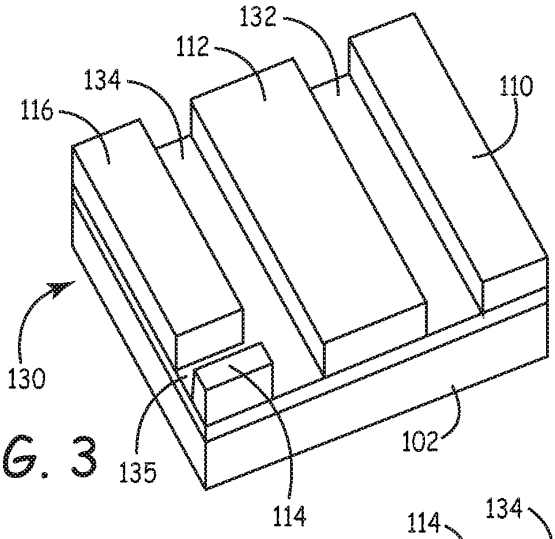



FIG. 3

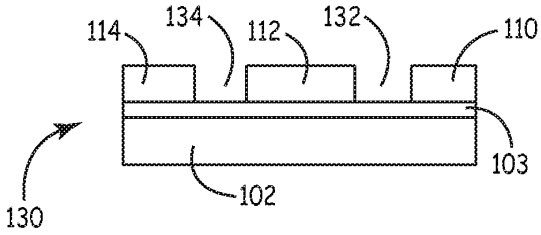



FIG. 4

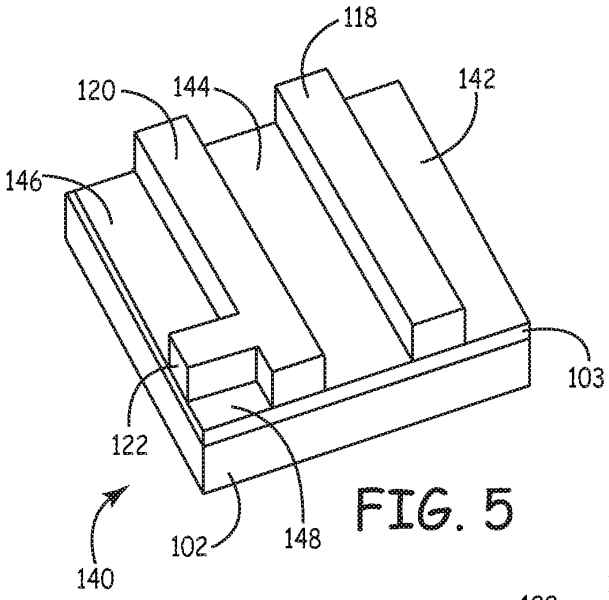

118
120
144
142
146
103
122
102
148
140

FIG. 5

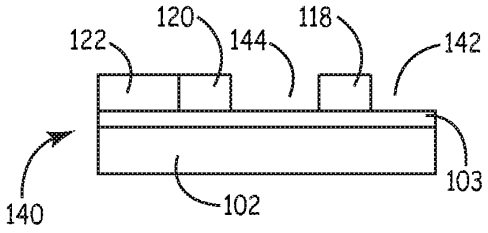

120
118
122
144
142
103
140
102

FIG. 6

Fig. 7

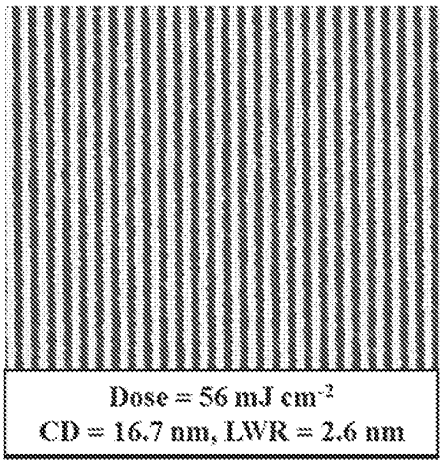

Dose = 56 mJ cm$^{-2}$
CD = 16.7 nm, LWR = 2.6 nm

Fig. 8

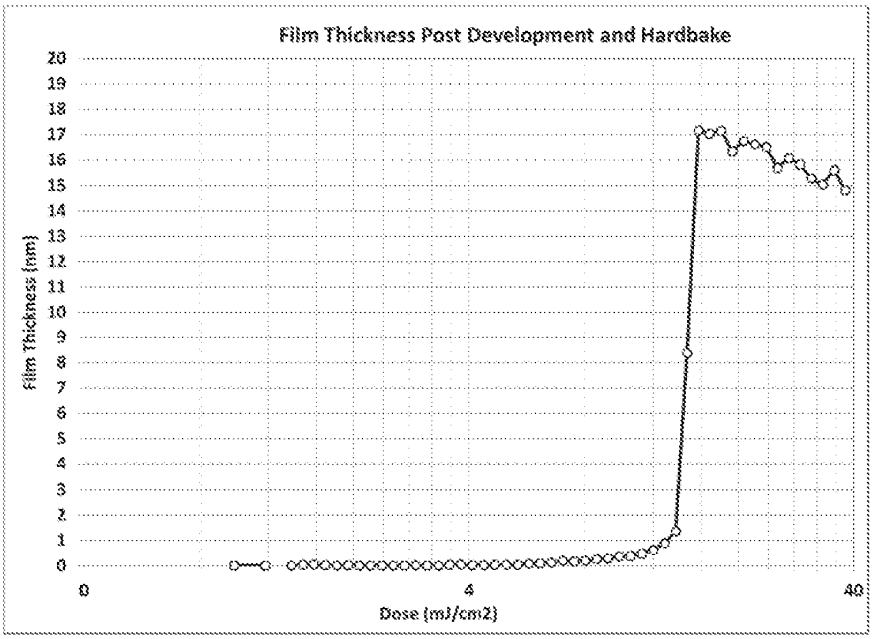

Film Thickness Post Development and Hardbake
Film Thickness (nm)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
4
40
Dose (mJ/cm2)

Fig. 9

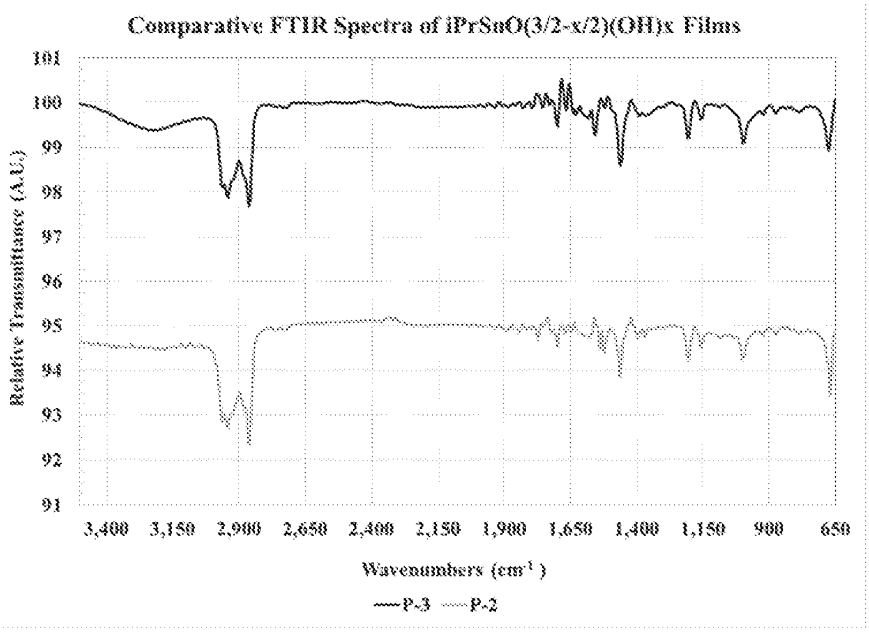

Comparative FTIR Spectra of iPrSnO(3/2-x/2)(OH)x Films
Relative Transmittance (A.U.)
101
100
99
98
97
96
95
94
93
92
91
3,400
3,150
2,900
2,650
2,400
2,150
1,900
1,650
1,400
1,150
900
650
Wavenumbers (cm-1)
P-3
P-2

Fig. 10

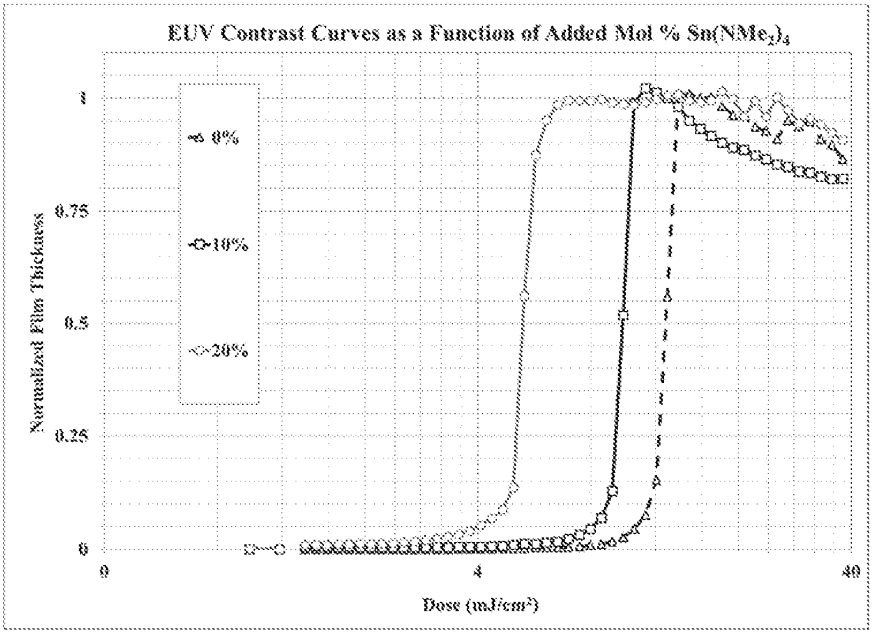

EUV Contrast Curves as a Function of Added Mol % Sn(NMe2)4
Normalized Film Thickness
1
0.75
0.5
0.25
0
0%
10%
20%
0
4
40
Dose (mJ/cm2)

Fig. 11

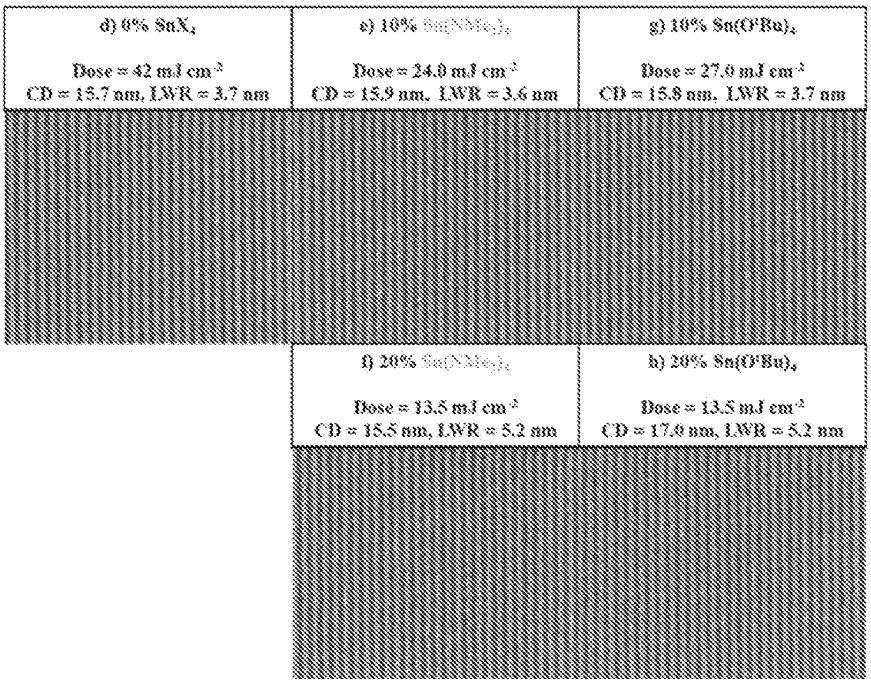

d) 0% SnX4
Dose = 42 mJ cm-2
CD = 15.7 nm, LWR = 3.7 nm
e) 10% Sn(NMe2)4
Dose = 24.0 mJ cm-2
CD = 15.9 nm, LWR = 3.6 nm
g) 10% Sn(OtBu)4
Dose = 27.0 mJ cm-2
CD = 15.8 nm, LWR = 3.7 nm
f) 20% Sn(NMe2)4
Dose = 13.5 mJ cm-2
CD = 15.5 nm, LWR = 5.2 nm
h) 20% Sn(OtBu)4
Dose = 13.5 mJ cm-2
CD = 17.0 nm, LWR = 5.2 nm

Fig. 13

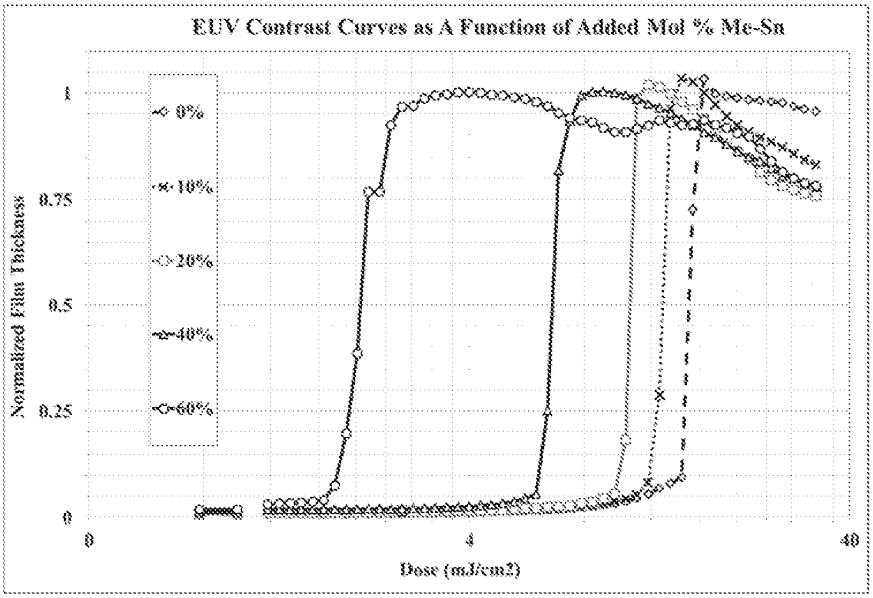

EUV Contrast Curves as A Function of Added Mol % Me-Sn
Normalized Film Thickness
Dose (mJ/cm2)
0%
10%
20%
40%
60%
0
0.25
0.5
0.75
1
0
4
40

Fig. 14

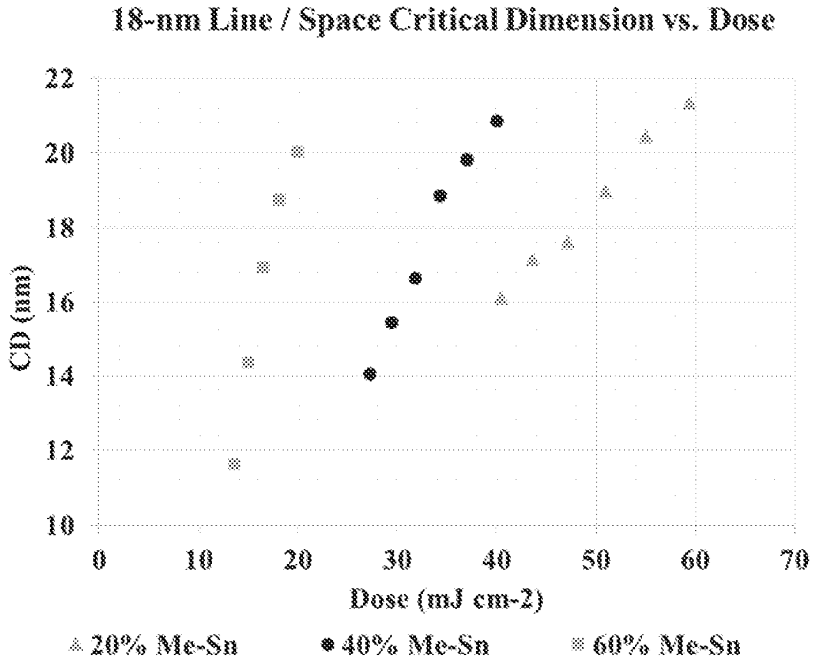

18-nm Line / Space Critical Dimension vs. Dose
CD (nm)
22
20
18
16
14
12
10
0
10
20
30
40
50
60
70
Dose (mJ cm-2)
20% Me-Sn
40% Me-Sn
60% Me-Sn

Fig. 15

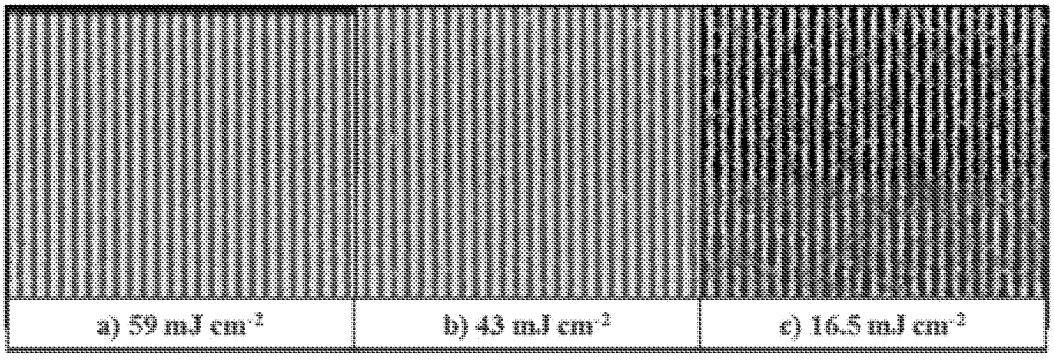

a) 59 mJ cm-2
b) 43 mJ cm-2
c) 16.5 mJ cm-2

Fig. 12

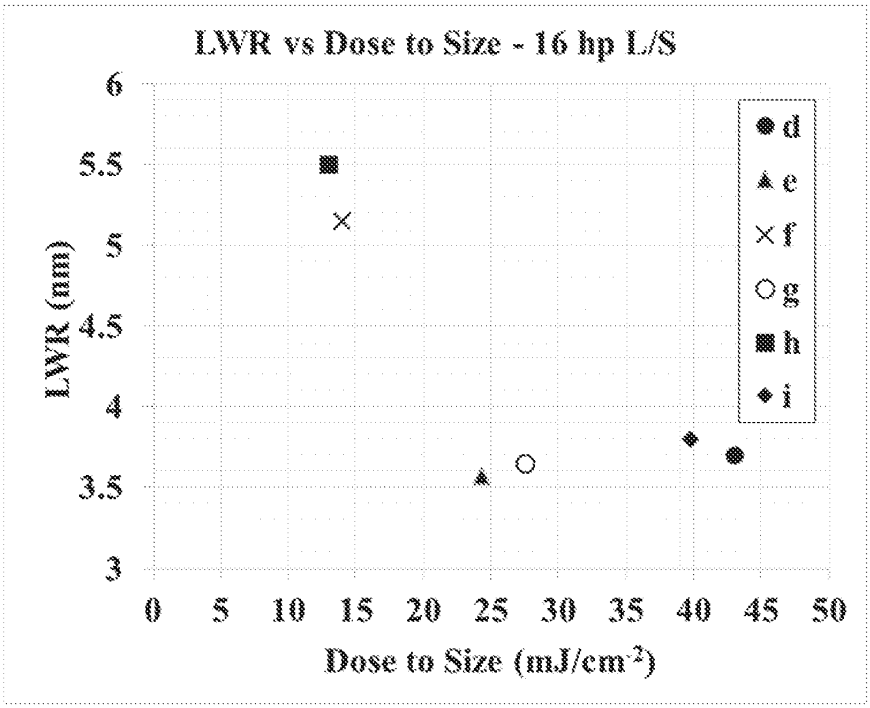
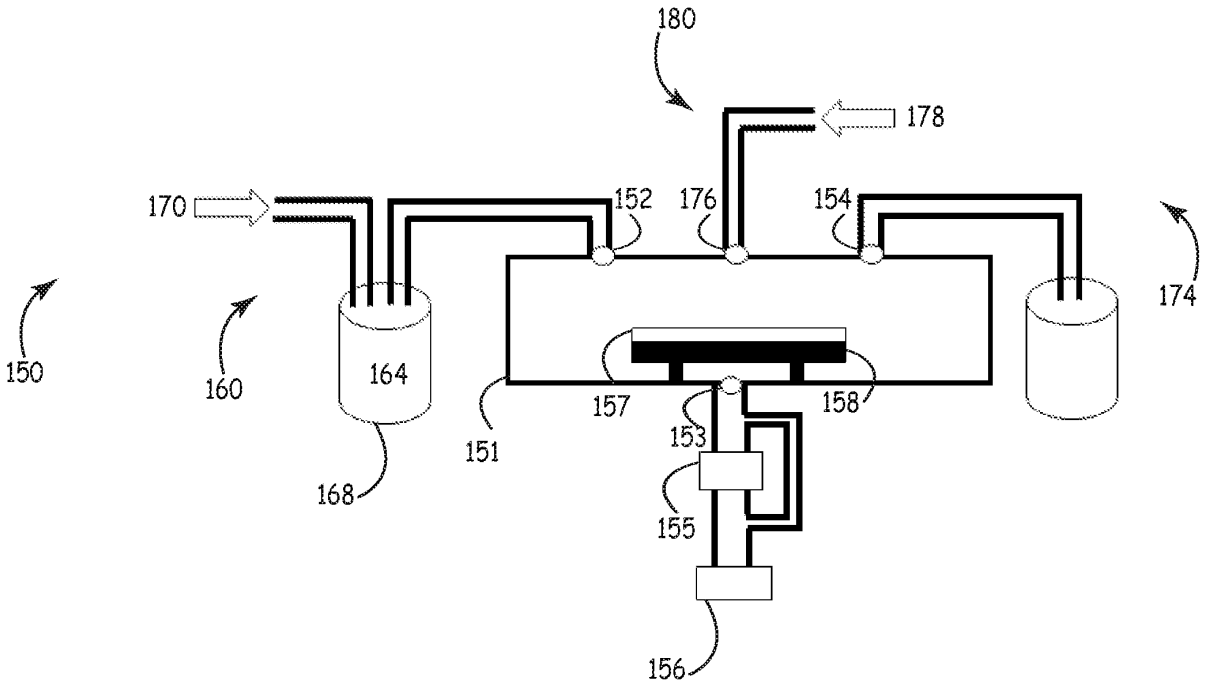

LWR vs Dose to Size - 16 hp L/S
LWR (nm)
6
5.5
5
4.5
4
3.5
3
0
5
10
15
20
25
30
35
40
45
50
Dose to Size (mJ/cm-2)
d
e
f
g
h
i

Fig. 16


180
178
170
152
176
154
174
150
160
164
157
158
153
151
168
155
156

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 42371755 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 05-APR-2021 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 21:37:21 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
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| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | | AmendmentAF.pdf | 95817<br>ab9363b389af543a2e029999ef2d41254297fabb | yes | 16 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Response After Final Action | 1 | 1 |
| | Specification | 2 | 2 |
| | Claims | 3 | 6 |
| | Drawings-other than black and white line drawings | 7 | 7 |
| | Applicant Arguments/Remarks Made in an Amendment | 8 | 16 |

| | | | | | |
|---|---|---|---|---|---|
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Drawings-only black and white line drawings | ReplacementDrawings.pdf | 958652<br>4477be70c67a0e5205e7d14e0deb96413a4d9a47 | no | 8 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 1054469 | | |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

AMENDMENTS TO THE DRAWINGS

Fig. 16 is amended to add elements 176, 178, and 180.

Attachment: Replacement Drawings



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## REMARKS

Claims 1-25 are pending. By this Amendment, claims 1 and 2 are amended. Specifically, claim 1 is amended to specify that the apparatus comprises a supply of an organotin compound. The specification supports the amendment of claim 1, for example, at page 3, line 26 to page 4, line 2. Claim 1 is correspondingly amended to update the antecedent basis in line 8. Claim 2 is amended to add a period to the end of the claim. The Drawings are amended to add elements 176, 178, and 180 to Fig. 16. The specification supports the amendment of the Drawings, for example, at page 36, line 4, via the incorporation by reference of Maeng et al. Applicant refers in particular to Fig. 1 of Maeng et al. which illustrates the apparatus for the introduction of a vapor phase (gas) reactant, as further described, for example, at page 2279 in the last paragraph of the left hand column and in the first paragraph of the Discussion on page 2280. The specification is amended to refer to the elements added to Fig. 16. No new matter is introduced.

### Election/Restrictions

The Examiner has indicated that claims 22-25 have been withdrawn from consideration as being directed to a non-elected invention. Claims 22-25 are herein provided with a status identifier of "Withdrawn."

### Objections to the Drawings

The Examiner objected to the drawings under 37 CFR 1.83(a) for failing to show every feature of the invention specified in the claims. The drawings have been amended. In particular, Fig. 16 has been amended to add structure 180, configured to supply third precursor vapor 178 to deposition chamber 151 through inlet 176. It is believed that the issues of rejection are therefore resolved.

### Rejections under 35 U.S.C 112

The Examiner first lists "a configuration providing for selection of the pressure and/or the temperature in the deposition chamber" in numbered paragraph 6 as invoking 35 U.S.C. 112(f) without any reference to a specific claim. In paragraph 9, the Examiner asserts unpatentability for indefiniteness under 35 U.S.C. 112(b), which presumably corresponds with a rejection of a claim



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with the elements in paragraph 6. Based on the claim features noted in paragraph 6, the Examiner appears to refer to claim 13.

As previously amended, the specification discloses pump 155 and pump 156 connected to the deposition chamber via outlet 153. The specification also discloses thermal block 158. One of ordinary skill in the art would understand these configurations to provide for selection of the pressure and/or the temperature in the deposition chamber. Furthermore, Applicant refers the Examiner to the specification at page 25 lines 12-13 and 21-22 and the specification as previously amended at page 25, after line 22. In these sections, respectively, the Applicant discloses that "[t]he pressure and temperature in the reaction chamber can be selected to control the reaction process" and discloses one embodiment of selection in which "[i]nert gases…may be used in appropriate capacities as pressure modulating gases in both sequential and continuous flow regimes" and "supply of inert gas 170." Furthermore, with all due respect, configurations to control pressure and temperature in a chamber are well-known.

"Cognizant of the competing concerns, we read § 112, ¶ 2 to require that a patent's claims, viewed in light of the specification and prosecution history, inform those skilled in the art about the scope of the invention with reasonable certainty. The definiteness requirement, so understood, mandates clarity, while recognizing that absolute precision is unattainable. The standard we adopt accords with opinions of this Court stating that 'the certainty which the law requires in patents is not greater than is reasonable, having regard to their subject-matter.'" *Nautilus, Inc. v Biosig Instruments, Inc.*, 134 S.Ct. 2120, 2129 (2014).

Applicant respectfully requests withdrawal of the rejection under 35 U.S.C. 112(b) as being indefinite.

Rejection Under 35 U.S.C. 103 Over Maeng

The Examiner rejected claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng (as provided). Applicant believes that the Examiner is referring to Maeng et al., J. Vac. Sci. Tech B., 2006, 24, 2276 as provided in the present Office Action in the Notice of References Cited section, the reference hereinafter referred to as "Maeng." Claims 2-20 depend from claim 1. Claim 1 is amended to more particularly point out Applicant's claimed invention. In particular, the organotin supply is now positively recited in the claim. In view of the amendment, Applicant



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asserts that Maeng does not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejection based on the following arguments.

The Examiner has raised legal issues in the application of the rejection. While the claim amendments substantially address these issues, Applicant would like to address these legal issues prior to close consideration of the facts in the context of the cited reference. The Examiner relies on two USPTO board decisions and four CCPA decisions. Two CCPA decisions were handed down prior to the existing modern form of section 103 and will not be considered further. Applicant distinguishes the two CCPA cases and two Board decisions from the present facts and provides Federal Circuit Appellate court decisions to provide appropriate context for the further analysis.

The Examiner referred to *Ex parte Thibault*, 164 U.S.P.Q. 666 (Pat.& Tr. Office Bd.App.), 1969, 1970 WL 9523. There is no indication that this opinion is precedential. In *Thibault*, the Board considered method claims, a composition claim and an apparatus claim. Most of the decision is directed to the method claims. One short paragraph is directed to the apparatus claim, which is not actually recited in the Westlaw version of the case, and only the method and composition claims are presented. The full discussion of the rejection of the apparatus claim is as follows.

> "Appellant's arguments do not persuade us of error in the examiner's rejection of claim 12 as unpatentable over Walker. If the apparatus as claimed is not fully described in Walker (35 U.S.C. 102), it differs so little therefrom as to be obvious to the designer of apparatus. The purpose to which the apparatus is to be put and the numerous expressions relating the apparatus to contents thereof during an intended operation are of no significance in determining patentability of the apparatus claim. Walker, as pointed out by the examiner, in the drawing (also see column 2, lines 21-36) discloses a vaporizer, a heater, a cooler ("condenser"), and a cold trap in the sequence claimed. The first component of appellant's claim, "a reservoir * * * molten condition," reads on either a heated or an insulated tank. It finds full response in the heated feed tank specifically disclosed in Walker (column 4, line 2). The examiner's rejection of this claim is clearly sustainable."



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With all due respect, Applicant's present claim involves significant structural differences, which provide clear distinctions from the narrow pronouncements of *Thibault*. It is not clear from this case if the basis for the applicant's arguments were found in the claim language at all, and the implication is that they were not since it refers to "numerous expressions."

The second Board opinion relied upon by the Examiner is *Ex parte Masham*, 2 U.S.P.Q.2d 1647 (Bd.Pat.App. & Interf.), 1987 WL 123826, which again does not seem to be precedential. This case involved a single apparatus claim, which was as follows:

> 1. An apparatus for mixing flowing developer material, including:
>
> means, defining a chamber, for receiving the flowing developer material therein; and
>
> means for mixing the flowing developer material, said mixing means being stationary and completely submerged in the developer material.

To state the obvious regarding this claim, it is extremely broad being directed to a chamber with a mixer containing a developer material which possibly is defined in the specification. The applicant in this case argued the distinction being that the prior art reference did not show the mixing means being fully submerged under the developer material. Contrary to the assertions of the Examiner in the present case, the Board did not dismiss the relevance of the material being worked upon by the Masham apparatus. "The apparatus disclosed by Williams is employed to mix developer material. Accordingly, the disclosed apparatus satisfies the recitations in claim 1 with respect to the identity of the material intended to be worked upon by the claimed apparatus and the general manner in which the claimed apparatus is intended to be employed. At any rate, a recitation with respect to the material intended to be worked upon by a claimed apparatus does not impose any structural limitations upon the claimed apparatus which differentiates it from a prior art apparatus satisfying the structural limitations of that claimed." *Id.* Dicta in the *Masham* decision suggests potential broader limits on features of apparatus claims, but this aspect was not relied upon in *Masham* since the only aspect of the claim not taught by the reference in that case was the submersion of the mixing element.

Regarding *In re Dulberg*, the claim at issue in that case was as follows (289 F.2d 522 (CCPA 1961)):

> 1. A holder for soft sticks comprising: an elongated holder body having an internal opening extending longitudinally therethrough, a carrier having a longitudinally extending



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peripheral wall for frictionally engaging one end of a soft stick and having a laterally extending wall for limiting movement of said soft stick in one direction relative to said peripheral wall, said carrier being open at both ends and said laterally extending wall forming a passage of lesser diameter than the internal opening extending through the longitudinally extending peripheral wall which frictionally engages the soft stick in assembled position, said carrier being positioned in said holder body internal opening, cooperative means between said carrier and said holder body for advancing and retracting said carrier relative to said holder body, and the bottom opening of said holder body and of said passage sage formed by the laterally extending wall of said carrier being sufficiently large to permit an instrument having sufficient surface engaging area to push against the bottom of the soft stick without passing through the soft stick, for ejecting the soft stick from said carrier, to pass through said bottom opening of the holder body and through said passage of the carrier.'

It can be seen from this claim that the composition of the soft sticks is not an issue, and the structural contribution of the soft sticks is not in dispute.

The court's decision in *Dulberg* was based on arguments not directed to features of the claim. "A large part of appellant's argument is directed to his method of removing the used lipstick by pushing it out of the carrier, but the appealed claims are not drawn to that method. The claims are directed to a structure, each element of which is old in Peterson. The Peterson structure fully satisfies the terms of each of the appealed claims with the addition of the obvious expedient of making the cap readily removable. Accordingly, it is immaterial that neither Peterson nor Noble actually suggests pushing the remnant of the old lipstick out of the carrier." *Id.* at 523. Respectfully, *Dulberg* is not on point.

With respect to *In re Casey*, the claim at issue for this case is as follows (370 F.2d 576 (CCPA 1967)):

"1. A taping machine comprising a supporting structure, a brush attached to said supporting structure, said brush being formed with projecting bristles which terminate in free ends to collectively define a surface to which adhesive tape will detachably adhere, and means for providing relative motion between said brush and said supporting structure while adhesive tape is adhered to said surface."



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With respect to this claim, the adhesive tape is not positively recited, but it only suggests a potential use for a surface.

In *Casey*, the applicant again argued use of the structure and no feature of the structure itself. "The claims in issue call for an apparatus or machine, viz. a tape dispensing machine. The manner or method in which such machine is to be utilized is not germane to the issue of patentability of the machine itself." *Id.* at 580.

The principle that carries over from these earlier apparatus cases is that how an apparatus is used generally does not limit the apparatus. Referring to *In re Otto*, "[a]lthough the structure claims do not recite any means by which the core member could be attached to the hair and thus the manner of its intended use is of no significance, it might be well to note that the Moses pad impregnated with a dry hair curling substance would be operable with a non-liquid solution." 312 F.2d 937, 941 (CCPA 1963). Under *Otto*, even the method of use can be limiting for an apparatus claim if the method of use helps to define structure. Respectfully, the case law is clear that actual words of the claims generally need consideration if they can be construed as defining structure. This is well stated in the context of the following case. Also, the present claim has been amended to more positively recite the feature of relevance.

"We are not construing a composition claim that contains a material that in fact protects it from light. No brown bottle appears as part of the claim, nor is there any ingredient in the composition that protects the composition from light. The only apparent distinction between the claimed composition protected from light and that not protected from light is how it is treated; that is not a structural or otherwise meaningful claim limitation. If anything, the inventors discovered only a property—light sensitivity in the context of TCAP formation—of the composition recited in the method patents. A direction for care that does no more than reflect the inventor's recognition of a newly discovered property does not itself impart patentability to that composition. *See, e.g., In re Spada,* 911 F.2d 705, 708, 15 USPQ2d 1655, 1657 (Fed.Cir.1990) (holding that the discovery of a new property of an old product does not render the old product patentable); *Ex parte Masham,* 2 USPQ2d 1647, 1648, 1987 WL 123826 (Bd. Pat.App. & Int.1987) (holding that a claimed apparatus was anticipated because it did not "undergo a metamorphosis to a new apparatus merely by affixing instructions thereto" that it be completely submerged, which the prior art device was also capable of). Thus, the "protected from light" language provides no distinguishing structure



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to the claim. There is simply "no there there." We therefore construe the expression "protected from light" to be non-limiting." *Research Corp. Technologies, Inc. v. Gensia Laboratories, Inc.*, 10 Fed.Appx. 856, 861, 862 (Fed. Cir. 2001) (unpublished). This case indicates that the brown bottle would be considered if recited.

The question presented in 35 U.S.C. § 103 is whether the inventions set forth in the individual claims "each as a whole, would have been obvious to one of ordinary skill in the art when they were made," *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1537 (Fed. Cir. 1983). "The test for obviousness vel non is statutory. It requires that one compare the claim's 'subject matter as a whole' with the prior art 'to which said subject matter pertains.'" *In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992).

The teaching of Maeng is limited to one Ta-based precursor: $Ta(NMe_2)_5$, also referred to as "PDMAT". Maeng makes clear that "one of the critical issues for successful ALD process is the proper selection of precursor and reactant." (See page 2276, second paragraph.) Maeng concludes on page 2281 by noting that only the reaction of PDMAT with water or oxygen plasmas as a reactant resulted in pure films. Using the same equipment with a different reactant, such as $NH_3$, resulted in a "considerable incorporation of [carbon] impurity." (See also second full paragraph on page 2279 of Maeng.] Applicant respectfully asserts that Maeng clearly teaches that there is not a reasonable expectation of success in using a different reagent in a given apparatus. In the study of Maeng, the tantalum-based reagent, PDMAT, was the same in each case. One of ordinary skill in the art would have even less expectation of success if an **organotin** compound, comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer, were used in place of PDMAT.

Maeng does not teach or suggest all of the features of Applicant's claimed invention. The specific embodiments and purpose of Maeng teach away from the presently claimed invention. Specifically, the use of an organotin compound would render Maeng unsuitable for its intended purpose of making tantalum based thin films. Thus, Maeng does not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-21 under 35 U.S.C. 103 as being unpatentable over Maeng. While Applicant does not acquiesce with respect to the specific assertions in the rejection directed to the features of the



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dependent claims, Applicant does not comment further on these issues in view of the amendments and arguments above, which are dispositive.

Rejection Under 35 U.S.C. 103 Over Pore

The Examiner rejected claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over Pore (US 2017/0100742). Claims 2-20 depend from claim 1. As noted above, claim 1 is amended to positively recite the organotin supply in claim 1. In view of the amendment and in light of the arguments presented above, Applicant asserts that Pore does not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests reconsideration of the rejection based on the following arguments.

As discussed above, the case law is clear that actual words of the claims generally need consideration if they can be construed as defining structure. As amended, claim 1 positively recites a supply of an organotin compound. Pore does not teach or suggest all of the features of the claimed apparatus.

Further positively recited in claim 1 are features of the organotin compound: a hydrolysable or oxidizable ligand, a metal-carbon bond, and a (post-) transition metal (Sn), which are not a features one of ordinary skill in the art would associate with the field of organic chemistry or "organic films." However, the title of Pore clearly identifies the reference as being directed to organic films, with Pore being generally more specifically directed to forming **organic polymer** films. Pore does not mention tin or organotin compounds or any apparatus for use with such compounds to make films. Pore certainly does not teach or suggest to one of ordinary skill in the art an apparatus comprising a supply of an organotin compound nor does Pore teach or suggest structure configured to deliver flow from the supply of the organotin compound.

Pore does not teach or suggest all of the features of Applicant's claimed invention. Specifically, Pore does not teach the use of an organotin compound, and such processing would render Pore unsuitable for its intended purpose of making organic films. Thus, Pore does not render Applicant's claimed invention *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-18 and 21 under 35 U.S.C. 103 as being unpatentable over Pore. While Applicant does not acquiesce with respect to the specific assertions in the rejection



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directed to the features of the dependent claims, Applicant does not comment further on these issues in view of the amendments and arguments above, which are dispositive.

## CONCLUSION

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

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/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| PATENT APPLICATION FEE DETERMINATION RECORD<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 04/05/2021 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 25 | Minus | ** 25 | = 0 | | x $100 = | 0 |
| | Independent<br>(37 CFR 1.16(h)) | * 1 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 0 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /KAREN T WASHINGTON/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

DocCode – SCORE

# SCORE Placeholder Sheet for IFW Content

Application Number: 16987120 Document Date: 04/05/2021

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

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- Drawing

At the time of document entry (noted above):

- USPTO employees may access SCORE content via DAV or via the SCORE web page.
- External customers may access SCORE content via PAIR using the Supplemental Content tab.

Form Revision Date: March 1, 2019

DocCode – SCORE

# SCORE Placeholder Sheet for IFW Content

Application Number: 16987120 Document Date: 04/05/2021

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

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- Drawing

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- USPTO employees may access SCORE content via DAV or via the SCORE web page.
- External customers may access SCORE content via PAIR using the Supplemental Content tab.

Form Revision Date: March 1, 2019

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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AMENDMENT AFTER FINAL

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Final Office Action of February 5, 2021, please enter the following amendments and consider the following remarks. This Amendment After Final includes the following:

A. Amendments to the Specification
B. Amendments to the Claims
C. Amendments to the Drawings
D. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

April 5, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 02/05/2021

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Maple Grove, MN 55369

| EXAMINER |
|---|
| THOMAS, BINU |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 02/05/2021 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket@cfd-ip.com
patents@cfd-ip.com



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| *Office Action Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 01/20/2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-25 is/are pending in the application.

5a) Of the above claim(s) 22-25 is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-21 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 01/20/2021 is/are: a)☐ accepted or b)☑ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



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## DETAILED ACTION

1. The Applicant's amendment filed on January 20, 2021 was received. Claims 1-2, 6, 9 and 16-20 were amended. Claims 22-25 were added.

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action issued October 8, 2020.

### *Election/Restrictions*

3. Newly submitted claims 22-25 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons: the subject matter of aforementioned claims are directed to method of forming an organotin layer as classified in C23C 16/44, which is distinct from the apparatus as recited in the original claims.

Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claims 22-25 withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

### *Drawings*

4. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore,

a. a flow comprising a third precursor vapor;

must be shown or the feature(s) canceled from the claim(s).

No new matter should be entered.

5. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

***Claim Rejections - 35 USC § 112***

6. Claim limitation "a configuration providing for selection of the pressure and/or the temperature in the deposition chamber" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

7. However, the written description fails to disclose the corresponding structure, material, or acts for performing the entire claimed functions and to clearly link the structure, material, or acts to the functions.

8. No clear structure is found in the drawings or specification which delivers a flow of from a supply of an inert gas, deliver a first precursor vapor deliver, a second precursor vapor, deliver

a third precursor vapor, deliver flow comprises one or more vapor inputting structures, deliver a first flow, deliver a second flow or deliver a third flow. No clear structure is found in the drawings or specification for selection of the pressure and/or the temperature in the deposition chamber.

9. Therefore, the claim is indefinite and is rejected under 35 U.S.C. 112(b) or pre-AIA 35 U.S.C. 112, second paragraph.

Applicant may:

(a) Amend the claim so that the claim limitation will no longer be interpreted as a limitation under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph;

(b) Amend the written description of the specification such that it expressly recites what structure, material, or acts perform the entire claimed function, without introducing any new matter (35 U.S.C. 132(a)); or

(c) Amend the written description of the specification such that it clearly links the structure, material, or acts disclosed therein to the function recited in the claim, without introducing any new matter (35 U.S.C. 132(a)).

If applicant is of the opinion that the written description of the specification already implicitly or inherently discloses the corresponding structure, material, or acts and clearly links them to the function so that one of ordinary skill in the art would recognize what structure, material, or acts perform the claimed function, applicant should clarify the record by either:

(a) Amending the written description of the specification such that it expressly recites the corresponding structure, material, or acts for performing the claimed function and clearly links or associates the structure, material, or acts to the claimed function, without introducing any new matter (35 U.S.C. 132(a)); or

(b) Stating on the record what the corresponding structure, material, or acts, which are implicitly or inherently set forth in the written description of the specification, perform the claimed function. For more information, see 37 CFR 1.75(d) and MPEP §§ 608.01(o) and 2181.

***Claim Rejections - 35 USC § 102***

10. The claim rejections under 35 U.S.C. 102(a)(1) as being anticipated by Russo et al. on claims 1, 5, 12, 14-16 and 21 are withdrawn because independent claim 1 has been amended.

***Claim Rejections - 35 USC § 103***

11. The claim rejections under 35 U.S.C. 103 as being unpatentable over Nishida et al. on claims 1-8, 11-16 and 21 are withdrawn because independent claim 1 has been amended.

12. The claim rejections under 35 U.S.C. 103 as being unpatentable over Jursich et al. on claims 1, 3, 5, 6-12 and 14-21 are withdrawn because independent claim 1 has been amended. Please consider the following.

13. **Claims 1-21 are rejected under 35 U.S.C. 103 as being unpatentable over Maeng** (as provided).

**In regards to claim 1**, Maeng teaches a PE-ALD system (apparatus) comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate (see 8-inch wafer) within the interior of the deposition chamber, the substrate receives a deposition on a surface of the substrate;

an inlet (see pipes connected to bubblers) into the deposition chamber;

structure (see label of Ar gas) delivers flow from a supply of an inert gas; and

structure (see label of PDMAT bubbler) delivers flow from a supply of a liquid precursor with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 1).

Maeng does not explicitly teach the organotin compound, to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

As Maeng teaches the structural limitations of the claim, one would be capable of using an organotin compound as the material solution and using the PE-ALD system to provide formation of the organotin layer on the substrate as claimed.

**In regards to claim 2**, Maeng teaches the substrate is a silicon substrate (pg. 2277).

**In regards to claims 3-4**, Maeng teaches the structure (see label of Ar gas) which provides the inert gas of argon, where argon is used as the carrier gas (pg. 2277).

**In regards to claims 5 and 14**, Maeng teaches the structure which supplies the liquid precursor is a bubbler which bubbles the inert carrier gas through the liquid PDMAT to supply the vapor to the chamber (fig. 1)

**In regards to claims 6-10 and 15-20**, Maeng teaches PDMAT bubbler supplies the first vaporized material and a $H_2O$ bubbler provides a second vaporized material and a $NH_3$, $O_2$, $H_2$ gas supplies a third flow of material to the chamber (fig. 1).

Maeng does not explicitly teach the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim. *Ex parte Masham*, 2 USPQ2d 1647 (Bd. Pat. App. & Inter. 1987) (MPEP2114). As Maeng teaches the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the material solution and a third precursor vapor as SnL4 as recited in the claim, and with the flow process as recited in the claim.

**In regards to claims 11-12 and 21**, Maeng teaches a pressure of the chamber of 0.1 to 10-mtorr and reactor growth temperature of 150-250°C (pg. 2277-2278).

**In regards to claim 13**, Maeng teaches a selection of the temperature within the deposition chamber (pg. 2278).

14. **Claims 1-18 and 21 are rejected under 35 U.S.C. 103 as being unpatentable over Pore** (US 2017/0100742).

**In regards to claims 1 and 4**, Pore teaches an apparatus (100) comprising:

a deposition chamber having a reaction space (115, interior) isolated from the ambient atmosphere (fig. 2a; para. 46);

a substrate (120) within the interior of the deposition chamber which receives a deposition on a surface of the substrate (fig. 2a; para. 46);

an inlet into the deposition chamber is provide at inlet manifold (135) (fig. 2a; para. 47);

an inert gas source (150, structure) delivers flow from a supply of an inert gas such as argon or nitrogen which is well known (fig. 2a; para. 49); and

a first reactant vessel (105 structure) delivers flow from a supply of a first reactant vapor with the inert gas as a carrier gas to the inlet of the deposition chamber (fig. 2a; para. 47).

Pore does not explicitly teaches the organotin compound and to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

As Pore teaches the structural limitations of the claim, one would be capable of using an organotin compound as the first reactant and using the apparatus to provide formation of the organotin layer on the substrate as claimed.

**In regards to claim 2**, Pore teaches the substrate is silicon wafer (para. 17).

**In regards to claim 3**, Pore teaches the inert gas source (150, structure) delivers flow from a supply of an inert gas (fig. 2a; para. 49).

**In regards to claims 5 and 14**, Pore teaches the first reactant vessel (105) vaporizes the first organic reactant (110) (fig. 2a; para. 46).

**In regards to claims 6-10 and 15-18**, Pore teaches first reactant vessel vaporizes the first organic reactant and the a second reactant vessel (140) vaporizes a second reactant (145), where the first and second reactant vessels are connected to the inlet manifold of the deposition chamber(fig. 2a; para. 46, 48).

Pore does not explicitly teach the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than

function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim. *Ex parte Masham*, 2 USPQ2d 1647 (Bd. Pat. App. & Inter. 1987) (MPEP2114). As Pore teaches the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the first reactant and the second reactant of SnL4 as recited in the claim, and with the flow process as recited in the claim(s).

**In regards to claims 11-12 and 21**, Pore teaches a pressure of the chamber of 100-mtorr to 100-torr and a temperature of 100-250ºC (para. 43).

**In regards to claim 13**, Pore teaches a control system (125) which controls a vacuum pump (165) to maintain the pressure in the deposition chamber (fig. 2a; para. 50).

### *Response to Arguments*

15. Applicant's arguments with respect to claim(s) 1-21 have been considered but are moot because the new ground of rejection does not rely on any reference applied in the prior rejection of record for any teaching or matter specifically challenged in the argument.

### *Conclusion*

16. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached on Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Binu Thomas/
Primary Examiner, Art Unit 1717
January 25, 2021

| Notice of References Cited | Application/Control No. 16/987,120 | Applicant(s)/Patent Under Reexamination Meyers et al. | |
|---|---|---|---|
| | Examiner Binu Thomas | Art Unit 1717 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | CPC Classification | US Classification |
|---|---|---|---|---|---|---|
| * | A | US-20170100742-A1 | 04-2017 | PORE; VILJAMI J. | H01L51/001 | 1/1 |
| | B | | | | | |
| | C | | | | | |
| | D | | | | | |
| | E | | | | | |
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**FOREIGN PATENT DOCUMENTS**

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|---|---|---|---|---|---|---|
| | N | | | | | |
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| | P | | | | | |
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| | R | | | | | |
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| | T | | | | | |

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| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | Maeng, W. J.; Pak, S. J.; Kim, H. J. Vac. Sci. Tech B. 2006, 24, 2276 (Year: 2006) |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
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| Symbol | Date | Examiner |
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| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| | | | |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |
| Updated search | 01/2021 | BT |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| | | | |

| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
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IPR2025-00309 - U.S. Patent No. 11,537,048

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
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| L1 | 1 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 11:23 |
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| L3 | 84 | L2 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 12:02 |
| L4 | 17 | (US-20110293888-$ or US-20040067444-$ or US-20050266700-$ or US-20030118947-$ or US-20120027937-$ or US-20090155535-$ or US-20060211271-$ or US-20040156987-$ or US-20080022896-$).did. or (US-6583071-$ or US-4601917-$ or US-4104292-$ or US-6825131-$ or US-5894064-$ or US-6251473-$ or US-6066575-$ or US-6116184-$).did. | US-PGPUB; USPAT | OR | ON | 2021/01/25 12:48 |
| L6 | 19 | ("4293594").PN. OR ("4601917").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:44 |
| L7 | 1,323 | (C23C16/45525).cpc. and carrier near3 gas | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| L8 | 554 | (C23C16/45525).cpc. and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:46 |
| L9 | 21 | ("20040209190" \| "20050186339" \| "20060124057" \| "20070194157" \| "20080146011" \| "20090152371" \| "20100300221" \| "20110097507" \| "20110163062" \| "20110198620" \| "20120074575" \| "20120088315" \| "20130316541" \| "20140262461" \| "20170140920" \| "6146767" \| "6503701" \| "7718011" \| "7954730" \| "8840037" \| "9677984").PN. OR ("10163629").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:49 |

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| L11 | 1 | "16987120" and (oxide and hydroxide) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 13:59 |
| L12 | 9 | (c23c14/$ c23c16/$).cpc. and organotin and oxide near10 hydroxide | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:00 |
| L13 | 2 | "20170100742" "20160284553" and organotin | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |
| L15 | 4 | ("20170100742" "20160284553") and carrier near3 gas near20 inert | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:01 |
| L16 | 1 | "16987120" and (third near5 vapor) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:32 |
| L17 | 2 | ("20170100742" "20160284553") and carrier near3 gas near20 inert and (argon nitrogen) | US-PGPUB; USPAT; USOCR | OR | ON | 2021/01/25 14:41 |
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| S2 | 6 | "15291738" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
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| S6 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 11:47 |

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| S11 | 3 | ("20130253161" \| "4104292" \| "9310684").PN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
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| S13 | 20 | ("20020048770" \| "20030116091" \| "20030118947" \| "20040087184" \| "5456945" \| "5759923" \| "6116184" \| "6231933" \| "6261373" \| "6358559" \| "6365266" \| "6376634" \| "6406794" \| "6428847" \| "6455443" \| "6472076" \| "6576568" \| "6583071" \| "6592980").PN. OR ("7446055").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:21 |
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| S15 | 25 | S13 S14 | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:29 |
| S16 | 59,271 | H01L21/02274-02282.cpc. c23c16/$.cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| S17 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| S18 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:17 |
| S19 | 6 | "15291738" and structure | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:23 |
| S20 | 6 | "15291738" and precursor near2 vapor | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:24 |
| S21 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:27 |
| S22 | 6 | "15291738" and thickness near2 variation | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:28 |
| S23 | 6 | "15291738" and select$4 near5 (temperature pressure) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 16:55 |

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| S24 | 3 | "20080022896" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 18:07 |

**EAST Search History (Interference)**

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1/25/2021 3:09:28 PM
C:\Users\bthomas\Documents\EAST\Workspaces\16987120-vapor deposition organotin.wsp

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 16987120 |
| Filing Date | 2020-08-06 |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | 1717 |
| Examiner Name | Binu Thomas |
| Attorney Docket Number | 5063.08US05 |

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|---|---|---|---|---|---|---|---|---|
| | 1 | 1457504 | CN | A | 2003-11-19 | EKC Technology | English Abstract Only | |
| | 2 | 2015-026482 | WO | A1 | 2015-02-26 | Inpria Corporation | | |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|
| | 1 | Office Action from co-pending Korean Application No. 10-2018-7013486 dated August 4, 2020. | ☒ |
| | 2 | Office Action from co-pending Chinese Application No. 201680060193.7 dated August 28, 2020. | ☒ |

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**EXAMINER SIGNATURE**

| Examiner Signature | /Binu Thomas/ (01/25/2021) | Date Considered | 01/25/2021 |
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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 16987120 |
| | Filing Date | 2020-08-06 |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | 1717 |
| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2021-01-20 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
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| Application Number | 16987120 |
| Filing Date | 2020-08-06 |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | 1717 |
| Examiner Name | Binu Thomas |
| Attorney Docket Number | 5063.08US05 |

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|---|---|---|---|---|---|---|---|---|
| | 1 | 1457504 | CN | A | 2003-11-19 | EKC Technology | English Abstract Only | |
| | 2 | 2015-026482 | WO | A1 | 2015-02-26 | Inpria Corporation | | |

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| | Examiner Name | Binu Thomas |
| | Attorney Docket Number | 5063.08US05 |

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|
| | 1 | Office Action from co-pending Korean Application No. 10-2018-7013486 dated August 4, 2020. | ☒ |
| | 2 | Office Action from co-pending Chinese Application No. 201680060193.7 dated August 28, 2020. | ☒ |

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| Examiner Signature | | Date Considered | |
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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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IPR2025-00309 - U.S. Patent No. 11,537,048

Espacenet

# Bibliographic data: CN1457504 (A) — 2003-11-19

## Method of making electronic materials

**Inventor(s):** MALONEY D J [US]; LEE W M [US]; ROMAN P J JR [US] ± (D.J. MALONEY, ; W.M. LEE, ; P.J. ROMAN JR, ; D.J. MALONEY,W.M. LEE,P.J. ROMAN JR)

**Applicant(s):** EKC TECHNOLOGY INC [US] ± (EKC TECHNOLOGY INC)

**Classification:** - international: ***B05D3/00; B05D5/12; G03F7/004; G03F7/32; G03F7/40; H01L21/00; H01L21/027; H01L21/033; H01L21/06; H01L21/266; H01L21/3065; H01L21/308; H01L21/31; H01L21/311; H01L21/316; H01L21/3205; H01L21/469; H01L21/768; H01L23/52; H01L35/24;*** *H01L21/314;* (IPC1-7): H01L21/302; H01L21/461

- cooperative: **G03F7/0042 (EP); H01L21/02186 (US); H01L21/02189 (US); H01L21/02197 (US); H01L21/022 (US); H01L21/02205 (US); H01L21/02282 (US); H01L21/02318 (US); H01L21/0271 (EP); H01L21/0332 (EP); H01L21/0337 (EP); H01L21/0338 (EP); H01L21/3081 (EP); H01L21/3086 (EP); H01L21/3088 (EP); H01L21/31144 (EP); H01L21/31691 (EP, EP); H01L21/76807 (EP); H01L21/76811 (EP); H01L21/76813 (EP)**

**Application number:** CN20018012334 20010606

**Priority number(s):** US20000209947P 20000606

**Also published as:** AU6539001 (A) CN1268177 (C) EP1305824 (A1) EP1305824 (A4) JP2004512672 (A) KR20030007904 (A) TW513745 (B) US2002076495 (A1) US6566276 (B2) WO0195690 (A1) less

Abstract not available for CN1457504 (A)
Abstract of corresponding document: WO0195690 (A1)



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

The present invention involves fabrication of a hard mask. An embodiment involves the conversion of a precursor into a top-surface imaging layer during a direct patterning step. Another embodiment of the present invention is a method of forming an etched pattern in a substrate. A further embodiment of the present invention is a method of forming an implanted region in a substrate. Preferred precursors are formed from a metal complex comprising at least one ligand selected from the group consisting of acac, carboxylato, alkoxy, azide, carbonyl, nitrato, amine, halide, nitro, and mixtures thereof and at least one metal selected from the group consisting of Li, Al, Si, Ti, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, Sr, Y, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Ba, La, Pr, Sm, Eu, Hf, Ta, W, Re, Os, Ir, Pt, Au, Pb, Th, U, Sb, As, Ce, Mg, and mixtures thereof.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

[19] 中华人民共和国国家知识产权局

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H01L 21/302
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[12] 发明专利申请公开说明书

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[86] 国际申请 PCT/US01/18413 2001.6.6
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[85] 进入国家阶段日期 2003.1.6
[71] 申请人 EKC 技术公司
地址 美国加利福尼亚
[72] 发明人 D·J·马洛尼 W·M·李
P·J·小罗曼 M·A·富利
R·H·希尔

[74] 专利代理机构 北京纪凯知识产权代理有限公司
代理人 沙 捷 彭益群

权利要求书 8 页 说明书 44 页 附图 30 页

[54] 发明名称 电子材料的制造方法

[57] 摘要

本发明涉及构造硬掩膜。一个实施方案涉及到在直接形成图案的过程中把前驱体转化为顶表面图案层。本发明的另一个实施方案是在基底上形成刻蚀图案的方法。本发明的再一个实施方案是在基底上形成注入区的方法。优选的前驱体由一种金属络合物形成，该金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

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1.在基底上形成硬掩膜的方法，该方法包括如下的步骤：
选择至少一种前驱体材料；
在基底的顶上形成一层含有该前驱体的层；
将至少一部分该前驱体层进行转化；
将该前驱体层显影，由此在该前驱体层上形成图案，以及
将该图案转移到基底上，由此在形成图案时不使用光刻胶。

2.如权利要求 1 的方法，该方法进一步包括用显影剂把该前驱体层的未转化部分显影去掉。

3.如权利要求 2 的方法，其中所述显影剂是液体显影剂，含有至少一种醇和至少一种酮，其中存在的所有醇的总体积大于在该液体显影剂中存在的所有醇的体积加上存在的所有酮的体积总和的 50%。

4.如权利要求 3 的方法，其中至少一种醇是异丙醇，至少一种酮是甲基异丁基酮，异丙醇和甲基异丁基酮的体积比大于大约 1:1，而小于大约 40:1。

5.如权利要求 1 的方法，该方法进一步包括用显影剂显影去掉该前驱体层的已转化部分。

6.如权利要求 5 的方法，其中所述显影剂是液体显影剂，含有至少一种醇和至少一种酮，其中存在的所有醇的总体积大于在该液体显影剂中存在的所有醇的体积加上存在的所有酮的体积总和的 50%。

7.如权利要求 6 的方法，其中至少一种醇是异丙醇，至少一种酮是甲基异丁基酮，异丙醇和甲基异丁基酮的体积比大于大约 1:1，而小于大约 40:1。



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8.如权利要求 1 的方法，该方法进一步包括从金属络合物中选择至少一种前驱体材料，该金属络合物包括至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

9.在基底上形成硬掩膜的方法，该方法包括如下的步骤：

选择至少一种前驱体材料；

在基底的顶上任选形成一保护层；

在该保护层的顶上形成一层含有该未转化前驱体的层；

将至少一部分该未转化前驱体层进行部分转化；

基本上除去至少一部分未转化前驱体层，形成图案，以及

通过把至少一部分部分转化的前驱体层进行转化，形成硬掩膜。

10.如权利要求 9 的方法，该方法进一步包括用选自光、电子束辐照、离子束辐照和它们的组合的能源，通过包括至少一部分对该能源基本上透明的带图案掩膜进行部分转化的步骤。

11.如权利要求 9 的方法，该方法进一步包括使用显影剂基本上除去至少一部分未转化前驱体层。

12.如权利要求 9 的方法，该方法进一步包括使用选自光、电子束辐照、离子束辐照、热退火和它们的组合的能源进行转化而形成硬掩膜的步骤。

13.如权利要求 9 的方法，该方法进一步包括从金属络合物中选择至少一种前驱体的步骤，该金属络合物包括至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、



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Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

14.在基底上形成刻蚀图案的方法，该方法包括如下的步骤：

选择至少一种前驱体材料；

在基底的顶上形成一层含有未转化前驱体的层；

将至少一部分未转化前驱体层进行部分转化；

基本上除去至少一部分未转化前驱体层；

通过转化至少一部分部分转化前驱体层来形成硬掩膜，以及

通过刻蚀至少一部分基本上未被硬掩膜覆盖的基底在该基底上形成至少一个图案区。

15.如权利要求 14 的方法，该方法进一步包括从金属络合物选择至少一种前驱体材料的步骤，该金属络合物包括至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

16.形成带图案的薄顶表面的方法，该方法包括如下步骤：

选择至少一种含有金属络合物的前驱体材料；

在基底顶上形成图案转移层；

在图案转移层的顶上形成一层含有未转化前驱体的层；

通过包括至少一部分对光基本上透明的带图案掩膜将一部分未转化前驱体层曝光，由此将已曝光部分部分转化；

基本上除去至少一部分未转化前驱体层，因而至少一部分图案转移层被曝露出来；

通过转化至少一部分部分转化的前驱体层来形成硬掩膜；

刻蚀至少部分转化的前驱体层和图案转移层的曝露部分，由此从



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未覆盖的图案转移层形成至少一个被刻蚀的部分；以及

基本上除去保留的至少部分转化前驱体层和图案转移层，由此曝露出至少一部分基底。

17.如权利要求16的方法，该方法进一步包括从光刻胶、聚酰亚胺、聚甲基丙烯酸甲酯、线形酚醛树脂和环氧树脂中选择图案转移层。

18.如权利要求16的方法，该方法进一步包括选择金属络合物以使所述金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg和它们的混合物。

19.在一揭起层的上面形成带图案薄顶表面的方法，该方法包括如下步骤：

选择至少一种含有金属络合物的前驱体材料；

在基底的顶上形成一隔离层；

在该隔离层的顶上形成一揭起层；

在该揭起层的顶上形成一层含有未转化前驱体的层；

通过包含至少一部分对光基本上透明的带图案掩膜，将一部分未转化前驱体层曝光，由此将已曝光部分进行部分转化；

基本上除去至少一部分未转化前驱体层，由此曝露出至少一部分揭起层，该揭起层具有被部分转化前驱体层覆盖的揭起层的保留部分；

通过将至少一部分部分转化前驱体层进行转化，形成硬掩膜；

使至少部分转化前驱体和揭起层的曝露部分经受各向异性的去除方法，由此基本上除去揭起层的未覆盖部分和至少一部分在该揭起层未覆盖部分底下的隔离层，并曝露出至少一部分基底；

使至少部分转化的前驱体、揭起层的覆盖部分和至少一部分在揭起层覆盖部分底下的隔离层经受各向同性去除方法；



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在至少一部分曝露的基底顶上和在至少部分转化的前驱体顶上沉积上一层金属膜；

基本上除去至少部分转化前驱体顶上的金属；以及

基本上除去保留的至少部分转化前驱体、揭起层和隔离层，由此在基底顶上形成金属的图案。

20.如权利要求 19 的方法，该方法进一步包括选择金属络合物以使该金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

21.在一揭起层上形成带图案薄顶表面的方法，该方法包括如下步骤：

选择至少一种含有金属络合物的前驱体材料；

在基底顶上形成一层含有未转化前驱体材料的层；

将至少一部分该未转化前驱体层进行部分转化；

基本上除去至少一部分未转化前驱体层，由此在部分转化前驱体部分形成向内呈锥形的侧壁断面并曝露出至少一部分基底；

通过转化至少一部分部分转化前驱体层来形成硬掩膜；

在至少一部分曝露的基底顶上和在至少部分转化前驱体的顶上沉积金属膜；

基本上除去在至少部分转化前驱体顶上的金属；以及

基本上除去保留的至少部分转化前驱体，由此在基底顶上形成金属图案。

22 如权利要求 21 的方法，该方法进一步包括选择金属络合物以使该金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、



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硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

23.在基底中形成注入区的方法，该方法包括如下步骤：

选择至少一种前驱体材料；

任选在该基底的顶上形成一保护层；

在该保护层的顶上形成一层含有至少一种未转化前驱体材料的层；

通过把至少一部分未转化前驱体层进行转化，形成前驱体层的部分转化部分；

使用显影剂基本上除去至少一部分未转化前驱体层；

通过转化至少一部分部分转化前驱体层来形成硬掩膜；以及

通过在至少一部分基本上未被硬掩膜覆盖的基底上注入离子来在该基底上形成至少一个注入区。

24.如权利要求 23 的方法，该方法进一步包括用选自光、电子束辐照、离子束辐照和它们的组合的能源通过包含至少一部分对所述能源基本上是透明的带图案掩膜进行部分转化。

25.如权利要求 23 的方法，该方法进一步包括使用选自光、电子束辐照、离子束辐照、热退火和它们的组合的能源进行转化而形成硬掩膜。

26.如权利要求 23 的方法，该方法进一步包括将未覆盖的基底曝露于离子束下而注入离子。

27.如权利要求 23 的方法，该方法进一步包括从金属络合物中选择至少一种前驱体材料的步骤，该金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮



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基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

28.在一个介电层中形成双波纹构筑的方法，该方法包括如下步骤：

选择至少一种前驱体材料；

在基底的顶上形成具有特征厚度的介电层；

在该介电层的顶上形成一层含有第一未转化前驱体的层；

通过在至少一部分未转化的第一前驱体层上使用第一部分转化方法，形成第一前驱体层的部分转化部分；

通过使用第一去除方法基本上除去至少一部分第一未转化前驱体层，曝露出至少一部分介电层，形成未被至少部分转化的第一前驱体层覆盖的第一图案；

在至少一部分部分转化的第一前驱体层上使用第一转化方法形成硬掩膜；

在介电层的曝露部分顶上和至少部分转化的第一前驱体层顶上形成一个旋转平面化层；

在该旋转平面化层的顶上形成一层含有第二未转化前驱体的层；

在至少一部分该未转化的第二前驱体层上使用第二部分转化方法形成第二前驱体层的部分转化部分；

使用第二去除方法基本上除去至少一部分第二未转化前驱体层，曝露出至少一部分旋转平面化层，形成未被至少部分转化的第二前驱体层覆盖的第二图案；

在至少一部分部分转化的第二前驱体层上使用第二转化方法形成硬掩膜；

在基本上未被第二硬掩膜覆盖的至少一部分介电层及其底下的旋转平面化层上使用第一刻蚀方法，在介电层上形成至少一个第二图案区，使得被第一刻蚀方法除去的深度小于介电层的厚度；

通过使用第三去除方法基本上除去剩下的至少部分转化的第二前



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驱体层和旋转平面化层，由此曝露出至少部分转化的第一前驱体层；

通过在至少一部分基本上未被第一硬掩膜覆盖的至少一部分介电层上使用第二刻蚀方法，在介电层上形成至少一个第一图案区，使得在第一图案区中用第二刻蚀方法除去介电层的深度小于其厚度，而且在第二图案区通过第二刻蚀方法基本上除去整个介电层的厚度，从而曝露出至少一部分基底；以及

任选地用第四去除方法基本上除去剩下的至少部分转化的第一前驱体层。

29.如权利要求 28 的方法，该方法进一步包括从低介电常数介电材料中选择介电层。

30.如权利要求 28 的方法，该方法进一步包括从金属络合物中选择至少一种前驱体材料的步骤，该金属络合物含有至少一种配位体和至少一种金属，所述配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；所述金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

31.如权利要求 28 的方法，该方法进一步包括选择第一和第二刻蚀方法中的至少一种作为各向异性含氧等离子体。



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# 电子材料的制造方法

## 发明领域

本发明涉及电子材料的织构方法，在此方法中涉及形成硬掩膜。在一个实施方案中，涉及在直接形成图案的步骤中，把一种前驱体转化为顶表面影像层。

## 发明背景

在半导体和封装工业中使用传统的方法在其产品中形成薄的金属和金属氧化物膜。这种方法的例子包括蒸发、溅射沉积或溅射、化学气相沉积（CVD）和热氧化方法等。蒸发是在希望沉积的基底附近加热待沉积金属的一种方法。一般在真空条件下进行，要沉积的材料挥发然后在基底上凝聚，在此基底上产生一个覆盖层，或者说无图案的所需材料的膜。此方法有几个缺点，包括须要把希望成膜的材料加热到高温并需要高真空的条件。除非在蒸发的过程中使用屏蔽或者掩蔽物，用此方法都会导致无图案的覆盖膜。

溅射是一种与蒸发相类似的技术，在此技术中通过用具有足够动能的入射原子轰击用于沉积的材料使之转化为气相，因而该材料的粒子被驱逐进入气相并随后在基底上凝聚。溅射具有和蒸发一样的缺点，另外还需要能够产生足够动能的入射粒子，以驱逐出这些沉积材料的粒子的设备和消耗品。

CVD 和蒸发以及溅射相似，但还要求在沉积的过程中使沉积在基底上的粒子经过化学反应，以在此基底上形成膜。虽然在需要化学反应这一点上 CVD 与蒸发和溅射不同，可是在膜沉积的过程中，CVD 方法仍然须要使用复杂的设备以及温度和压力的苛刻条件。

热氧化也需要温度和氧气气氛的苛刻条件。在这种技术中，通过对早先在基底上沉积的未氧化层进行氧化，在基底上产生一层氧化膜覆盖层。

有几种现有的膜沉积方法可以在环境温度和压力下进行，这包括



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溶胶-凝胶法和其它旋压法。在这些方法中，在基底上涂布含有一种前驱体粒子的溶液，这些颗粒随后可转变为所需的膜成分。可以用旋涂或旋注的方法进行此溶液的涂布，此时将基底围绕一根轴旋转，同时将溶液滴到基底的中间。在进行这样的涂布以后，使涂布好的基底经受高温处理，这样就把前驱体膜转变为所需材料的膜。因此，这些方法不允许直接成像以形成无定形膜的图案。相反，他们会产生由所需材料形成的无图案覆盖膜。这些方法与气相法相比，对设备的要求不那么苛刻，但对外界温度仍然有要求，以影响沉积膜向所需材料的转化。

在一种给覆盖膜形成图案的方法中，用光敏涂层涂布在覆盖膜上（一般是使用旋涂或其它溶液基的涂布方法，或者应用干光敏膜）。通过掩膜用特定波长的光使此光敏层进行选择性地曝光。曝光改变了光敏层曝光区的溶解性，使得能够用显影溶液选择性地除去曝光区或未曝光区。然后使用剩余的材料作为图案转移介质，或者叫刻蚀介质的掩膜，此刻蚀介质在所需材料上形成出图案。在此刻蚀步骤之后，除去剩下的材料（从前的光敏材料），如果需要，清洗掉在刻蚀方法的过程中产生的所有副产物。

在基底上形成有图案薄膜的另一种方法中，可以如上所述为光敏材料形成图案。在形成图案以后，在形成了图案的材料（从前的光敏材料）的表面上可沉积上所需材料的保形覆盖层，然后将带有所形成图案的材料和所需材料覆盖膜的基底进行曝光，对从前的光敏材料进行腐蚀处理。此处理除去残留的原光敏材料，与其一起还除去了在表面上的一部分所需材料的覆盖膜。以这样的方式得到了所需材料的带图案膜，在此“揭层(liftoff)”方法中，刻蚀步骤不是必需的。然而，仍然须要使用中间图案转移介质（光敏材料），这就是本方法的缺点。已知此“揭层”法对分辨率（最小尺寸）有严格的限制，这可由所需材料的图案来确定。此缺点严格地限制了此方法的用途。

因此很明显的是，沉积以后须要形成图案的覆盖膜都需要几个极其昂贵和困难的加工步骤。

在另外一个形成带图案膜的方法中，可以通过比如上述方法之一在一个比如用前面所述的刻蚀方法预先形成了图案的基底上沉积所需



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材料的覆盖膜。用这样的方法沉积的覆盖膜，使其厚度充满并完全覆盖在基底上现有的图案。然后按照各向同性的方式除去一部分覆盖膜，直到残留的所需材料和预先形成了图案的基底表面处于同一高度。因此，所需材料存在于镶嵌于预先形成了图案的基底中的图案中。可以通过刻蚀的方法来实现将所需材料进行的各向同性地去除；一般在制造半导体器件的情况下，通过已知的方法，比如化学机械平面化（CMP）来实现此去除。这就涉及到使用带有化学试剂的粒子浆液，通过化学作用和机械作用的结合，来除去有足够数量的所需材料，镶嵌在有图案的基底中的所需位置上留下了所需材料。这种形成带有图案膜的方法须要使用昂贵的和复杂的平面化设备和额外的消耗材料，包括平面化的垫子、浆液和化学试剂。另外，使用浆液的小颗粒要求这些颗粒以后要从平面化的表面上被除去，这也需要额外的加工步骤。

虽然这些方法中，某一些比另外一些对设备的要求更高，而且在使用溶液，还是使用气相的方法中是不同的，而对于形成金属膜和金属氧化物膜来说，这样的传统工艺都不是最佳的方法，因为比如它们各自都需要昂贵的设备、操作费时间、要求使用高温来达到希望的结果，而且得到的覆盖膜是没有形成图案的，如果须要形成图案，还需要另一个形成图案的步骤。许多这样的方法还具有另外的缺点，在许多情况下会形成多晶膜，对于许多应用，这种膜是不适用的。这些方法的另外一种有希望的方案，是使用一种前驱体材料，此材料可以涂布在基底上，并选择性地形成出影像和图案，无须中间步骤就能够形成无定形的膜。

在半导体加工中膜的一个用途就是形成薄的顶部表面影像层（在后面称为 TSI），一般是一种已经涂布在基底上的有机表层。在此情况下，此有机层无须是光活性的，因为要沉积的膜随后要用常规的方法形成图案。对于 TSI 来说，使用这样的膜赋予加工方法有几个优点，这包括不用光刻胶掩膜就能够提供耐等离子体刻蚀的性能，以及用很薄的膜提供增大的平版印刷的分辨率。对于 TSI 典型的膜包括金属和硅的氮化物和氧化物的膜，对已知是甲硅烷基化的方法已经进行了许多研究。此方法涉及在预先沉积的有机层的表面上有蒸汽沉积的方法沉积含硅化合物的膜。然后可在此含硅化合物膜上形成出影像，形成



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氧化硅膜，在下面的有机层进行氧-等离子体刻蚀图案时，它可作为 TSI 层。由于方法和成本的限制，半导体和封装工业对甲硅烷基化的接受是无关紧要的。

膜在半导体加工中的另一个应用是形成硬掩膜，比如用于离子注入方法中。离子注入(ion implantation)法是公知使用的技术，比如在半导体织构中用于在基底上形成掺杂区(doped regions)。离子注入经常要求带图案的阻隔层，此层已知作为硬掩膜，此膜使待要注入的离子只导向预先确定的区域。比如，在 Shimizu 等人的 US5,436,176 的实施方案 1 中公开了一种在被氧化硅膜覆盖的硅基底上进行无掩膜注入的技术，据公开是用硼原子进行的三次注入。另外同一个专利在实施方案 3 中公开了在三次重复法中使用多重硬掩膜进行注入的方法，此方法依次包括如下步骤：在氧化硅膜覆盖的硅基底上形成掩膜、用含磷化合物进行注入，形成二次掩膜、用硼注入，以及最后进行退火。

正如在前面所讨论的，用这些方法中的任何一种形成硬掩膜都要求比较多的加工步骤。取消在刻蚀或离子注入前的某些步骤将是有益的，因为这将比如简化使用的方法，提高其效率以及降低其成本。

解决此问题的一个办法涉及使用光刻胶作为掩膜。然而，众所周知的是，对某些等离子体的刻蚀化学品，特别是用于有机层形成图案时，光刻胶的耐受性很低，这种有机层可作为中间保护层，或者作为低介电常数（低 K 值）的介电材料和低离子终止能，发现了日益增多的用途。因此，需要难以接受的厚掩膜，使得在遮掩层被完全腐蚀掉以前完成待形成图案的层的刻蚀，或者避免在基底上涂布了掩膜的区域进行了注入。另一个缺点是，被注入了离子的光刻胶非常难以从晶片上除掉。也尝试过用另外的办法解决此问题，比如先涂布一层硬掩膜，然后在硬掩膜的上面再涂布一层光刻胶层，然后在进行刻蚀或离子注入前形成上图案。在等离子体刻蚀或离子注入前，合并现有技术方法中公开的多个步骤中的某一些，或者甚至取消一种或几种，将有助于使这些方法简化。因此，在等离子体形成图案或离子注入方法中取消某些步骤的方法将是我们十分希望的。

作为制造金属和金属氧化物硬掩膜的廉价的方法，开发出了用于金属络合物前驱体沉积的本方法。此方法的一个实施方案，即光化学



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金属有机化合物沉积法，涉及到使用金属络合物前驱体用的金属有机化合物，还涉及把金属有机化合物转化为金属或金属氧化物膜的方法，比如入射的辐射或热能。具体说，在此方法中，比如通过把金属有机化合物的前驱体溶解于适当的有机溶剂形成前驱体溶液，用任何已知的方法将其沉积在表面上，从而就把金属有机化合物前驱体涂布在表面上。然后通过部分转化方法和/或转化方法，比如在能源，如在光、离子束轰击、电子束轰击下曝光或在热处理或退火下曝光就把此前驱体至少部分转化为金属或金属氧化物层。因此，本方法在例如半导体和封装工业中具有用途。

Hill 等人的 US5,534,312 公开了一种在基底上制造带图案的含金属材料的不用光刻胶的方法，该方法包括在基底表面上沉积一层金属络合物的无定形膜、把膜放置在选择的气氛中以及用电磁辐射，优选用紫外线，任选经过掩膜对此膜被选择的区域进行曝光，以引起在此选择区的金属络合物发生光化学反应等步骤。然而，此参考材料没有设想使用带图案的含金属的材料作为硬掩膜来保护底层不受等离子体刻蚀环境的影响。

Thomson 等人的 US6,071,676 公开，其集成电路的制造方法引起所涂布化合物的降解，此时该化合物与辐射或离子束接触。换句话说，发生化合物降解的沉积层的尺度正比于辐射束的聚焦宽度。据公开，此方法可达到纳米级的尺度。在化合物降解之处就形成了金属或其它导体物质的沉积层，然后可使用该方法直接在基底上制造集成电路。据说此沉积层优选是金属或者金属合金，此金属可以是金、锡或者铬，或者此沉积层可以是非金属或半金属导体，比如锗。在另外一方面，提供一种集成电路的制造方法，此方法包括在基底上涂布一种在辐射或离子束作用下会发生降解，得到导体的，优选是金属的沉积层、在该化合物的选择表面区域上照射辐射或离子束，以及从基底上去掉降解的化合物和未受影响的化合物。

本发明的方法能够提供带图案的硬掩膜，以此代替在传统的 TSI 法和离子注入法中使用的氧化物层和光刻胶层，而且通过减少必须进行的加工步骤数简化这些方法。本发明的另一个优点是，得到的材料具有更好的耐受等离子体刻蚀化学品的性能。这还赋予本发明另外一



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个优点，就是允许使用极薄的膜作为掩膜，提高了平版印刷方法的最终分辨率，能够形成更小、更细的印刷外貌。本发明的再一个优点是，得到的材料具有更好的离子注入阻隔性能和终止能。另外，本发明的方法在如下方面是有利的，即使得能够将新材料用于形成图案层，比如用铂、铱、氧化铱、钌和氧化钌，已知在现有技术中这些材料是很难或者根本不能用传统方法刻蚀的。

## 发明概述

本发明的一个实施方案是在一个基底上形成硬掩膜的方法，该方法包括如下的步骤：

—选择至少一种前驱体材料；

—在基底的顶部形成含有该前驱体的一层；

—覆盖至少一部分该前驱体层；

—给该前驱体层显影，由此在该前驱体层上形成图案；以及

—将该图案转移到基底上，因此在形成图案时就不使用光刻胶。

可以用显影剂把前驱体层的未转化部分显影而去掉。另外，也可以用显影剂把前驱体层的转化部分显影而去掉。显影剂可以是含有至少一种醇和至少一种酮的液体显影剂，其中全部醇的总体积大于在此液体显影剂中所存在的所有醇的体积加上所有酮的体积总和的 50%。此显影剂的至少一种醇优选是异丙醇，至少一种酮优选是甲基异丁基酮，异丙醇和甲基异丁基酮的体积比大于大约 1:1，而小于大约 40:1。

本发明的另一个实施方案是在基底上形成硬掩膜的方法，该方法包括如下的步骤：

—选择至少一种前驱体材料；

—在基底顶部任选地形成一层保护层；

—在该保护层上形成含有未转化前驱体的一层；

—将至少部分未转化前驱体层进行部分转化；

—基本上去掉至少部分未转化前驱体层，形成图案；以及

—将至少一部分部分转化的前驱体层进行转化，形成硬掩膜。

可以用选自光、电子束辐照、离子束辐照和它们的组合的能源，经过包括至少一部分对此能源基本上是透明的带图案掩膜来实现部分



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转化。使用显影剂可以基本上去掉至少部分未覆盖的前驱体层。可以用选自光、电子束辐照、离子束辐照、热退火和它们组合的能源来实现转化。

本发明的再一个实施方案是一种在基底上形成刻蚀图案的方法，该方法包括如下步骤：

—选择至少一种前驱体材料；

—在基底的顶部形成含有未转化前驱体的一层；

—将至少一部分未转化的前驱体层进行部分转化；

—基本上去掉至少一部分未转化前驱体层；

—通过把至少一部分的部分转化的前驱体层进行转化，形成硬掩膜；以及

—通过刻蚀至少部分基本上被硬掩膜覆盖的基底，在基底上形成至少一个图案区。

本发明的又一个实施方案是形成带图案薄顶表面的方法，该方法包括如下步骤：

—选择至少一种含有金属络合物的前驱体材料；

—在基底的顶上形成图案转移层；

—在图案转移层的顶上形成含有未转化前驱体的一层；

—通过包括至少一部分对光基本上透明的部分的带图案掩膜使一部分未转化前驱体层曝光，由此将该曝光部分进行转化；

—基本上去掉至少一部分未转化前驱体层，由此去掉至少一部分图案转移层的覆盖；

—通过将至少一部分的部分转化前驱体层进行转化来形成硬掩膜；

—对至少部分转化的前驱体和图案转移层的未覆盖的部分进行刻蚀，由此从未覆盖的图案转移层形成至少一个刻蚀部分；以及

—基本上去掉剩下的至少部分转化的前驱体层和图案转移层，由此暴露至少一部分基底。

此图案转移层可选自光刻胶、聚酰亚胺、聚甲基丙烯酸甲酯、线型酚醛树脂和环氧树脂。

本发明的另外一个实施方案是在揭起层上形成带图案薄顶表面的



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方法，此方法包括如下步骤：

—选择至少一种含有金属络合物的前驱体材料；

—在基底顶上形成一个隔离层(release layer)；

—在隔离层的顶上形成一个揭起层；

—在此揭起层的顶上形成一层含有未转化前驱体的层；

—通过一个图案掩膜使一部分未转化前驱体层曝光，此掩膜包括至少一部分对光是基本上透明的，由此把曝光部分进行部分转化；

—基本上除去至少一部分未转化前驱体层，由此使至少一部分揭起层曝露出来，而其余部分揭起层被部分转化的前驱体层所覆盖；

—通过将至少一部分的部分转化的前驱体层进行转化来形成硬掩膜；

—使至少部分转化的前驱体和揭起层的暴露部分经受各向异性去除步骤(mean)，由此基本上除去揭起层的曝露部分和至少一部分在揭起层曝露部分下面的隔离层，曝露出至少一部分基底；

—将至少部分转化的前驱体、揭起层的覆盖部分和至少一部分在揭起层覆盖部分底下的隔离层经受各向同性去除方法(mean)；

—在至少一部分曝露的基底顶上和至少部分转化的前驱体顶上沉积上金属膜；

—基本上除去在至少部分转化的前驱体顶上的金属；以及

—基本上除去残留的至少部分转化的前驱体、揭起层和隔离层，由此在基底顶上形成金属图案。

本发明的另外一个实施方案是在揭起层的上面形成带图案薄顶表面的方法，该方法包括如下步骤：

—选择至少一种含有金属络合物的前驱体材料；

—在基底顶上形成含有未转化前驱体材料的一个层；

—将至少一部分未转化前驱体层进行部分转化；

—基本上除去至少一部分未转化前驱体层，由此在部分转化的前驱体部分形成向里具有锥度的侧壁轮廓并曝露至少一部分基底；

—通过转化至少一部分部分转化的前驱体层来形成硬掩膜；

—在至少一部分曝露的基底上和至少部分转化的前驱体顶上沉积上金属膜；



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—基本上除去在至少部分转化的前驱体顶上上的金属；以及

—基本上除去残留的至少部分转化的前驱体，由此在基底顶上形成金属的图案。

本发明的另一个实施方案是一种在基底上形成注入区的方法，该方法包括如下步骤：

—选择至少一种前驱体材料；

—任选地在基底顶上形成一保护层；

—在此保护层的顶上形成一含有至少一种未转化前驱体材料的层；

—通过把至少一部分未转化前驱体层进行部分转化，形成一部分部分转化的前驱体层；

—通过使用显影剂，基本上除去至少一部分未转化前驱体层；

—通过把至少一部分部分转化的前驱体层进行转化，形成硬掩膜；

—通过在至少一部分基本上没有被硬掩膜覆盖的基底上注入离子，在基底上形成至少一个注入区。

可以用选自光、电子束辐照、离子束辐照和它们的组合的能源，通过包括至少一个对这些能源透明部分的带图案掩膜来实现部分转化。可以用选自光、电子束辐照、离子束辐照、热退火和它们组合的能源来实现转化。可通过将未覆盖的基底曝露在离子束下来进行离子注入。

本发明还有一个实施方案是在一个介电层中形成双重波纹构筑(damascene architecture)的方法，此方法包括如下步骤：

—选择至少一种前驱体材料；

—在基底顶上形成具有特征厚度的介电层；

—在此介电层的顶上形成一个含有第一未转化前驱体的层；

—对至少一部分未转化的第一前驱体层使用第一部分转化方法(mean)，形成部分转化的第一前驱体层部分；

—使用第一除去方法基本上除去至少一部分第一未转化前驱体层，曝露出至少一部分介电层，形成没有被至少部分转化的第一前驱体层覆盖的第一图案；

—对至少一部分部分转化的第一前驱体层使用第一转化方法，形



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成硬掩膜；

—在介电层曝露部分的顶上和在至少部分转化的第一前驱体层的顶上形成旋转平面化层；

—在旋转平面化层的顶上形成含有第二未转化前驱体的一个层；

—通过对至少一部分第二未转化前驱体层使用第二部分转化方法，形成一部分部分转化的第二前驱体层；

—通过使用第二除去方法，基本上除去至少一部分第二未转化前驱体层，曝露出至少一部分旋转平面化层，形成没有被至少部分转化的第二前驱体层覆盖发第二图案；

—通过对至少一部分部分转化的第二前驱体层使用第二转化方法，形成硬掩膜；

—通过对至少一部分介电层和在其底下基本上没有被第二硬掩膜覆盖的旋转平面化层使用第一刻蚀方法，在介电层中形成至少一个图案区，使得第一刻蚀方法在深度方向上去掉比厚度小的一层介电层；

—通过使用第三去除方法，基本上除去残留的至少部分未转化第二前驱体层和旋转平面化层，由此曝露出至少部分转化的第一前驱体层；

—通过对至少一部分基本上没有被第一硬掩膜覆盖的介电层使用第二刻蚀方法，在介电层中形成至少一个第一图案区，使得在第一图案区中，通过第二刻蚀方法在介电层的深度方向上去掉比厚度小的一部分；还使得在第二图案区中，用第二刻蚀方法基本上在深度方向除去整个厚度的介电层，由此使至少一部分基底去掉覆盖，以及

—任选地，通过使用第四去除方法，基本上除去残留的至少部分转化第一前驱体层。

此介电层优选是低介电常数的介电材料。第一和第二刻蚀方法中至少一种优选是含氧的各向异性等离子体。

在这些实施方案中的每一种当中，优选的前驱体材料是含有至少一种配位体和至少一种金属的金属络合物，这些配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸基、胺、卤素基、硝基和它们的混合物；而金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、



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La、Pr、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

## 附图概述

图 1 是一个方法流程图，该图把方法的步骤看作是方法的变量；

图 2 说明在本发明方法的一个实施方案中的步骤的基本顺序；

图 3 说明现有技术的制造方法以及在半导体接插件中使用的硬掩膜的用途；

图 4 说明按照本发明的制造方法和硬掩膜的用途；

图 5 说明用 TSI 形成图案的现有技术；

图 6 说明按照本发明的制造方法和 TSI 层的使用；

图 7 说明实施揭层方法的现有技术方法；

图 8 说明按照本发明实施揭层的方法；

图 9 说明按照本发明实施揭层的另一种方法；

图 10 说明用于双波纹方法集成的现有技术的方法；

图 11 说明按照本发明用于双波纹方法集成的方法，此方法的步骤比图 10 的方法更少；

图 12 说明制造离子注入硬掩膜和使用其注入离子的现有技术方法；

图 13 说明按照本发明的一个实施方案制造离子注入硬掩膜和使用其进行离子注入的现有技术方法；

图 14 显示由两种不同前驱体形成的 $ZrO_2$ 膜显示出的不同折射率性能；

图 15 显示通过热转化和光化学转化形成的不同 $ZrO_2$ 的折射率；

图 16 描述由在基底上涂布前驱体溶液后使用特殊溶剂引起的条纹；

图 17 显示对于 BST 的热对比曲线；

图 18 显示对于 BST 的光化学对比曲线；

图 19 显示对于 BST 的热/光化学组合对比曲线；

图 20 是对于线形酚醛树脂的厚度对刻蚀时间的图；

图 21 是对于完全转化的 PZT 和 $TiO_2$ 的厚度对刻蚀时间的图。



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本发明的详细说明

本方法考虑到其它膜沉积和制造方法所不可能得到的优点。结果，使用户具有更强的控制和操纵所得到的膜，使之适应所需应用的能力。因此，本方法可用于广泛的应用中。

本发明提供一种制造所需材料的带图案膜的方法。重要的是要认识到无定形的膜与多晶膜和结晶膜的区别，同时要认识到无定形膜和更有序的膜的区别，此外还要认识到用不同成膜方法得到的无定形膜彼此是不同的。再有，由不同方法形成的不同无定形膜的不同性能可以得到控制，而且会造成可用于特定应用中的特殊化学、物理和机械性能，比如，作为半导体器件和/或其制造中的各种层。通过包括至少一个转化这样的无定形膜的步骤的本方法形成的硬掩膜优选是带有图案的，因此可用于把图案转移到基底上。硬掩膜包括但不限于注入掩膜、刻蚀掩膜和图案转移层或掩膜，比如揭起掩膜。

本方法实施方案的一个优点是，在形成图案时，它用不着使用传统的形成图案的材料，即光刻胶就能产生带图案的电子材料。本方法的另一个优点是，可以形成的前驱体材料的无定形膜可任选地直接在基底上形成图案，用不着使用中间的形成图案的材料。作为理解本发明实施方案的结果，可得到重要的和独特的性能，尽管此沉积方法没有使用其它的沉积和形成膜的方法。图 1 用流程图提供了本方法的总体情况，此流程图显示出作为例子的各个步骤，用这些相继的步骤得到对特定应用具有最佳性能的所需材料膜。这些步骤当中有许多都是可根据膜的最终应用而任意选择的。本发明也不限于这些步骤，根据膜的最终用途，可以包括另外一些步骤。本领域的专业人员都会知道，为了达到特定应用的希望的结果，哪些步骤应该包括，哪些不应该包括。

在每一步骤中都存在着不同的选择方案，操作这些选择方案都会对得到的膜有所影响。比如，在图 1 的步骤 1 中，选择方案可以包括前驱体材料的组成、在此前驱体材料中使用的溶剂，不管在此前驱体材料中是否使用溶剂，在前驱体材料中可以使用的添加剂和/或可以在此前驱体材料中包括的增强剂(rate enhancer)。



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在图 1 的步骤 2 中，选择方案可以包括基底的清洗、阻隔层的沉积、粘接促进剂的沉积和/或使用活性层。

在图 1 的步骤 3 中，选择方案可以包括涂布前驱体膜的方法、涂布前驱体时的气氛和/或沉积温度。

在图 1 的步骤 4 中，选择方案可包括热处理、用电子束进行的处理、用离子束进行处理、用微波进行处理和/或使用特殊的气氛。

在图 1 的步骤 5 中，选择方案可包括此膜是覆盖的、曝露的还是带有图案的，或者是彼此混合的，和/或使用特定的气氛。

在图 1 的步骤 6 中，选择方案可包括热退火、使用微波处理、用电子束处理、用离子束处理、电镀和/或使用特定的气氛。

在图 1 的步骤 7 中，选择方案可包括是使用湿技术还是干技术形成图案。

在图 1 的步骤 8 中，选择方案可包括退火和/或使用特定的气氛。在此步骤中，形成的任何无定形膜也可以通过例如应用高温或各种其它成核技术，如光诱发成核转化为多晶或结晶膜，而且对于某些应用，这可能是一个特别希望的步骤。

这些选择方案都是举例的性质，都不是可以操作以影响所得到膜性能的选择方案的穷举性清单。下面将详细叙述本发明的特定的特征和实施方案。

当需要带图案的膜时，在这里叙述的方法可以按光化学的方方式进行，用不着中间形成图案的材料，比如光刻胶，可以在环境条件下进行，也可以在另外的条件下进行，比如在空气或其它组成的气氛中和/或在不同的压力下，比如在环境压力、高于或低于环境压力下，可以结合使用其它的加工步骤，都产生唯一的材料、层和结构。

当按照光分解的方式实施此方法时，此方法基本在环境温度下实施，而其它的现有技术方法则要求使用高温来进行图案转移，此温度经常高于 100℃。从制造的观点出发，此限制赋予了严格的加工上的制约，限制了应用这些方法有关的器件组装时对使用材料的选择。

在基本上是环境压力下，本发明的方法一般可以满意地进行。反之，许多现有技术的沉积方法，除了具有上述限制以外，必须在高真空下进行，要使用难以运行和维护的昂贵而复杂的设备。



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本发明的方法使得能够很容易在基底上由前驱体材料形成薄层。此前驱体含有专门设计的分子，使其能够在基底上均匀地涂布，得到的膜具有很高的光学性能，在本方法的情况下，就是有很高的光敏感度。前驱体分子的特性是很不同的—各种各样的通式为 $M_aL_b$ 的金属络合物，含有至少一种金属（M）和至少一种或几种适当的配位体（L），即 a 和 b 都是至少为 1 的整数，这样的金属络合物是本发明所设想的。

如果使用多种金属，所有的金属原子可以是一样的，也可以不都是一样原子的和/或具有不同价，比如 BaNa Fe（II）Fe（III），或者一些是一样的，而另外一些是不一样原子的和/或具有不同的价，比如 $Ba_2Fe$（II）Fe（III）。在任何情况下，金属 M 可以是碱金属或碱土金属，比如 Ba 或 Li、过渡金属，比如 Cr 或 Ni、主族金属，比如 Al 或 Sn 或锕系元素，比如 U 或 Th。优选每个金属独立地选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce 和 Mg。

如果使用多种配位体，所有的配位体可以是一样的，也可以是不同的，或者一些是一样的，而另一些是不同的。在任何情况下，选择配位体都要使得可以形成基本上未转化的前驱体络合物，并具有如下的性能：

1）可以以无定形的形式沉积在基底上；

2）无定形的膜是稳定的，或者至少是亚稳定的；

3）在吸收能量，例如所需能量的光子时，通过化学反应，此膜可转化为不同的含金属的材料，以及

4）任何由能量诱发的化学反应的副产物应该是可以除去的，即应该有足够的挥发性，使得能够从膜中除去。

为了得到这些结果中的前两个，此络合物应该具有低的极性和低的分子间力。由于有机基团一般具有低的分子间力，在其外周具有有机基团的配位体倾向于满足前两个要求。如果吸收的能量是光，已知步骤（3）的化学反应就是光诱导反应。

基本上未转化前驱体的沉积膜是无定形的，或者至少是基本上无定形的。因此，为了制造阻碍结晶的金属络合物，配位体 L 优选使得



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络合物成为不对称的。使用本身具有两个或多个立体异构形式的配位体就能够把络合物制成不对称的。例如，如果 L 是外消旋的 2-乙基己酸根，得到的金属络合物就是不对称的，因为此络合物具有几种不同的立体异构形式。可以选择配位体有机部分的尺寸和形状，使膜的稳定性达到最佳，并调节了通过选择的膜沉积方法所沉积的膜的厚度。

通过制造在每个金属原子上连接着几个不同配位体的络合物膜，也可以增强无定形膜对结晶的稳定性。这样的金属络合物具有几种异构体的形式。例如 $CH_3HNCH_2NHCH_3$ 与镍盐（II）和 KNCS 的混合物反应导致产生各种异构体的混合物。已知不同异构体的化学性能是明显不同的，在膜中有几种异构体存在就削弱了膜中络合物结晶的能力。

络合物必须是稳定的，或者至少是亚稳定的，意思是在此方法的条件下，络合物将不会迅速而自发地分解。对于给定金属络合物的稳定性可能取决于例如在络合物中的金属氧化态。例如已知在空气中 Ni（0）络合物是不稳定的，而 Ni（II）络合物在空气中是稳定的。因此，用于包含有在空气中加工步骤的沉积 Ni 基膜的方法，就应该包括优于 Ni（0）络合物的 Ni（II）络合物。

部分转化和转化是由在膜中的化学反应造成的，这将把部分转化区或转化区变成所需的转化材料。按照理想的方式，至少一个配位体与络合物反应并通过键连接，在络合物受到部分转化方法和/或转化方法的影响而产生激发状态时，该键裂解。在通过光，更优选通过紫外线作为部分转化方法和/或转化方法所引发的光化学反应中，优选从络合物上切下活性基团。为了使方法中这样的光化学步骤更加有效，特别优选中间产物在活性基团被切断而成为不稳定并自发转变为所需的新材料和挥发性副产物时产生。

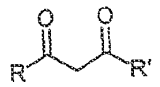
有几种可以发生适当光化学反应的机理。按照本发明可以单独或组合操作的适当反应机理的例子如下：（a）吸收光子可把络合物置于配位体-金属电荷转移的激发态，在此状态下，金属络合物中的金属-配位体键是不稳定的，键断裂并且络合物的余下部分自发分解；（b）吸收光子可把络合物置于金属-配位体电荷转移激发态，在此状态下，络合物中的金属-配位体键是不稳定的，键回断裂，且络合物的剩下部分自发分解；（c）光子的吸收可把络合物置于 d-d 激发态，在此状态下，



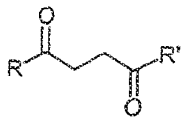
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络合物中的金属-配位体键是不稳定的，键断裂而络合物的余下部分自发分解；（d）吸收光子可把络合物置于分子内电荷转移激发态，在此状态下，络合物中的金属-配位体键是不稳定的，键断裂而络合物的余下部分自发分解；（e）吸收光子可把络合物的至少一个配位体置于局部配位体激发态，激发的配位体和络合物之间的键是不稳定的，键断裂而络合物的余下部分自发分解；（f）吸收光子可把络合物置于分子内电荷转移激发态，使得络合物的至少一个配位体是不稳定的，而且发生分解，然后络合物剩下的部分是不稳定的并自发分解；（g）吸收光子可把络合物的至少一个配位体置于局部化配位体激发态，其中受激发的配位体是不稳定的，并且发生了分解，然后络合物剩下的部分是不稳定的，并自发分解；以及（h）吸收光子可把络合物置于金属-配位体电荷转移激发态，在此状态下，络合物的至少一个配位体是不稳定的，并发生分解，然后络合物的剩下部分是不稳定的，并自发分解。然而，在本发明的广泛特征上，构成本发明并不限于这些反应机理。

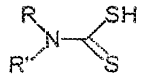
作为例子，在 US 5,534,312 中叙述了金属络合物及其金属和配位体组分，该专利整体在该引做参考。优选的金属络合物前驱体包括符合上面标准的各种配位体。更优选的配位体选自乙酰丙酮化物（已知还叫做 acac 或 2,4-戊二酮）及其阴离子、取代的乙酰丙酮化物，即：



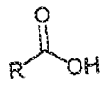
及其阴离子，丙酮基丙酮（已知也叫做 2,5-己二酮）及其阴离子、取代的丙酮基丙酮，即：



及其阴离子、二烷基二硫代氨基甲酸酯，即：



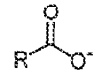
及其阴离子、羧酸，即：



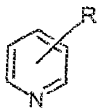


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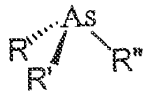
例如己酸，这里 R=$CH_3(CH_2)_4$，羧酸根，即：



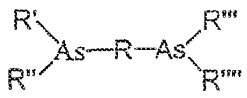
例如己酸根，这里 R=$CH_3(CH_2)_4$、吡啶和/或取代的吡啶，即：



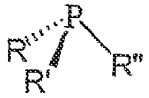
叠氮化合物，即 $N_3^-$、胺，即 $RNH_2$、二胺，例如 $H_2NRNH_2$、肼，即：



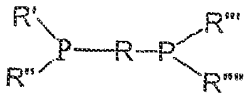
二肿，即：



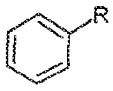
膦，即：



二膦，即：



芳烃，即：



羟基，即 $OH^-$、烷氧基配位体如 $RO^-$，配位体如$(C_2H_5)_2NCH_2CH_2O^-$、



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烷基配位体如 R–、芳基配位体和它们的混合物，这里每个 R、R'、R"、R"'和 R""独立地选自有机基团，优选独立地选自烷基、烯基、芳烷基和芳烯基。

正如在本文中使用的，术语“烷基”指的是直链或分支的烃链。正如在本文中使用的，直链烃链或分支烃链意味着任何取代的或未取代的非环含碳化合物，包括烷烃、烯烃和炔烃。烷基的例子包括低级烷基，如甲基、乙基、正丙基、异丙基、正丁基、异丁基、叔丁基或异己基；高级烷基，例如正庚基、辛基、异辛基、壬基、癸基等。低级烯烃例如乙烯、丙烯、丙炔、丁烯、丁二烯、戊烯、正己烯或异己烯；以及高级烯烃，例如正庚烯、正辛烯、异辛烯、壬烯、癸烯等。一般专业人员都熟悉许多直链的，即线形的和分支的烷基，它们都在本发明的范围内。此外，这样的烷基还含有各种取代基，其中一个或几个氢原子被官能团或链内(in-chain)官能团取代。

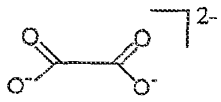
正如在本文中使用的，术语“烯基”指的是其中至少一个碳-碳键是碳-碳双键的直链或分支的烃链。正如在本文中使用的，术语“芳烷基”指的是其端部被至少一个芳基取代的烷基，例如苄基。正如在本文中使用的，术语“芳烯基”指的是其端部被至少一个芳基取代的烯基。正如在本文中使用的，术语“芳基”指的是具有共轭双键系统，经常包括至少 6 个 π 电子的环烃。芳基的例子包括但不限于苯基、萘基、茴香基、甲苯基、二甲苯基等。

如相关领域的专业人员所理解的，在本发明的文字中，术语“官能团”普遍指的是具有链内的、侧键的和/或端部官能团的部分。作为链内官能团的例子可以举出酯、醚、酰胺、氨基甲酸酯及它们的硫代衍生物，即其中有至少一个氧原子被硫原子替代。作为侧键和/或端官能团的例子，可以举出卤素、例如氟和氯以及含氢的基团，如羟基、氨基、羧基、巯基和酰胺基、异氰酸酯基、氰基、环氧基和烯键式不饱和基团，例如烯丙基、丙烯酰基和甲基丙烯酰基以及马来酸根和马来酰亚胺基。

为了加强所需的光化学特性，包括光化学反应产物自发热分解的倾向，可以单独或与上面列出的配位体一起使用含有和/或选自下面的一个或几个基团的配位体：氧代，即 $O_2^-$、草酸根，即：



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卤化物、氢、氢化物，即 $H^-$、二氢化物，即 $H_2$、羟基、氰基，即 $CN^-$、羰基、硝基，即 $NO_2$、亚硝酸根，即 $NO_2^-$、硝酸根，即 $NO_3^-$、亚硝基，即 NO、乙烯、乙炔，即

R≡R'

硫氰酸根，即 $SCN^-$、异硫氰酸根，即 $NCS^-$、水合，即 $H_2O$、叠氮、碳酸根，即 $CO_3^{-2}$、胺和硫代羰基，这里每个 R 和 R'独立地选自有机基团，优选独立地选自烷基、烯基、芳烷基和芳烯基。每个配位体甚至更优选选自乙酰丙酮化物、羧酸根、烷氧基、草酸根、叠氮基、羰基、硝基、硝酸根、胺、氢及它们的阴离子。

优选地，金属络合物前驱体选自含有至少一个配位体和至少一个金属的络合物，其中该配位体选自乙酰丙酮化物、羧酸根、烷氧基、叠氮基、羰基、硝酸根、胺、卤素、硝基和它们的混合物；其中金属选自 Li、Al、Si、Ti、V、Cr、Mn、Fe、Ni、Co、Cu、Zn、Sr、Y、Zr、Nb、Mo、Ru、Rh、Pd、Ag、In、Sn、Ba、La、Pr、Sm、Eu、Hf、Ta、W、Re、Os、Ir、Pt、Au、Pb、Th、U、Sb、As、Ce、Mg 和它们的混合物。

前驱体可以直接涂布在基底上。另外也是优选地，可以把前驱体溶解于一种或几种溶剂形成前驱体溶液。这样使得可通过各种本领域专业人员公知的方法，很容易地涂布到基底上，例如把溶液旋涂或喷涂到基底上。可以根据几个单独或组合的标准来选择溶剂，这包括溶剂溶解前驱体的能力、溶剂对前驱体的惰性、溶剂的粘度、氧或其他环境或其他气体在溶剂中的溶解度、溶剂的紫外线、可见光和/或红外线的吸收光谱、溶剂相对于电子束和/或离子束的吸收截面、溶剂的挥发性、溶剂通过随后形成的膜的扩散能力、溶剂相对于存在的不同溶剂异构体的纯度、溶剂相对于存在的金属离子的纯度、溶剂的热稳定性、溶剂对随后形成的膜中缺陷点或成核点产生影响的能力、涉及溶剂的环境考虑。溶剂的例子包括烷烃，例如己烷、酮类，例如甲基异丁基酮(MIBK)和甲乙酮(MEK)以及丙二醇但甲醚醋酸酯(PGMEA)。



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溶液内前驱体的浓度可以在很宽的范围内变化，可由本领域的专业人员通过尽可能少的常规实验进行选择，使得包括其厚度和/或对光或粒子束辐照的敏感度在内的前驱体膜的性能符合所需的应用。

然而，对前驱体的选择对所需膜的性能可能有明显的影响，是本领域的专业人员不容易预测的。例如，两个前驱体 ML 和 ML'，每个都由金属 M 和两组不同的配体 L 或 L'中的一个组成，预期它们可形成相同的所需材料的膜，因为例如在该前驱体转化为硬掩膜的过程中，彼此不同的配位体部分将被去掉。实际上，这两个类似试剂假设相同的膜产物在其性能上可能有明显的不同。在该方法中可能被影响的性能的例子包括介电常数和在膜中有/无任何次级或三级结构存在。该差别可能的原因可以涉及无定形材料的形成速度和光逐出配位体从所需材料光致生成膜中除去能量的能力。在曝光过程中有配位体片段的存在可以影响成膜的方法，对例如膜的扩散性能、成核和晶体生长等现像造成影响。

再有，在成膜和光化学曝光时对前驱体的选择可能对所需材料膜对形成所需膜所处的气氛的气体组分的活性产生进一步的影响。这可能会影响到例如所沉积膜的氧化速度，而根据所需产物不同，高速度或低速度都可能是优点。另外，也认识到，通过选择前驱体可能对膜的复原能力，即尽可能减小裂纹的能力和收缩或致密化能力会有基本上的影响，而本领域的专业人员则会看到不同前驱体会产生同样的结果。

在前驱体或前驱体溶液中任选存在着化学添加剂。这可以是出于如下原因中的任何一个或几个：控制随后沉积的前驱体或膜的光敏感性、有助于在基底上沉积出均匀的、没有缺陷的膜、改变溶液的粘度、加大成膜速度、有助于避免在随后的曝光过程中膜开裂、改变溶液的其它整体性能以及以重要的方式改变所需材料膜的性能。除了在选择适当的溶剂时使用的标准以外，要按照这些标准来选择添加剂。优选该前驱体或前驱体溶液基本上不含有颗粒污染，以增强其成膜性能。

对该方法来说，将要涂布前驱体的基底的性质并不是关键的，虽然这会影响前驱体膜的沉积方法和沉积用的溶剂（如果使用的话）。基底可以包括但不限于简单盐，例如 $CaF_2$、半导体表面，包括硅、化合



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物半导体，包括硅-锗和 III-V 和 II-VI 半导体、印刷和/或层压电路板基底、金属、陶瓷和玻璃。硅晶片、陶瓷基底和印刷电路板已经得到普遍应用。在将它们使用于本方法之前，基底可以涂布上单层或多层涂层，例如介电层、光刻胶、聚酰亚胺、金属氧化物、热氧化物、导体材料、绝缘材料、铁电体材料或在电子器件的结构中使用的其它材料。在用氧等离子体进行形成图案，以及把前驱体材料用做 TSI 试剂的情况下，底层适合是有机材料，包括但不限于线形酚醛树脂、聚甲基丙烯酸甲酯（PMMA）、聚甲基戊二酰亚胺（PMGI）、聚酰亚胺和聚对羟基苯乙烯（PHOST）。

一旦形成了硬掩膜，其中的金属原子在一定程度上会在随后的步骤中“撞”到底下的基底上，这可通过仔细选择前驱体的配方条件和/或厚度加以克服。另外，可以在基底和前驱体层之间使用任选的保护层，在硬掩膜形成工艺完成以后，它仍然可以对基底构成保护。在涂布前驱体或前驱体溶液以前，基底上可任选涂布至少一层保护层。可以用本领域专业人员公知的各种方法在基底上涂布该保护层。当该方法包括离子注入步骤时，特别希望该保护层。

在沉积前驱体膜之前制备该基底对所需的硬掩膜的最终性能可能具有明显的影响。因此，例如某些表面性能可以是需要的，反之可能是须要避免的，这取决于所用的特定硬掩膜。基底制备可包括简单的清洗过程，以从基底表面上除去不希望的物质，在形成图案步骤之前，沉积阻隔材料、沉积粘接促进材料或沉积活性材料，用于诱发在所沉积材料膜中的化学变化，例如偶联剂。

前驱体或前驱体溶液的涂布方法可根据基底的情况和打算的应用情况进行选择。为本领域专业人员公知的可用的涂布方法的某些例子包括旋涂、喷涂、滴涂和辊涂、压印、弯月面式涂布和各种油墨印刷方法，例如喷墨(inkjet-type)的方法。可以选择涂布方法的各种变量以控制所沉积膜的厚度和均匀度，尽可能减小边缘效应并减少在膜中形成空隙或针孔，并确保在涂布过程中消耗的前驱体或前驱体溶液体积不比需要的更多。用最佳方法涂布前驱体膜会按照希望得到很光滑的膜。

沉积好的膜，任选经受烘烤或真空的步骤，在这些步骤中，在沉



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积膜中残留的任何溶剂都可被驱赶掉。当然，如果使用烘烤的步骤，重要的是要保持该步骤的温度低于前驱体分子的热分解温度。本发明的方法允许对前驱体浇注膜进行热覆盖或热处理或退火，以便通过热将其转化为所需材料的均匀覆盖涂层或者膜，其较不用热处理时转化为用于形成图案的部分转化和/或转化的剂量可能更少膜。在该加工步骤中，沉积的膜可任选地经受其它处理，包括但不限于覆盖式光化学曝光或电子束曝光和微波处理。

已经认识到在本方法步骤中的烘烤步骤可以有助于从前驱体膜中排出溶剂，也引起热分解过程。这两种机理都有助于本方法的总体效果，导致例如在随后的部分转化和/或转化步骤中降低所需的剂量。进一步还认识到，在这样的烘烤步骤中，可以形成与沉积的膜或所需材料的膜都不同的新材料。其效果可能明显地改变所需材料以后的性能，这包括介电常数、成核性能、形成材料晶种的性能以及结晶性能，这都是本领域的专业人员不容易预见的。例如在某些应用中，优选使用一种双组分系统，其中一种材料在预烘烤步骤中被活化，而选择另一种化合物得以光化学或高能热方法活化。从前驱体混合物中进行沉积将使得能够有效地设计一个系统，该系统具有由烘烤和随后的部分转化和/或转化步骤形成的材料的不同化学性能的优点。

然后将沉积好的膜经受部分转化和/或转化，即能源的作用，使得该前驱体至少被部分转化。沉积好的膜的整体或者选择的部分可以对能源进行曝光。该能源可以是例如特殊波长的光源、特殊一段或几段波长的相干光源、宽带光源和电子束（e-束）源或离子束源。波长范围为大约 150~大约 600nm 的光是适合于使用的。优选的光波长是大约 157~大约 436nm。

在本发明的某些实施方案中，能源是通过用来在表面上界定影像的光学掩膜而定向的光源。该掩膜由基本上透明和基本上不透明的或光吸收区域构成。该掩膜还可以包括光学增强特征，例如相位移技术。然而，该能源无须一定要通过掩膜照射。例如如果给材料形成图案不是必须的，就可以使用漫射或覆盖式的能源进行曝光，由热能能源或宽的光束来提供曝光能源。

在其中使沉积膜进行至少部分转化的气氛和压力（既包括总压，



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也包括分压）可以是重要的方法参数。一般说来，作为是空气的气氛是适宜和经济的，但在至少部分转化的过程中，改变气氛的组成可能是优选的。这样做的一个原因是，如果使用短波的光，可以增大曝光光的透过率，因为空气可能削弱这样的光。因此，通过改变光的强度，例如增强光，就能够在膜中引发热反应，产生产物膜。也可能希望改变气氛的组成来改变产物膜的组成或性能。例如，在空气或氧气氛中对铜络合物曝光会导致产生氧化铜。通过从气氛中基本上除去氧，可以形成主要由还原的铜组成的膜。例如如果转化的前驱体必须是介电膜，优选在氧存在下进行部分转化或转化步骤，或者如果转化的前驱体必须是金属膜，就优选在还原性气体，例如氢存在下进行部分转化或转化步骤。另外，通过改变气氛中的湿度，可以改变膜中水的含量。

使用部分转化步骤或者已知也称为“基底预处理”的不同的依次进行的多个步骤，从工艺流的观点出发可以是有利的，例如使在昂贵的设备，例如步进器中，在基底顶上的前驱体进行曝光所需的时间尽可能短。

在沉积好的膜进行至少部分转化之后，前驱体膜可任选地被本领域已知的各种方法中任何一种进行处理，然后再除去至少一部分未转化的前驱体层。这些方法包括但不限于退火处理，例如热退火、激光退火或等离子体退火的步骤、曝露在特殊气氛中，例如氧化性或还原性气氛、离子注入、微波处理和电子束处理。如果部分转化的区域可以作为对前驱体未转化区无电电镀的成核点，在该步骤中可以使用任选的电镀步骤。

然后可以通过使用去除方法（或显影）除去沉积膜的未曝光区或部分未曝光区。例如，显影方法可以包括显影组合物，可将其作为液体或溶液以浆液显影法(puddle development)或浸渍湿法显影法进行涂布。另外，可以使用与半导体工业传统上使用的干法形成图案方法相类似的干法显影法作为显影方法。优选的去除方法包括喷雾显影法、浆液显影法和浸渍湿法显影法。

显影剂的配方和/或使用条件应该使得在膜的已曝光区和未曝光区之间存在着溶解度的差别。用该溶解度上的差别来除去膜的优选选择的区域，使得膜的某些选定区域被显影剂基本上去掉，而希望在基底



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上保留的区域基本上完整地保留下来。可以需要相当多的实验来优化显影剂的配方。例如，在一个希望把已对入射能曝光的区域在基底上保留下来的方法中，在对入射辐照曝光后使用浇注溶剂(casting solvent)对膜显影是太具有侵蚀性的。提供浇注溶剂在另一种液体中的稀溶液用于改进的显影方法，在该另外的液体中，（a）与浇注溶剂是可混溶的；（b）膜的未曝光区是微溶的（但无须完全溶解）；（c）膜的曝光区是基本上不溶的。

例如，在本发明的一个优选实施方案中，可以由酮类溶液浇注出无定形的膜。只使用酮作为显影剂，或者使用富含酮的醇-酮混合物，即含酮高于 50vol%的混合物，会导致比醇作为主要成分的显影剂效果更差的显影方法。例如 10:1（v/v）的 IPA:MIBK 溶液对于 $Ba_xSr_yTi_zO_3$（BST）是比单用 MIBK 或 1:1（v/v）的 IPA:MIBL 更为有效的显影剂，这里 IPA 表示异丙醇。10:1 的混合物本身不如 20:1 的 IPA:MIBK 有效。然而，无论 10:1，还是 20:1 的溶液都比 40:1（v/v）的 IPA:MIBK 更为有效。再有，这些溶液的相对效果与在形成带图案膜时使用的其它方法有很密切的关系，这包括例如入射辐照的类型和能量以及在涂布和形成图案的过程中的基底温度等。因此，为本发明确定适当的显影剂配方须要进行实验，对本领域的普通专业人员来讲并不是显而易见的。例如可以用与如上所述的光刻胶基方法中使用的显影方法相类似的方式，以物理方式涂布液体和/或溶液基的显影剂。

在显影以后，至少部分转化的前驱体可以任选地被本领域专业人员公知的各种方法中任何一种进行处理，然后再经受转化方法。这些方法包括但不限于退火处理，例如热退火、激光退火或等离子体退火。这样的退火的温度和时间都是重要的变量。该退火步骤也可以受到前面的表面处理的影响，例如氧等离子体、激光或快速热退火（RTA）方法等。能够选择适当的条件，使已经退火的至少部分转化的前驱体仍然保持其无定形的性质，而其物理性能或电性能中至少一种已经按照需要被改变了。另外，根据将要使用膜的应用不同，会引起膜转化为结晶状态的退火条件，例如高温可以是希望的。例如，在该阶段可以使用适当的热处理来诱发从无定形或至少基本上无定形的至少部分转化前驱体形成高度取向的结晶膜。以这样的方式，可以对无定形膜的



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性能进行细调，或者其物理性能可在很宽范围内变化—从一个极端的完全无定形相到半结晶的中间相，再到另一个极端的单取向的晶体相。这样的热处理一般起着进一步使前驱体转化的作用。

如果前驱体还要进行基本上充分的转化，随后前驱体膜就要任选，但是典型地经受转化方法的作用，使得该前驱体被基本上充分转化。可以把前驱体膜的整个膜或者选择的一部分对能源进行曝光。该转化方法可以是能源，该能源与前面使用的任何部分转化方法可以相同或者不同。例如，该转化方法可以是特殊波长的光源、特殊波长的相干光源、宽带光源、电子束源和/或离子束源。在本发明的某些实施方案中，如上面所讨论的能源，或者至少部分能源是通过用来在表面上界定影像的光学掩膜照射的光源。然而，该能源无须一定要通过掩膜照射。例如如果在转化步骤中给材料形成图案不是必须的，例如由于前驱体上已经形成有图案，就可以使用漫射或覆盖式的曝光作为转化方法。优选的转化方法包括光、电子束、离子束和热处理。如在上面对部分转化所讨论的，也是在本文中应用的，在其下进行转化的气氛条件，例如气氛的组成、压力（既包括总压也包括分压），还有湿度，都是重要的工艺变量。在转化的过程中，这些变量可以与在任何前面的部分转化步骤中使用的设定值相同，也可以不同。

当然应该理解，作为一个优选的膜，例如掩膜，可以通过将至少一部分部分转化的前驱体层基本上进行充分转化而得到，术语“基本上充分转化的前驱体”、“充分转化的前驱体”、“转化的前驱体”、“基本上充分转化的部分转化前驱体”、“充分转化的部分转化前驱体”和“已转化的部分转化前驱体”，如在本文中所使用的，都描述了这样的膜。

已经认识到，在把前驱体膜进行部分转化和/或基本上充分转化为所需材料的膜的过程中，膜会发生某些收缩，这就是说，所需材料膜的厚度经常比未转化的前驱体膜更薄。厚度上的这个变化是本发明的一个重要特征，给所需材料的膜赋予了有用的性能。例如，对于使电容最大化来说，形成极薄的膜是有利的，而同时，形成这样的膜从制造的观点出发又是一个挑战。本发明的方法提供了涂布比较薄浇注膜的能力，这样就赋予了制造上的便利，但也提供了比较更薄的所需至



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少部分转化前驱体材料的膜，这也就给所需材料的膜赋予了改善的性能。可以通过明智地操纵工艺变量来控制和调节沉积膜的收缩性能，这些变量包括选择前驱体、选择溶剂和溶剂的量、前驱体添加剂的种类、如沉积方法所决定的前驱体膜的厚度、在膜形成图案之前、过程中和以后的热处理以及已曝光膜的显影等。本发明的方法允许精确控制所需膜的厚度范围，使总厚度从埃（Å）的级别到微米（μm）级别。

在转化以后，随后任选的操作步骤可以包括转化后处理、包括但不限于如上所述的新显影方法的显影步骤以及显影后的处理步骤。要根据产物的最终应用选择具体的步骤。例如在 US5,534,312、5,821,017 和 6,071,676 中都叙述了使用的方法，这些专利的内容在该引做参考。

在本发明的某些实施方案中，在转化后是注入步骤，其中在基本上没有被硬掩膜覆盖的至少一部分基底上，通过使用注入方法，在该基底上形成至少一个注入区。使用离子束作为注入方法是本领域中已知的。然而，本方法不限于使用离子束，任何有效的注入方法都可以使用。适合于注入的离子包括但不限于砷、硼和磷。可以在高能结合低剂量的条件下进行离子注入，即高于大约 300KeV 的能量和小于约 $10^{20}$ 个原子/$cm^2$的剂量，或者在低能，即小于大约 300KeV，结合高剂量，即大于大约 $10^{20}$ 个原子/$cm^2$的条件下进行。在注入后可任选除去硬掩膜层。经过注入的基底可任选进行进一步的处理，例如退火，借该将注入的基底区转化为掺杂区(doped region)。如果这两个任选的步骤都进行，可以调节它们进行的次序，以适应本发明所涉及的特定应用。

本发明的其它实施方案设想，通过把本方法形成的至少部分转化前驱体作为耐刻蚀层。在一步或几步刻蚀步骤中，将例如等离子体、活性离子或湿刻蚀溶液等刻蚀方法通过硬掩膜提供的图案，与基底的选择区域相接触，只在这些需要的区域去掉基底。当前通常使用的硬掩膜材料，例如二氧化硅和氮化硅在使用刻蚀的电子制造方法中被用做保护掩膜。

本发明的一个优选实施方案设想，将通过本方法形成的至少部分转化的前驱体或硬掩膜作为耐刻蚀层。在一个或几个刻蚀步骤中，诸如等离子体、活性离子或湿刻蚀溶液的刻蚀方法通过由例如硬掩膜提供的图案与基底的选定区域接触，只在这些需要的区域除去基底。当



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前通常应用的硬掩膜材料，例如二氧化硅和氮化硅在使用刻蚀的电子制造方法中被用作保护掩膜。

图 2 说明对于本发明一个优选实施方案的各个步骤的基本顺序，即步骤 2A、2B、2C 和 2D，在加工前在步骤 2A 中所显示的基底 10 上进行这些步骤。例如，基底 10 可以是已经涂布有有机层的硅晶片。在步骤 2B 中，在基底 10 上涂布有未转化的前驱体 11。在步骤 2C 中，在至少一部分未转化前驱体 11 上施加转化方法，如在光化学金属有机沉积法中的光，或热处理，形成已转化的前驱体层 12。在步骤 2D 中，使用去除方法例如显影组合物除去至少一部分，优选基本上全部未转化前驱体层 11，剩下完整的已转化前驱体层 12，借该形成基底 10 的硬掩膜。这样的掩膜适当地允许某些形成图案方法通过到达基底的所需区域，同时对形成图案方法遮挡住或阻隔住某些另外的基底区域。

另外，在图 2 的步骤 2C 中，可以对至少一部分选择的未转化前驱体 11 施加部分转化方法，例如光或热处理，以形成部分转化前驱体层 12。在步骤 2D 中，使用去除方法例如显影组合物，除去至少部分，优选基本上全部未转化前驱体层 11，剩下完整的部分转化前驱体层 12。然后可在至少一部分部分转化前驱体使用在图上没有表示的转化方法，例如光或热处理，使得那部分发生基本上的转化，借该形成硬掩膜。该部分转化方法与转化方法可以相同，也可以不同。图 2 显示出在通过本发明的方法形成带图案的硬掩膜时很节省步骤。

相反，图 3 说明制造带图案硬掩膜时冗长的现有技术方法。在步骤 3A 中，如在图 2 中所说明的提供基底 200。在步骤 3B 中，在基底上形成硬掩膜层 210。该硬掩膜层可以是例如二氧化硅 210。在步骤 3C 中，在硬掩膜层 210 的顶上涂布光刻胶层 220。在步骤 3D 中，通过掩膜 235 将光刻胶层 220 对光 230 曝光。掩膜 235 包括透明的玻璃基底 240，它具有对光基本上不透明的区域 250，因此就阻隔了一部分光，在光刻胶层的已曝光部分 222 上形成了图案。在步骤 3E 中，已曝光的光刻胶区 222 被显影，借该曝露出硬掩膜层 210。在步骤 3F 中，通过用适当的刻蚀组合物刻蚀掉硬掩膜层 210 的未被保护部分，在硬掩膜层 210 中形成开口 255。在步骤 3G 中，除去剩下的部分光刻胶 220。在步骤 3H 中，选择使得能够刻蚀基底 200 而不刻蚀硬掩膜层 210 的等



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离子体刻蚀化学品在基底 200 上形成出图案。这就得到如在步骤 3I 中所定义的图案特征。因此，从图 3 可以明显看出，对于制造带图案的硬掩膜，传统的方法，例如通过带图案掩膜的离子注入技术与本发明的方法相比，需要更多的步骤。

图 4 说明本方法的一个优选实施方案，用来制造硬掩膜，使用的是金属络合物前驱体，形成带图案的硬掩膜，该方案去掉了与硬掩膜刻蚀有关的所有步骤，即上述步骤 3C 到步骤 3G。在步骤 4A 中，如在图 2 中所说明供应基底 300。在步骤 4B 中，在基底 300 的顶上形成了一个前驱体层 310，即含有金属络合物的层。在步骤 4C 中，通过胰脂酶 320 使前驱体 310 对部分转化方法，在该为光 315 曝光。掩膜 320 包括具有对部分转化方法基本上不透明区域 340 的透明玻璃基底 330。对部分转化方法 315 曝光的部分前驱体 310 被至少部分转化或反应，形成部分转化前驱体 350 的区域。在步骤 4D 中，整个组装体被曝露于去除方法（未显示），例如液体显影剂中。通过显影剂或去除方法除去基本上未转化前驱体 310，曝露出基底 310，同时把部分转化而又耐受去除方法的部分转化前驱体 350 被保留下来。在步骤 4E 中，对部分转化前驱体施加转化方法（未显示），形成基本上完全转化的前驱体 360，即带图案的硬掩膜。该转化可通过例如漫射光曝光步骤或热退火步骤来实现。在步骤 4C 和 4E 的每一步中，如果已转化前驱体 360 是介电膜，优选在氧存在下进行转化；而如果已转化前驱体 360 是金属膜，则优选在还原性气体存在下进行。在步骤 4F 中，刻蚀方法给基底形成上图案，在该该刻蚀方法选择是等离子体刻蚀化学品，它能够刻蚀基底 300，但不能刻蚀掩膜层 360。这样就形成了如在步骤 4G 中所定义的图案特征 390。

图 5 说明例如通过一般已知作为顶上甲硅烷基化形成影像的方法在光刻胶上形成 TSI 的现有技术的方法。在步骤 5A 中，提供一个基底 400。在步骤 5B 中，在基底 400 上涂布一层适合于进行顶上甲硅烷基化的光刻胶层 410。在步骤 5C 中，通过掩膜 435 使光刻胶层 410 对光 430 曝光。掩膜 435 包括一个具有对曝光方法基本上不透明的区域 450 的透明玻璃基底 440，从而阻挡一部分光，在光刻胶层的曝光部分 432 上形成图案。作为该曝光的结果，给予已曝光的光刻胶区不同的化学



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和/或物理性能。在步骤 5D 中，基底 400、光刻胶层 410 和已曝光的光刻胶区 432 都曝露在气体 TSI 试剂 460 中，它被选择性地吸收到已曝光的光刻胶区 432 中，形成改性的光刻胶表面 470。TSI 试剂 460 的例子是本领域已知的，包括含硅的气体。

在步骤 5E 中，把表面曝露在等离子体处理 480 中，使改性光刻胶表面更加惰性，由此形成耐蚀的硬掩膜 490。在步骤 5F 中，等离子体处理 495 除去直接在耐蚀硬掩膜表面 490 底下残留的光刻胶 410（。在步骤 5G 中，使用等离子体处理 497 给基底 400 形成图案，使用了由光刻胶层 410、改性光刻胶表面 470 和耐蚀硬掩膜表面 490 形成的复合堆积层来确定转移到基底 400 上的图案。通过在步骤 5H 中的刻蚀区 499 来说明得到的图案。在步骤 5I 中，使用了去除方法（未显示）来除去由光刻胶层 410、改性光刻胶表面 470 和耐蚀硬掩膜表面 490 形成的复合堆积层。同时在图 5 中说明的方法在形成用于形成图案的薄表面时可赋予其优点的，这有助于改善可得到的分辨率，而在松弛焦深时需要多个等离子体处理的步骤，这就产生需要 TSI 试剂的缺点，而且涉及到在其他的传统技术中不存在的图案转移时提高成本和复杂性。

反之，图 6 说明应用于 TSI 的本方法使用金属络合物形成带图案薄顶表面的一个优选实施方案。在步骤 6A 中，提供一个涂布有图案转移层 505 的基底 500。图案转移层 505 可任选地含有有机成膜树脂，这包括光刻胶、聚酰亚胺、PMMA、线形酚醛树脂、环氧树脂和本领域的专业人员已知的其他有机或相关涂层。在步骤 6B 中，在基底 500 的顶上形成前驱体层 510，直接覆盖在图案转移层 505 上面。在此情况下，前驱体 510 含有金属络合物。在步骤 6C 中，通过掩膜 520 将前驱体曝露于部分转化方法中，在此说明的是光 515。掩膜 520 包括透明的基底 530 例如说玻璃基底，该玻璃基底具有对部分转化方法基本上不透明的区域 540。对部分转化方法 515 曝光的部分前驱体 510 至少被部分转化或反应，形成部分转化前驱体的区域 550。在步骤 6D 中，整个组装体被曝露在去除方法（未显示）例如液体显影剂中。通过去除方法例如显影剂除去了基本上未转化的前驱体 510，曝露出图案转移层 505，同时留下了被部分转化并耐受去除方法的部分转化前驱体 550。在任选的步骤 6E 中，在部分转化前驱体 550 上施加转化方法（未显示），形成



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基本上充分转化的前驱体 560。该转化可通过例如漫射光曝光步骤或热退火步骤来实现。

在步骤 6F 中，表面曝露在刻蚀方法 570 中，举例说例如等离子体刻蚀化学品中。例如，等离子体刻蚀方法可主要由氧组成。该刻蚀方法除去图案转移层 505 的已曝光区域，而部分转化或基本上充分转化的前驱体层 560 被选择和加工，使得对刻蚀方法 570 基本上是惰性的，这样就形成了刻蚀区 580。在步骤 6G 中，通过刻蚀方法，使用在至少部分转化的前驱体 560 底下的图案转移层 505 中形成的图案为基底 500 形成图案（未显示），形成刻蚀区 590。在步骤 6H 中，去除方法（未显示）去掉了所有残留的图案转移层 505 和至少部分转化前驱体 560，曝露出所需的带有刻蚀区 590 的带图案基底 500。图 6 的方法优于在图 5 中显示的方法，因为它需要的步骤较少，等离子体步骤也少，而且不需要 TSI 试剂。同时，图 6 的方法保留下使用图 5 的方法所获得的全部优点。

图 7 说明在基底顶上沉积带图案金属层的现有技术方法。当所需的金属很难刻蚀时，例如是金或铂时习惯使用该方法。在步骤 7A 中，提供一个基底 600。在步骤 7B 中，在基底 600 的顶上涂布一层隔离层 605，而在隔离层 605 的顶上涂布一层揭起层 610。在步骤 7C 中，在揭起层 710 的顶上沉积上一层任选的硬掩膜层 620。在步骤 7D 中，在由任选的硬掩膜层 620、揭起层 610 和隔离层 605 组成的复合堆积层的顶上涂布上光刻胶层 630。在步骤 7E 中，通过掩膜 635 将光刻胶层 630 对光 645 曝光。掩膜 635 包括一个透明的玻璃基底 640，该基底具有对曝光方法基本上不透明的区域 650，这样就遮断了一部分光，并在光刻胶层的曝光部分 630 上形成了图案。在步骤 7F 中，使用去除方法，例如湿显影剂来除去在光刻胶层 630 上的已曝光部分 632。

在步骤 7G 中，使用等离子体刻蚀化学品 660 通过任选的硬掩膜层 620（如果存在）进行刻蚀。等离子体刻蚀化学品 660 也可以具有使光刻胶层 630 的大部分厚度受到侵蚀的作用。在步骤 7H 中，使用等离子体刻蚀化学品 670 通过揭起层 610 和隔离层 605 进行刻蚀。在该步骤中可以制造出侧壁，这可通过先以各向异性的模式使用等离子体刻蚀化学品 670，例如先将等离子体的带电粒子在垂直方向运动，然后转换



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为各向同性的模式，使等离子体中负责刻蚀的带电粒子在所有方向上均衡地运动来实现，该侧壁优选如在步骤 7H 中所说明的呈曲线状。在步骤 7I 中，使用一种沉积方法用所需的金属 680（例如金、铂或其他所需金属）来覆盖表面的特征。在步骤 7J 中，使用去除方法（未显示）例如通过溶剂处理来揭起所有残留的隔离层 605、揭起层 610、硬掩膜层 620（如果存在的话）和光刻胶层 630。这就在基底 600 上只剩下所需金属 680 的所需图案。这个给金属沉积物形成图案的方法是很困难的，涉及许多步骤，须要使用厚的光刻胶层。这样的厚光刻胶层消耗的量比需要的要更多，是很昂贵的。此外，除去光刻胶是很困难的，因为它比另外情况下使用得更厚。

相反，图 8 说明本方法的一个优选实施方案，使用金属络合物，应用于揭起方法，在揭起层上形成带图案的薄顶表面。在步骤 8A 中，提供一个基底 700。在步骤 8B 中，在基底 700 上涂布隔离层 705，而在隔离层 705 上涂布揭起层 710。在步骤 8C 中，把前驱体层 720 涂布在揭起层 710 上。在此情况下，前驱体 720 含有金属络合物。在步骤 8D 中，通过掩膜 735，将前驱体 720 对部分转化方法曝光，在该部分转化方法是例如光 745。掩膜 735 包括一个透明的玻璃基底 740，它具有对部分转化方法基本上不透明的区域 750。曝露于部分转化方法 745 的一部分前驱体 720 被至少部分转化或反应，形成部分转化前驱体 732 的区域。在步骤 8E 中，整个组装体曝露在去除方法（未显示）例如液体显影剂中。通过显影剂或去除方法去掉基本上未转化的前驱体 720，曝露出揭起层 710，同时留下被部分转化而且耐受去除方法的部分转化前驱体 732。在一个任选的步骤（未显示）中，对部分转化前驱体 732 施加转化方法（未显示），形成基本上充分转化的前驱体。

在步骤 8F 中，以各向异性的方式应用去除方法 760，例如等离子体刻蚀化学品，以除去不在前驱体 732 底下的揭起层 710 和底下的隔离层 705 的这些区域。在步骤 8G 中，通过让去除方法 760 以各向异性的方式刻蚀揭起层 710 和隔离层 705，从而形成如同所描述的曲线断面的揭起层。在步骤 8H 中，通过沉积方法在组合体上沉积上所需金属 770 的膜。在步骤 8I 中，通过显影方法，例如溶剂或干式显影法，与前驱体 732、揭起层 710 和隔离层 705 一起除去所需金属 770 的不需要



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部分，在基底 700 的顶上剩下所需金属 770 的所需图案。该方法优于在图 7 中概述的现有技术的方法，因为它需要的步骤较少，而且无须使用光刻胶。

图 9 说明本方法的另一个实施方案，使用金属络合物，应用于揭起方法，在揭起层的上面形成带图案的薄顶表面膜。在步骤 9A 中，提供一个基底 800。在步骤 9B 中，在基底 800 上涂布前驱体层 810。在该情况下，前驱体含有金属络合物。在步骤 9C 中，通过掩膜 835 使前驱体层 810 对部分转化方法曝光，在此部分转化方法是例如光 845。掩膜 835 包括透明的玻璃基底 840，它具有对部分转化方法基本上不透明的区域 850。曝露于此部分转化方法的部分前驱体 850 被至少部分转化或反应，形成已曝光区 832。在步骤 9D 中，整个组装体曝露于去除方法（未显示）如液体显影剂中。通过该去除方法除去基本上未转化的前驱体 810，曝露出基底 800，同时留下被部分转化而且耐受去除方法的已曝光区域 832。如在本发明的其他实施方案中所叙述的，已曝光区域 832，在去除方法步骤 9D 以后，可任选地再进行转化。如在步骤 9D 中所描述，通过对曝光和在步骤 9C 和 9D 中介绍的去除方法的控制，可以在已曝光区域 832 中得到向内具有锥度的侧壁断面，这些方法分别如在上面步骤 8D、8F 和 8G 中叙述过。在步骤 9E 中，通过沉积方法，在组装体上沉积上所需金属 870 的膜。在步骤 9F 中，通过显影方法例如溶剂或干式显影法，与前驱体 832 一起除去所需金属 870 的不需要的部分，在基底 800 的顶上剩下金属 870 的所需图案。

在本发明的另一个优选实施方案中，可使用 TSI 层集成的方法，制造把铜集成到半导体接插结构时使用的双波纹结构。图 10，从步骤 A 到步骤 H 说明了制造波纹结构的现有技术的方法，该方法被称为“via-first”方法。在步骤 10A 中，提供一个基底 900，如在图上所示，该基底上相继涂布有第一介电层 905、隔离层 915、第二介电层 910 和硬掩膜 920。介电层 905 和 910 一般是，但不必须是相同的材料，而隔离层和掩膜层 915 和 920 可以是相同的材料，也可以是不同的材料，但经常是氮化硅和/或氧化硅。在步骤 10B 中，在硬掩膜 920 的顶上，用底部抗反射涂层（BARC）925 和光刻胶层 930 涂布组装体。如图所示，光刻胶上形成上图案并通过传统方法显影。在步骤 10C 中，使用



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等离子体刻蚀化学品除去 BARC 层 925、硬掩膜 920、介电层 910、隔离层 915 和介电层 905 上所指出的部分。在步骤 10D 中，在步骤 10C 的等离子体方法以后，从组装体上除去剩余的光刻胶 930 和 BARC 层 925。在步骤 10E 中，如图所示，在组装体硬掩膜 920 的顶上涂布第二 BARC 层 935 和第二光刻胶层 940，该光刻胶层 940 上形成了图案并被传统方法显影。在步骤 10F 中，使用了第二等离子体刻蚀化学品步骤除去 BARC 层 935 和介电层 910 的指定部分。在步骤 10G 中，在步骤 10F 的等离子体方法以后，除去剩余的光刻胶 940 和 BATC935。

与此相反，图 11 说明本发明的方法如何可用更少的步骤制造双波纹结构。在步骤 11A 中，提供一个涂布有介电层 1005 的基底 1000。在步骤 11B 中，在该介电层的顶上涂布上例如含有金属络合物的前驱体层，通过至少部分转化而形成上图案，然后用如前面在本发明的另一个实施方案中所讨论的技术进行显影，得到如图所示的带图案层 1010。例如，可以通过例如溶剂或如上所述的干式显影法进行图案显影步骤。然后在带图案层 1010 的顶上涂布上旋转平面化层 1015。该旋转平面化层 1015 可以是任何有机基的涂层，可以旋涂在组装体这。在步骤 11C 中，如图所示，例如使用与形成带图案层 1010 时使用的相同技术沉积上带图案层 1020，并形成图案和显影。在步骤 11D 中，应用刻蚀方法(未显示)，例如等离子体刻蚀化学品，除去旋转平面化层 1015 的所显示区域和介电层 1005 的一部分厚度。对刻蚀方法进行控制是很重要的，如图所示使其只除去一部分介电层 1005 的厚度。例如，可以使用的等离子体刻蚀，限制其时间短于刻蚀介电层整个厚度所需的时间。

在步骤 11E 中，通过去除方法，例如用溶剂处理组装体来除去带图案层 1020 和旋转平面化层 1015，旋转平面化层在该溶剂中是可溶的，而且该溶剂对组装体的其他部分没有基本上的不良影响。在步骤 11F 中，应用受到控制的刻蚀方法（未显示），例如如上所述的等离子体刻蚀化学品除去介电层 1005 上所描绘的区域。该受控制的刻蚀在由带图案层 1020 所形成的图案中同时除去了介电层 1005 的剩余厚度，而在带图案层 1010 所形成的图案中只除去介电层 1005 的一部分厚度。可以以这样的方式组合出双波纹的模式。



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在步骤 11F（未显示）以后可以任选地除去带图案层 1010，另外把带图案层 1010 剩下，在沉积了铜和平面化以后用做 CMP 终止点。

很明显，在图 11 中所描述的方法优于在图 10 中叙述的方法，因为前者使用的步骤较少，无需多层光刻胶和 BARC 的步骤，避免了在传统方法中使用的隔离层和硬掩膜。

图 12 说明一个由现有技术使之简化的复杂的离子注入的方法，用来制造带图案离子注入掩膜。在步骤 12A 中，如在图 2 中所述提供一个基底 1200。在步骤 12B 中，在基底 1200 上形成一个任选的保护层 1205，然后是注入掩膜层 1210。在一个实施例中，注入掩膜层是氧化硅。在步骤 12C 中，在注入掩膜层 1210 的顶上，在基底 1200 上涂布光刻胶层 1220。在步骤 12D 中，通过掩膜 1235 使光刻胶层 1220 对光 1230 曝光。掩膜 1235 包括一个透明的玻璃基底 1240，它具有对曝光方法 1250 基本上不透明的区域，因该遮挡住一部分光，在光刻胶层的已曝光部分 1222 上形成了图案。在步骤 12E 中，已曝光的光刻胶区 1222 被显影，曝露出注入掩膜层 1210。在步骤 12F 中，用适当的刻蚀组合物，通过刻蚀掉注入掩膜层的未保护部分，在注入掩膜层 1210 上形成了开口。在步骤 12G 中，除去剩余部分的光刻胶层 1220。在步骤 12H 中，将基底在离子束下曝光，以在注入掩膜中的开口下直接形成注入区 1270。在任选的步骤 12I 中，除去注入掩膜层 1210，将基底退火，由此把注入区 1270 转化为搀杂区 1280。因此，由图 12 可以明显地看出，传统的方法需要比本方法更多的步骤来形成带图案的注入掩膜并通过该掩膜进行离子注入。

反之，图 13 说明本方法的另一个优选实施方案，使用金属络合物，用来制造离子注入掩膜，形成带图案的注入掩膜，该方法去掉了与注入掩膜刻蚀有关的所有步骤，即如上所述的步骤 12C 到 12G。在步骤 13A 中，提供一个基底 1300。在步骤 13B 中，在基底 1300 上形成一个任选的保护层 1312，在保护层 1312 的顶上形成一个前驱体层 1310。在此情况下，前驱体 1310 是金属络合物。在步骤 13C 中，通过掩膜 1320 使前驱体 1310 对部分转化方法曝光，在该部分转化方法是光 1315。掩膜 1320 包括一个透明的玻璃基底 1330，它具有对部分转化方法基本上不透明的区域 1340。对部分转化方法 1315 曝光的一部分前驱



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体 1310 被至少部分转化或反应，形成部分转化前驱体区 1350。在步骤 13D 中，该组合体曝露在去除方法（未显示），例如液体显影剂中。通过显影剂或去除方法除去未转化前驱体 1310，曝露出保护层 1312，同时留下被部分转化而且耐受去除方法的部分转化前驱体 1350。在步骤 13E 中，对部分转化前驱体 1350 施加转化方法（未显示），形成基本上充分转化的前驱体 1360。该转化可通过例如漫射光曝光步骤或热退火步骤来实现。在步骤 13C 和 13E 的每一步，如果已转化前驱体 1360 将是介点膜，该转化优选在氧存在下进行；而如果已转化前驱体将是金属膜，则优选在还原性气体，例如氢存在下进行。在步骤 13F 中，基底 1300 经受离子注入方法例如离子束 1370 的处理，以在基底上形成注入区 1380。在任选的步骤 13G 中，除去注入掩膜并进行热退火，以把基底上的注入区 1370 转化为掺杂区 1390。

本发明方法很宽的范围使得能够广泛地得到应用。本发明的一个优选实施方案包括无定形的金属氧化物膜，用于在印刷线路板（PWB）中形成集成的电容结构，其中使用适当的前驱体溶液按照本发明涂布和直接在 PWB 基底上形成图案。本发明的优点包括能够直接形成图案，并与此有关省略掉其他的工艺步骤、使用 PWB 加工所要求的环境温度和环境压力，以及形成的膜是高电容所能够接受的。

在另一个优选的实施方案中，通过本发明，在透明的基底形成带图案的金属氧化物或混合金属氧化物膜，成为不透明的图案。这样实施本发明，在半导体制造方法中进行平版印刷的图案转移时，可用做图案掩膜。

在本发明另外的一个优选实施方案中，使用无定形的金属氧化物或混合金属氧化物膜在高级的连接半导体器件的连接界面中，形成去偶电容结构，其中按照本发明的方法，在改性硅基底上用适当的前驱体溶液进行涂布并形成图案。在该实施方案中固有的优点包括直接形成图案的能力，由此可以省去许多其他的工艺步骤，再一个优点是使用环境温度和环境压力，这与这样的高级连接件组装时的条件没有什么不同。

本发明的再一个实施方案设想，使用的前驱体膜可用于给记忆储存元件制造图案，无论是以电容性储存节点的方式，即动态随机存取



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存储器（DRAM），还是作为铁电体记忆存储节点（FeRAM），再有，在该实施方案中固有的优点包括能够直接形成图案，这样就省略了许多其他的工艺步骤，再一个优点是使用环境温度和环境压力，这与这样的记忆器件组装时是没有什么不同的。

本发明还有一个实施方案设想在半导体制品的前端形成门介电材料，因为高级硅基器件在优选的门介电材料中可以使氧化硅转变为具有更高介电常数的新材料。这种具有高介电常数的新材料，对于同样的电气性能，允许把门介电材料的物理厚度制造得比二氧化硅更厚。该更厚的物理厚度使得更容易制造，也使通过该门的量子通道效应更小。很明显，当把本发明的方法用于线前端（FEOL）半导体工艺时，比其他已知的要求较低温度和严格低真空的方法具有更大的优点。有各式各样的高介电常数的材料适合于本发明的方法，这包括但不限于$Ba_xSr_yTi_zO_3$（BST）、$BaTiO_3$、$SrTiO_3$、$PbTiO_3$、$Pb_xZr_yTi_zO_3$（PZT）、(Pb,La)(Zr,Ti)$O_3$(PLZT)、(Pb,La)$TiO_3$(PLT)、$LiNbO_3$、$Ta_2O_5$、$SrBi_2Ti_2O_9$、$Al_2O_3$、$TiO_2$、$ZrO_2$和$HfO_2$。

与此类似，本发明可用于制造 FEOL 半导体制品的门电极材料。这些材料在与门介电材料形成电接触的门介电材料的顶上。过去，门电极一直是由硅制造的。按照与门介电材料从二氧化硅向外迁移相类似的方式，具有推动力，使门电极转变为基本上比硅具有更好特性的材料。可供门电极的用途候选材料包括铂、铱、钌、氧化钌、氧化铱和其他新材料。所有这些材料提出都对沉积和形成图案进行挑战，然而它们都适合于本发明的应用。另外，在传统方法中的许多步骤都要求高温、严格的真空要求以及使用苛刻的等离子体加工条件，这些都预示着会损害敏感的硅基底。使用本发明的方法就可以避免这些苛刻的条件。对传统方法更大的挑战是如在 US-P-6048769 中所述，须要把不同的电极材料放置在不同偏压的门晶体管上。对于传统集成路径的这个要求就使本来已经很多的步骤再次加倍，因此从制造的观点出发，本发明的这个优选实施方案为减少步骤数提供了戏剧性的优势。

贵金属和导电金属氧化物的应用并不限于制造门电极。对于这些材料有几个隔离层的应用，无论是导电层还是绝缘层，都用在 FEOL 半导体的加工中。很明显，这些应用中有几个依赖于形成所需材料的



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膜，这些材料具有作为电容性材料使用的高介电常数（高 k 值）。按照类似的方式，可以对膜进行优化，使膜对于作为感应材料的磁导率（μ）达到最佳。类似地可能是电阻元件，就像是磁性元件、压电元件、热电元件和铁电元件一样。

本发明方法的其他可能的应用是非常宽广的。某些例子包括：用于半导体制造（晶体管门电路组、电容性结构等）的高介电常数材料的直接图案沉积、用于微电子包（电容性结构）的高介电常数材料的直接图案沉积、用于半导体制造（晶体管门电路组、电容性结构等）的高介电常数材料的低温沉积、用于微电子包（电容性结构等）高介电常数材料的低温沉积、用于半导体制造（晶体管门电路组、电容性结构等）的高介电常数材料的非真空基沉积、用于微电子包（电容性结构等）的高介电常数材料的非真空基沉积、用于半导体制造（绝缘子结构等）的金属氧化物的直接图案沉积、用于微电子包的金属氧化物的直接图案沉积、用于半导体制造的金属氧化物低温沉积、用于微电子包（电容性结构）的金属氧化物的低温沉积、用于半导体制造的金属氧化物非真空基沉积、用于微电子包的金属氧化物非真空基沉积、用于半导体制造（晶体管门电路组）的金属的直接图案沉积、用于微电子包（连接件等）的金属直接图案沉积、用于半导体制造的金属低温沉积、用于微电子包的金属低温沉积、用于半导体制造的金属非真空基沉积、用于微电子包的金属非真空基沉积、用于半导体制造（片上电阻元件）的电阻材料的直接图案沉积、用于微电子包（包封电阻器）的高电阻材料的直接图案沉积、用于半导体制造的电阻材料的低温沉积、用于微电子包（包封电阻器）的电阻材料的低温沉积、用于半导体制造的电阻材料的非真空基沉积、用于微电子包的电阻材料的非真空基沉积、通过混合金属/氧化物沉积受控制的电阻材料、用于半导体制造（片上感应器）的制造感应器材料的直接图案沉积、用于微电子包（包封感应器）制造感应器材料的直接图案沉积、用于半导体制造的制造感应器材料的低温沉积、用于微电子包（包封感应器）的感应器制造材料的低温沉积、用于半导体制造的感应器制造材料的非真空基沉积、用于微电子包的感应器制造材料的非真空基沉积、用于制造使用有机半导体和/或有机基底的器件的金属和氧化物材料的直接



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图案沉积、用于制造使用有机半导体和/或有机基底的器件的金属和氧化物材料的低温沉积、用于制造使用有机半导体和/或有机基底的器件的金属和氧化物材料的低温沉积、用于制造使用有机半导体和/或有机基底的器件的金属和氧化物材料的非真空基沉积、在双层或 TSI 光刻胶方法中用做光敏、电子束敏层、磁性材料的直接图案沉积、低温沉积、非真空基沉积、混合金属和混合氧化物材料的沉积、金属和金属氧化物结构的喷墨状（液滴）打印、在基底上的喷雾涂布、使用用于厚膜的液相涂布（旋涂或弯月面涂布）的材料，以简化和改善涂布方法和性能，然后利用转化时的体积收缩以得到薄涂层（这样的应用是制造包封的电容器，这里涂布上厚层以得到最终薄的膜，用以改善该结构的电容）的用途、在聚合物/天然纤维上液态涂布金属有机前驱体，然后通过光化学转化或低温热转化，沉积出金属或金属氧化物涂层（例如涂布银/氧化银制造抗微生物纤维和织物，用于医院的应用、抗臭味的服装例如袜子或衬垫等）、将前驱体进行液相渗透，然后进行热转化，形成具有催化活性的多孔材料、用做聚合物溶液的添加剂，通过形成纳米级组合物以改善得到的材料的物理、化学、光学和电性能的应用、合成和配合水溶性前驱体以减少上述方法中的挥发份的排放、门电极材料、平面显示器、FeRAM、直写材料、微细流体、掩膜和波导。

对于制造电子材料用的方法的补充叙述包括在同时提交的 US 专利申请 09/_____中叙述的内容，题目是《基底预处理的方法和设备》，其公开的内容在该引做参考。

## 实施例

下面的实施例进一步说明本发明的某些实施方案。提供这些实施例仅用于说明的目的，不以任何方式对本发明构成限制。

### 实施例 1

通过将其溶解于适当的溶剂并将该溶液旋涂在硅芯片表面上，浇注出两种不同的含锆前驱体膜，即 Zr(乙酰丙酮)$_4$（也已知作为 Zr(acac)$_4$ 和四(2,4-戊二酮基)锆(IV)）和 Zr(羧酸根)$_4$。每一种都经受长时间的覆盖式热处理，即直到前驱体膜的厚度不再有变化为止。在该处理之后，使用可变角光谱椭圆仪（VASE）测量每个试样的折光指数与波长的关



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系。在图 14 中描述了得到的结果。在图 14 中，曲线 101 来自由 Zr(acac )$_4$ 前驱体形成的试样，曲线 102 来自由 Zr(羧酸根)$_4$ 前驱体形成的试样。这些结果显示出，在每个试样的折光指数性能上存在着明显的差别，这直接与前驱体的化学组成有关。Za(acac)$_4$ 前驱体形成的膜具有的折光指数为对于 3%，高于由 Zr(羧酸根)$_4$ 形成的膜的折光指数。

实施例 2

先制造两种不同的铜前驱体，即 $Cu(OH_2)_2(O_2C(CH_2)_4CH_3)_4$ 和($\mu$-$(C_2H_5)_2NCH_2CH_2O)_2Cu_2(N_3)_2$。据认为每种前驱体都经受光化学反应，这导致失去配位体并产生铜原子。然后认为铜原子互相结合，形成金属铜，或者与氧结合形成氧化铜，然而，作为先形成的金属铜氧化的结果，也可能生成氧化铜。基于现有技术的化学，没有理由假设在类似的条件下这些不同的前驱体将提供不同的产物，虽然都承认作为对前驱体进行选择的结果，反应的成膜性能和效率会有很大的差别。

因此，把这两种前驱体的每一种都进行溶解，通过旋涂的方法在硅片上使每种溶液沉积，然后在真空中通过光分解，使在涂布的每块晶片上的前驱体层进行基本上的充分转化。光分解一直持续到在对膜进行 DTIR 光谱分析时不再观察到与配位体有关的吸收。然后把试样转移到烧结炉中，在 400℃的氮气下加热。

然后用已知的宽角度 X 射线衍射法对每个试样进行检测。发现 $Cu(OH_2)_2(O_2C(CH_2)_4CH_3)_4$ 前驱体在转化后得到更多的氧化铜，而对于($\mu$-$(C_2H_5)_2NCH_2CH_2O)_2Cu_2(N_3)_2$ 前驱体则产生更多的晶体金属铜。这样的结果显示出这些方法结果的依存性，即在转化以后，对前驱体的组成具有现有技术无法预见的依存性。

给定前驱体材料的膜转化为无定形膜的方法，例如热方法或光分解方法，对这些膜的性能可以具有明显的影响。如在实施例 3 和 4 中所显示的，在汇总光学的折射率数据中就显示出这一点，通过比较介电常数的数据也清楚地显示出这一点。

实施例 3

将前驱体 Zr(acac)$_4$（乙酰丙酮锆(IV)，来自 Chemat Technology 公司，Northridge，CA）溶解于甲苯，以 1250rpm 的转速在 30sec 将该溶液旋涂在硅晶片上。得到的未转化前驱体膜的厚度为 436Å。在 180℃



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的加热板上加热 1hr，将 $ZrO_2$ 进行热转化。在 180℃的加热板上再进行延长的热转化。使用具有 220 nm 冷镜的 Karl SussMJB-3 型掩膜直线对准器对 $ZrO_2$ 进行光化学转化。由于掩膜直线对准器在深紫外线区的输出强度比较小（大约 0.38mW/cm²），要使用 5hr 的曝光时间，因为已经发现再多的曝光剂量也不会使厚度进一步缩减。使用 VASE 测定得到的膜的厚度和折光指数与波长的关系。这些膜测量的厚度如下：

| | |
|---|---|
| 未转化的 $Zr(acac)_4$ 前驱体 | 436Å |
| 热转化 | 360Å |
| 延长热转化 | 316Å |
| 光转化 | 330Å |

将前驱体 $Zr(O(O)CC_7H_{15})_4$（2-乙基己酸锆(IV)，来自 Chemat Technology 公司，Northridge，CA）溶解于己烷，以 1500rpm 的转速在 30sec 将该溶液旋涂在硅晶片上。得到的未转化前驱体膜的厚度为 2335Å。在 180℃的加热板上加热 3hr，将 $ZrO_2$ 进行热转化。在 180℃的加热板上再进行延长的热转化。包括热转化时间总共达到 6hr。如上面对 $ZrO(acac)_4$ 所述，$ZrO_2$ 进行光化学转化，只是由于前驱体 $Zr(O(O)CC_7H_{15})_4$ 的光敏感度比较低，曝光强度也低，所以使用的曝光时间大约是 30hr。也是使用 VASE 测定得到的膜的厚度和折光指数与波长的关系。这些膜测量的厚度如下：

| | |
|---|---|
| 未转化的 $Zr(O(O)CC_7H_{15})_4$ 前驱体 | 2335Å |
| 热转化 | 1141Å |
| 延长热转化 | 977Å |
| 光转化 | 1487Å |

在图 15 上显示的是折光指数的结果，这里光化学转化的 $Zr(acac)_4$ 是曲线 1，热转化的 $Zr(acac)_4$ 是曲线 2，热转化的 $Zr(O(O)CC_7H_{15})_4$ 是曲线 3，而光化学转化的 $Zr(O(O)CC_7H_{15})_4$ 是曲线 4，延长热转化的 $Zr(O(O)CC_7H_{15})_4$ 是曲线 5，延长热转化的 $Zr(acac)_4$ 是曲线 6。

这些结果显示出，对于每种试样的折光率性能有明显的差别，这直接关系到前驱体的化学组成及其制备方法。

实施例 4



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在涂铝的硅晶片上旋涂上大约 7000Å 的前驱体在己烷中的溶液，该前驱体设计其在在至少部分转化后会得到 BST 膜。通过将 3.7gTi(二(乙酰丙酮)二(异丙氧基))、2.8g2-乙基己酸钡和 5.6g2-乙基己酸根（在 2-乙基己酸中，浓度 40wt%）溶解于 182g 己烷中制备 BST 前驱体膜，相当于 Ba:Sr:Ti(IV)的摩尔比为 1:0.8:1。通过热处理或者通过光分解材料把前驱体膜转化为 BST 膜。把得到的薄的 BST 膜制成膜电容器并测量膜的电性能。如同在下面的结果可以看出的，每种膜的介电常数和平均电导率都有着戏剧性的不同：

由热转化得到的 BST 膜

| | |
|---|---|
| 介电常数 | 4.66 |
| 平均电导率 | 0.009992S |

由光化学转化得到的 BST 膜

| | |
|---|---|
| 介电常数 | 27.26 |
| 平均电导率 | 0.04311S |

这些结果显示出对于每个试样，在电性能上有着明显的差别，这直接涉及到转化前驱体的制备方法。

实施例 5

在例如旋涂膜前驱体时，对溶剂的选择是重要的，因为它可以影响到膜的光学质量。例如，该实施例显示出，由含有用于转化为 BST 膜的前驱体在 MIBK 和正庚烷中的溶液浇注得到的膜，可得到很高的光学质量，而从 PGMEA 的溶液就得到带斑纹的膜。

在这些溶剂的每一种当中，通过将前驱体溶解于溶剂，或者用所需的溶剂替代前驱体溶液中的一部分或全部溶剂。每种溶液都用旋涂法沉积在覆盖有铝的硅晶片上。硅晶片以 1500rpm 的转速旋转 30sec。在旋涂以后，在 110 的加热板上烘烤 2min，以除去任何残留的溶剂。使用带有 220nm 冷镜的 Karl Suss MJB-3 型掩膜直线对准器以大约 1.2mW/cm²的强度把前驱体膜转化为氧化物。每块晶片曝光 1.5hr，以确保完全转化。在转化以后，进行显影和去除步骤，这时用与旋涂试样同样的溶剂漂洗，洗掉每块前驱体膜的未转化、未曝光的部分。使用 VASE 测量在转化前（即未转化的）、刚刚在转化以后的和显影后的膜厚度。



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由 MIBK 和正庚烷得到的高光学质量的前驱体膜表面，基本上没有上面表面特征，所以就没有图可以显示这个。反之，由 PGMEA 溶液旋涂得到的BST前驱体膜显示出明显的条纹，这可以在图16中看出。在上述溶剂中，MIBK 得到最均匀的和可以重现的膜。

实施例 6

在如何使用热处理把前驱体膜转化为所需材料的膜的实施例中，用设计在转化时用来形成 BST 膜的前驱体溶液旋涂一系列的裸硅晶片。通过在 160℃的加热板上以 10min 的间隔加热每块晶片，使总加热时间为 120min，从而使晶片进行至少部分转化。在每次转化间隔以后，用异丙醇漂洗给前驱体图案显影，除去未转化的前驱体。这样就能够测定出热印该膜所需的时间，即在用异丙醇显影后具有明显量的残留膜所需的时间。如在图 17 上所看到的，对于热转化，测定的这个时间大约是 20min。

用光化学转化代替热转化进行类似的实验，该结果显示在图 18 中。该图显示出，光化学印膜所需的时间为大约 30~60min。在第三个实验中，设计的是将热部分转化或预处理与光化学转化结合起来，晶片先在 160℃下进行 10min 的预热处理，然后如上所述进行光化学转化的操作。热/光化学打印的结果如在图 19 中所示，该图显示出热/光化学转化组合方法所需的时间，即形成图案所需的最大时间，从只用光化学转化的 30~60min 缩短为大约 20min。

实施例 7

缩短成像光的波长和增加透镜系统的数字光圈都可以改善光投射系统的分辨率。然而，在整个光刻胶膜上保持图像聚焦的能力，随着厚度增加而降低。减小光刻胶膜的厚度可保持焦深，但对于图案转移步骤所需的刻蚀的要求限制了光刻胶的最大厚度。为了减弱焦深的限制，使用的薄的膜成像，只在光刻胶顶层上形成图案。在给光刻胶顶层成像以后，把图案显影，然后使用刻蚀的方法转移到基底上。

对于使用金属络合物前驱体的双层方法，可以使用含有底层和金属络合物前驱体的两组膜，每一层都是例如旋涂的。金属络合物前驱体的作用是刻蚀掩膜的要求，而底层被用于使用刻蚀把图案转移到基底上。测试了三种不同的底层：PMMA、PHOST 和线形酚醛树脂。



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PHOST 和线形酚醛树脂是在 160℃的加热板上进行 2hr 的硬烘烤以后进行金属络合物前驱体的旋涂的。在实验中使用的金属络合物前驱体，设计得能够形成 BST、PZT 或二氧化钛（$TiO_2$）。按照在实施例 4 中叙述的操作程序制备 BST 前驱体。通过把 18.48g2-乙基己酸铅溶解于 57.4g 己烷中，加入 24.2g2-乙基己酸锆(IV)和 9.5gTi(二(乙酰丙酮)二(异丙氧基))，然后再添加 327g 己烷来制备 PZT 前驱体，这相当于 Pb(II):Zr(IV):Ti(IV)的摩尔比是 2.5:1:1.3。下面的表列出了使用的不同组合以及底层和金属络合物前驱体是否被认为是相容的。

| 底层 | 前驱体 | 使用己烷浇注溶剂的相对相容性 |
|---|---|---|
| PMMA | BST | 差 |
| PMMA | PZT | 差 |
| PHOST | BST | 差 |
| PHOST | PZT | 差 |
| 线形酚醛树脂 | BST | 好 |
| 线形酚醛树脂 | PZT | 好 |
| 线形酚醛树脂 | $TiO_2$ | 好 |

发现硬烘烤的线形酚醛树脂与 BST、PZT 和 $TiO_2$ 前驱体都是相容的，而测试的 PMMA 和 PHOST 底层材料在旋涂金属络合物层的时候会溶解。在有 BST 和 PZT 前驱体使用的浇注溶剂己烷存在下，PMMA 和 PHOST 会溶解掉。硬烘烤的线形酚醛树脂与 BST 和 PZT 的相容性使得能够进行图案的形成和转移。

实施例 8

通过监测刻蚀时厚度的变化来确定在硬烘烤线形酚醛树脂和两种金属络合物之间的刻蚀选择性。按照实施例 7 制备硬烘烤线形酚醛树脂和充分转化的 PZT 或 $TiO_2$ 试样，把试样装入刻蚀室，用氧等离子体进行 30sec 间隔的刻蚀，总刻蚀时间至少是 120sec。在每个刻蚀间隔之后测量试样的厚度。从厚度对刻蚀时间的图上确定每个试样的刻蚀速度。图 20 显示的是硬烘烤线形酚醛树脂的厚度对刻蚀时间图，而图 21 是对于充分转化的 PZT 和 $TiO_2$ 的同样的图。下面的表格列出了各自的斜率和线形最小二乘方线的相关系数。



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| 被氧刻蚀的层 | 厚度~刻蚀时间图的斜率 | 相关系数 |
|---|---|---|
| 硬烘烤线形酚醛 | -76.3 | 0.999 |
| 充分转化 PZT | -0.195 | 0.985 |
| 充分转化 $TiO_2$ | -0.0866 | 0.992 |

由各个刻蚀速度图的斜率比确定出刻蚀选择性。硬烘烤线形酚醛树脂和充分转化 PZT 之间的刻蚀选择性是大约 390:1。硬烘烤线形酚醛树脂和充分转化的 $TiO_2$ 之间的刻蚀选择性是大约 880:1。在同样条件下，$TIO_2$ 的刻蚀选择性与 $SiO_2$ 的刻蚀选择性大致相当。

实施例 9

进行了 BST 和 PZT 的电子束对比度测试，通过给每种材料的一系列充分转化的膜曝光，增加电子束的剂量，并注意在显影以后保留膜的百分比是 0 的最高剂量和保留膜的比例达到 1 的最低剂量，以确定这些材料的光速。PZT 和 BST 的对比度在大约相同的范围，从大约 60 至大约 100 μ $C/cm^2$。

本领域的专业人员将能够理解，本发明的范围并不限于在此所公开的内容，而且还要包括其扩展的内容。



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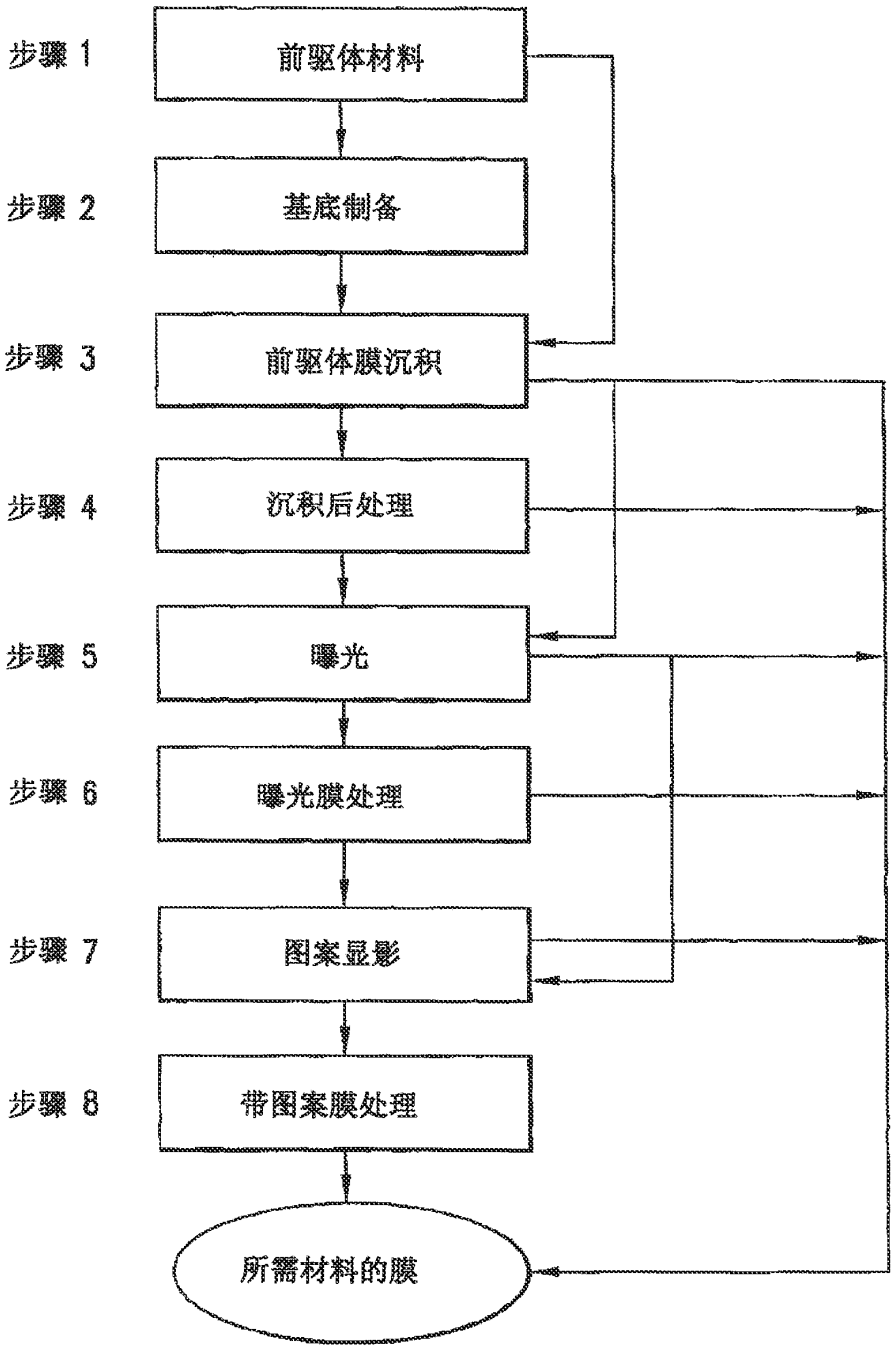



图1



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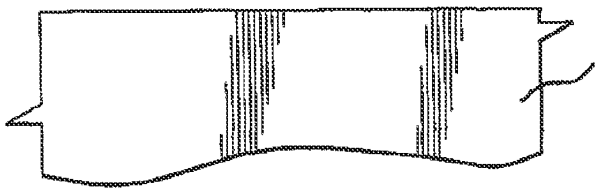



图2A

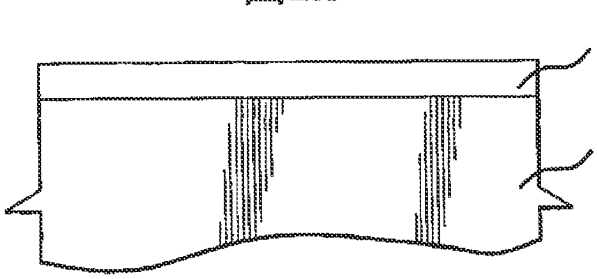



图2B

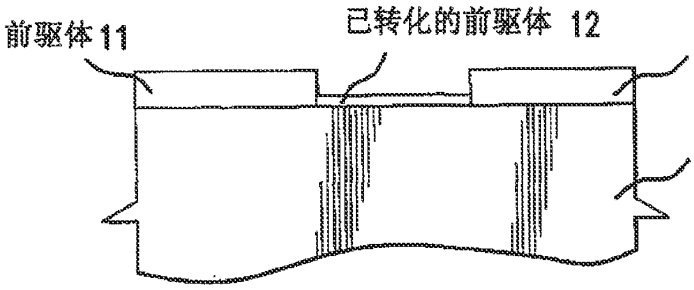



图2C

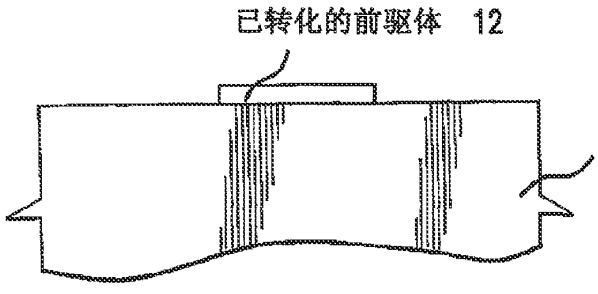
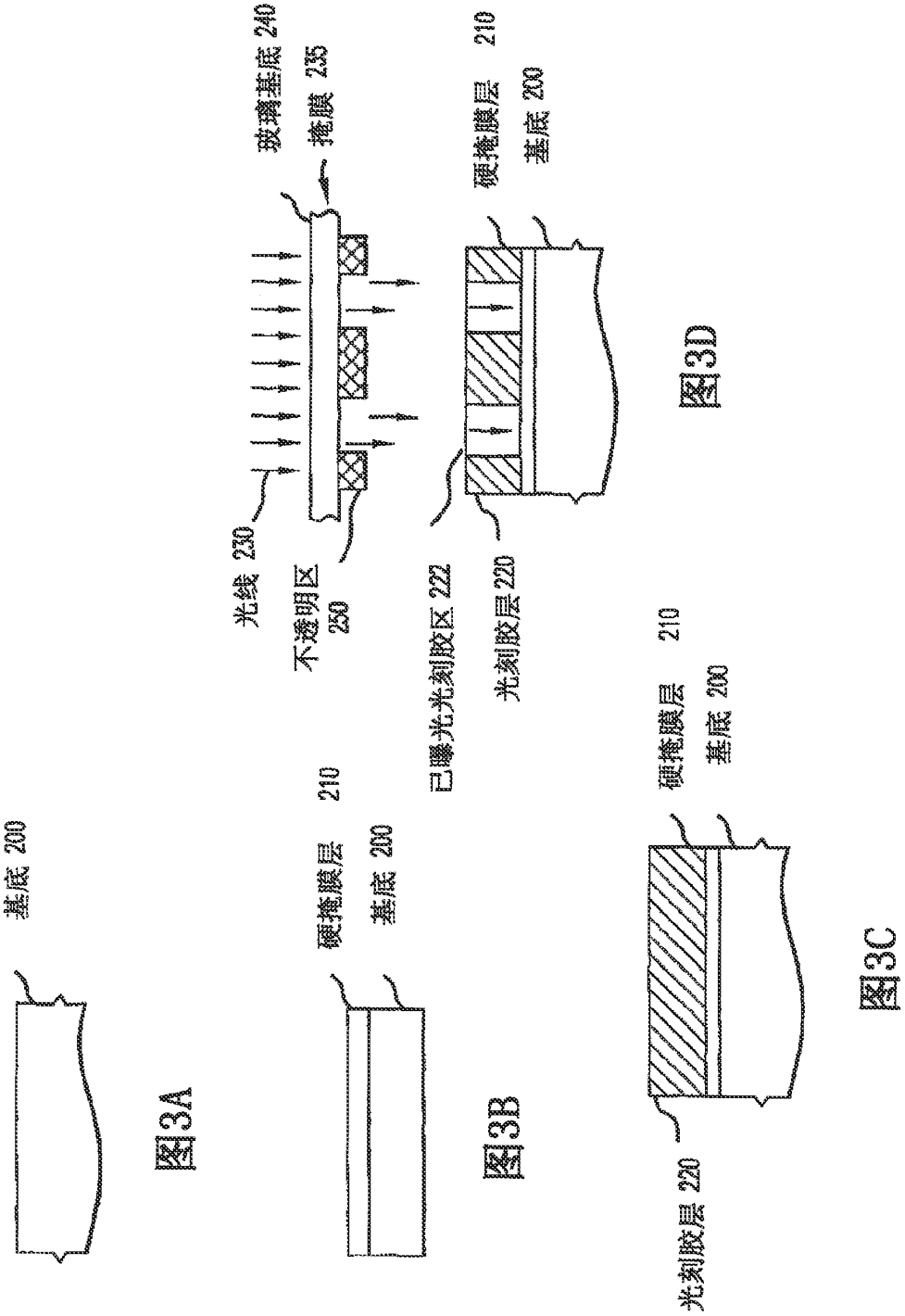



图2D

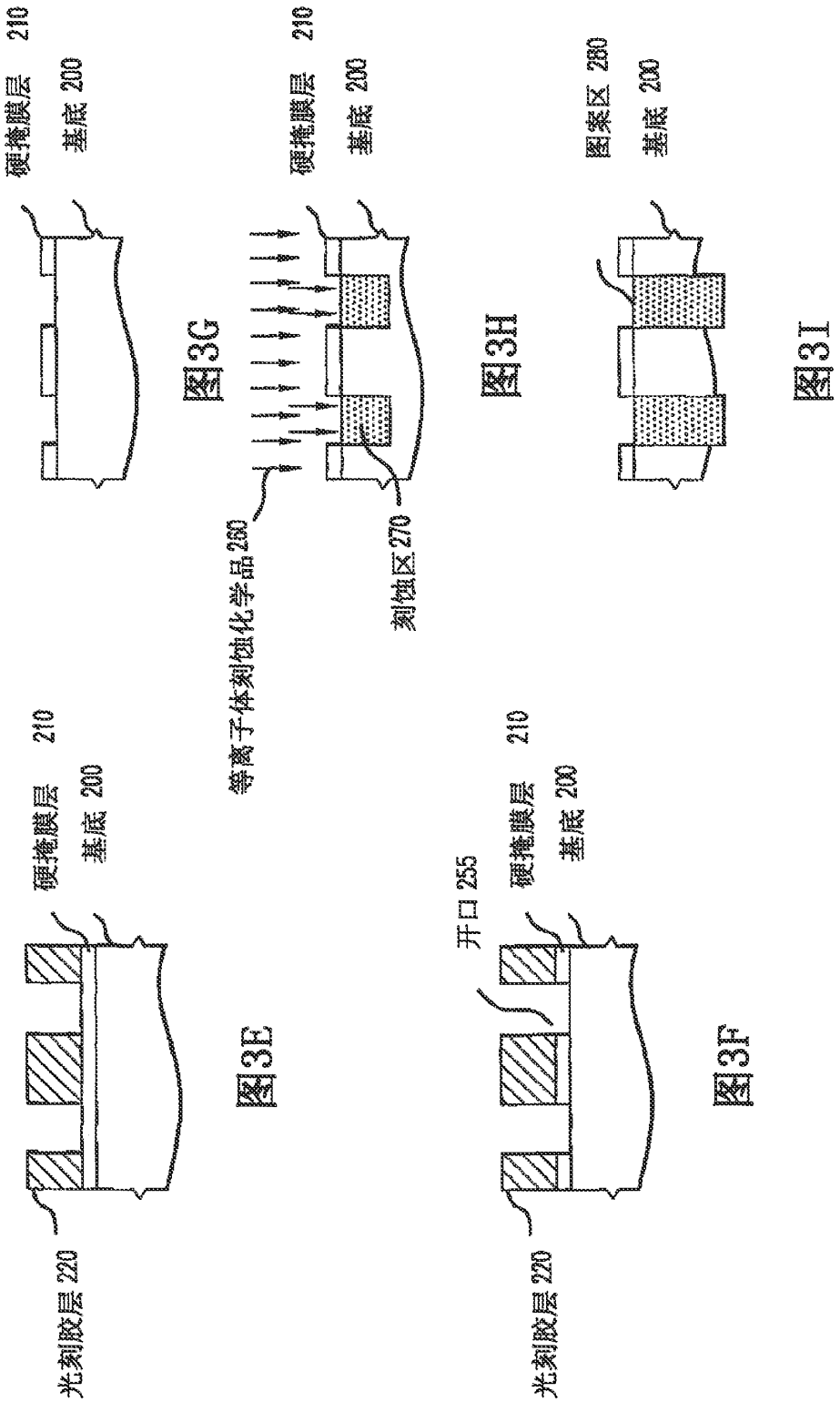


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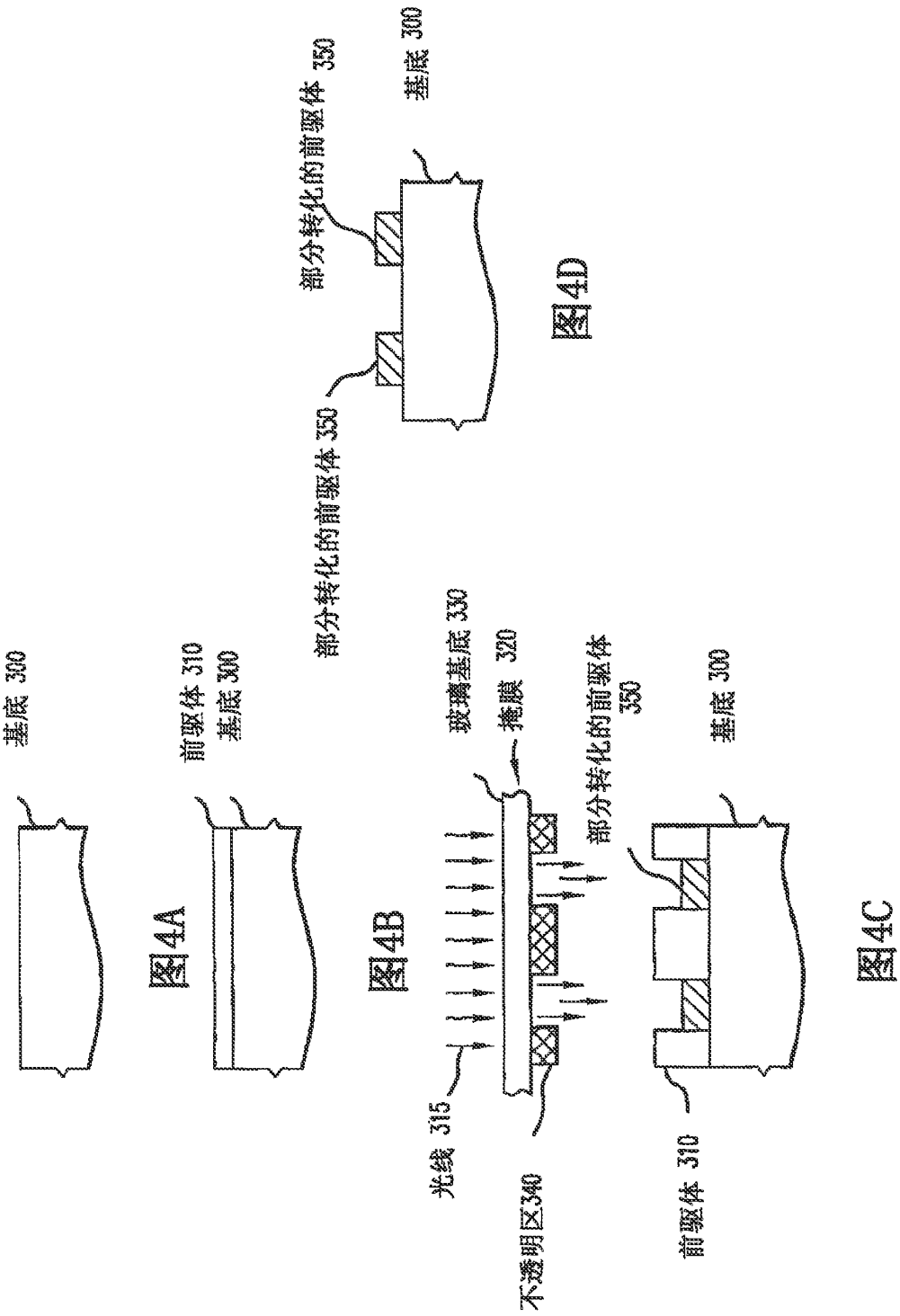



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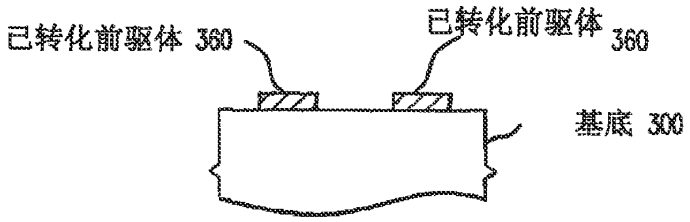



图4E

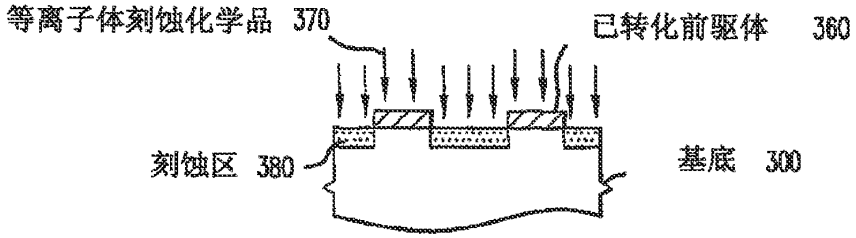



图4F

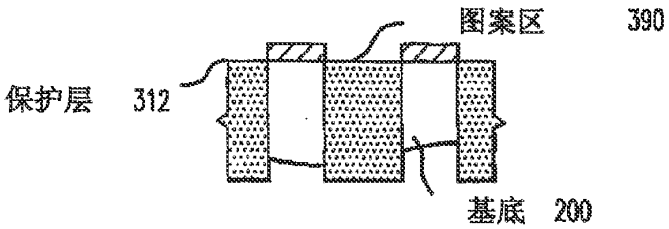
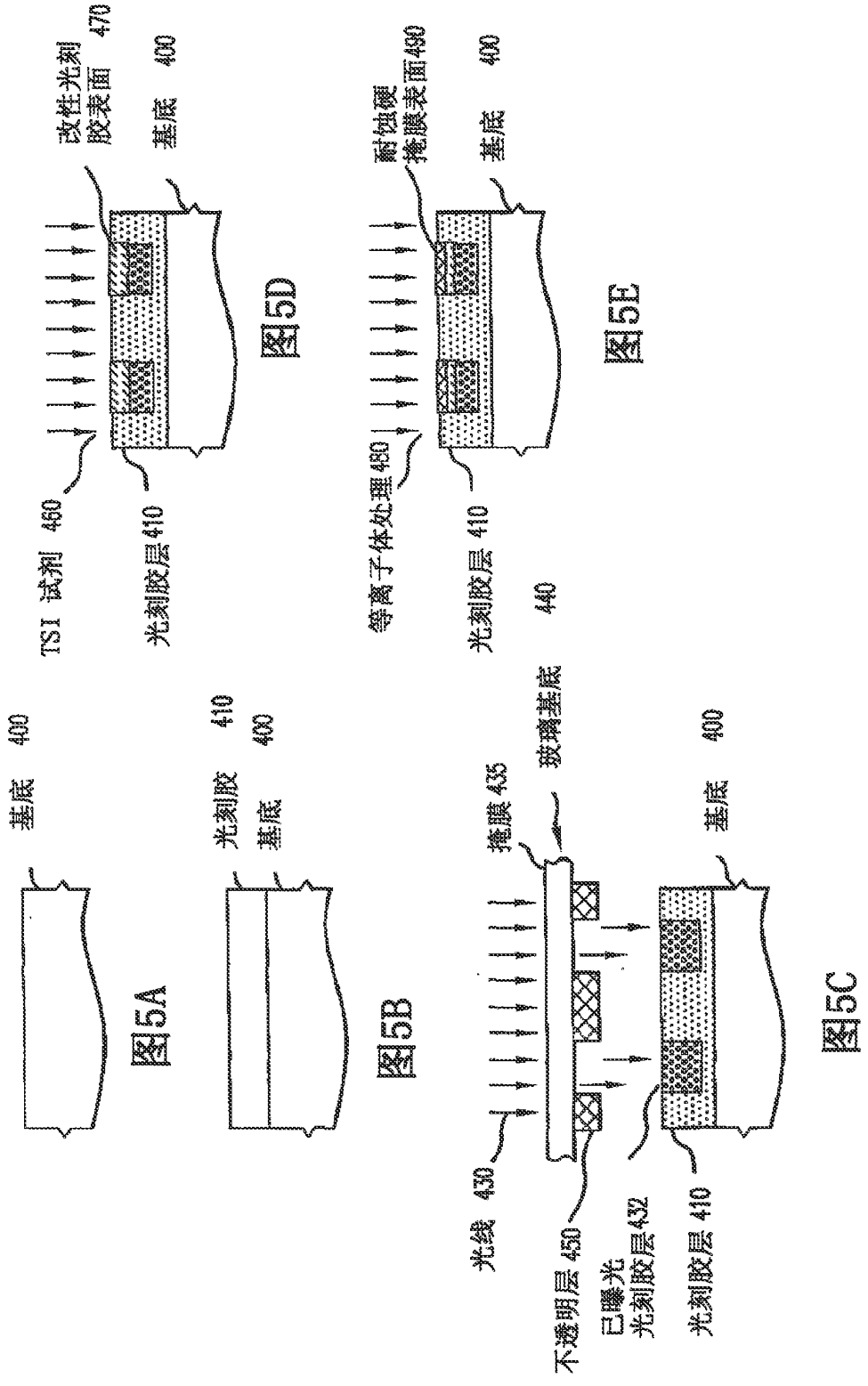



图4G



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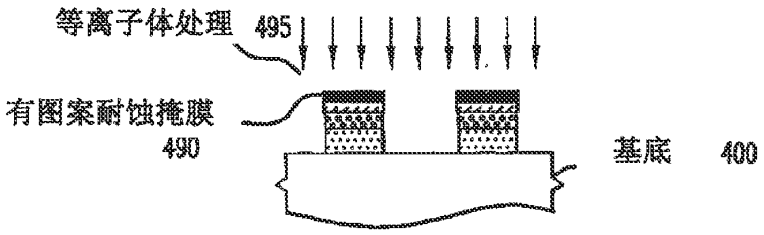



图5F

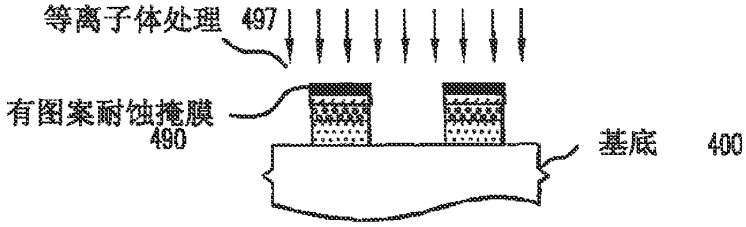



图5G

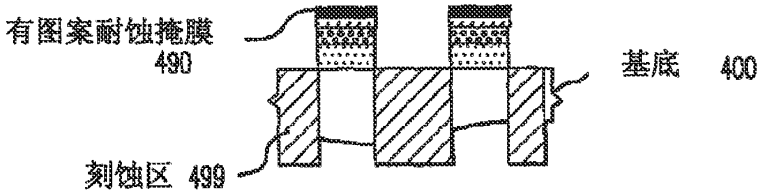



图5H

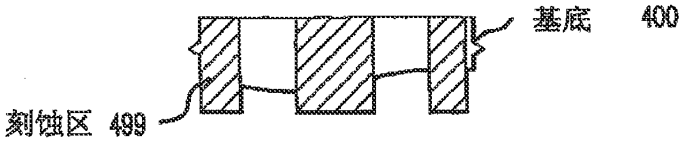
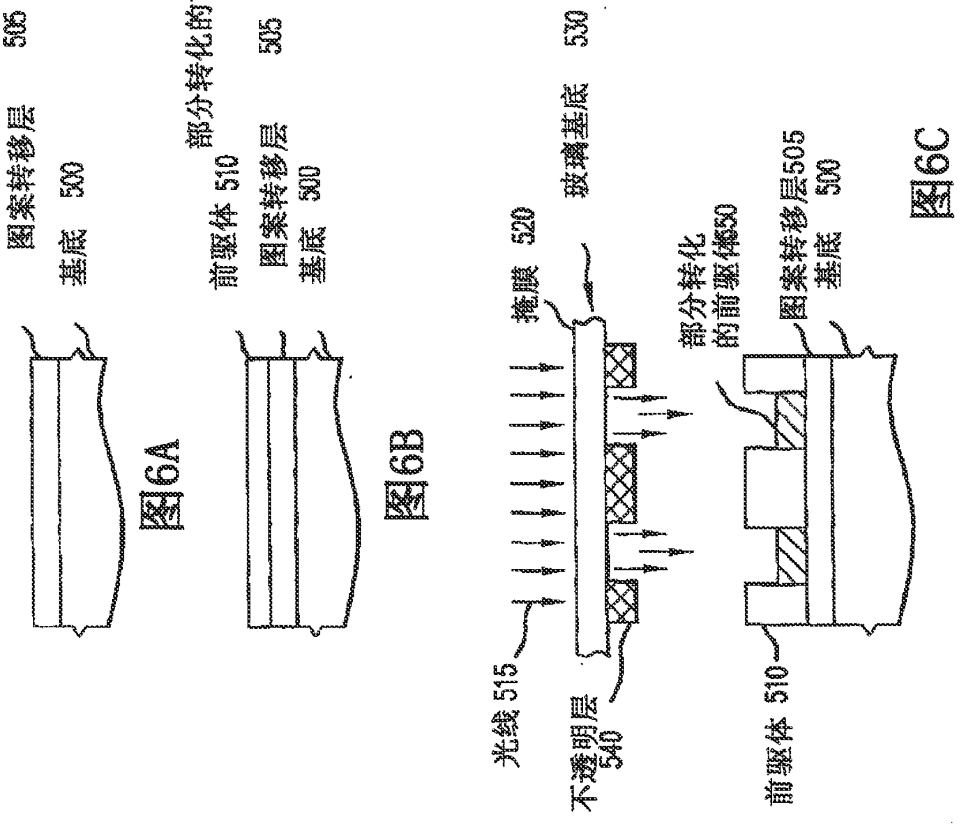



图5I



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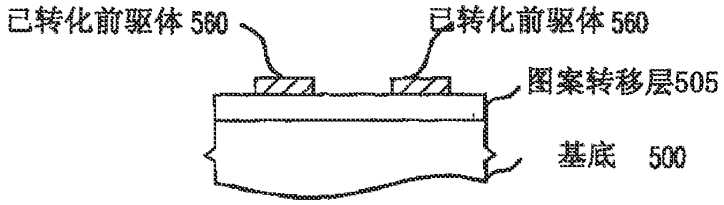



图6E

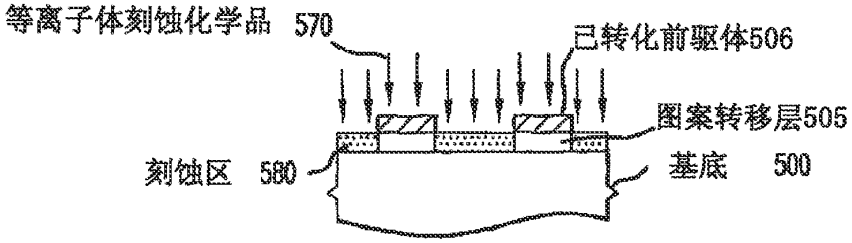



图6F

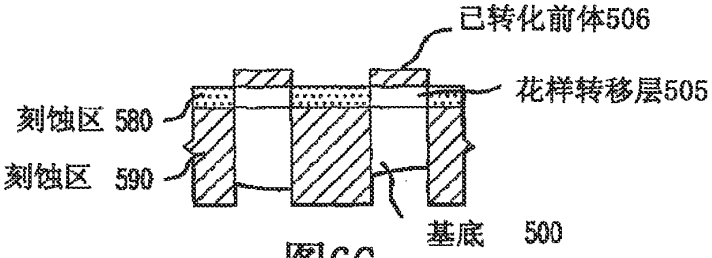



图6G

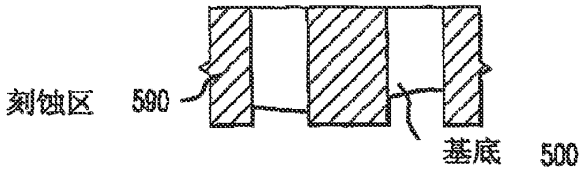



图6H



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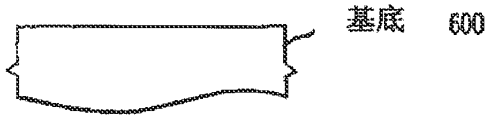



图7A

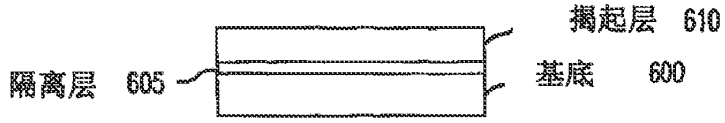



图7B

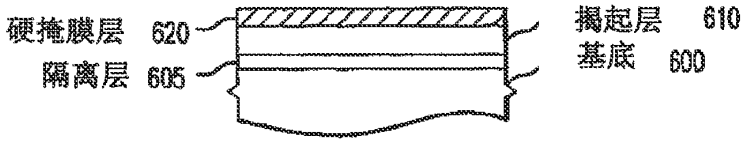



图7C

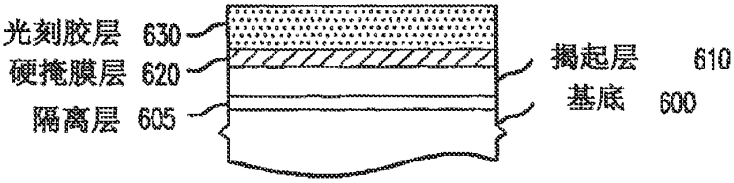



图7D

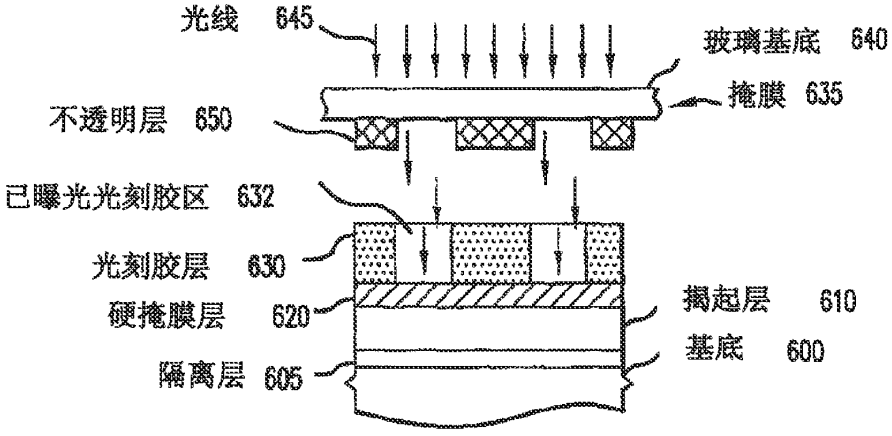



图7E



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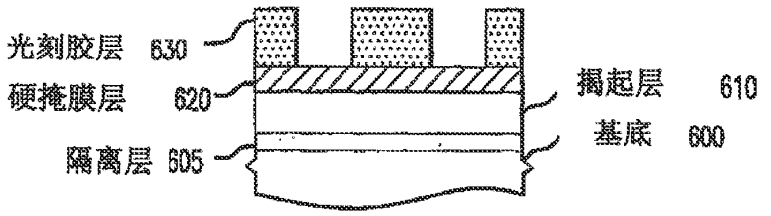



图7F

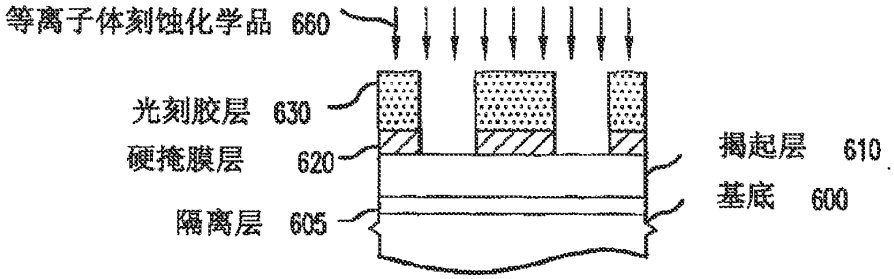



图7G

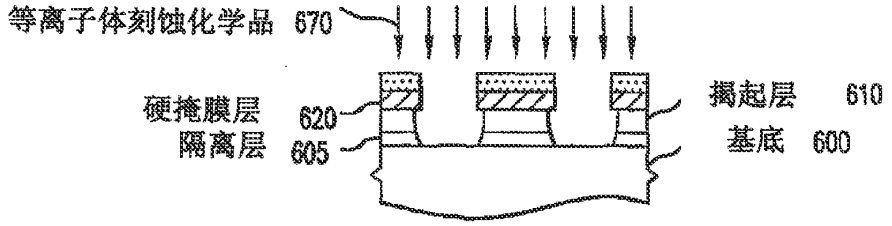



图7H

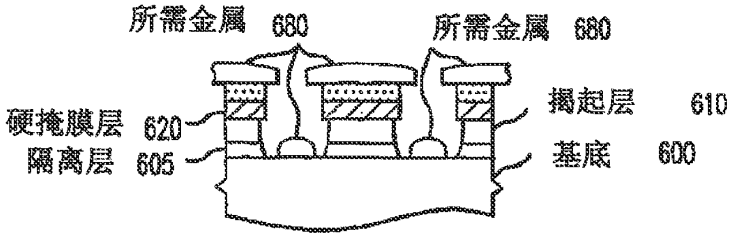



图7I

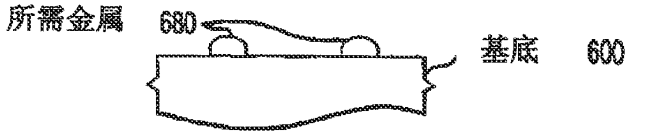
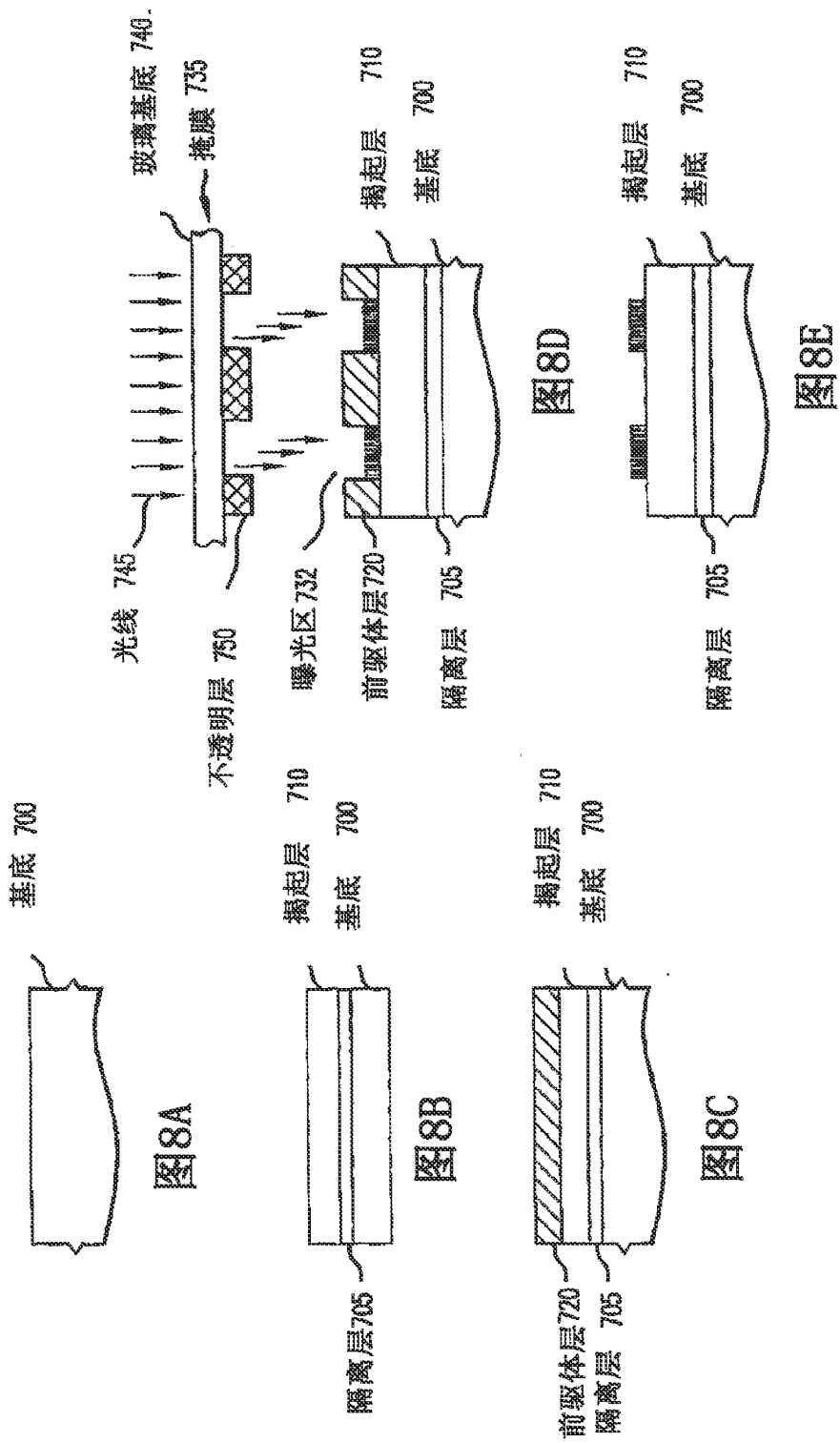



图7J



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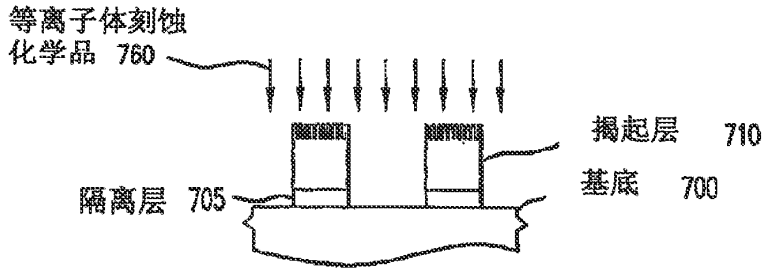



图8F

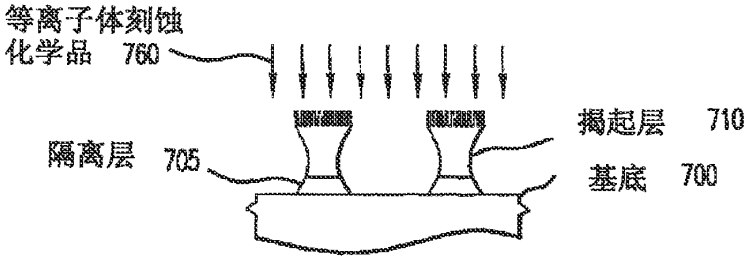



图8G

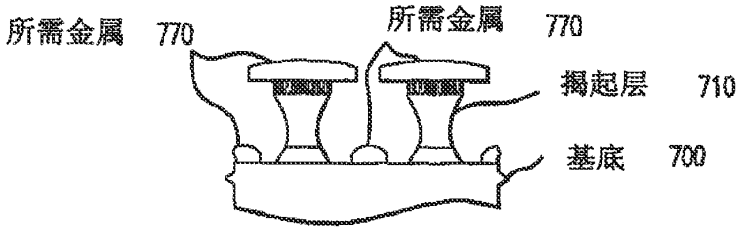



图8H




图8I



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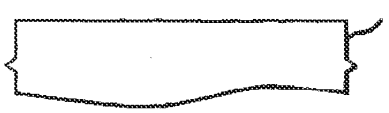



图9A

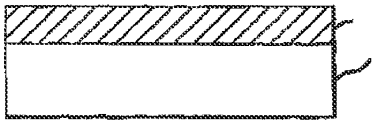



图9B

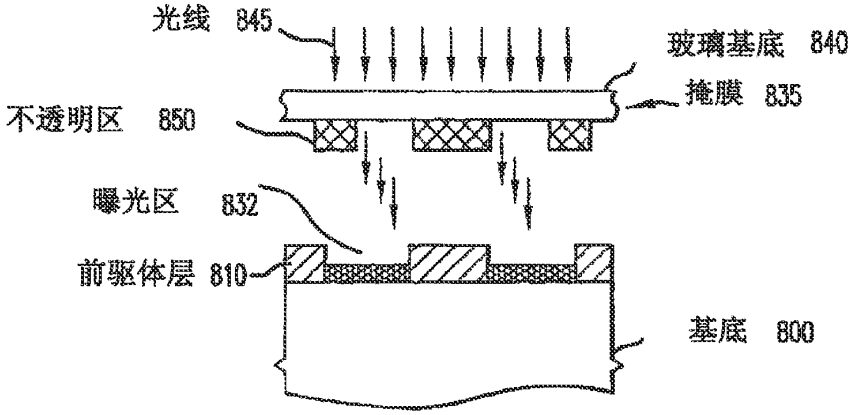



图9C

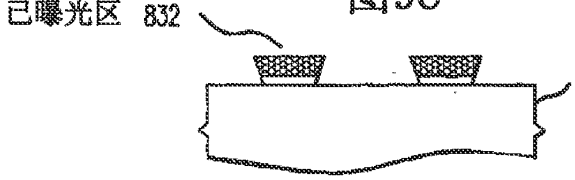



图9D

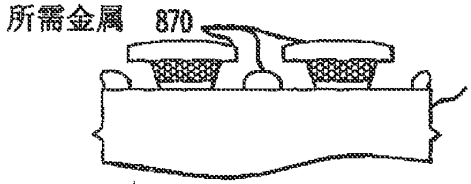



图9E

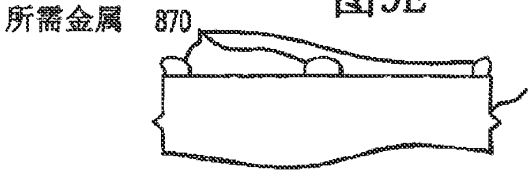



图9F



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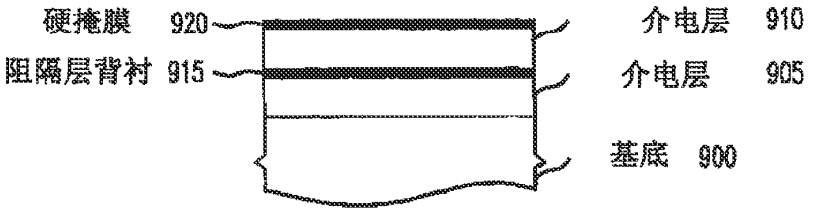



图10A

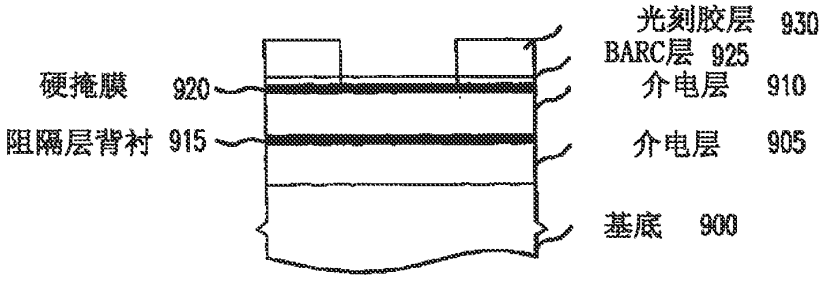



图10B

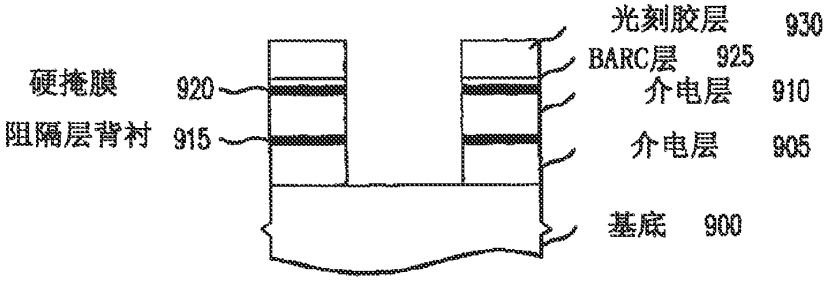



图10C

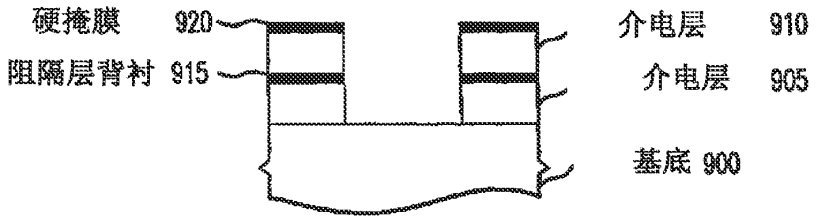



图10D



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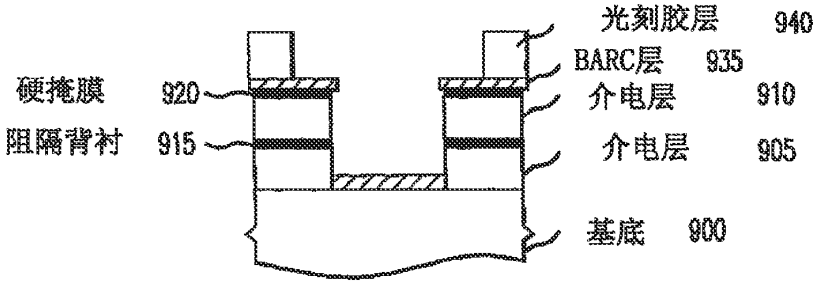



图10E

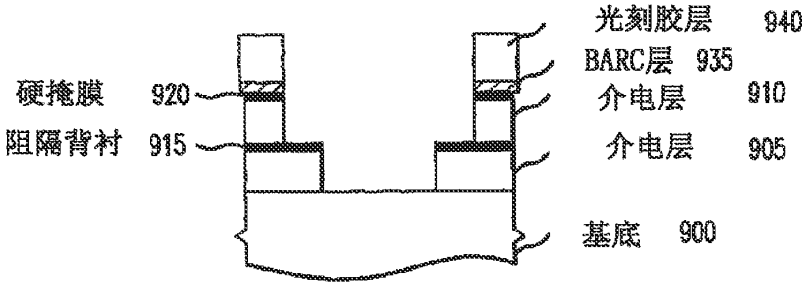



图10F

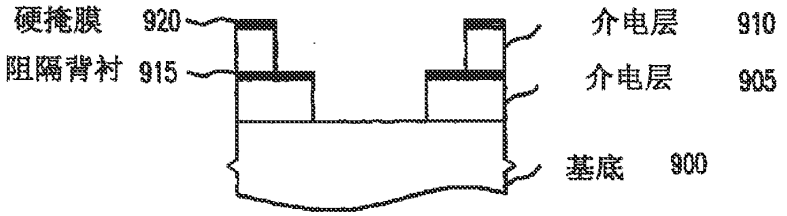



图10G



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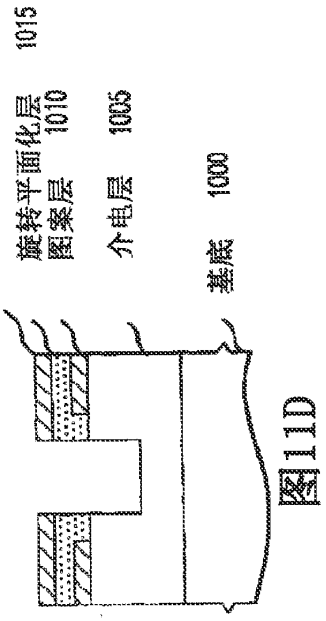



图11D

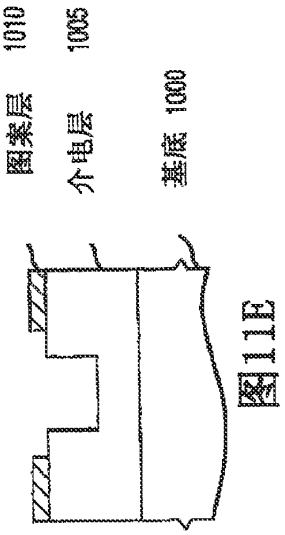



图11E

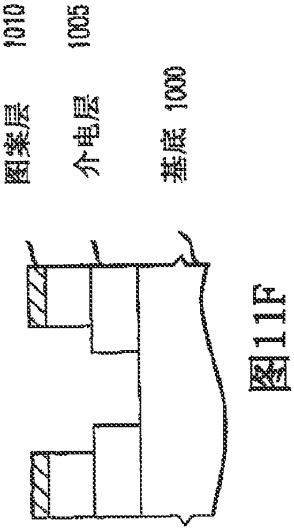



图11F

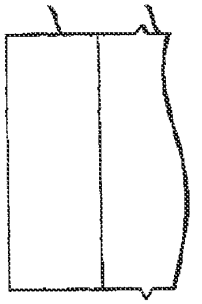



图11A

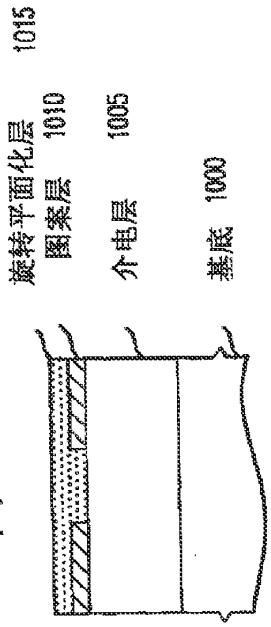



图11B

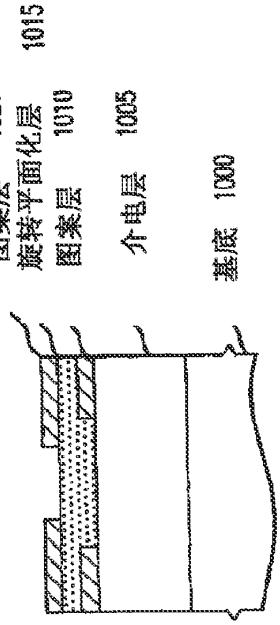



图11C



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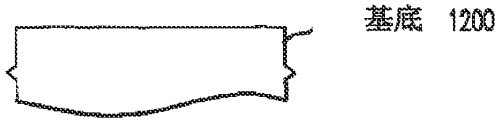



图12A

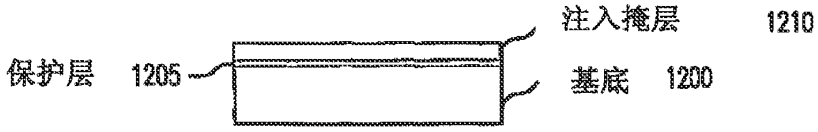



图12B

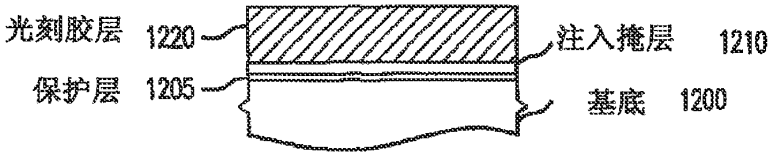



图12C

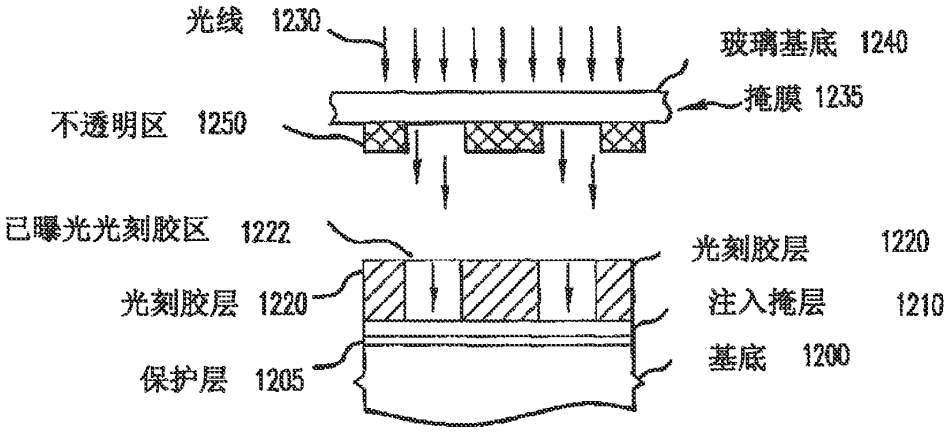



图12D



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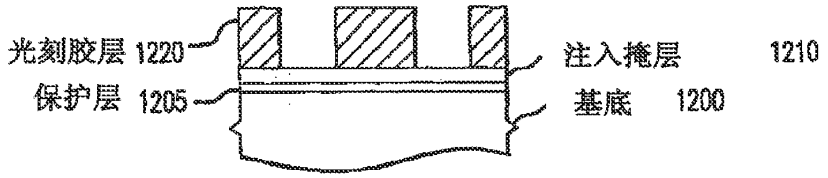



图12E

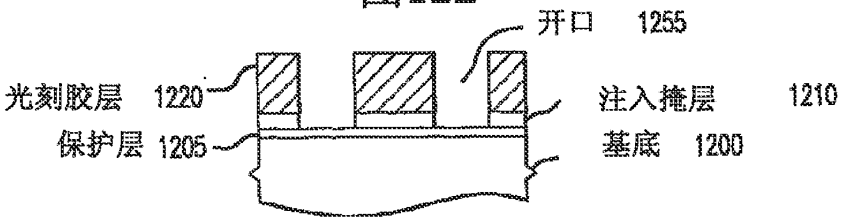



图12F

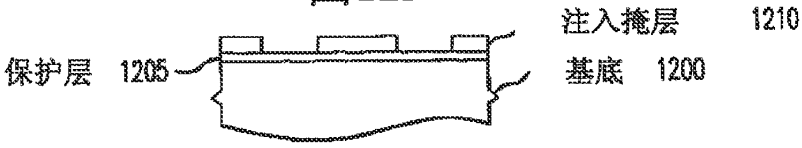



图12G

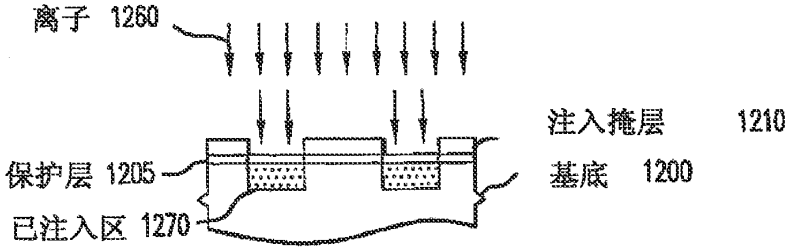



图12H

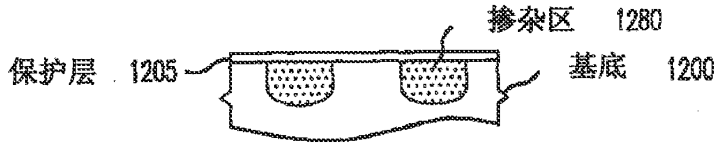



图12I



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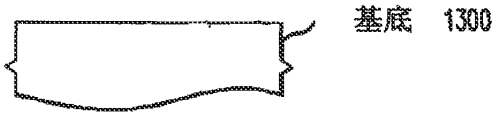



图13A

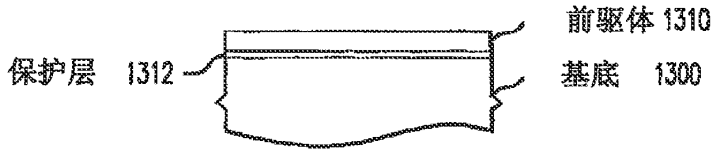



图13B

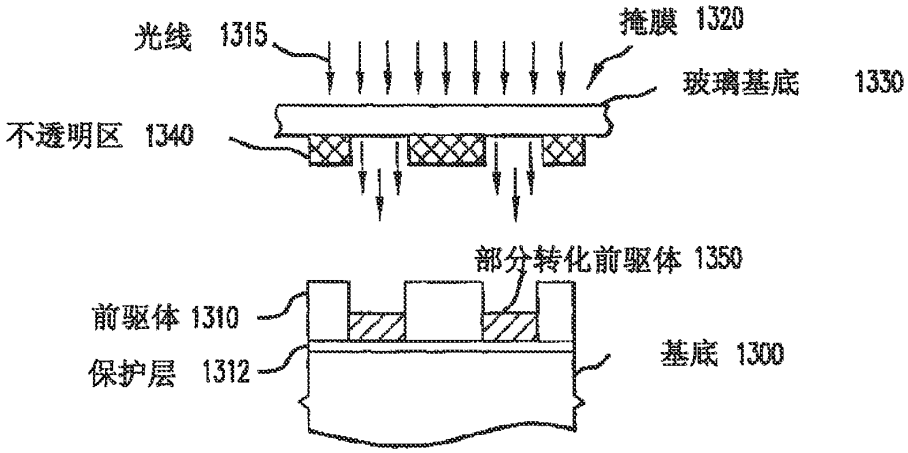



图13C



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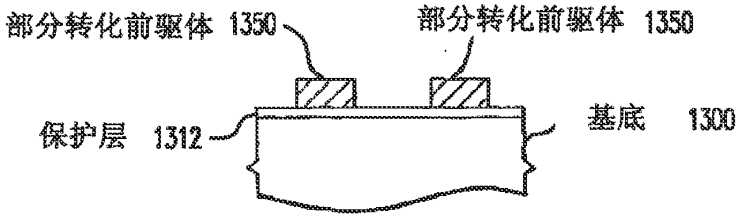



图13D

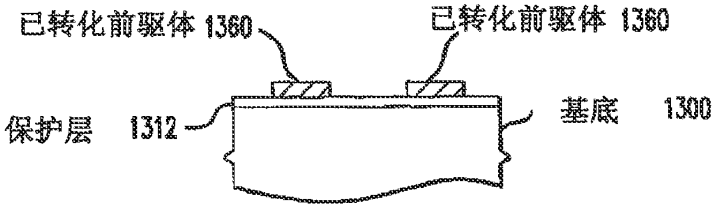



图13E

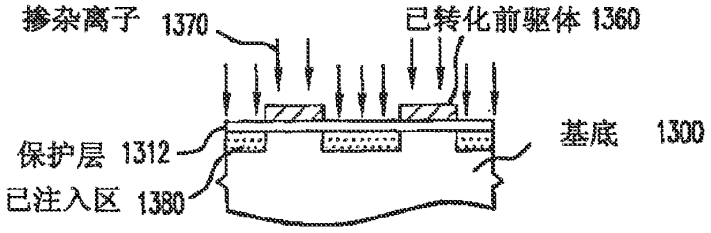



图13F

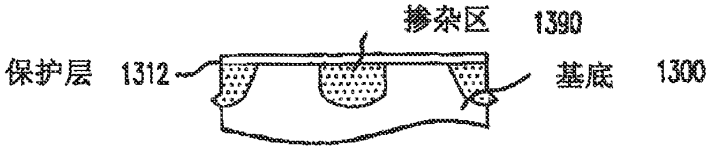



图13G



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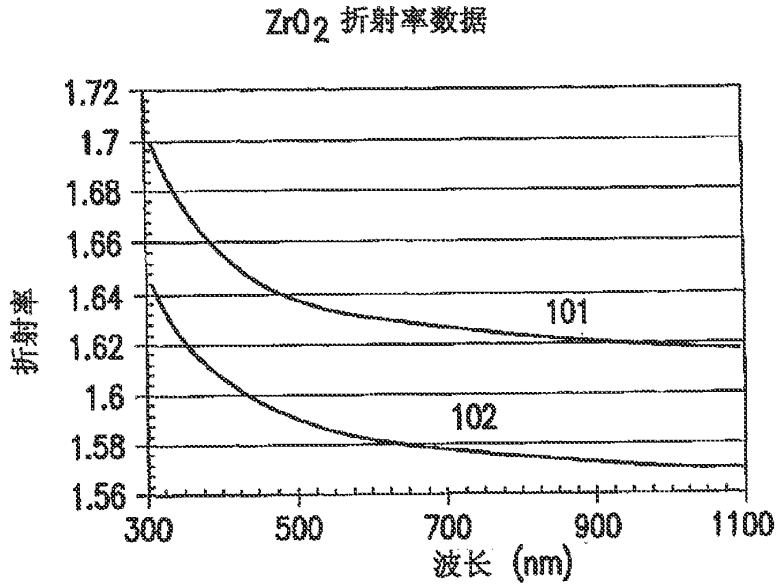



图14



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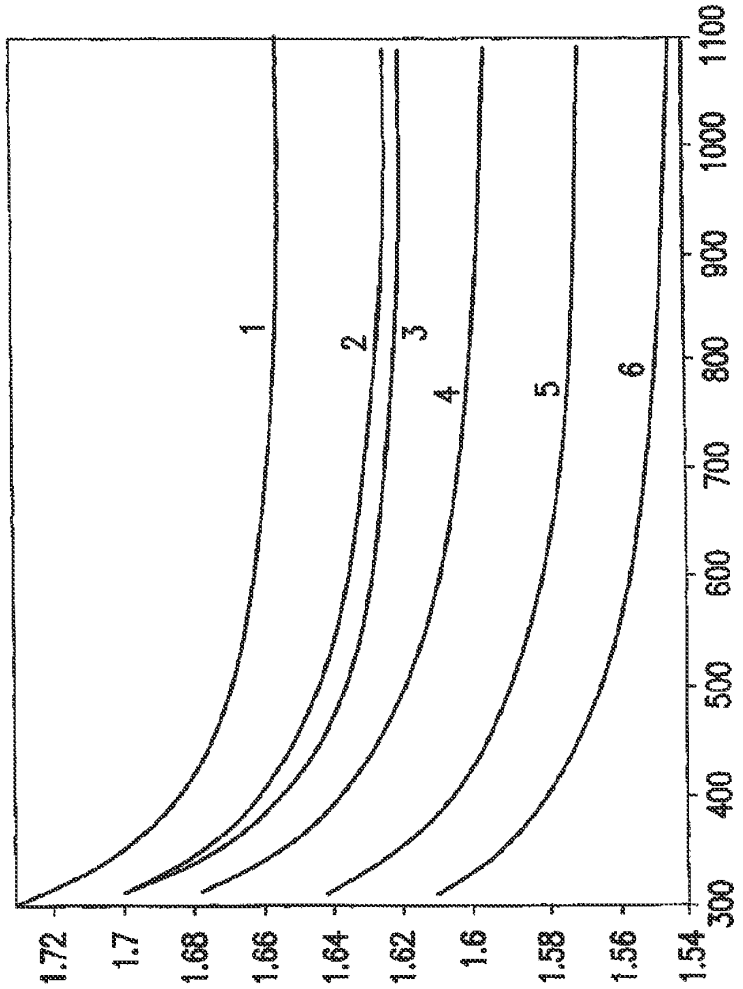



图15



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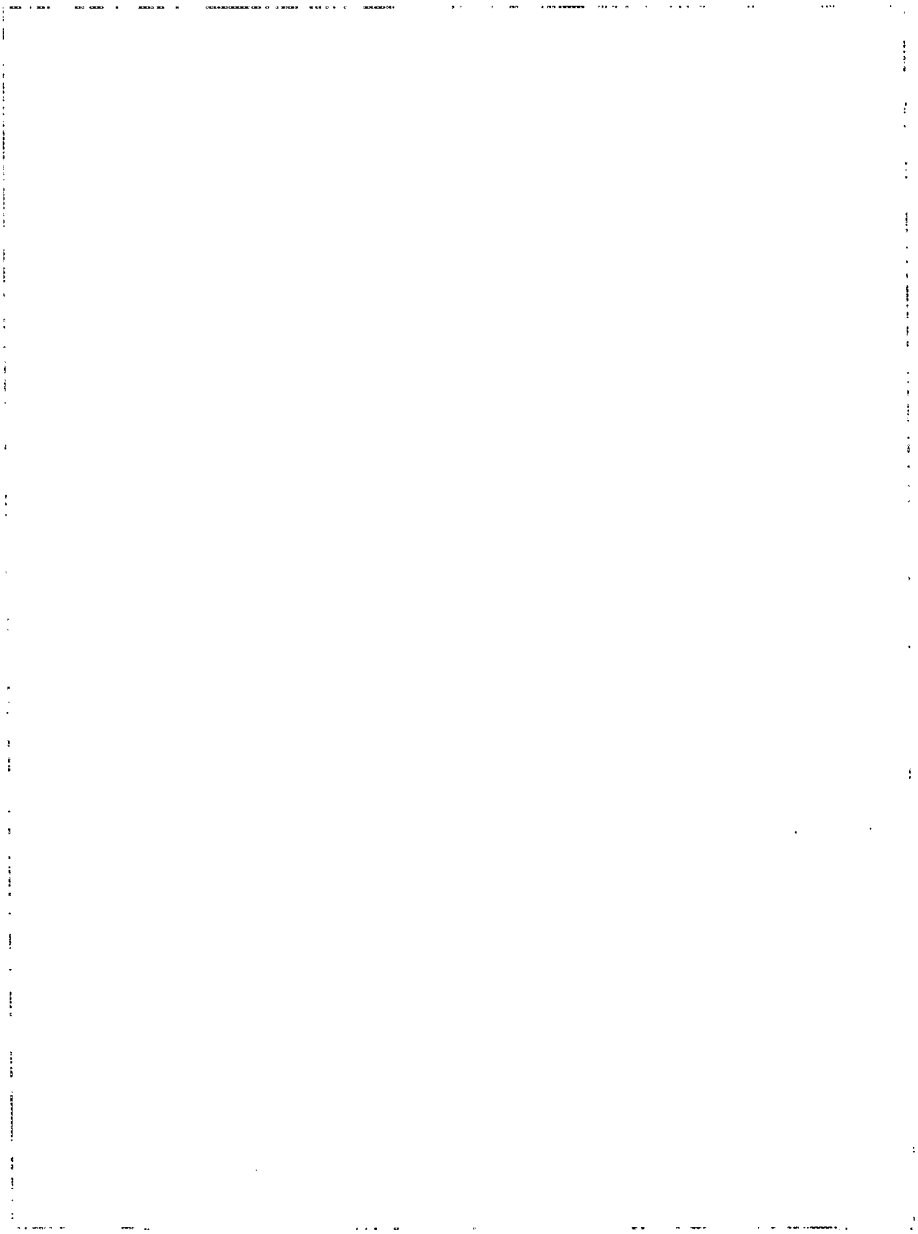


图16



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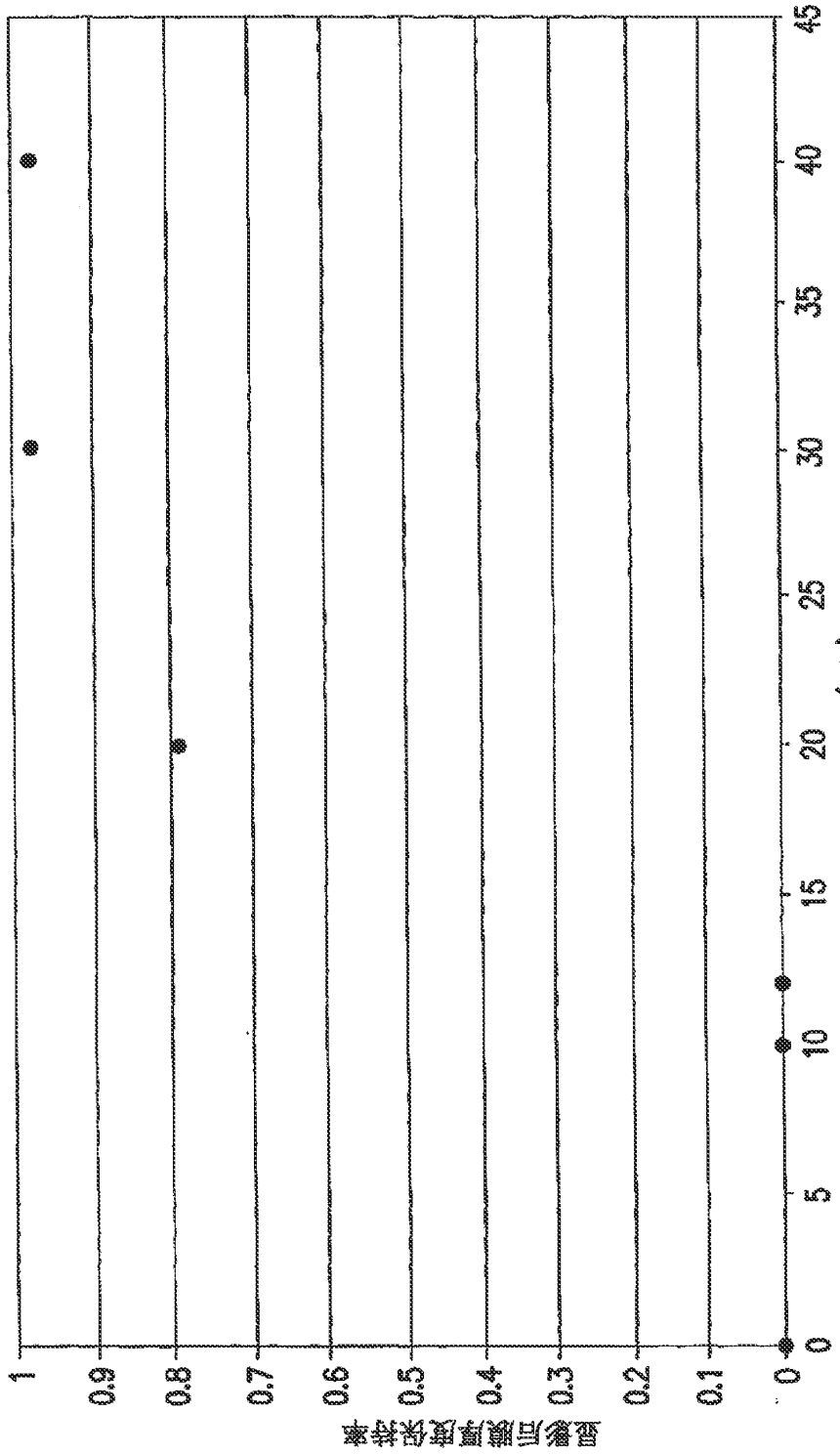



图17



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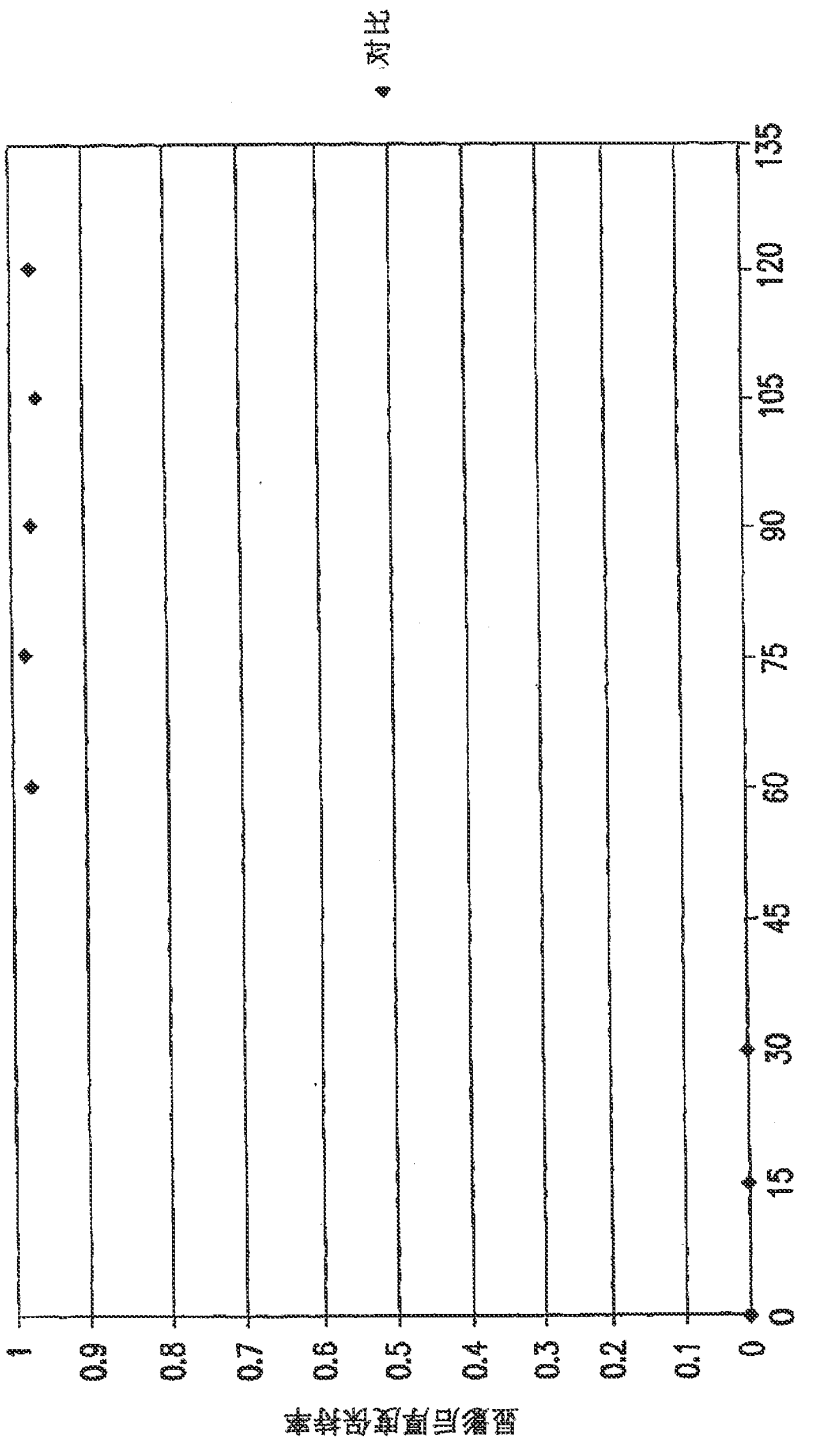



图18



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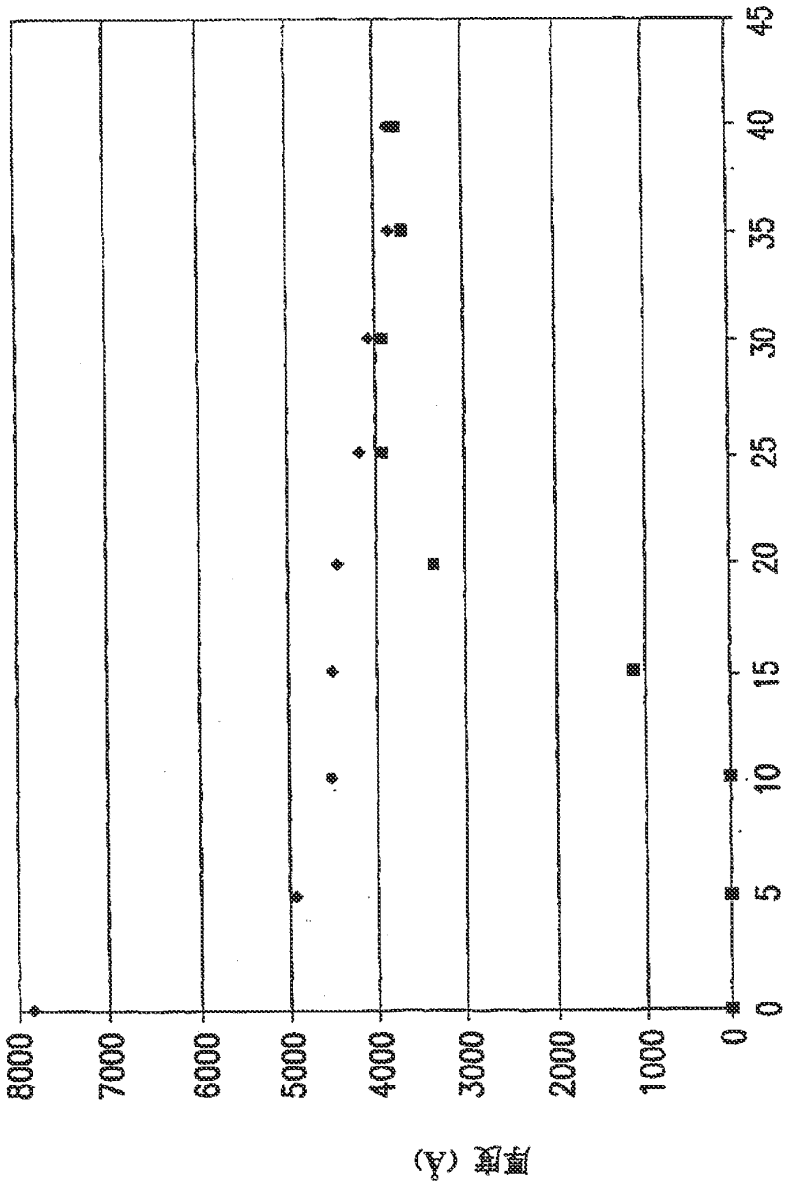



图19



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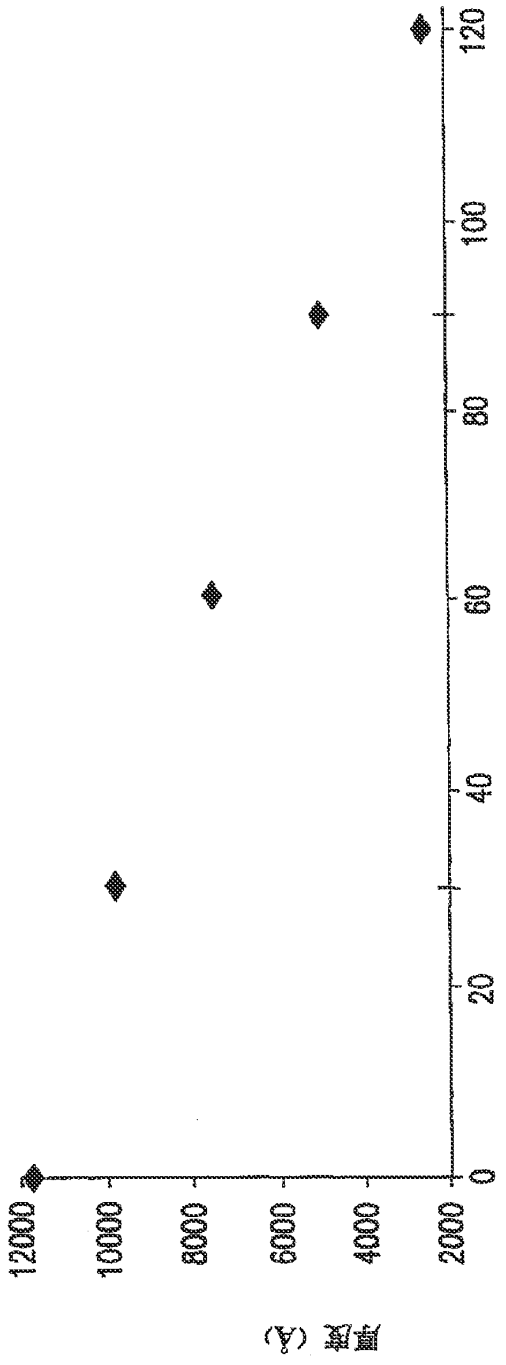



图20



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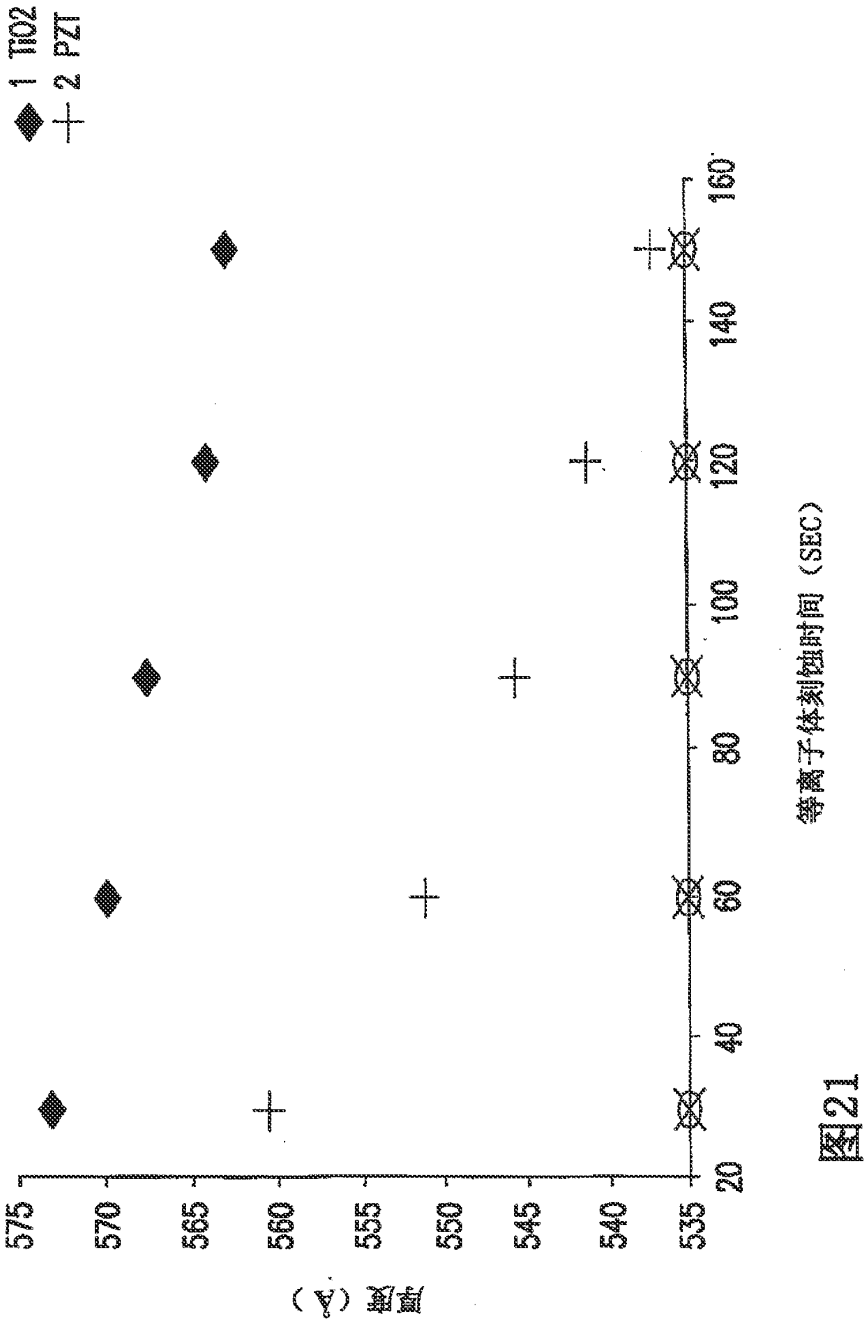



图21



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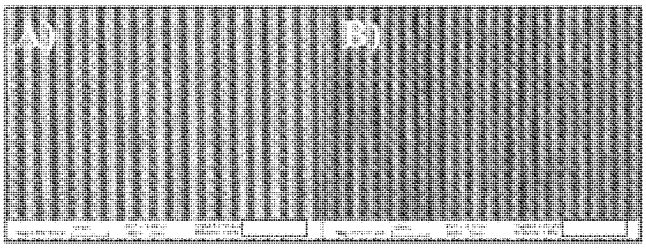



FIG. 12

(57) Abstract: Organometallic solutions have been found to provide high resolution radiation based patterning using thin coatings. The patterning can involve irradiation of the coated surface with a selected pattern and developing the pattern with a developing agent to form the developed image. The patternable coatings may be susceptible to positive-tone patterning or negative-tone patterning based on the use of an organic developing agent or an aqueous acid or base developing agent. The radiation sensitive coatings can comprise a metal oxo/hydroxo network with organic ligands. A precursor solution can comprise an organic liquid and metal polynuclear oxo-hydroxo cations with organic ligands having metal carbon bonds and/or metal carboxylate bonds.

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# ORGANOMETALLIC SOLUTION BASED HIGH RESOLUTION PATTERNING COMPOSITIONS

## STATEMENT AS TO GOVERNMENT RIGHTS

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## FIELD OF THE INVENTION

The invention relates to radiation based methods for the performance of patterning materials using an organometallic coating composition. The invention further relates to precursor solutions that can be deposited to form organometallic coatings that can be patterned with very high resolution with radiation and to the coated substrates and coatings formed with the precursor solutions before and after patterning.

## BACKGROUND OF THE INVENTION

For the formation of semiconductor-based devices as well as other electronic devices or other complex fine structures, materials are generally patterned to integrate the structure. Thus, the structures are generally formed through an iterative process of sequential deposition and etching steps through which a pattern is formed of the various materials. In this way, a large number of devices can be formed into a small area. Some advances in the art can involve that reduction of the footprint for devices, which can be desirable to enhance performance.

Organic compositions can be used as radiation patterned resists so that a radiation pattern is used to alter the chemical structure of the organic compositions corresponding with the pattern. For example, processes for the patterning of semiconductor wafers can entail lithographic transfer of a desired image from a thin film of organic radiation-sensitive material. The patterning of the resist generally involves several steps including exposing the resist to a selected energy source, such as through a mask, to record a latent image and then developing and removing selected regions of the resist. For a positive-tone resist, the exposed regions are transformed to make such regions selectively removable, while for negative-tone resist, the unexposed regions are more readily removable.

Generally, the pattern can be developed with radiation, a reactive gas, or liquid solution to remove the selectively sensitive portion of the resist while the other portions of the resist act as a protective etch resistant layer. Liquid developers can be particularly effective for



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developing the image. The substrate can be selectively etched through the windows or gaps in the remaining areas of the protective resist layer. Alternatively, desired materials can be deposited into the exposed regions of the underlying substrate through the developed windows or gaps in the remaining areas of the protective resist layer. Ultimately, the protective resist layer is removed. The process can be repeated to form additional layers of patterned material. The functional inorganic materials can be deposited using chemical vapor deposition, physical vapor deposition or other desired approaches. Additional processing steps can be used, such as the deposition of conductive materials or implantation of dopants. In the fields of micro- and nanofabrication, feature sizes in integrated circuits have become very small to achieve high-integration densities and improve circuit function.

## SUMMARY OF THE INVENTION

In a first aspect, the invention pertains to a method for patterning a substrate with radiation, the method comprising the steps of irradiating a coated substrate along a selected pattern to form an irradiated structure with a region of irradiated coating and a region with un-irradiated coating and selectively developing the irradiated structure to remove a substantial portion of the irradiated coating or of the un-irradiated coating to form a patterned substrate. The coated substrate generally comprises a coating that comprises a metal oxo-hydroxo network with organic ligands with a metal carbon bonds and/or with metal carboxylate bonds.

In a further aspect, the invention pertains to a coated substrate comprising a radiation sensitive coating having an average thickness of no more than about 10 microns and a thickness variation of no more than about 50% from the average at any point along the coating, the coating comprising metal oxo-hydroxo network with metal cations having organic ligands with a metal carbon bonds and/or with metal carboxylate bonds.

In another aspect, the invention pertains to a patterned substrate comprising a substrate with a surface and a first coating at selected regions along the surface and absent at other regions along the surface. Generally, the first coating comprises metal oxo-hydroxo network and organic ligands with metal cations having organic ligands with a metal carbon bonds and/or with metal carboxylate bonds. Alternatively, the first coating is soluble in at least some organic liquids, or the first coating is soluble in aqueous bases.

In additional aspects, the invention pertains to a precursor solution comprising an organic liquid and from about 0.01M to about 1.4M metal polynuclear oxo/hydroxo cation with organic ligands having a metal carbon bonds and/or with metal carboxylate bonds, the precursor solution having a viscosity from about 0.5 centipoises (cP) to about 150cP. The



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organic liquid can have a flash point of at least 10°C and a vapor pressure at 20°C less than about 10kPa.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of a radiation patterned structure with a latent image.

Fig. 2 is a side plan view of the structure of Fig. 1.

Fig. 3 is a schematic perspective view of the structure of Fig. 1 after development of the latent image to remove un-irradiated coating material to form a patterned structure.

Fig. 4 is a side view of the patterned structure of Fig. 3.

Fig. 5 is a schematic perspective view of the structure of Fig. 1 after development of the latent image to remove irradiated coating material to form a patterned structure.

Fig. 6 is a side view of the patterned structure of Fig. 5.

Fig. 7 is a side plan view of the patterned structure of Figs. 3 and 4 following etching of the underlayer.

Fig. 8 is a side plan view of the structure of Fig. 7 following etching to remove the patterned, condensed coating material.

Fig. 9 is a side plan view of a "thermal freeze" double patterning process flow. The process shown in Figs. 1-3 is repeated after a bake that renders the first layer insoluble to the second layer.

Fig. 10A is a plot of the autocorrelation scattering intensity decay versus time of a precursor solution with monobutyltin oxide hydrate.

Fig. 10B is a histogram of the calculated mass averaged particle size distribution of a precursor solution comprising monobutyltin oxide hydrate in 4-methyl-2-pentanol.

Fig. 11A is a scanning electron micrograph of negative tone patterned coating with 18 nm wide lines on a 36 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30kV electron beam at a dose of 1191 $\mu C/cm^2$, and developed in 4-methyl-2-pentanol.

Fig. 11B is a scanning electron micrograph of negative tone patterned coating with 18 nm wide lines on a 36 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30kV electron beam at a dose of 1191 $\mu C/cm^2$, and developed in ethyl lactate.

Fig. 11C is a scanning electron micrograph of negative tone patterned coating with 18 nm wide lines on a 36 nm pitch in a coating material formed with monobutyltin oxide hydrate



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following irradiation with a 30kV electron beam at a dose of 1191 μC/cm$^2$, and developed in propylene glycol monomethyl ether (PGMEA).

Fig. 11D is a scanning electron micrograph of negative tone patterned coating with 18 nm wide lines on a 36 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30kV electron beam at a dose of 1191 μC/cm$^2$, and developed in n-butyl acetate.

Fig. 12A is a scanning electron micrograph of a negative tone patterned coating with 22 nm wide lines on a 44 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with EUV projection lithography with a 13.5 nm radiation at a dose of 101 mJ cm$^{-2}$ and developed with PGMEA.

Fig. 12B is a scanning electron micrograph of a negative tone patterned coating with 18 nm wide lines on a 36 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with EUV projection lithography with 13.5 nm radiation at a dose of 101 mJ cm$^{-2}$ and developed with PGMEA

Fig. 13 is a plot of relative hydrocarbon concentration versus electron beam dose as calculated from FTIR transmission measurements of C-H stretching mode absorbance for a coating material formed with monobutyltin oxide hydrate.

Fig. 14 is a scanning electron micrograph of positive tone patterned coating with 30-nm wide lines and a 60 nm pitch in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30 kV electron beam at a dose of 511 μC/cm$^2$ and development with 2.38% TMAH.

Fig. 15A is a scanning electron micrograph of negative-tone patterned coating with 18 nm wide lines on a 36 nm pitch and a line-width roughness (LWR) of 2.78 nm in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30 kV electron beam at a dose of 1191 μC/cm$^2$ of a film that was deposited from a freshly prepared precursor solution and immediately exposed and developed in PGMEA.

Fig. 15B is a scanning electron micrograph of negative-tone patterned coating with 18 nm wide lines on a 36 nm pitch and a LWR of 2.87 nm in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30 kV electron beam at a dose of 1191 μC/cm$^2$ of a film that was deposited from a precursor solution aged 39 days at room-temperature and then immediately exposed and developed in PGMEA.

Fig. 15C is a scanning electron micrograph of a negative-tone patterned coating with 18 nm wide lines on a 36 nm pitch and a LWR of 2.68 nm in a coating material formed with monobutyltin oxide hydrate following irradiation with a 30 kV electron beam at a dose of 1191



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$\mu C/cm^2$ of a resist film that was deposited from a freshly prepared precursor solution and aged 39 days at room-temperature as a coated film then exposed and developed in PGMEA.

Fig. 16 is a scanning electron micrograph of a negative-tone patterned coating with lines on a 100 nm pitch in a coating formed with a divinyltin hydroxide/oxide coating material following irradiation with a 30 kV electron beam at a dose of 75 $\mu C/cm^2$ and developed in PGMEA.

Fig. 17 is a plot of relative vinyl (C-H stretch) absorbance versus dose as calculated from FTIR transmission spectra of a coating formed with divinyltin hydroxide/oxide coating materials exposed with a 30 kV electron beam.

Fig. 18 is a scanning electron micrograph of a negative-tone patterned coating with lines on a 32 nm pitch in a coating formed with a dibutyltin oxo-carboxylate coating material following irradiation with a 30 kV electron beam at a dose of 1500 $\mu C/cm^2$ and developed in PGMEA.

Fig. 19 is a comparative transmission-mode FTIR transmission spectra of a dibutyltin oxo-carboxylate film in an unexposed state and after exposure with a 30 kV electron beam at a dose of 800 $\mu C/cm^2$.

## DETAILED DESCRIPTION OF THE INVENTION

Desirable organometallic precursor solutions, generally with non-aqueous solvents, with a ligand structure that provides for high resolution patterning in which the solutions have a high degree of stability for the formation of radiation patternable coatings with good radiation sensitivity. Desirable ligands for forming metal oxo/hydroxo complexes can comprise M-C bonds or M-O$_2$C bonds, where M is a selected metal atom, with particularly desirable results obtainable where M is tin, indium, antimony or a combination thereof. Desirable features of coatings formed with the organometallic precursor solutions provide for superior direct patterning for the formation of a patterned metal oxide coating. In embodiments of particular interest, exposure to radiation converts the irradiated coating material into a material that is resistant to removal with a developer composition, or exposure sufficiently changes the polarity of the coating material such that it can be selectively removed. Thus, in some embodiments, the coating can be either negatively patterned or positively patterned with the same coating. Selective removal of at least a portion of the coating material can leave a pattern where regions of coating have been removed to expose the underlying substrate. After development of the coting following irradiation, the patterned oxide materials can be used for facilitating processing in device formation with excellent pattern resolution. The coating materials can be



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designed to be sensitive to selected radiation, such as extreme ultraviolet light, ultraviolet light and/or electron beams. Furthermore, the precursor solutions can be formulated to be stable with an appropriate shelf life for commercial distribution.

To simplify the discussion herein, the metal ions with a M-C ligand bond and/or a M-$O_2C$ ligand bonds can be referred to as organo-stabilized metal ions. The metal ions generally also are further bound to one or more oxo-ligands, i.e., M-O and/or hydroxo-ligands, i.e., M-O-H, in addition to the organic ligands. The organo-stabilizing ligands and the oxo/hyclroxo ligands provide desirable features to precursor solution and corresponding coating by providing significant control over the condensation process to a metal oxide with resulting significant processing advantages. The use of organic solvents supports the stability of the solution, while surprisingly the non-aqueous solution based processing maintains the ability to selectively develop the resulting coating following the formation of a latent image with excellent development rate contrast, for both positive tone patterning and negative tone patterning. Desirable precursor solutions with dissolved organo-stabilized metal ions provide for convenient solution based deposition to form a coating that can have high radiation sensitivity and excellent contrast with respect to etch resistance to allow for fine structure formation. The design of the precursor composition can provide for the formation of a coating composition with a high sensitivity to a particular radiation type and/or energy/wavelength.

The radiation sensitive coating material can be used as either a positive radiation patterning coating or a negative radiation patterning coating. In the negative patterning, exposure to radiation converts the irradiated coating material into a material that is more resistant to removal with a developer composition relative to the non-irradiated coating material. In the positive patterning, exposure sufficiently changes the polarity of the exposed coating material, e.g., increasing the polarity, such that the exposed coating material can be selectively removed with an aqueous solvent or other highly polar solvent. Selectively removal of at least a portion of the coating material leaves a pattern where regions have been removed to expose the underlying substrate.

The formation of integrated electronic devices and the like generally involves the patterning of the materials to form individual elements or components within the structures. This patterning can involve different compositions covering selected portions of stacked layers that interface with each other vertically and/or horizontally to induce desired functionality. The various materials can comprise semiconductors, which can have selected dopants, dielectrics, electrical conductors and/or other types of materials. To form high resolution patterns, radiation sensitive organic compositions can be used to introduce patterns, and the compositions can be



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referred to as resists since portions of the composition are processed to be resistant to development/etching such that selective material removal can be used to introduce a selected pattern. Radiation with the selected pattern or the negative of the pattern can be used to expose the resist and to form a pattern or latent image with developer resistant regions and developer dissolvable regions. The radiation sensitive organometallic compositions described herein can be used for the direct formation of desired inorganic material structures within the device and/or as a radiation patternable inorganic resist that is a replacement for an organic resist. In either case, significant processing improvements can be exploited, and the structure of the patterned material can be also improved.

Specifically, the precursor solution can comprise sufficient radiation sensitive organic ligands such that the solution has a molar concentration ratio of radiation sensitive ligands to metal cations from about 0.1 to about 3. The coating formed from the precursor solution is influenced by the ligand structure of the ions in the precursor solution and may be an equivalent ligand structure around the metal upon drying or the ligand structure can be altered during the coating and/or drying process. In particular, the organic ligand concentrations provide for a surprisingly large improvement in the precursor stability and control in network formation with solutions formed with organic solvents, generally polar organic solvents. While not wanting to be limited by theory, the increase in the radiation sensitive ligand concentration evidently reduces agglomeration of the metal cations, with corresponding oxo-ligands and/or hydroxo-ligands, to stabilize the solution. Thus, the precursor solution can be stable relative to settling of solids without further stirring for at least one week and possibly for significantly longer periods of time, such as greater than a month. Due to the long stability times, the improved precursors have increased versatility with respect to potential commercial uses. The overall molar concentration can be selected to achieve a desired coating thickness and desired coating properties, which can be obtained consistent with desired stability levels. Ligands with metal-carbon or metal-carboxylate bonds provide desirable radiation sensitive ligands, and specific ligands include, for example, alkyl groups (e.g., methyl, ethyl, propyl, butyl, t-butyl), aryl groups (e.g., phenyl, benzyl), alkenyl groups (e.g., vinyl, allyl), carboxylate (e.g., acetate, propanoate, butanoate, benzoate) groups, or combinations thereof.

The polyatomic metal oxo/hydroxo cations with organic ligands can be selected to achieve the desired radiation absorption. In particular, indium and tin based coating materials exhibit good absorption of far ultraviolet light at a 193 nm wavelength and extreme ultraviolet light at a 13.5 nm wavelength. Table 1 lists optical constants (n=index of refraction and



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k=extinction coefficient) at selected wavelengths for a coating material formed from monobutyltin oxide hydrate and baked at 100°C.

TABLE 1

| Wavelength (nm) | n | k |
|---|---|---|
| 193 | 1.75 | 0.211 |
| 248 | 1.79 | 0.0389 |
| 365 | 1.63 | 0 |
| 405 | 1.62 | 0 |
| 436 | 1.61 | 0 |

Some precursor solutions effectively incorporate a blend of additional metals to provide for desirable overall properties of the coating materials. The precursor solutions can comprise additional metal cations to increase the absorption of some radiation wavelengths of significance for lithography. The metal ion concentration can be selected to provide desired properties for the precursor solution, with more dilute solutions generally consistent with the formation of thinner coating materials, although coating properties also depend on the deposition technique.

The ligand structure of the precursor compositions are believed to provide the desirable stability of the precursor solutions as well as the radiation patterning function. In particular, it is believed that the absorption of radiation can provide for the disruption of the bonds between the metal and the organic ligands to create a differentiation of the composition at the iiTadiated and non-irradiated sections of the coated material. Thus, the compositional changes to form the improved precursor solutions also provide for improved development of the image. In particular, the irradiated coating material may result in a stable inorganic metal oxide material with a tunable response to the developer, e.g., through proper developer selection either positive or negative-tone images can be developed. In some embodiments, suitable developers include, for example, 2.38% TMAH, i.e., the semiconductor industry standard. The coating layers can be made thin without pattern loss during development from removing the coating material from regions where the coating material is intended to remain following development. Compared to conventional organic resists, the materials described herein have extremely high resistance to many etch chemistries for commercially relevant functional layers. This enables process simplification through avoidance of intermediate sacrificial inorganic pattern transfer layers that would otherwise be used to supplement the patterned organic resists with respect to the mask function. Also, the coating material can provide for convenient double patterning.



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Specifically, following a thermal treatment, patterned portions of the coating material are stable with respect to contact with many compositions including further precursor solutions. Thus, multiple patterning can be performed without removing previously deposited hard-mask or resist coating materials.

The patterned coating material can be subsequently removed after the patterned material is used as a mask to pattern desired functional materials. Alternatively, the resulting patterned material can be incorporated into the structure following appropriate stabilization through at least some condensation into an inorganic metal oxide material, as a component of ultimate device(s). If the patterned inorganic coating material is incorporated into the structure, for example as a stable dielectric layer, many steps of the processing procedure can be eliminated through the use of a direct patterning of the material with radiation. Alternatively, it has been found that very high resolution structures can be formed using thin inorganic coating materials exposed using short wavelength electromagnetic radiation and/or electron beams, and that line-width roughness can be reduced to very low levels for the formation of improved patterned structures.

The precursor solution comprises polynuclear metal oxo/hydroxo cations and organic ligands. Polynuclear metal oxo/hydroxo cations, also described as metal suboxide cations, are polyatomic cations with a metal element and covalently bonded oxygen atoms. Metal suboxide cations with peroxide based ligands are described in U.S. patent 8,415,000 to Stowers et al. (the '000 patent), entitled "Patterned Inorganic Layers, Radiation Based Patterning Compositions and Corresponding Methods," incorporated herein by reference. Aqueous solutions of metal suboxides or metal hydroxides can tend to be unstable with respect to gelling and/or precipitation. In particular, the solutions are unstable upon solvent removal and can form oxo-hydroxide networks with the metal cations. Incorporation of a radiation-sensitive ligand such as peroxide into such a solution can improve stability, but the background instability associated with network formation may persist. This uncontrolled network formation effectively decreases the radiation sensitivity and/or development rate contrast of the coated material by providing a development rate determining pathway independent of irradiation.

The new precursor solutions have been formulated with improved stability and control of network formation and precipitation relative to inorganic resist materials with peroxide based ligands. Characterization of ligands as radiation sensitive in this case refers to the lability of the metal-ligand bond following absorption of radiation, so that radiation can be used to induce a chemical change in the material. In particular, organic ligands stabilize the precursor solutions while also providing control over the processing of the materials, and selection of the



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ratio of organic ligands to metal ions can be adjusted to control properties of the solution and the resulting coatings. In particular, if the mole ratio of organic ligands to the metal cations is between about 0.1 and about 3, more stable solutions generally can be formed. The more stable precursor solutions provide an added advantage of greater contrast between the ultimate irradiated coating material and un-irradiated coating material since the rupture of the organic ligand bonds with the metal can be accomplished with radiation to improve development rate contrast in the coating material with the latent image.

Refined precursor solutions with greater stability also provide for a coating material having the potential of a greater development rate contrast between the radiation exposed and unexposed portions of the substrate, which surprisingly can be achieved simultaneously with either positive tone patterning or negative tone patterning. Specifically, the irradiated coating material or the un-irradiated coating material can be relatively more easily dissolved by suitable developer compositions. Thus, with the improved compositions and corresponding materials, positive- or negative-tone imaging can be achieved through choice of developer. At the same time, the pitch can be made very small between adjacent elements with appropriate isolation, generally electrical isolation, between the adjacent elements. The irradiated coating composition can be very sensitive to a subsequent development/etching process so that the coating composition can be made very thin without compromising the efficacy of the development process with respect to selective and clean removal of the coating composition while leaving appropriate portions of the irradiated patterning composition on the surface of the substrate. The ability to shorten the exposure time to the developer further is consistent with the use of thin coatings without damaging the patterned portions of the coating.

The precursor solutions can be deposited generally with any reasonable coating or printing technique as described further below. The coating generally is dried, and heat can be applied to stabilize the coating prior to irradiation. Generally, the coatings are thin, such as with an average thickness of less than 10 microns, and very thin submicron coatings can be desirable to pattern very small features. The dried coating can be subjected to appropriate radiation, e.g., extreme ultraviolet light, e-beam or ultraviolet light, to form a latent image in the coating. The latent image is contacted with the developer to form a physical image, i.e., a patterned coating. The patterned coating can be further heated to stabilize the remaining coating patterned on the surface. The patterned coating can be used as a physical mask to perform further processing, e.g., etching of the substrate and/or deposition of additional materials according to the pattern. At appropriate points of the processing, the remaining patterned coating can be removed, although the patterned coating can be incorporated into the



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ultimate structure. Very fine features can be accomplished effectively with the patterning compositions described herein.

Precursor Solutions

The precursor solutions for forming the resist coatings generally comprise metal cations with appropriate organic-stabilizing ligands in an organic solvent, generally an organic solvent. The precursor solutions and the ultimate resist coatings are based on metal oxide chemistry, and the organic solutions of metal polycations with organic ligands provide stable solutions with good resist properties. The ligands provide the radiation sensitivity, and the particular selection of ligands can influence the radiation sensitivity. In particular, the precursor solutions can be designed to achieve desired levels of radiation absorption for a selected radiation based on the selection of the metal cations as well as the associated ligands. The concentration of ligand stabilized metal cations in the solution can be selected to provide suitable solution properties for a particular deposition approach, such as spin coating. Metals of particular effectiveness with respect to stability and processing effectiveness are group 13, 14 and 15 metals. To correspondingly provide a high absorption of radiation generally used for patterning, it is desirable to include Sn, In and Sb metals in the precursor solutions, although these metals can be combined with other metals to adjust the properties, especially the radiation absorption. The precursor solutions have been formulated to achieve very high levels of stability such that the precursor solutions have appropriate shelf lives for commercial products. As described in the following section, the precursor solutions can be applied to a substrate surface, dried and further processed to form an effective radiation resist. The precursor solutions are designed to form a coating composition upon at least partial solvent removal and ultimately an inorganic solid dominated by metal oxides upon irradiation and/or thermal treatment, exposure to a plasma, or similar processing.

The precursor solutions generally comprise one or more metal cations. In aqueous solutions, metal cations are hydrated due to interactions with the water molecules, and hydrolysis can take place to bond oxygen atoms to the metal ion to form hydroxide ligands or oxo bonds with the corresponding release of hydrogen ions. The nature of the interactions is generally pH dependent. As additional hydrolysis takes place in aqueous solutions, the solutions can become unstable with respect to precipitation of the metal oxide or with respect to gelation. Ultimately, it is desirable to form the oxide material, but this progression can be controlled better with the precursor solutions based on organic solvents with organic ligand stabilized metal cations. With the precursor solutions based on organic-stabilization ligands



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and an organic solvent, progression to the oxide can be controlled as part of the procedure for processing the solution first to a coating material and then to the ultimate metal oxide composition with organic ligands. As described herein, organic ligands can be used to provide significant control to the processing of the solution to an effective radiation resist composition.

Thus, the solutions of the metal cations are poised for further processing. In particular, it can be desirous to use as an added component of the precursor solution, a polynuclear metal oxo/hydroxo cation that can poise the solution further toward a metal oxide composition. In general, the precursor solution comprises from about 0.01M to about 1.4M metal polynuclear oxo/hydroxo cation, in further embodiments from about 0.05M to about 1.2M, and in additional embodiments from about 0.1M to about 1.0M. A person of ordinary skill in the art will recognize that additional ranges of metal polynuclear oxo/hydroxo cations within the explicit ranges above are contemplated and are within the present disclosure.

Tin, antimony and/or indium are particularly suitable metals for formation of polynuclear metal oxo/hydroxo cations for the precursor solutions described herein. In particular, tin has a desirable chemistry based on organic ligands. Additional metals can be provided to produce more complex polynuclear metal oxo/hydroxo cation formulations, including, for example, Ti, Zr, Hf, V, Co, Mo, W, Al, Ga, Si, Ge, P, As, Y, La, Ce, Lu or combinations thereof. The additional metals can be as alternatives to or in addition to tin ions, antimony ions and/or indium ions (tin/antimony/indium ions). If blends of metal ions are used, in some embodiments the mole ratio of tin/antimony/indium with additional metal ion(s) can be up to about 1 non-tin/antimony/ indium metal ion per each tin/antimony/indium ion and in further embodiments from about 0.1 to about 0.75 non-tin/indium metal ion per tin/antimony/indium metal ion. If blends of metal ions are used, the metal ions may be in complex multiple metal oxo-hydroxo clusters in solution or in distinct metal oxo-hydroxo clusters. The precise cluster form in solution may or may not be known, and the resulting coating generally can provide desired function whether or not the cluster structure in solution is known. As noted above, the state of the cations in solution is pH dependent, such that the initial state of oxygen coordination can change in solution, but the trend is toward hydrolysis and condensation leading to oxide formation. It has been found that organic ligands can hinder the formation of a metal-oxygen network that leads to gelation and ultimately precipitation. Thus, the organic ligand can be used to form a stable state that is poised for transformation to oxide through selective radiation exposures. The use of organic ligands also extends the choices of precursor solvents and developer to include both water-based and organic solvents.



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The metal generally significantly influences the absorption of radiation. Therefore, the metal cations can be selected based on the desired radiation and absorption cross section. Indium and tin provide strong absorption of extreme ultraviolet light at 13.5 nm. In combination with organic ligands they also provide good absorption of ultraviolet light at 193 nm wavelength. Hf also provides good absorption of electron beam material and extreme UV radiation. Further tuning of the composition for radiation absorption can be adjusted based on the addition of other metal ions. For example, one or more metal compositions comprising Ti, V, Mo, or W or combinations thereof can be added to the precursor solution to form a coating material with an absorption edge moved to longer wavelengths, to provide, for example, sensitivity to 248 nm wavelength ultraviolet light. The energy absorbed is modulated by the metal-organic interactions, which can result in the rupturing of the metal-ligand and the desired control over the material properties.

The organic-based ligands stabilize the composition with respect to condensation. In particular, at high relative concentration of organic-based ligands, formation of condensed metal oxides or metal hydroxides are very slow if the condensation spontaneously occurs at all at room temperature. Based on the discovery of this stabilization property, solutions can be formed with high concentrations of radiation sensitive ligands that have good shelf stability while retaining convenient processing to form coatings. Radiation sensitive ligands include carboxylates and organic moieties forming a metal-carbon bond, e.g., tin-carbon bond. Energy from absorbed radiation can break the metal-organic ligand bond. As these bonds are broken, the corresponding stabilization with respect to condensation is reduced or lost. The composition can change through formation of M--OH or through condensation to form M--0-- M bonds, where M represents a metal atom. Thus, chemical changes can be controlled with radiation. Compositions with high radiation sensitive ligand concentrations can be highly stable with respect to the avoidance of spontaneous formation of hydroxide and condensation. Some suitable metal compositions with desired ligand structures can be purchased from commercial sources, such as Alfa Aesar (MA, USA) and TCI America (OR, USA), see Examples below, and other metal-ligand compositions can be synthesized as described below.

The organic ligands can be, for example, alkyls (e.g., methyl, ethyl, propyl, butyl, t-butyl, aryl (phenyl, benzyl)), alkenyls (e.g., vinyl, allyl), and carboxylates (acetate, propanoate, butanoate benzoate). The precursor composition generally comprises a ligand concentration of from a factor of about 0.25 to about 4 times the metal cation concentration, in further embodiments from about 0.5 to about 3.5 in additional embodiments from about 0.75 to about 3, and in other embodiments from about 1 to about 2.75 times the metal cation concentration.



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A person of ordinary skill in the art will recognize that additional ranges of ligand concentrations within the explicit ranges above are contemplated and are within the present disclosure.

With respect to the oxo/hydroxo ligands for the metal ions, these ligands can be formed during processing through hydrolysis. In some embodiments, the hydrolysis can involve replacement of halide ligands in a basic aqueous solution with subsequent transfer to an organic solvent. A specific example is presented below. Basically, a composition comprising the metal ions with organic stabilizing ligands and halide ligands are dissolved in an organic solvent, which is then contacted with a basic aqueous solution, whereupon substitution of the halide ligands with hydroxo ligands may occur. After providing enough time to form hydroxo ligands, the aqueous solution can be separated from the organic phase assuming that the organic liquid is not soluble in the aqueous liquid. In some embodiments, the oxo/hydroxo ligands can be formed through hydrolysis from atmospheric water. The hydrolyzable metal ion composition can be heated in the presence of atmospheric moisture so that the oxo/hydroxo ligands form directly in the coating material, which can be relatively facile due to the high surface area. An example of hydrolysis from atmospheric water is also described below.

With respect to formation of the organo-stabilizing ligands, these can also be formed in solution to form desired compositions. With respect to the carboxylate ligands, the corresponding carboxylic acid or a salt thereof can be dissolved in solution with the metal cations. If desired the pH of the solution can be adjusted to facilitate bonding of the carboxylate groups to the metal, and heat may be applied to further drive the process. In general, the reaction can be performed in an aqueous solvent with subsequent transfer to an organic solvent or directly performed in an organic solvent. Also, M-C bonds can also be formed in a solution phase substitution reaction. The following reactions are representative suitable reactions for the substitution reactions to form Sn-C bonds, and similar reactions follow for other metal ions:

$$n\ RCl + Sn \rightarrow R_nSnCl_{4-n} + \text{Residual}$$

$$4\ RMgBr + SnCl_4 \rightarrow R_4Sn + 4\ MgBrCl$$

$$3\ SnCl_4 + 4R_3Al \rightarrow 3\ R_4Sn + 4\ AlCl_3$$

$$R_4Sn + SnCl_4 \rightarrow 2\ R_2SnCl_2,$$

Where R represents an organic ligand. Generally, different suitable halides can be substituted in the above reactions. The reactions can be carried out in a suitable organic solvent in which the reactants have reasonable solubility.



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In general, the desired compounds can be dissolved in an organic solvent, e.g., alcohols, esters or combinations thereof. In particular, suitable solvents include, for example, aromatic compounds (e.g., xylenes, toluene), esters (propylene glycol monomethyl ether acetate, ethyl acetate, ethyl lactate), alcohols (e.g., 4-methyl-2-propanol, 1-butanol, anisole), ketones (e.g., methyl ethyl ketone), and the like. In general, organic solvent selection can be influenced by solubility parameters, volatility, flammability, toxicity, viscosity and potential chemical interactions with other processing materials. After the components of the solution are dissolved and combined, the character of the species may change as a result of partial hydration and condensation, especially during the coating process. When the composition of the solution is referenced herein, the reference is to the components as added to the solution, since complex formulations may produce metal polynuclear species in solution that may not be well characterized. For certain applications it is desirable for the organic solvent to have a flash point of no less than about 10°C, in further embodiments no less than about 20°C and in further embodiment no less than about 25°C and a vapor pressure at 20°C of no more than about 10 kPa, in some embodiments no more than about 8 kPa and in further embodiments no more than about 6 kPa. A person of ordinary skill in the art will recognize that additional ranges of flash point and vapor pressure within the explicit ranges above are contemplated and are within the present disclosure.

In general, precursor solutions are well mixed using appropriate mixing apparatuses suitable for the volume of material being formed. Suitable filtration can be used to remove any contaminants or other components that do not appropriately dissolve. In some embodiments, it may be desirable to form separate solutions that can be combined to form the precursor solution from the combination. Specifically, separate solutions can be formed comprising one or more of the following: the metal polynuclear oxo/hydroxo cations, any additional metal cations, and the organic ligands. If multiple metal cations are introduced, the multiple metal cations can be introduced into the same solution and/or in separate solutions. Generally, the separate solutions or the combined solutions can be well mixed. In some embodiments, the metal cation solution is then mixed with the organic-based ligand solution such that the organic-based ligand can conjugate with the metal cations. The resulting solution can be referred to as a stabilized metal cation solution. In some embodiments, the stabilized metal cation solution is allowed to react for a suitable period of time to provide for stable ligand formation, which may or may not also involve cluster formation in solution, whether or not mixed metal ions are introduced. In some embodiments, the reaction or stabilization time for the solution can be for at least about five minutes, in other embodiments at least about 1 hour, and in further



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embodiments from about 2 hours to about 48 hours prior to further processing. A person of ordinary skill in the art will recognize that additional ranges of stabilization periods are contemplated and are within the present disclosure.

The concentrations of the species in the precursor solutions can be selected to achieve desired physical properties of the solution. In particular, lower concentrations overall can result in desirable properties of the solution for certain coating approaches, such as spin coating, that can achieve thinner coatings using reasonable coating parameters. It can be desirable to use thinner coatings to achieve ultrafme patterning as well as to reduce material costs. In general, the concentration can be selected to be appropriate for the selected coating approach. Coating properties are described further below.

As noted above, a relatively large ratio of organic-based ligand relative to the metal cations can be used to greatly stabilize the precursor solutions. Stability of the precursor solutions can be evaluated with respect to changes relative to the initial solution. Specifically, a solution has lost stability if phase separation occurs with the production of large sol particles or if the solution loses its ability to perform desired pattern formation. Based on the improved stabilization approaches described herein, the solutions can be stable for at least about a week without additional mixing, in further embodiments at least about 2 weeks, in other embodiments at least about 4 weeks. A person of ordinary skill in the art will recognize that additional ranges of stabilization times are contemplated and are within the present disclosure. The solutions can be formulated with sufficient stabilization times that the solutions can be commercially distributed with appropriate shelf lives.

Coating Material

A coating material is formed through the deposition and subsequent processing of the precursor solution onto a selected substrate. A substrate generally presents a surface onto which the coating material can be deposited, and the substrate may comprise a plurality of layers in which the surface relates to an upper most layer. In some embodiments, the substrate surface can be treated to prepare the surface for adhesion of the coating material. Also, the surface can be cleaned and/or smoothed as appropriate. Suitable substrate surfaces can comprise any reasonable material. Some substrates of particular interest include, for example, silicon wafers, silica substrates, other inorganic materials, polymer substrates, such as organic polymers, composites thereof and combinations thereof across a surface and/or in layers of the substrate. Wafers, such as relatively thin cylindrical structures, can be convenient, although any reasonable shaped structure can be used. Polymer substrates or substrates with polymer layers



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on non-polymer structures can be desirable for certain applications based on their low cost and flexibility, and suitable polymers can be selected based on the relatively low processing temperatures that can be used for the processing of the patternable materials described herein. Suitable polymers can include, for example, polycarbonates, polyimides, polyesters, polyalkenes, copolymers thereof and mixtures thereof. In general, it is desirable for the substrate to have a flat surface, especially for high resolution applications.

In general, any suitable coating process can be used to deliver the precursor solution to a substrate. Suitable coating approaches can include, for example, spin coating, spray coating, dip coating, knife edge coating, printing approaches, such as inkjet printing and screen printing, and the like. Some of these coating approaches form patterns of coating material during the coating process, although the resolution available currently from printing or the like has a significantly lower level of resolution than available from radiation based patterning as described herein. The coating material can be applied in multiple coating steps to provide greater control over the coating process. For example, multiple spin coatings can be performed to yield an ultimate coating thickness desired. The heat processing described below can be applied after each coating step or after a plurality of coating steps.

If patterning is performed using radiation, spin coating can be a desirable approach to cover the substrate relatively uniformly, although there can be edge effects. In some embodiments, a wafer can be spun at rates from about 500 rpm to about 10,000 rpm, in further embodiments from about 1000 rpm to about 7500 rpm and in additional embodiments from about 2000 rpm to about 6000 rpm. The spinning speed can be adjusted to obtain a desired coating thickness. The spin coating can be performed for times from about 5 seconds to about 5 minutes and in further embodiments from about 15 seconds to about 2 minutes. An initial low speed spin, e.g., at 50 rpm to 250 rpm, can be used to perform an initial bulk spreading of the composition across the substrate. A back side rinse, edge bead removal step or the like can be performed with water or other suitable solvent to remove any edge bead. A person or ordinary skill in the art will recognize that additional ranges of spin coating parameters within the explicit ranges above are contemplated and are within the present disclosure.

The thickness of the coating generally can be a function of the precursor solution concentration, viscosity and the spin speed for spin coating. For other coating processes, the thickness can generally also be adjusted through the selection of the coating parameters. In some embodiments, it can be desirable to use a thin coating to facilitate formation of small and highly resolved features in the subsequent patterning process. For example, the coating materials after drying can have an average thickness of no more than about 10 microns, in other



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embodiments no more than about 1 micron, in further embodiments no more than about 250 nanometers (nm), in additional embodiments from about 1 nanometers (nm) to about 50 nm, in other embodiments from about 2 nm to about 40 nm and in some embodiments from about 3 nm to about 25 nm. A person of ordinary skill in the art will recognize that additional ranges of thicknesses within the explicit ranges above are contemplated and are within the present disclosure. The thickness can be evaluated using non-contact methods of x-ray reflectivity and/or ellipsometry based on the optical properties of the film. In general, the coatings are relatively uniform to facilitate processing. In some embodiments, the variation in thickness of the coating varies by no more than ±50% from the average coating thickness, in further embodiments no more than ±40% and in additional embodiments no more than about 25% relative to the average coating thickness. In some embodiments, such as high uniformity coatings on larger substrates, the evaluation of coating uniformity may be evaluated with a 1 centimeter edge exclusion, i.e., the coating uniformity is not evaluated for portions of the coating within 1 centimeter of the edge. A person of ordinary skill in the art will recognize that additional ranges within the explicit ranges above are contemplated and are within the present disclosure.

The coating process itself can result in the evaporation of a portion of the solvent since many coating processes form droplets or other forms of the coating material with larger surface areas and/or movement of the solution that stimulates evaporation. The loss of solvent tends to increase the viscosity of the coating material as the concentration of the species in the material increases. An objective during the coating process can be to remove sufficient solvent to stabilize the coating material for further processing. In general, the coating material can be heated prior to radiation exposure to further drive off solvent and promote densification of the coating material. The dried coating material may generally form a polymeric metal oxo/hydroxo network based on the oxo-hydroxo ligands to the metals in which the metals also have some organic ligands, or a molecular solid comprised of polynuclear metal oxo/hydroxo species with organic ligands.

The solvent removal process may or may not be quantitatively controlled with respect to specific amounts of solvent remaining in the coating material, and empirical evaluation of the resulting coating material properties generally can be performed to select processing conditions that are effective for the patterning process. While heating is not needed for successful application of the process, it can be desirable to heat the coated substrate to speed the processing and/or to increase the reproducibility of the process. In embodiments in which heat is applied to remove solvent, the coating material can be heated to temperatures from about



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45°C to about 250°C and in further embodiments from about 55°C to about 225°C. The heating for solvent removal can generally be performed for at least about 0.1 minute, in further embodiments from about 0.5 minutes to about 30 minutes and in additional embodiments from about 0.75 minutes to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges of heating temperature and times within the explicit ranges above are contemplated and are within the present disclosure. As a result of the heat treatment and densification of the coating material, the coating material can exhibit an increase in index of refraction and in absorption of radiation without significant loss of contrast.

Patterned Exposure and Patterned Coating Material

The coating material can be finely patterned using radiation. As noted above, the composition of the precursor solution and thereby the corresponding coating material can be designed for sufficient absorption of a desired form of radiation. The absoiption of the radiation results in energy that can break the bonds between the metal and organic ligands so that at least some of the organic-based ligands are no longer available to stabilize the material. With the absorption of a sufficient amount of radiation, the exposed coating material condenses, i.e. forms an enhanced metal oxo/hydroxo network, which may involve water absorbed from the ambient atmosphere. The radiation generally can be delivered according to a selected pattern. The radiation pattern is transferred to a corresponding pattern or latent image in the coating material with irradiated areas and un-irradiated areas. The irradiated areas comprise chemically altered coating material, and the un-irradiated areas comprise generally the as-formed coating material. As noted below, very sharp edges can be formed upon development of the coating material with the removal of the un-irradiated coating material or alternatively with selective removal of the irradiated coating material.

Radiation generally can be directed to the coated substrate through a mask or a radiation beam can be controllably scanned across the substrate. In general, the radiation can comprise electromagnetic radiation, an electron beam (beta radiation), or other suitable radiation. In general, electromagnetic radiation can have a desired wavelength or range of wavelengths, such as visible radiation, ultraviolet radiation or x-ray radiation. The resolution achievable for the radiation pattern is generally dependent on the radiation wavelength, and a higher resolution pattern generally can be achieved with shorter wavelength radiation. Thus, it can be desirable to use ultraviolet light, x-ray radiation or an electron beam to achieve particularly high resolution patterns.



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Following International Standard ISO 21348 (2007) incorporated herein by reference, ultraviolet light extends between wavelengths of greater than or equal 100 nm and less than 400 nm. A krypton fluoride laser can be used as a source for 248 nm ultraviolet light. The ultraviolet range can be subdivided in several ways under accepted Standards, such as extreme ultraviolet (EUV) from greater than or equal 10 nm to less than 121 nm and far ultraviolet (FUV) from greater than or equal to 122 nm to less than 200 nm A 193 nm line from an argon fluoride laser can be used as a radiation source in the FUV. EUV light has been used for lithography at 13.5 nm, and this light is generated from a Xe or Sn plasma source excited using high energy lasers or discharge pulses. Soft x-rays can be defined from greater than or equal 0.1 nm to less than 10 nm.

The amount of electromagnetic radiation can be characterized by a fluence or dose which is obtained by the integrated radiative flux over the exposure time. Suitable radiation fluences can be from about 1 $mJ/cm^2$ to about 150 $mJ/cm^2$, in further embodiments from about 2 $mJ/cm^2$ to about 100 $mJ/cm^2$, and in further embodiments from about 3 $mJ/cm^2$ to about 50 $mJ/cm^2$. A person of ordinary skill in the art will recognize that additional ranges of radiation fluences within the explicit ranges above are contemplated and are within the present disclosure.

With electron beam lithography, the electron beam generally induces secondary electrons which generally modify the irradiated material. The resolution can be a function at least in part of the range of the secondary electrons in the material in which a higher resolution is generally believed to result from a shorter range of the secondary electrons. Based on high resolution achievable with electron lithography using the inorganic coating materials described herein, the range of the secondary electrons in the inorganic material is limited. Electron beams can be characterized by the energy of the beam, and suitable energies can range from about 5 V to about 200 kV (kilovolt) and in further embodiments from about 7.5 V to about 100 kV. Proximity-corrected beam doses at 30 kV can range from about 0.1 microcoulombs per centimeter squared to about 5 millicoulonibs per centimeter squared ($mC/cm^2$), in further embodiments from about 0.5 $\mu C/cm^2$ to about 1 $mC/cm^2$ and in other embodiments from about 1 $\mu C/cm^2$ to about 100 $nC/cm^2$. A person of ordinary skill in the art can compute corresponding doses at other beam energies based on the teachings herein and will recognize that additional ranges of electron beam properties within the explicit ranges above are contemplated and are within the present disclosure.

Based on the design of the coating material, there is a large contrast of material properties between the irradiated regions that have condensed coating material and the un-



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irradiated, coating material with substantially intact organic ligands. It has been found that the contrast can be improved with a post-irradiation heat treatment, although satisfactory results can be achieved in some embodiments without post-irradiation heat treatment. The post-exposure heat treatment seems to anneal the irradiated coating material to increase its condensation without significantly condensing the un-irradiated regions of coating material based on thermal breaking of the organic ligand-metal bonds. For embodiments in which a post irradiation heat treatment is used, the post-irradiation heat treatment can be performed at temperatures from about 45°C to about 250°C, in additional embodiments from about 50°C to about 190°C and in further embodiments from about 60°C to about 175°C. The post exposure heating can generally be performed for at least about 0.1 minute, in further embodiments from about 0.5 minutes to about 30 minutes and in additional embodiments from about 0.75 minutes to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges of post-irradiation heating temperature and times within the explicit ranges above are contemplated and are within the present disclosure. This high contrast in material properties further facilitates the formation of sharp lines in the pattern following development as described in the following section.

Following exposure with radiation, the coating material is patterned with irradiated regions and un-irradiated regions. Referring to Figs. 1 and 2, a patterned structure 100 is shown comprising a substrate 102, a thin film 103 and patterned coating material 104. Patterned coating material 104 comprises regions 110, 112, 114, 116 of in-adiated coating material and uncondensed regions 118, 120, 122 of un-irradiated coating material. The patterned formed by condensed regions 110, 112, 114, 116 and uncondensed regions 118, 120, 122 represent a latent image in to the coating material, and the development of the latent image is discussed in the following section.

Development and Patterned Structure

Development of the image involves the contact of the patterned coating material including the latent image to a developer composition to remove either the un-irradiated coating material to form the negative image or the irradiated coating to form the positive image. Using the resist materials described herein, effective negative patterning or positive patterning can be performed with desirable resolution using appropriate developing solutions, generally based on the same coating. In particular, the irradiated regions are at least partially condensed to increase the metal oxide character so that the irradiated material is resistant to dissolving by organic solvents while the un-irradiated compositions remain soluble in the organic solvents.



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Reference to a condensed coating material refers to at least partial condensation in the sense of increasing the oxide character of the material relative to an initial material. On the other hand, the un-irradiated material is not soluble in weak aqueous bases or acids due to the hydrophobic natural of the material so that aqueous bases can be used to remove the irradiated material while maintaining the non-irradiated material for positive patterning.

The coating compositions with organic-stabilization ligands produce a material that is inherently relatively hydrophobic. Irradiation to break at least some of the organic metal bonds converts the material into a less hydrophobic, i.e., more hydrophilic, material. This change in character provides for a significant contrast between the irradiated coating and non-irradiated coating that provides for the ability to do both positive tone patterning and negative tone patterning with the same resist composition. Specifically, the irradiated coating material condenses to some degree into a more of a metal oxide composition; however, the degree of condensation generally is moderate without significant heating so that the irradiated material is relatively straightforward to develop with convenient developing agents. In contrast, inorganic resist materials based on metal oxo-hydroxo chemistry with peroxide stabilization ligands, as described in the '000 patent cited above, are inherently more hydrophilic prior to irradiation, and the irradiated peroxide-based coatings can be condensed to a more significant degree by irradiation so that the un-irradiated resist can be removed with weak acids or bases while the irradiated peroxide-based coatings can be developed similar to a metal oxide material.

With respect to negative tone imaging, referring to Figs. 3 and 4, the latent image of the structure shown in Figs. 1 and 2 has been developed through contact with a developer to form patterned structure 130. After development of the image, substrate 102 is exposed along the top surface through openings 132, 134. Openings 132, 134, 135 are located at the positions of uncondensed regions 118, 120, 122 respectively. With respect to positive tone imaging, referring to Figs. 5 and 6, the latent image of the structure shown in Figs. 1 and 2 has been developed to form patterned structure 140. Patterned structure 140 has the conjugate image of patterned structure 130 in Fig. 3. Patterned structure 140 has substrate 102 exposed at positions of irradiated regions 110, 112, 114, 116 in Figs. 1-4 that are developed to form openings 142, 144, 146, 148. Uncondensed regions 118, 120, and 122 are retained.

For the negative tone imaging, the developer can be an organic solvent, such as the solvents used to form the precursor solutions. In general, developer selection can be influenced by solubility parameters with respect to the coating material, both irradiated and non-irradiated, as well as developer volatility, flammability, toxicity, viscosity and potential chemical interactions with other process material. In particular, suitable developers include, for



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example, aromatic compounds (e.g., benzene, xylenes, toluene), esters (e.g., propylene glycol monomethyl ester acetate, ethyl acetate, ethyl lactate, n-butyl acetate, butyrolactone), alcohols (e.g., 4-methyl-2-propanol, 1-butanol, isopropanol, anisole), ketones (e.g., methyl ethyl ketone, acetone, cyclohexanone), ethers (e.g., tetrahydrofuran, dioxane) and the like. The development can be performed for about 5 seconds to about 30 minutes, in further embodiments from about 8 seconds to about 15 minutes and in addition embodiments from about 10 seconds to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges within the explicit ranges above are contemplated and are within the present disclosure.

For positive tone imaging, the developer generally can be aqueous acids or bases. In some embodiments, aqueous bases can be used to obtain sharper images. To reduce contamination from the developer, it can be desirable to use a developer that does not have metal atoms. Thus, quaternary ammonium hydroxide compositions, such as tetraethylammonium hydroxide, tetrapropylammonium hydroxide, tetrabutylammonium hydroxide or combinations thereof, are desirable as developers. In general, the quaternary ammonium hydroxides of particular interest can be represented with the formula $R_4NOH$, where R = a methyl group, an ethyl group, a propyl group, a butyl group, or combinations thereof. The coating materials described herein generally can be developed with the same developer commonly used presently for polymer resists, specifically tetramethyl ammonium hydroxide (TMAH). Commercial TMAH is available at 2.38 weight percent, and this concentration can be used for the processing described herein. Furthermore, mixed quaternary tetraalkyl- ammonium hydroxides can be used. In general, the developer can comprise from about 0.5 to about 30 weight percent, in further embodiments from about 1 to about 25 weight percent and in other embodiments from about 1.25 to about 20 weight percent tetra-alkylammonium hydroxide or similar quaternary ammonium hydroxides. A person of ordinary skill in the art will recognize that additional ranges of developer concentrations within the explicit ranges above are contemplated and are within the present disclosure.

In addition to the primary developer composition, the developer can comprise additional compositions to facilitate the development process. Suitable additives include, for example, dissolved salts with cations selected from the group consisting of ammonium, d-block metal cations (hafnium, zirconium, lanthanum, or the like), f-block metal cations (cerium, lutetium or the like), p-block metal cations (aluminum, tin, or the like), alkali metals (lithium, sodium, potassium or the like), and combinations thereof, and with anions selected from the group consisting of fluoride, chloride, bromide, iodide, nitrate, sulfate, phosphate, silicate, borate, peroxide, butoxide, formate, ethylenediamine-tetraacetic acid (EDTA), tungstate,



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molybdate, or the like and combinations thereof. Other potentially useful additives include, for example, molecular chelating agents, such as polyamines, alcohol amines, amino acids or combinations thereof. If the optional additives are present, the developer can comprise no more than about 10 weight percent additive and in further embodiments no more than about 5 weight percent additive. A person of ordinary skill in the art will recognize that additional ranges of additive concentrations within the explicit ranges above are contemplated and are within the present disclosure. The additives can be selected to improve contrast, sensitivity and line width roughness. The additives in the developer can also inhibit formation and precipitation of metal oxide particles.

With a weaker developer, e.g., lower concentration aqueous developer, diluted organic developer or compositions in which the coating has a lower development rate, a higher temperature development process can be used to increase the rate of the process. With a stronger developer, the temperature of the development process can be lower to reduce the rate and/or control the kinetics of the development. In general, the temperature of the development can be adjusted between the appropriate values consistent with the volatility of the solvents. Additionally, developer with dissolved coating material near the developer-coating interface can be dispersed with ultrasonication during development.

The developer can be applied to the patterned coating material using any reasonable approach. For example, the developer can be sprayed onto the patterned coating material. Also, spin coating can be used. For automated processing, a puddle method can be used involving the pouring of the developer onto the coating material in a stationary format. If desired spin rinsing and/or drying can be used to complete the development process. Suitable rinsing solutions include, for example, ultrapure water, methyl alcohol, ethyl alcohol, propyl alcohol and combinations thereof for negative patterning and ultrapure water for positive patterning. After the image is developed, the coating material is disposed on the substrate as a pattern.

After completion of the development step, the coating materials can be heat treated to further condense the material and to further dehydrate the material. This heat treatment can be particularly desirable for embodiments in which the oxide coating material is incorporated into the ultimate device, although it may be desirable to perform the heat treatment for some embodiments in which the coating material is used as a resist and ultimately removed if the stabilization of the coating material is desirable to facilitate further patterning. In particular, the bake of the patterned coating material can be performed under conditions in which the patterned coating material exhibits desired levels of etch selectivity. In some embodiments,



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the patterned coating material can be heated to a temperature from about 100°C to about 600°C, in further embodiments from about 175°C to about 500°C and in additional embodiments from about 200°C to about 400°C. The heating can be performed for at least about 1 minute, in other embodiment for about 2 minutes to about 1 hour, in further embodiments from about 2.5 minutes to about 25 minutes. The heating may be performed in air, vacuum, or an inert gas ambient, such as Ar or $N_2$. A person of ordinary skill in the art will recognize that additional ranges of temperatures and time for the heat treatment within the explicit ranges above are contemplated and are within the present disclosure.

With conventional organic resists, structures are susceptible to pattern collapse if the aspect ratio, height divided by width, of a structure becomes too large. Pattern collapse can be associated with mechanical instability of a high aspect ratio structure such that forces, e.g., surface tension, associated with the processing steps distort the structural elements. Low aspect ratio structures are more stable with respect to potential distorting forces. With the patternable coating materials described herein, due to the ability to process effectively the structures with thinner layers of coating material, improved patterning can be accomplished without the need for high aspect ratio patterned coating material. Thus, very high resolution features have been formed without resorting to high aspect ratio features in the patterned coating material.

The resulting structures can have sharp edges with very low line-width roughness. In particular, in addition to the ability to reduce line-width roughness, the high contrast also allows for the formation of small features and spaces between features as well as the ability to form very well resolved two-dimensional patterns (e.g., sharp corners). Thus, in some embodiments, adjacent linear segments of neighboring structures can have an average pitch of no more than about 60 nm, in some embodiments no more than about 50 nm and in further embodiments no more than about 40 nm. Pitch can be evaluated by design and confirmed with scanning electron microscopy (SEM), such as with a top-down image. As used herein, pitch refers to the spatial period, or the center-to-center distances of repeating structural elements. Feature dimensions of a pattern can also be described with respect to the average width of the feature, which is generally evaluated away from corners or the like. Also, features can refer to gaps between material elements and/or to material elements. In some embodiments, average widths can be no more than about 30 nm, in further embodiments no more than about 25 nm, and in additional embodiments no more than about 20 nm. Average line-width roughness can be no more than about 3.0 nm, and in further embodiments from about 1.5 nm to about 2.5 nm. Evaluating line-width roughness is performed by analysis of top-down SEM images to derive a $3\sigma$ deviation from the mean line-width. The mean contains both high-frequency and low-frequency



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roughness, i.e., short correlation lengths and long correlation lengths, respectively. The line-width roughness of organic resists is characterized primarily by long correlation lengths, while the present inorganic coating materials exhibit significantly shorter correlation lengths. In a pattern transfer process, short correlation roughness can be smoothed during the etching process, producing a much higher fidelity pattern. A person of ordinary skill in the art will recognize that additional ranges of pitch, average widths and line-width roughness within the explicit ranges above are contemplated and are within the present disclosure.

Further Processing of Patterned Coating Material

After forming a patterned coating material, the coating material can be further processed to facilitate formation of the selected devices. Furthermore, further material deposition, etching and/or patterning generally can be performed to complete structures. The coating material may or may not ultimately be removed. The quality of the patterned coating material can in any case be carried forward for the formation of improved devices, such as devices with smaller foot prints and the like.

The patterned coating material forms openings to the underlying substrate, as shown for example in Figs. 3 and 4. As with conventional resists, the patterned coating material forms an etch mask which can be used to transfer the pattern to selectively remove an underlying thin film. Referring to Fig. 7, underlying thin film 103 in Fig. 1 is patterned leaving features 152, 154, 156 respectively on substrate 102 and under condensed regions 110, 112, 114. Compared with conventional polymer resists, the materials described herein can provide significantly greater etch resistance. Similar processing can be undertaken with the mask pattern shown in Figs. 5 and 6 with corresponding shifting of the patterned structures that follow directly from the alternative mask pattern.

Alternatively or additionally, the deposition of a further material according to the mask pattern can alter the properties of the underlying structure and/or provide contact to the underlying structure. The further coating material can be selected based on the desired properties of the material. In addition, ions can be selectively implanted into the underlying structure through openings in the mask, as the density of the patterned inorganic coating material can provide a high implant resistance. In some embodiments, the further deposited material can be a dielectric, a semiconductor, a conductor or other suitable material. The further deposited material can be deposited using suitable approaches, such as solution based approaches, chemical vapor deposition (CVD), sputtering, physical vapor deposition (PVD), or other suitable approach.



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In general, a plurality of additional layers can be deposited. In conjunction with the deposition of a plurality of layers, additional patterning can be performed. Any additional patterning, if performed, can be performed with additional quantities of the coating materials described herein, with polymer-based resists, with other patterning approaches or a combination thereof.

As noted above, a layer of coating (resist) material following patterning may or may not be removed. If the layer is not removed, the patterned coating (resist) material is incorporated into the structure. For embodiments in which the patterned coating (resist) material is incorporated into the structure, the properties of the coating (resist) material can be selected to provide for desired patterning properties as well as also for the properties of the material within the structure.

If it is desired to remove the patterned coating material, the coating material functions as a conventional resist. The patterned coating material is used to pattern a subsequently deposited material prior to the removal of the resist/coating material and/or to selectively etch the substrate through the spaces in the condensed coating material. The condensed coating material can be removed using a suitable etching process. Specifically, to remove the condensed coating material, a dry etch can be performed, for example, with a BCl3 plasma, $Cl_2$ plasma, HBr plasma, Ar plasma or plasmas with other appropriate process gases. Alternatively or additionally, a wet etch with, for example, an aqueous acid or base, such as HF(aq), or buffered HF(aq)/$NH_4F$ or oxalic acid can be used to remove the patterned coating material. Referring to Fig. 8, the structure of Fig. 8 is shown after removal of the coating material. Etched structure 150 comprises substrate 102 and features 152, 154, 156.

The metal oxo/hydroxo based coating materials are particularly convenient for performing multiple patterning using a thermal freeze process, as described generally with conventional resists in P. Zimmerman, J. Photopolym. Sci. Technol., Vol. 22, No. 5, 2009, p. 625. A double patterning process with a "thermal freeze" is outlined in Fig. 9. In the first step, the coating material is formed into a pattern 160 on substrate 162 using a lithographic process and development as described with respect to Figs. 3 and 4. A heating step 164 is performed to remove solvent and condense the coating material, which may or may not involve full oxide formation.. This heating step is equivalent to the post-development heating step described in the Development section above. This "thermal freeze" process makes the coating material insoluble to a subsequent deposition of a second layer of the coating material. A second lithographic and development step 166 is performed to form a double patterned structure 168 on substrate 162. After an etch step 170, the product double patterned structure 172 is formed.



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Note that it is straightforward to extend this process to multiple coat and pattern steps, and such extensions are contemplated and are within the present disclosure. With respect to multiple patterning, a significant difference between the inorganic coating materials described herein and conventional organic resists is that organic resists remain soluble in conventional resist casting solvents even after a thermal bake. The resist materials described herein can be condensed with a thermal bake such that they are not soluble in organic solvents and subsequent coating layers can be applied.

EXAMPLES

Example 1 - Preparation of Precursor Solutions

This example described preparation of precursor solutions for the deposition of Tin based organometallic compositions for the formation of a radiation resist coating.

A resist precursor solution was prepared by adding 0.209 g monobutyltin oxide hydrate (BuSnOOH) powder (TCI America) to 10 mL of 4-methyl-2-pentanol. The solution was placed in a closed vial and allowed to stir for 24 h. The resulting mixture was centrifuged at 4000 rpm for 15 minutes, and filtered through a 0.45 μm PTFE syringe filter to remove insoluble material. Solvent evaporation and calcination of this sample at 600°C revealed a tin concentration of 0.093 M on the basis of $SnO_2$ residual mass. Dynamic light scattering (DLS) analysis with a Mobius apparatus (Wyatt Technology) of the precursor solution (Figs. 10A and 10B) is consistent with a monomodal distribution of particles with a mean diameter of ~ 2 nm, consistent with the reported diameter (Eychenne-Baron et al., Organometallics, 19, 1940-1949 (2000)) of dodecameric butyltin hydroxide oxide polyatomic cations. Thus, the results are consistent with cluster formation within the non-aqueous solutions.

Example 2 - Resist coating, Film Processing, Negative Tone Imaging

This example demonstrates the formation of a resist pattern based on negative tone imaging based on e-beam exposure or extreme ultraviolet exposure.

Silicon wafers (25x25 mm square) with a native-oxide surface were used as substrates for thin-film deposition. Si substrates were treated with a 10 minute cycle in an Ultra-Violet Ozone cleaning system before deposition. The resist precursor solution from Example 1 was then spin-coated on the substrate at 4500 rpm for 30 s and baked on a hotplate for 2 min at 100°C to remove residual solvent. Film thickness following coating and baking was measured via ellipsometry to be ~22 nm.



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A first substrate coated with a resist film was exposed to a 30-kV electron-beam rastered to form a pattern with a dose of 1100 $\mu C/cm^2$. The patterned resist and substrate were then subjected to a post-exposure bake (PEB) for 2 min at 150°C. The exposed film was then dipped in a polar organic solvent for 30 seconds and rinsed with in DI $H_20$ to form a negative tone image with unexposed portions of the coating removed. A final 5-min hotplate bake at 200°C was performed after development. Figs. 11A-l 1D exhibits SEM images of 18-nm lines on a 36-nm pitch in resist film developed in 4-methyl-2-pentanol (A), ethyl lactate (B), propylene glycol monomethyl ether (PGMEA) (C), and n-butyl acetate (D).

Another substrate was prepared with the identical precursor solution and coating/baking processes were used prior to exposure to extreme ultraviolet radiation, which is similarly suitable for high-resolution patterning. A pattern of 22 and 18-nm lines on 44 and 36-nm pitches, respectively, were exposed on the resist using projection with a numerical aperture of 0.3 operating at 13.5 lim wavelength and an imaging dose of 101 $mJ/cm^2$. After a 2-min, 165°C hotplate PEB, the film was developed by immersion in PGMEA, rinsed with DI $H_20$, and baked a final time for 5 min at 200°C. Negative images of the well-resolved line-space patterns are shown in Figs. 12A and 12B.

The chemical contrast generated upon radiation exposure that induces the polarity change revealed in development rate contrast and resist imaging performance is clearly illustrated with Fourier transform infrared (FTIR) spectroscopy. Transmission mode FTIR spectra of a butlytin hydroxide oxide resist film spin-coated on an un-doped Silicon wafer from a tetrahydrofuran (THF) solvent were collected as a function of exposure dose with a 30 kV electron beam. Analysis of several absorption peaks corresponding to Alkyl C-H stretching modes from 2800-2900 $cm^{-1}$ indicates a consistent decrease in the concentration of the alkyl ligand as a function of dose (Fig. 13).

Example 3 - Positive Tone Imaging

This example demonstrated the formation of a positive tone image using the resist solution from Example 1.

Another substrate was coated with a resist film deposited from an identical precursor solution from Example 1 and baked on a hotplate at 150°C for 2 min. The based wafer with the resist coating was exposed with an electron beam at 30 kV with a dose of 5 11 $\mu C/cm_1^2$, followed by a 2-min, 150°C post exposure bake. Positive tone imaging was achieved by developing the exposed resist film in an aqueous base such as 2.38% tetramethyl ammonium



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hydroxide (TMAH). Immersion in 2.38% TMAH etched the exposed resist, developing the 30-nm (60 nm pitch) lines shown the SEM image in Fig. 14.

Example 4 - Resist Stability

This example demonstrates resist precursor stability by consistent imaging performance of a resist precursor solution and coated film following aging.

A resist precursor solution prepared as previously described in Example 1 was applied via spin coating to a pair of wafer substrates, which were baked on a hotplate for 2 min at 100°C. A portion of the precursor solution was retained in a sealed vial and stored with one of the coated substrates (first substrate) in the dark, at uncontrolled room-temperature (20-30°C) under an atmospheric ambient. Immediately following coating, the second substrate with a resist film was successively patterned with a 30-kV electron beam, baked at 150°C for 2 min, developed for 30 s in PGMEA, rinsed, and hard baked at 200°C for 2 min. An SEM image of the resulting patterned second substrate is shown in Fig. 15A. This exposure and development process was repeated on the stored first substrate with the resist film 39 days later. An SEM image of the patterned first substrate is shown in Fig. 15B. Likewise, the retained portion of the original precursor solution was used on the same day after 39 days of storage to coat a third wafer substrate with a resist film, which was immediately processed, exposed, and developed identically to the first two substrates. An SEM image of the patterned third substrate is shown in Fig. 15C. The imaging performance of the three resist films on the same 36 nm pitch and 18 nm line width is found to be functionally identical, with no observable degradation in image fidelity, LWR, or sensitivity after aging of the coated resist film or precursor solution over a 39-day period.

Example 5 - Radiation Sensitivity Modulation Based On Organic Ligand Selection

This example demonstrates that modulation in resist radiation sensitivity is observed by selecting appropriate organic ligands.

Divinyltin dichloride (Alpha Aesar) was dissolved in PGMEA to a concentration of 0.1 M. A 15 mL quantity of this solution was placed in a separately funnel, to which was added 7.3 1 mL of 0.4 M NaOH (aq). Immediately following NaOH addition, the vessel was shaken thoroughly for ~ 1 minute, and the resulting emulsion was allowed to separate for ~24 h. During this period, a light flocculate formed at the phase interface between the two media was observed to dissipate, and two clear phases were obtained. The lower aqueous phase was removed from the funnel and the upper, PGMEA, phase was shaken over a 4A molecular sieve (Mallinkrodt,



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Grade 514) for ~ 5 minutes to remove residual water. Solvent evaporation and calcination of an aliquot of the sieved composition disclosed a tin concentration of 0.1 M on the basis of the residual mass $SnO_2$.

The preceding divinyltin hydroxide solution in PGMEA following separation and sieving was directly spin-cast on a silicon wafer at 1250 rpm and subjected to a 100 °C hotplate bake for 2 min. Ellipsometric measurement post-baking indicated a resist film thickness of ~ 16 nm. The resist film was exposed with 30 kV electron beam at a dose of 75 μC/cm$^2$ followed by a second hotplate bake at 100 °C, and development in PGMEA. An SEM image of a negative tone line/space pattern on a 100 nm pitch is displayed in Fig. 16. Note that the electron beam dose used to generate Fig. 16 was significantly less than used in Examples 2 and 3.

Transmission-mode FTIR spectra were collected on similar resist films deposited from an ethyl acetate solvent on undoped silicon wafers as a function of dose. The relative IR absorption as a function of electron beam dose is plotted in Fig. 17. Based on an analysis of the area of an absorption peak consistent with the vinyl C-H stretch centered at ~3055 1/cm, a drop in the area indicates the loss of vinyl groups as tin ligands on exposure that is much more rapid and comprehensive with respect to dose than the loss of alkyl ligands in the butyltin hydroxide oxide case shown in Fig. 13.

Example 6 - Organotin Oxo-Carboxylate Resist

This example demonstrates the effectiveness of a radiation resist formed with alkyl and carboxylate ligands for tin ions.

A resist precursor solution was prepared by dissolving dibutyltin diacetate (Alfa-Aesar) in n-propanol to a final concentration of 0.025 M. The solution was then filtered through a 0.45 μm PTFE syringe filter, and spin cast on a silicon wafer substrate rotated at 3000 rpm for 30 s. The coated film was then baked for 2 min at 60°C to remove residual solvent. During casting and baking the dibutyltin diacetate is partially hydrolyzed by atmospheric water, converting from a volatile molecular liquid carboxylate into a solid organotin oxo carboxylate. Ellipsometric measurements indicated a resist film thickness of ~22 nm.

Subsequent exposure of the film to a 30 kV electron beam rastered to form a pattern at a dose of 1500 μC/cm$^2$ was followed by a 60°C hotplate PEB, and immersion in PGMEA for 30s to develop the pattern by etching unexposed material. A final hardbake at 100°C for 5 min was performed prior to SEM imaging. Fig. 18 contains an electron micrograph of the resulting negative tone line/space pattern on a 32-nm pitch.



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Generation of chemical contrast in the foregoing material upon radiation exposure via electron-beam may be observed by using transmission FTIR spectroscopy as illustrated in Fig. 19. The transmission spectra of an organotin oxo-carboxylate thin-film deposited on an un-doped silicon wafer and baked at 50°C for 2 min was collected before and after exposure to a 30 kV electron beam (800 $\mu C/cm^2$). As with simple organotin oxo hydroxides, a strong decrease in the absorption peaks attributed to hydrocarbon C-H stretching and bending modes (2957, 2924, 2858, 1391, and 1331 $cm^{-1}$) is observed, confirming loss of alkyl ligands on exposure. Also readily apparent and unique to the carboxylate is the significant reduction in the absorbance centered at 1605 $cm^{-1}$, attributed to decomposition of carboxylate ligands and attendant reduction in carbonyl C=O absorption on exposure.

The embodiments above are intended to be illustrative and not limiting. Additional embodiments are within the claims. In addition, although the present invention has been described with reference to particular embodiments, those skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention. Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein.



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What is claimed is:

1. A method for patterning a substrate with radiation, the method comprising:

irradiating a coated substrate along a selected pattern to form an irradiated structure with a region of irradiated coating and a region with un-irradiated coating, wherein the coated substrate comprises a coating that comprises a metal oxo-hydroxo network with organic ligands with a metal carbon bonds and/or with metal carboxylate bonds; and

selectively developing the irradiated structure to remove a substantial portion of the irradiated coating or of the un-irradiated coating to form a patterned substrate.

2. The method of claim 1 wherein the irradiated structure has irradiated coating that is soluble in aqueous base and non-irradiated coating soluble in organic solvents such that the irradiated structure can be alternatively subjected to positive tone imaging or negative tone imaging.

3. The method of claim 1 or claim 2 wherein the development is performed with an organic solvent to remove the non-irradiated coating.

4. The method of claim 1 or claim 2 wherein the selective development is performed with an aqueous base.

5. The method of any of claims 1-4 wherein the irradiation is performed with an electron beam, ultraviolet light, extreme ultraviolet light, irradiation from an ArF laser, irradiation from a KrF laser, or a UV lamp.

6. The method of any of claims 1-5 wherein the etched pattern comprises features with an average pitch of no more than about 60 nm.

7. The method of any of claims 1-6 wherein the un-irradiated coating has a mole ratio between the organic ligands and the metal cations from about 0.1 to about 4 and has an average coating thickness of no more than about 1 micron.



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8. The method of any of claims 1-7 wherein the metal comprises a tin ion, antimony ion, indium ion or a combination thereof and wherein the organic ligand forms a metal carbon bond and wherein the ligand forming the metal carbon bond comprises an alkyl ligand, alkenyl ligand, aryl ligand, or a combination thereof, each ligand containing 1 to 16 carbon atoms and/or organic ligands form a metal-carboxyl bond and wherein the metal-carboxyl bond is formed by an alkyl carboxylate ligand, alkenyl carboxylate ligand, aryl carboxylate ligand or a combination thereof, each ligand having 1 to 16 carbon atoms.

9. The method of any of claims 1-8 further comprising forming the coating by depositing a liquid precursor solution and evaporating the solvent to solidify the coating.

10. A coated substrate comprising a radiation sensitive coating having an average thickness of no more than about 10 microns and a thickness variation of no more than about 50% from the average at any point along the coating, the coating comprising metal oxo-hydroxo network with metal cations having organic ligands with a metal carbon bonds and/or with metal carboxylate bonds.

11. The coated substrate of claim 10 wherein a mole ratio between the organic ligands and the metal cations is from about 0.1 to about 4.

12. The coated substrate of claim 10 wherein a mole ratio between the organic ligands and the metal cations is from about 0.5 to about 3.

13. The coated substrate of any of claim 10-12 having an average coating thickness of no more than about 1 micron.

14. The coated substrate of any of claims 10-12 having an average thickness from about 5 nm to about 200 run.

15. The coated substrate of any of claims 10-14 wherein the metal ion comprises a tin ion, antimony ion, indium ion or a combination thereof.



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16. The coated substrate of claim 15 wherein the metal cations further comprise a cation of another metal element and/or metalloid element at no more than about 50 mole% of total metal + metalloid content.

17. The coated substrate of any of claims 10-16 wherein the organic ligand forms a metal carbon bond and wherein the ligand forming the metal carbon bond comprises an alkyl ligand, alkenyl ligand, aryl ligand or combinations thereof, each containing 1 to 16 carbon atoms.

18. The coated substrate of any of claims 10-16 wherein the organic ligand forms a metal carboxyl bond and wherein the metal carboxyl bond is formed by an alkyl carboxylate ligand, alkenyl carboxylate ligand, an aryl carboxylate ligand or a combination thereof, each having 1 to 16 carbon atoms.

19. A patterned substrate comprising a substrate with a surface and a first coating at selected regions along the surface and absent at other regions along the surface, the first coating comprising metal oxo-hydroxo network and organic ligands with metal cations having organic ligands with a metal carbon bonds and/or with metal carboxylate bonds, wherein alternatively the first coating is soluble in at least some organic liquids or the first coating is soluble in aqueous bases.

20. The patterned substrate of claim 19 wherein the substrate surface is exposed at the regions of the substrate where the coating is absent.

21. The patterned substrate of claim 19 or claim 20 wherein the coating is effectively soluble in at least some organic liquids and further comprising a second coating along the surface at regions where the first coating is absent wherein the second coating is soluble in aqueous bases.

22. The patterned substrate of any of claims 19-21 wherein the patterned coating comprises features with an average pitch of no more than about 60 nm.



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23. A precursor solution comprising an organic liquid and from about 0.0 lM to about 1.4M metal polynuclear oxo/hydroxo cation with organic ligands having a metal carbon bonds and/or with metal carboxylate bonds, the precursor solution having a viscosity from about 0.5 centipoises (cP) to about 150cP and the organic liquid having a flash point of at least 10°C and a vapor pressure at 20°C less than about 10 kPa.

24. The precursor solution of claim 23 wherein the metal comprises tin and the organic liquid is an alcohol.



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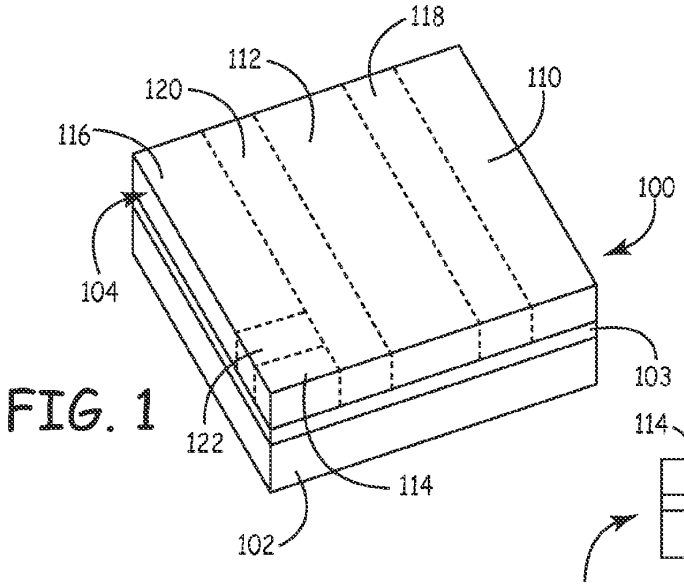



FIG. 1

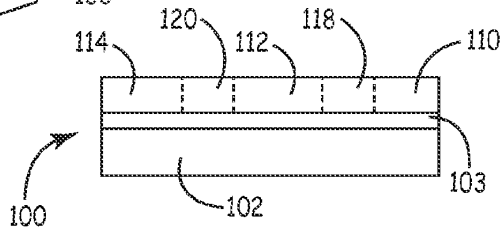



FIG. 2

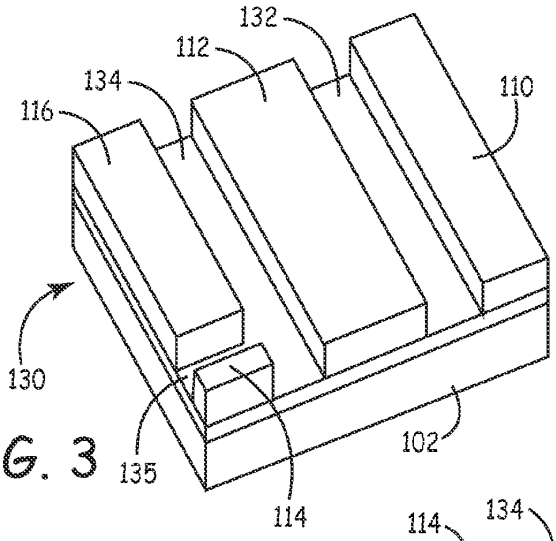



FIG. 3

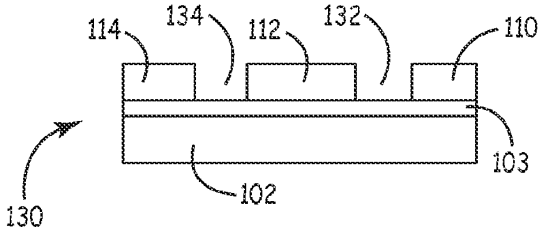



FIG. 4

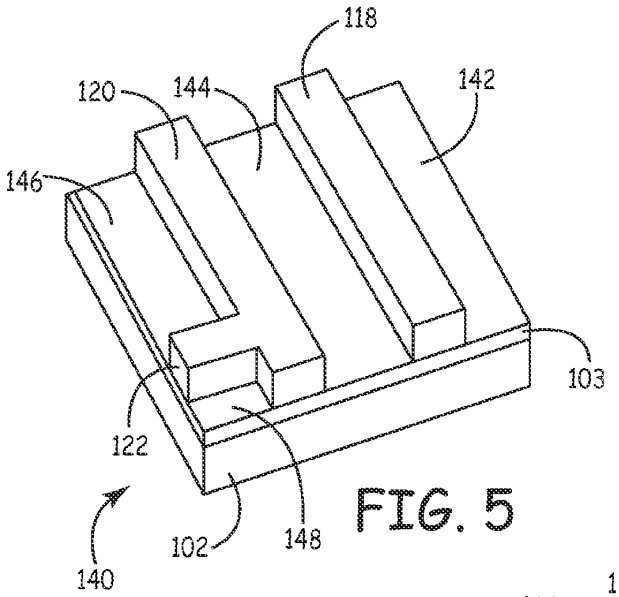

118
120
144
142
146
103
122
102
148
140

FIG. 5

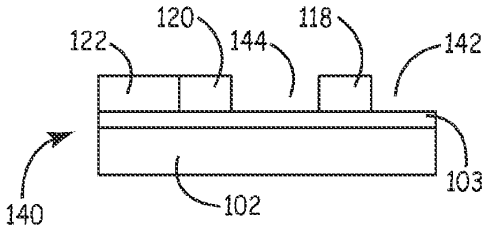

120
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103
140
102

FIG. 6

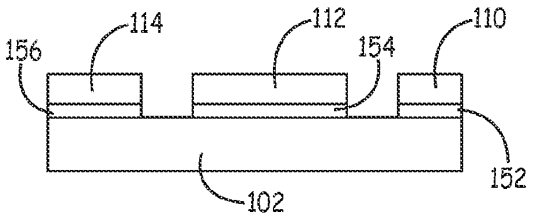



FIG. 7

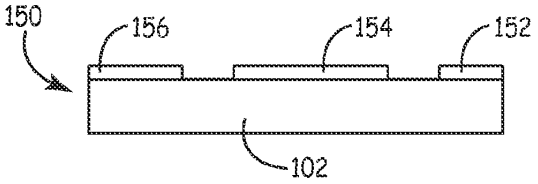



FIG. 8

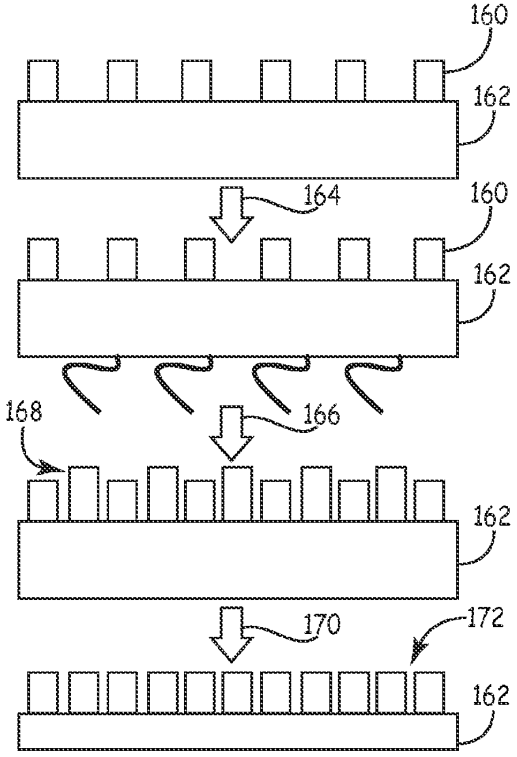



FIG. 9

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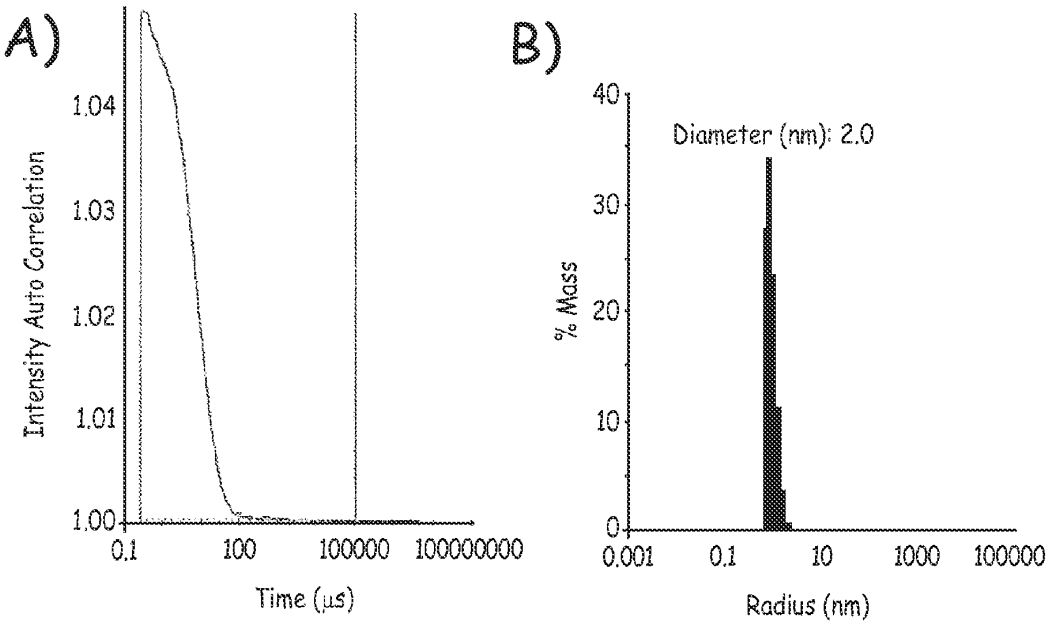

A)
1.04
1.03
1.02
1.01
1.00
Intensity Auto Correlation
0.1
100
100000
100000000
Time (µs)
B)
40
30
20
10
0
% Mass
Diameter (nm): 2.0
0.001
0.1
10
1000
100000
Radius (nm)

FIG. 10

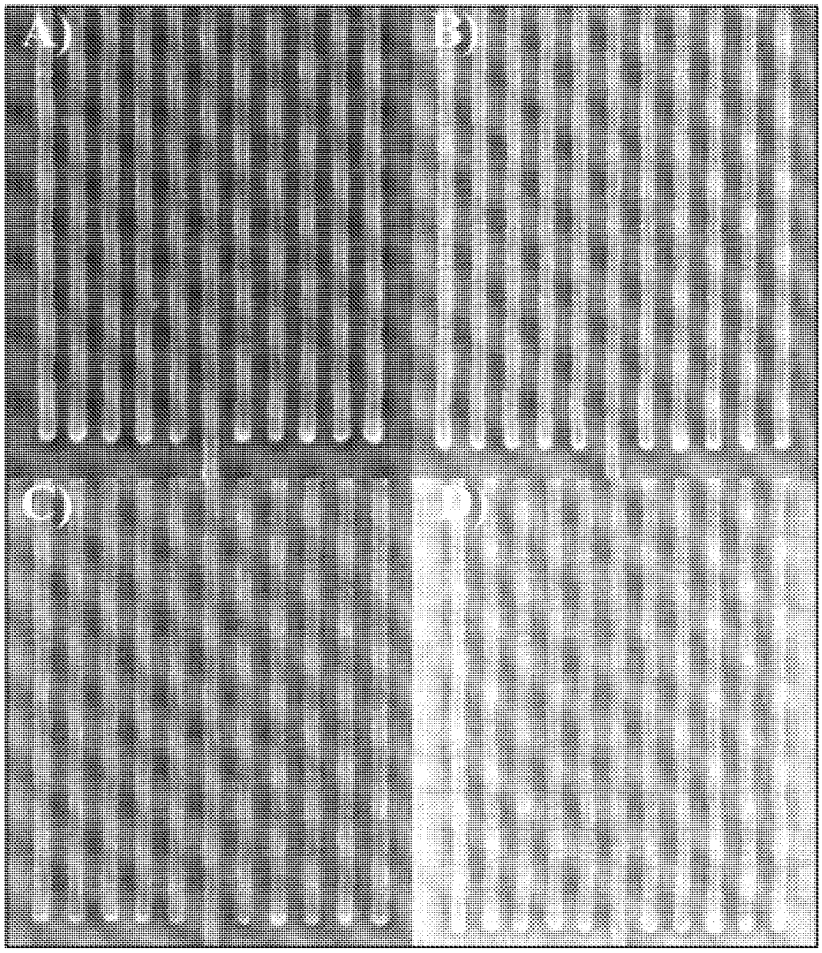



FIG. 11

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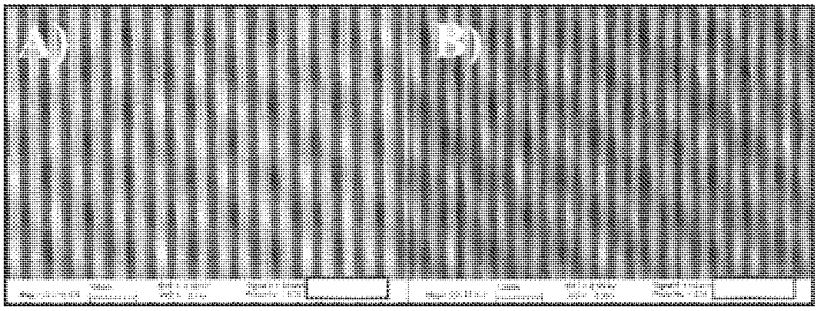

A)
B)

FIG. 12

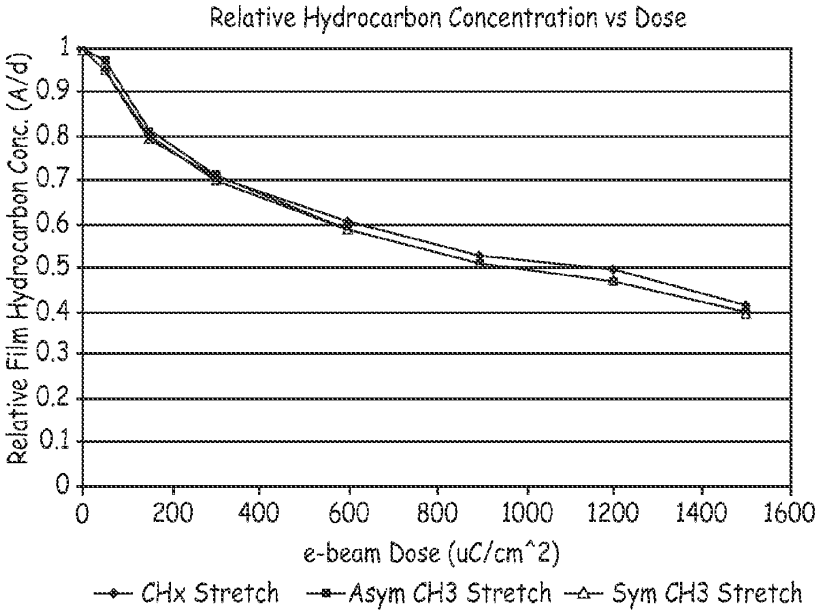

Relative Hydrocarbon Concentration vs Dose
Relative Film Hydrocarbon Conc. (A/d)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
1200
1400
1600
e-beam Dose (uC/cm^2)
CHx Stretch
Asym CH3 Stretch
Sym CH3 Stretch

FIG. 13

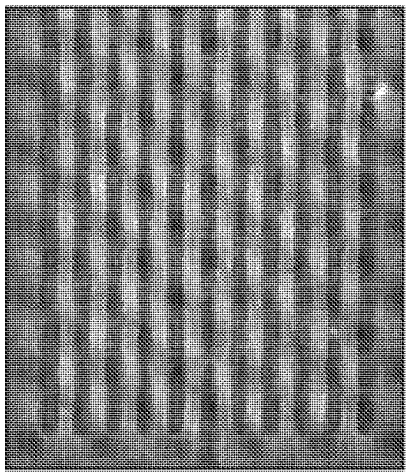


FIG. 14

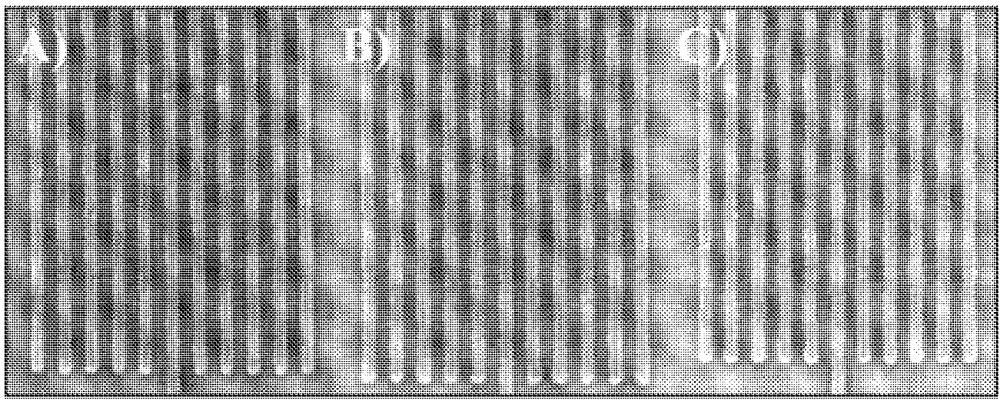



FIG. 15

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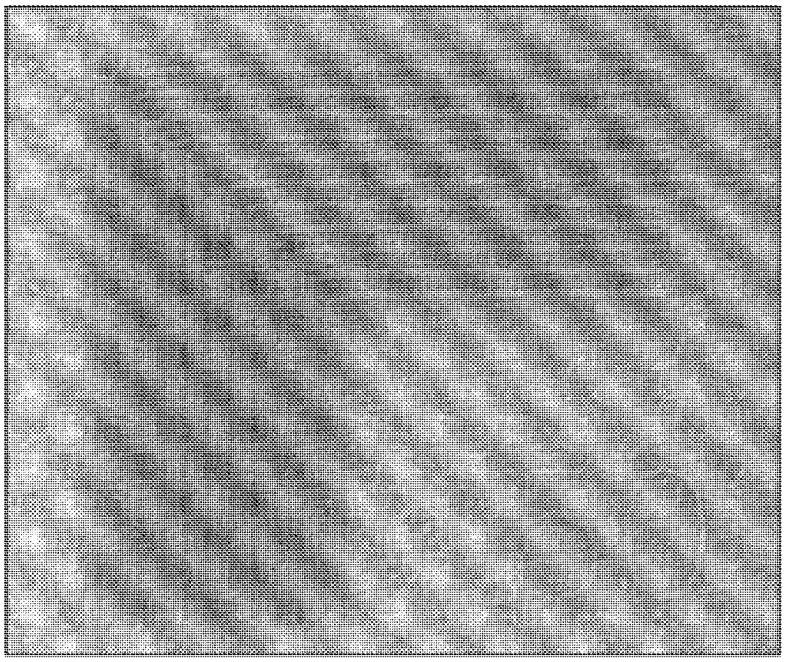


FIG. 16

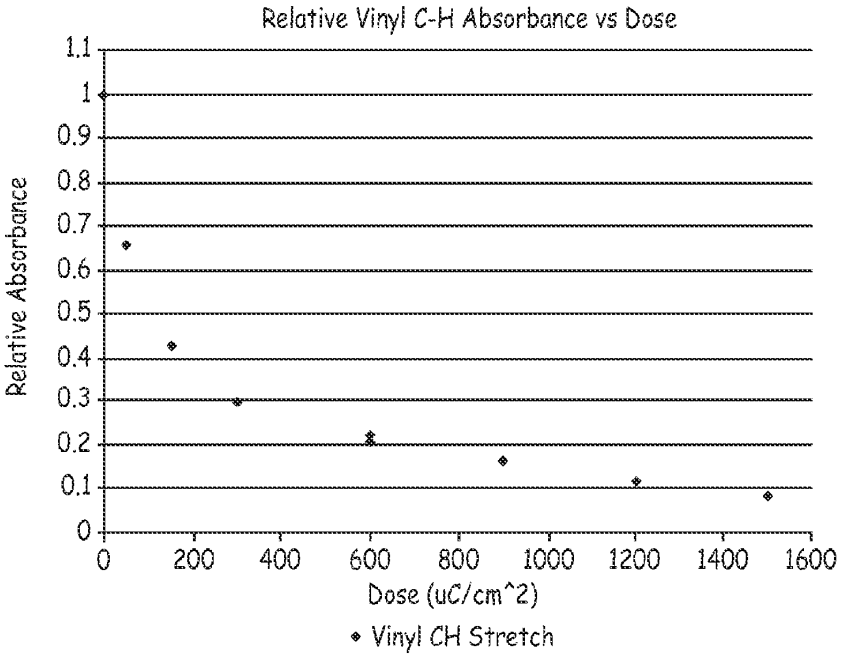

Relative Vinyl C-H Absorbance vs Dose
Relative Absorbance
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
1200
1400
1600
Dose (uC/cm^2)
Vinyl CH Stretch

FIG. 17

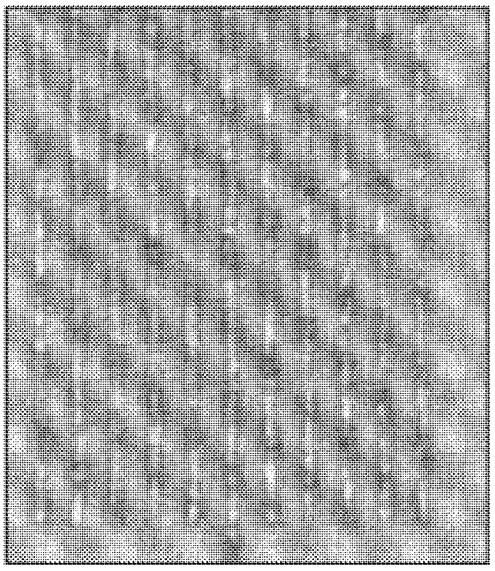


FIG. 18

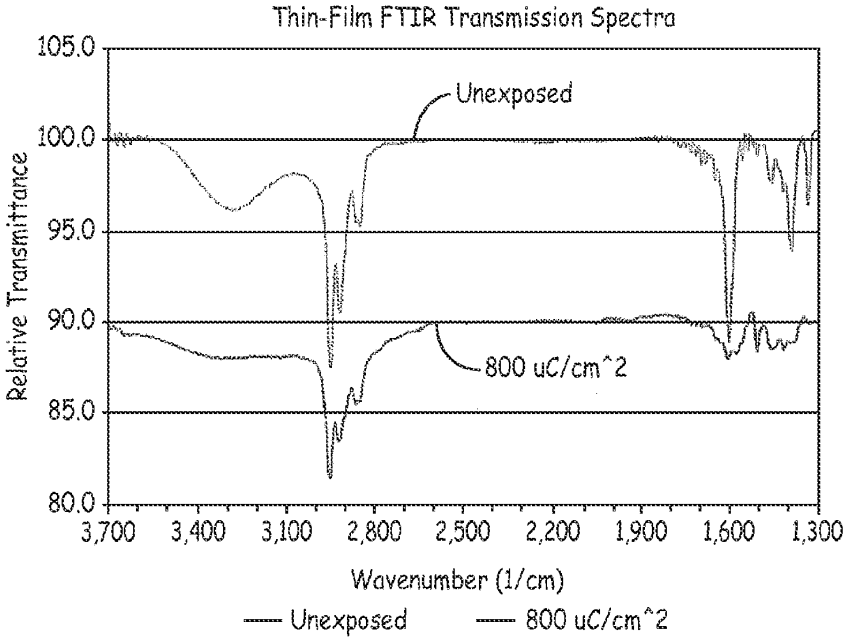

Thin-Film FTIR Transmission Spectra
105.0
100.0
95.0
90.0
85.0
80.0
Relative Transmittance
Unexposed
800 uC/cm^2
3,700
3,400
3,100
2,800
2,500
2,200
1,900
1,600
1,300
Wavenumber (1/cm)
Unexposed
800 uC/cm^2

FIG. 19

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16987120 |
| **Filing Date:** | 06-Aug-2020 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Filer:** | Diane Elizabeth Bennett/Michelle Douglas |
| **Attorney Docket Number:** | 5063.08US05 |

Filed as Large Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| CLAIMS IN EXCESS OF 20 | 1202 | 4 | 100 | 400 |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| Extension - 1 month with $0 paid | 1251 | 1 | 220 | 220 |
| **Miscellaneous:** | | | | |
| SUBMISSION- INFORMATION DISCLOSURE STMT | 1806 | 1 | 260 | 260 |
| | | **Total in USD ($)** | | **880** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 41693997 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T. Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08US05 |
| **Receipt Date:** | 20-JAN-2021 |
| **Filing Date:** | 06-AUG-2020 |
| **Time Stamp:** | 14:38:37 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | CARD |
| Payment was successfully received in RAM | $880 |
| RAM confirmation Number | E20211JE38571834 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Transmittal Letter | AmendmentTransmittal.pdf | 33590<br>dda37efa011a035d0b5fbc6257f1a9b0f821bfa0 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | | Amendment.pdf | 258038<br>a67793bbda1c65a9421185aa1781b904e5997458 | yes | 15 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Applicant Arguments/Remarks Made in an Amendment | 8 | 15 |
| | Drawings-other than black and white line drawings | 7 | 7 |
| | Claims | 3 | 6 |
| | Specification | 2 | 2 |
| | Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Drawings-only black and white line drawings | ReplacementDrawings.pdf | 938127<br>b98da2615fa93f5f2e29d9109d14b8f1814bf346 | no | 8 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Extension of Time | ExtensionOfTime-1mo.pdf | 21041<br>a68ed8de2bdd516bf823936b3306be53d30d70eb | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Information Disclosure Statement (IDS) Form (SB08) | IDS_Form_SB_08a-signed.pdf | 1035244<br>a7219edd5aa016a3b571fc4484b5bb60cce8f6f3 | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems. | | | | | |
| 6 | Foreign Reference | CN1457504A_EAO.pdf | 12843174<br>13929b29ecbb3cd72696d311d072a82c5e1fe088 | no | 85 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 7 | Foreign Reference | WO2015-026482A2.pdf | 2246038<br>2c2ccb00a342fd8ad8b277e86f3f477fe1b09dc8 | no | 47 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 8 | Other Reference-Patent/App/Search documents | KR_OfficeAction_8-4-20_trans.pdf | 2422786<br>fc8555739bf86f7c57108a59220e43610732ca96 | no | 14 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 9 | Other Reference-Patent/App/Search documents | CN_OfficeAction_8-28-20_trans.pdf | 1349159<br>5f866f2caef34e52bb287f363f6c7dfd38535505 | no | 16 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 10 | Fee Worksheet (SB06) | fee-info.pdf | 34407<br>289937eb790e809ea36655ab437121e198909d3e | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 21181604 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

Customer No. **62274**
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11322 86th Avenue North
Maple Grove, MN 55369
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Attorney Docket No. 5063.08US05

AMENDMENT TRANSMITTAL

In re the application of:

Meyers et al.

Confirmation No.: 5672

Application No.: 16/987,120

Examiner: Binu Thomas

Filed: August 6, 2020

Group Art Unit: 1717

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is an Amendment in the above-identified application.

Enclosed are:

[X] Amendment (15 pages).

[X] Replacement Drawings

[X] Petition for Extension of One Month for Amendment.

[X] Supplemental Information Disclosure Statement.

The filing fee has been calculated as shown below:

| | Claims Remaining After Amendment | Highest No. Previously Paid For | Present Extra (Equals) | ~~Small Entity Rate~~ | ~~Add'l Fee~~ | OR | **Large Entity Rate** | **Add'l Fee** |
|---|---|---|---|---|---|---|---|---|
| Total | 25 | - 21 | = 4 | ~~x 50~~ | ~~$~~ | | **x 100** | **$400** |
| Indep. | 1 | - 3 | = 0 | ~~x 240~~ | ~~$~~ | | **x 480** | **$0** |
| Ext of Time | | | + 1 | ~~+ 110~~ | ~~$~~ | | **+ 220** | **$220** |
| Supp IDS | | | = 1 | ~~+ 130~~ | ~~$~~ | | **+ 260** | **$260** |
| Mult. Dep. | | | = 0 | ~~+ 430~~ | ~~$~~ | | **+ 860** | **$0** |
| | | | | ~~TOTAL~~ | ~~$~~ | OR | **TOTAL** | **$880.00** |

[ ] First Presentation of Multiple Dependent Claim [MDC]

* If the entry in Column 1 is less than the entry in Column 2, write "0" in Column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space.
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Column 1 of a prior Amendment or the number of claims originally filed.

[ ] Applicant(s) is/are entitled to small entity status in accordance with 37 CFR 1.27.

[X] The Commissioner is hereby authorized to charge a credit card referenced in the electronic filing in the amount of **$880.00**. The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 60-1363.

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

January 20, 2021 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240



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IPR2025-00309 - U.S. Patent No. 11,537,048

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1. (Currently Amended) An apparatus comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate;

an inlet into the deposition chamber;

structure configured to deliver flow from a supply of an inert gas; and

structure configured to deliver flow from a supply of an organotin compound with the inert gas as a carrier gas to the inlet to provide for formation of an organotin layer on the substrate surface within the deposition chamber, the organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer.

2. (Currently Amended) The apparatus of claim 1 wherein the substrate comprises a silicon wafer ~~and wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness~~

3. (Original) The apparatus of claim 1 further comprising structure configured to deliver flow from a supply of an inert gas.

4. (Original) The apparatus of claim 2 wherein the inert gas comprises nitrogen or argon.

5. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin



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compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6. (Currently Amended) The apparatus of claim 1 wherein the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ wherein R is an organic ligand with 1-31 carbon atoms and is bound to Sn with a metal-carbon bond, n = 1 - 3 and X is a ligand having a hydrolysable bond with Sn; and the apparatus further comprising structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with X ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

7. (Original) The apparatus of claim 6 wherein the oxygen containing compound comprises water vapor, hydrogen peroxide, ozone, oxygen, an alcohol, or combinations thereof.

8. (Original) The apparatus of claim 6 wherein the second precursor vapor comprises water vapor.

9. (Currently Amended) The apparatus of claim 6 further comprising ~~structure configured to deliver~~ a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. (Original) The apparatus of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. (Original) The apparatus of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.



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12. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. (Original) The apparatus of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. (Original) The apparatus of claim 1 wherein the flow comprises a vapor.

15. (Original) The apparatus of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.

16. (Currently Amended) The apparatus of claim [[1]]15 wherein the vapor inputting structures provide for control of the flow.

17. (Currently Amended) The apparatus of claim [[15]]6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow at the same time.

18. (Currently Amended) The apparatus of claim [[15]]6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow, wherein the first vapor flow and the second vapor flow are sequential.

19. (Currently Amended) The apparatus of claim [[15]]6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow ~~and a third vapor inputting structure is configured to deliver a third flow~~, wherein the first vapor flow, the second vapor flow, and [[the]]a third vapor flow are sequential.



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20. (Currently Amended) The apparatus of claim [[15]]6 wherein a first vapor inputting structure is configured to deliver a first vapor flow and a second vapor inputting structure is configured to deliver a second vapor flow ~~and a third vapor inputting structure is configured to deliver a third flow~~, wherein the first vapor flow and the second vapor flow are at the same time and [[the]]a third vapor flow is sequential.

21. (Original) The apparatus of claim 1 wherein the interior has a temperature from about 45°C to about 250°C.

22. (New) A method for forming an organotin layer using the apparatus of claim 1, the method comprising:

delivering the organotin compound from the supply into the deposition chamber through the inlet to deposit the organotin layer onto the substrate in the deposition chamber.

23. (New) The method of claim 22 wherein the hydrolysable or oxidizable ligands are hydrolyzed or oxidized during deposition and wherein the organotin layer is an organotin oxide hydroxide layer.

24. (New) The method of claim 22 wherein the organotin compound is subjected to hydrolysis and/or oxidation to form an organotin oxide hydroxide layer.

25. (New) The method of claim 22 wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.



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AMENDMENTS TO THE SPECIFICATION

In the Specification

Please substitute the following amended paragraph(s) and/or section(s) (deleted matter is shown by strikethrough and added matter is shown by underlining):

At page 5, line 20, please insert the following paragraph:

Fig. 16 is a schematic of an apparatus for the formation of an organotin oxide hydroxide layer on a substrate.

At page 25, after line 22, please insert the following paragraph:

Fig. 16 illustrates apparatus 150 for the formation of an organotin oxide hydroxide layer on a substrate. Deposition chamber 151 interfaces with inlet 152, separate inlet 154 and outlet 153 connected with pump 155 and pump 156. Substrate 157 is mounted within the interior of deposition chamber 151 on thermal block 158. In this embodiment, vessel 168 is depicted as a bubbler connected to supply of inert gas 170. Structure 160 is configured to supply organotin compound 164 to deposition chamber 151 through inlet 152. Apparatus 150 also depicts structure 174, configured to deliver a second precursor vapor to deposition chamber 151 through separate inlet 154.



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AMENDMENTS TO THE DRAWINGS

Fig. 16 is added to the drawings.

Attachment: ReplacementDrawings



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REMARKS

Claims 1-25 are pending. By this Amendment, claims 1, 2, 6, 9, and 16-20 are amended and new claims 22-25 are added. Specifically, claim 1 is amended to specify that the apparatus comprises an inlet into the deposition chamber and structure configured to deliver flow from a supply of an inert gas. The specification supports the amendment of claim 1, for example, at page 25, line 18 via the disclosure of a separate inlet which implies an inlet. The specification further supports the amendment of claim 1, for example, at page 36, line 4, via the incorporation by reference of Maeng et al. Applicant refers in particular to Fig. 1 of Maeng et al. Claim 1 is further amended to specify "with the inert gas as a carrier gas to the inlet". The specification supports this amendment of claim 1, for example, at page 25, lines 21-22. Claim 1 is also amended to specify that the organotin compound comprises a hydrolysable or oxidizable ligand and a metal-carbon bond suitable for the formation of an organotin oxide hydroxide layer. The specification supports this amendment of claim 1, for example, at page 1, line 19 and page 3, line 26 to page 4, line 2. Claim 2 is amended to delete a feature which is currently recited in new claim 25. Claim 6 is amended for clarity by inserting the words "and is" in line 3. Claim 9 is amended to delete the phrase "structure configured to deliver". Claim 16 is amended to correct the claim dependency. Claims 17-20 are amended to recite a first vapor flow and a second vapor flow. The specification supports the amendment of claims 17-20, for example, at page 46, embodiment 1. Claims 19 and 20 are further amended to delete the phrase "and a third vapor inputting structure is configured to deliver a third flow". The specification supports new claims 22-24, for example, at at page 1, line 19; page 3, line 24 to page 4, line 2; and page 46, embodiment 1. New claim 25 recites a feature from original claim 2. The specification supports new claim 25, for example, at page 22, lines 24-29; page 23, lines 3-5; and page 26, lines 19-23. The Drawings are amended to include a Fig. 16. The specification supports Fig. 16, for example, at page 36, line 4, via the incorporation by reference of Maeng et al. Applicant refers in particular to Fig. 1 of Maeng et al. The specification is amended to refer to Fig. 16. No new matter is introduced.

Objections to the Drawings

The Examiner objected to the drawings under 37 CFR 1.83(a) for failing to show every feature of the invention specified in the claims. The drawings have been amended. In particular,



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Fig. 16 has been added to the Drawings as discussed above. In particular, Maeng et al. teaches the following apparatus:

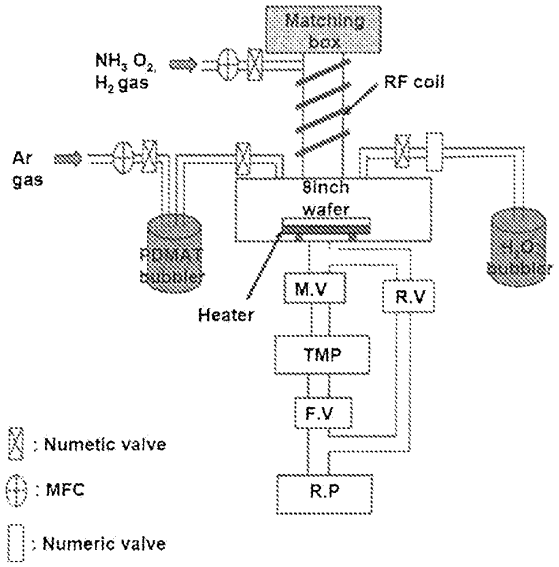



FIG. 1. Schematic diagram for the PE-ALD system.

Objections to the Claims

The Examiner objected to claims 1-21 for asserted informalities.

In item 3 on page 3, the Examiner stated that features found in claims 1, 3, 5, 6, 9, and 15-20 are not found in the specification. Claims 3, 5, 6, 9, and 15-20 depend from claim 1. As an initial matter, Applicant respectfully notes that the Examiner does not have the authority to reject claims without any statutory basis and call them objections. The issues raised in this section of the office action are not typographical errors or grammatical issues that are appropriate to form the basis for objections. But these issues may be appropriately the subject of a 112 rejection. The formulation of this section seems to invoke a lack of written description under 35 U.S.C. 112(a). While not clearly stated, the 112 section of the Office Action seems to invoke a lack of written description rejection, and these matters are discussed in detail below.

As explained below, Applicant asserts that the features of claim 1 are supported by the instant specification as filed, which includes the incorporations by reference therein as well as



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understanding well known in the art. However, the specification and drawings and claims 17-20 are also amended for an assurance of clarity and for consistency of terminology. In view of this explanation and the amendments, it is believed that the issues of objection are resolved.

In item 4 on page 3, the Examiner objected to the wording in claim 6. Claim 6 is amended for clarity. In view of the amendment of claim 6, it is believed that this issue of objection is also resolved.

Rejections Under 35 U.S.C. 112

The Examiner first lists 8 elements from the claims in numbered paragraphs 6-13 that are asserted to be means plus function features invoking 35 U.S.C. 112(f) without any reference to specific claims. In paragraph 14, the Examiner asserts a lack of written description, which presumably corresponds with a rejection of claims with the listed elements under 35 U.S.C. 112(a). In particular, the Examiner asserts that the written description fails to disclose the corresponding structure, material, or acts for performing the entire claimed functions and to clearly link the structure to the functions. The Examiner seems to assert unpatentability for lack of clarity under 35 U.S.C. 112(b), but no assertions are made regarding a lack of clarity, so Applicant responds to a lack of written description rejection. Based on the claim limitations noted on pages 4-5, paragraphs 6-13 of the Office Action, the Examiner appears to refer to claims 1, 3, 6, 9, 13, 15, and 17-20. Applicant respectfully maintains that the enumerated claim features are not means plus function limitations and have appropriate written description support.

First, it is well-established law, that what is well-known in the art does not need to be explicitly provided in a patent specification. "A patent need not disclose what is well known in the art." *In re Wands*, 858 F.2d 731, 735 (Fed. Cir. 1988). "The test is whether the disclosure 'conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.' This test requires an 'objective inquiry into the four corners of the specification from the perspective of a person of ordinary skill in the art.' Given this perspective, in some instances, a patentee can rely on information that is 'well-known in the art' to satisfy written description." *Streck, Inc. v. Research & Diagnostic Sys., Inc.*, 665 F.3d 1269, 1285 (Fed. Cir. 2012) cert. denied, 132 S. Ct. 2442, 182 L. Ed. 2d 1064 (U.S. 2012) (citing *Ariad,* 598 F.3d at 1351; *Boston Sci. Corp. v. Johnson & Johnson,* 647 F.3d 1353, 1366 (Fed.Cir.2011)) (internal citations omitted). "That



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which is common and well known is as if it were written out in the patent and delineated in the drawings." *In re Howarth*, 654 F.2d 103, 106 (C.C.P.A. 1981) (citing Webster Loom Co. v. Higgins et al., 105 U.S. 580, 586 (26 L.Ed. 1177) (1881)). The Supreme Court established more than 130 years ago that stating the well-known is unnecessary in a patent application.

With all due respect, reaction chambers and feed lines into reaction chambers are well-known. Tubing and other conduits made from appropriate material that is inert under the conditions of exposure are well within the well-established tool chest of the person of ordinary skill in the art. Furthermore, Applicant has amended the specification and figures based on incorporation by reference to provide the asserted missing disclosure.

As noted above, the specification is amended to refer to new Fig. 16. As amended, the specification discloses the structures in items 6-8 and 10 on page 4 of the Office Action. Items 9 and 13 on page 4 of the Office Action are addressed via amendments to claims 9 and 19-20.

In view of the amendments, it is believed that the issues are resolved. Applicant respectfully requests withdrawal of the rejection under 35 U.S.C. 112(a or b).

Rejections Under 35 U.S.C. 102 Over Russo

The Examiner rejected claims 1, 5, 12, 14-16, and 21 under 35 U.S.C. 102(a)(1) as being anticipated by U.S. patent 4,601,917 to Russo (hereinafter "Russo"). Claims 5, 12, 14-16, and 21 depend from claim 1. To clarify the scope of the claimed invention, claim 1 has been amended. Applicant respectfully maintains that Russo does not teach all of the claimed features, and thus Russo does not *prima facie* anticipate the claimed invention. Applicant respectfully requests reconsideration of the rejection based on the following comments.

Russo discloses the formation of fluorine-doped **tin oxide** coatings not the claimed **organotin oxide hydroxide** layer. See Abstract of Russo. The instantly claimed apparatus provides for the formation of an organotin oxide hydroxide layer in which the "R-Sn moiety is at least partially preserved through the hydrolysis and condensation process, and the resulting film has both M-C and M-O bonds." See the instant specification at page 7, lines 3-16. The organotin oxide hydroxide layer, Applicant explains, can be formed for use as a photoresist coating.

Significantly, the apparatus of Russo uses "a carrier gas 10 which includes oxygen, with air being preferred" and the "vaporized liquid coating composition in the air stream 22 travels to a



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deposition chamber 23." See Col. 3, lines 43 and lines 58-59. As amended, claim 1 specifies an inert gas as a carrier gas. Thus, the apparatus of Russo does not provide for the delivery to the chamber inlet of a flow of an organotin compound comprising a hydrolysable or oxidizable ligand, as presently claimed.

In summary, Russo does not teach the claimed structure configured to deliver flow of an organotin compound comprising a hydrolysable or oxidizable ligand and a metal-carbon bond to the inlet of a deposition chamber with an inert carrier gas for the formation of an organotin layer with the ligands and the metal-carbon bonds suitable for forming an organotin oxide hydroxide layer on a substrate surface.

Applicant respectfully asserts that Russo does not teach all of the features of the apparatus of instant claim 1.

Therefore, respectfully, Applicant asserts that the teachings of Russo do not *prima facie* anticipate the claimed apparatus. Applicant respectfully requests withdrawal of the rejection of claims 1, 5, 12, 14-16, and 21 under 35 U.S.C. 102(a)(1) as being anticipated by Russo. While Applicant does not acquiesce with respect to particular assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these issues here in view of the analysis presented above regarding independent claim 1, which are dispositive.

Rejection Under 35 U.S.C. 103 Over Nishida

The Examiner rejected claims 1-8, 11-16, and 21 under 35 U.S.C. 103 as being unpatentable over U.S. patent 6,825,131 to Nishida (hereinafter "Nishida"). Claims 2-8, 11-16, and 21 depend from claim 1. The Examiner states that Nishida teaches an apparatus for forming a coating from a metal element material solution. The Examiner notes that Nishida does not explicitly teach an organotin compound to provide for the formation of an organotin layer on the substrate surface. Applicant refers to the above disclosure regarding the proper selection of precursor and reactant. Nishida's lack of teaching of the claimed organotin compound as a reactant is a significant deficiency. Applicant notes that Nishida also does not teach the claimed organotin oxide hydroxide layer. The Examiner asserts that one would be capable of using the organotin compound with formula as recited in the claim, as the material solution of Nishida. However, one of ordinary skill would have not have a reasonable expectation of success in using the apparatus



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of Nishida with the claimed organotin compound to form the claimed layer. This lack of expectation of success is punctuated by the different fields of endeavor which characterize Nishida and the present invention. As per the title of the instant application, the field of endeavor is related to patterning compositions. However, Nishida makes no mention of a forming layer, such as the claimed organotin oxide hydroxide layer, which would be suitable as photoresists or patterning compositions.

The Examiner cited six cases for support of the idea that the features of the claim that are not taught by Nishida do not provide a basis for invention. With all due respect, the four CCPA cases do not support the Examiner's position. With respect to the two ex parte cases, these do not seem to be precedential, and Applicant could not readily obtain a copy of the decisions. Referring to *in re Casey*, 152 USPQ 235, 370 F.2d 576 (CCPA 1967), Appellant argued patentability based on methods of using the claimed apparatus relying on features not in the claim. Similarly, in *In re Rishoi*, 94 USPQ 71, 197 F.2d 342 (CCPA 1952), Appellant argued regarding formation of the liquid film over the apparatus surface, which was not in the claim language. Referring to *In re Young*, this case from 1935 involved a different obviousness statute than is presently operative. Respectfully, *In re Dulberg* 129 USPQ 348. 289 F.2d 522 (CCPA 1961) does not seem on point since it relates to whether or not a prior art cap was removable or not.

The Examiner further cites MPEP 2115. When interpreted in view of the cited cases, Applicant believes that this section is not on point. Furthermore, the MPEP does not have the force of law. Under the statute, claims must be considered as a whole. "A patent may not be obtained ... if the differences between the [claimed invention] and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the art." *Ecolochem, Inc. v. Southern California Edison Company*, 227 F.3d 1361, 1371 (Fed. Cir. 2000), citing 35 U.S.C. § 103(a). Section 103 states that (emphasis added) "if the differences between the claimed invention and the prior art are such that the claimed invention **as a whole** would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains." Respectfully, not considering the claims as a whole is clear legal error.

The Examiner has neglected features of the claim in rendering the rejection, which is legal error. Therefore, respectfully, Applicant asserts that the teachings of Nishida do not render the



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claimed apparatus *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1-8, 11-16, and 21 under 35 U.S.C. 103 as being unpatentable over Nishida. While Applicant does not acquiesce with respect to particular assertions in the rejection directed to the features of the dependent claims, Applicant does not comment further on these issues here in view of the analysis presented above regarding independent claim 1, which are dispositive.

Rejection Under 35 U.S.C. 103 Over Jurisch

The Examiner rejected claims 1, 3, 5, 6-12, and 14-21 under 35 U.S.C. 103 as being unpatentable over U.S. patent application 2005/0266700 to Jursich (hereinafter "Jursich"). Claims 3, 5, 6-12, and 14-21 depend from claim 1. The Examiner states that Jursich teaches a coating formed comprises from vaporized germanium precursor. The Examiner notes that Jursich does not explicitly teach an organotin compound to provide for the formation of an organotin layer on the substrate surface. The Examiner's basis for rejection is similar to that of Nishida, although Applicant notes that Jursich does teach deposition of tin oxide coatings. As with Nishida, Jursich's lack of teaching of the claimed organotin compound as a reactant is a significant deficiency. Applicant notes that Jursich also does not teach the claimed organotin oxide hydroxide layer. The Examiner asserts that one would be capable of using the organotin compound with formula as recited in the claim, as the material solution of Nishida. However, one of ordinary skill would have not have a reasonable expectation of success in using the method of Nishida with a different reagent to form a different layer. In particular, the disclosure of Jursich highlights that different metal compounds deposit differently. See paragraph [0085] of Jursich. The Examiner asserts that one would be capable of using an organotin compound as the material solution in the apparatus of Jursich, but Jursish does not suggest a reasonable expectation of success in using the claimed organotin compound to form the claimed organotin oxide hydroxide layer.

Thus, Applicant asserts that Jursich does not motivate the modification of the apparatus as suggested by the Examiner. Therefore, respectfully, Applicant asserts that the teachings of Jursich do not render the claimed apparatus *prima facie* obvious. Applicant respectfully requests withdrawal of the rejection of claims 1, 3, 5, 6-12, and 14-21 under 35 U.S.C. 103 as being unpatentable over Jursich. While Applicant does not acquiesce with respect to particular assertions in the rejection directed to the features of the dependent claims, Applicant does not comment



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further on these issues here in view of the analysis presented above regarding independent claim 1, which are dispositive.

## CONCLUSION

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

/Peter S. Dardi/

Peter S. Dardi, Ph.D.
Registration No. 39,650

/Diane Bennett/

Diane E. Bennett, Ph.D.
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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Office Action of October 8, 2020, please enter the following amendments and consider the following remarks. This Amendment includes the following:

A. Amendments to the Specification

B. Amendments to the Claims

C. Amendments to the Drawings

D. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

January 20, 2021
Date

/Diane Bennett/
Diane E. Bennett, Ph.D., Reg. #63,240

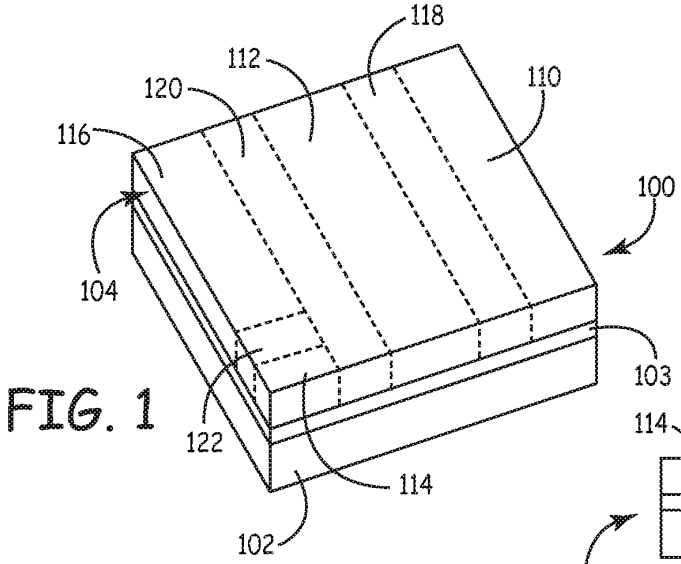



FIG. 1

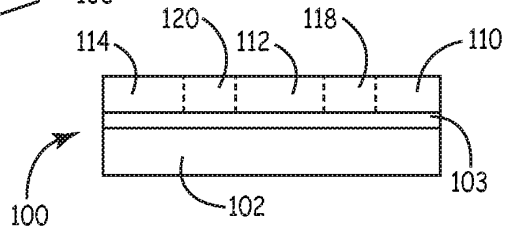



FIG. 2

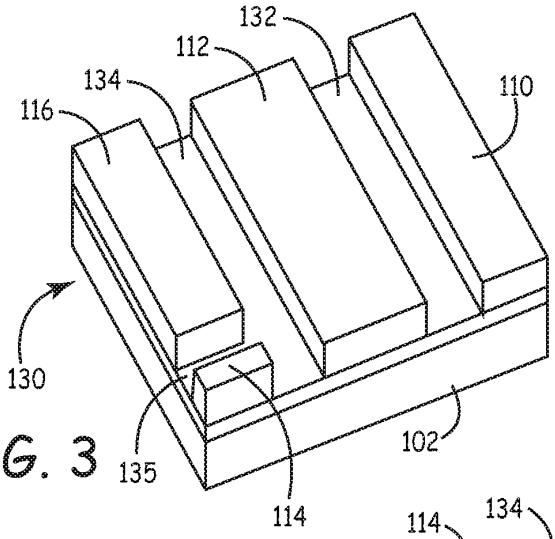



FIG. 3

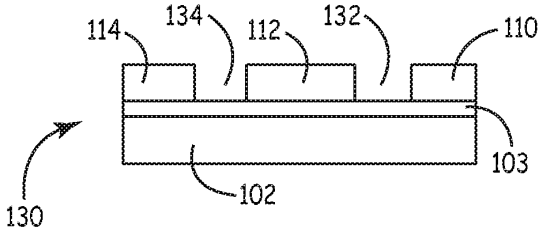



FIG. 4

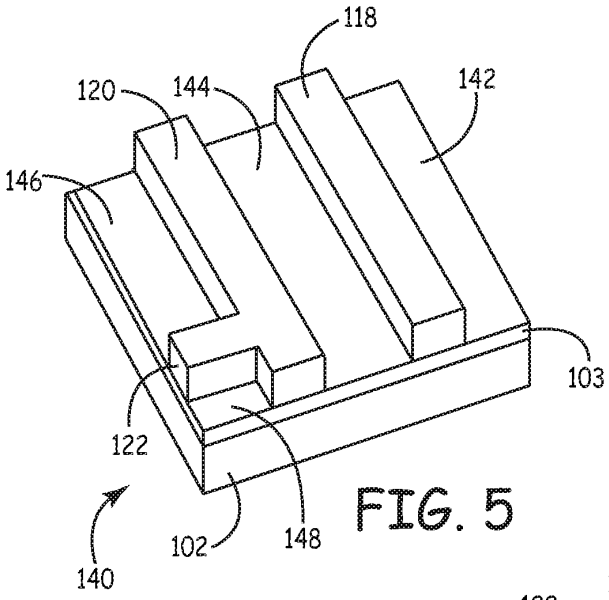

118
120
144
142
146
103
122
102
148
140

FIG. 5

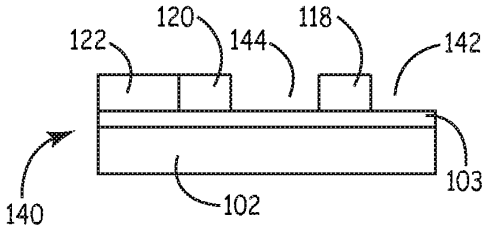

120
118
122
144
142
103
140
102

FIG. 6

Fig. 7

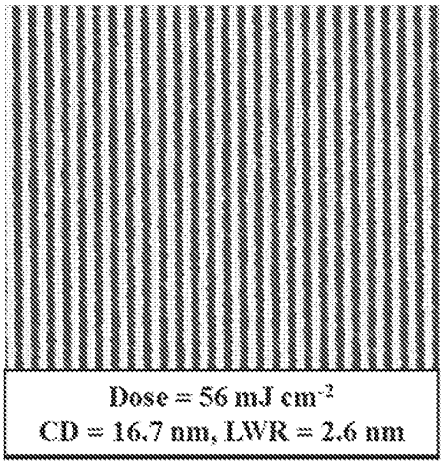

Dose = 56 mJ cm-2
CD = 16.7 nm, LWR = 2.6 nm

Fig. 8

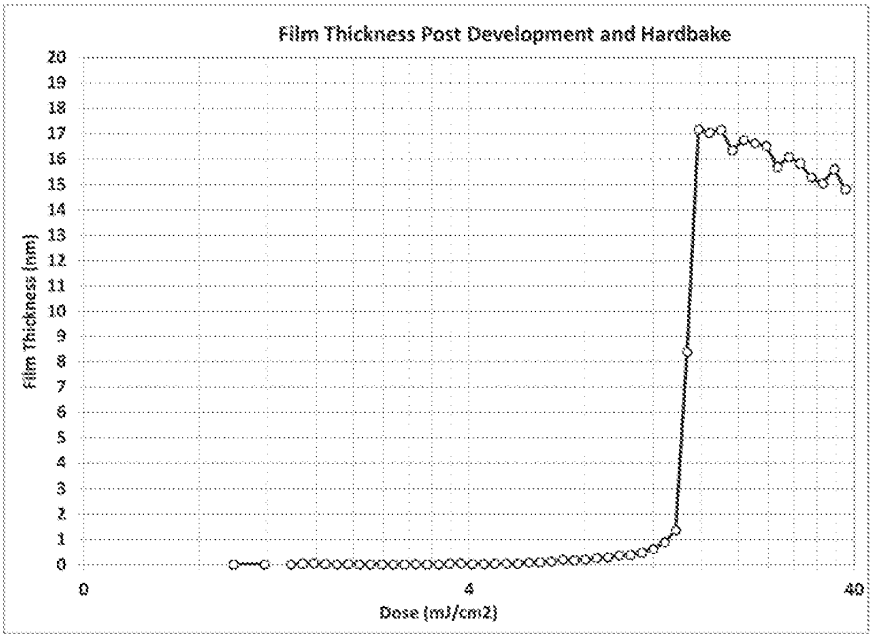

Film Thickness Post Development and Hardbake
Film Thickness (nm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
4
40
Dose (mJ/cm2)

Fig. 9

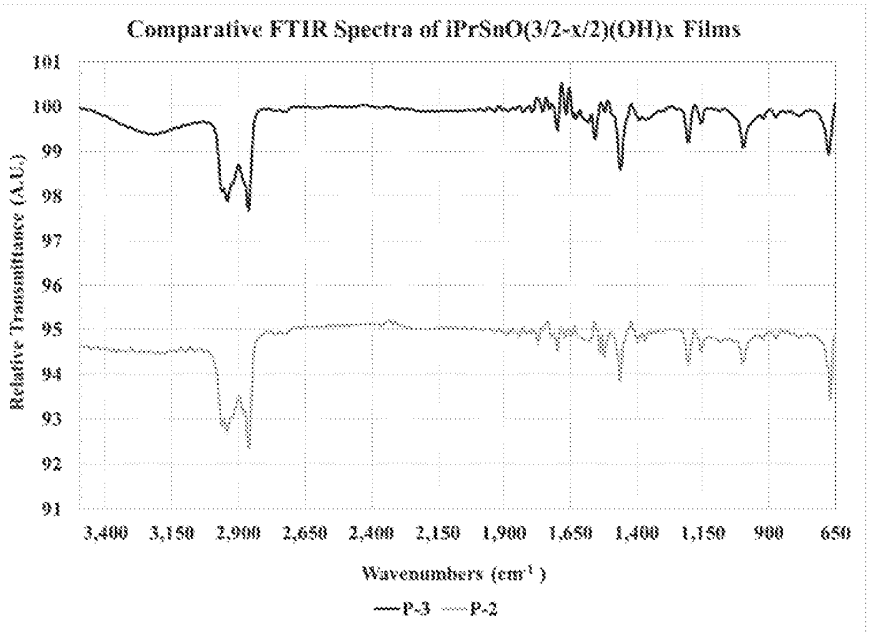

Comparative FTIR Spectra of iPrSnO(3/2-x/2)(OH)x Films
Relative Transmittance (A.U.)
101
100
99
98
97
96
95
94
93
92
91
3,400
3,150
2,900
2,650
2,400
2,150
1,900
1,650
1,400
1,150
900
650
Wavenumbers (cm-1)
P-3
P-2

Fig. 10

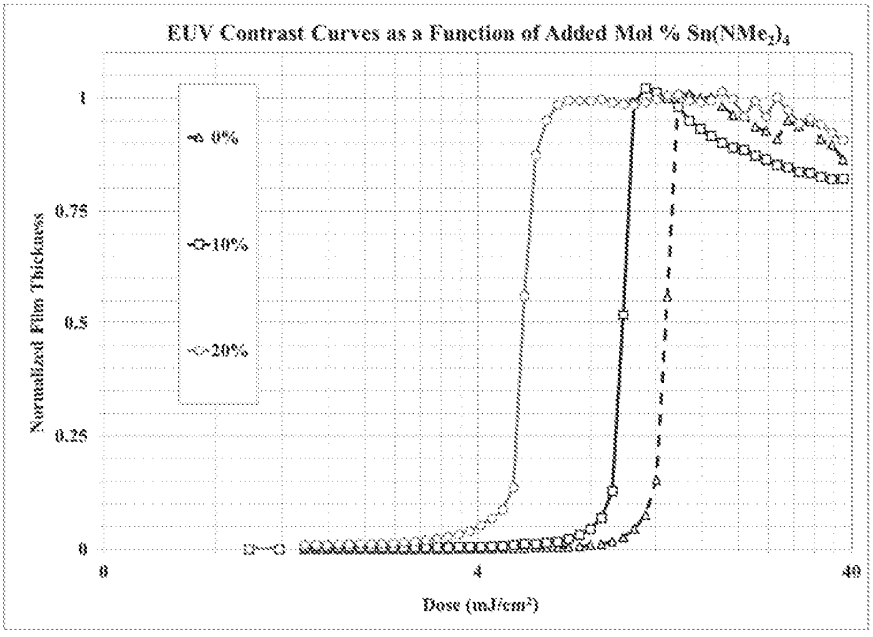

EUV Contrast Curves as a Function of Added Mol % Sn(NMe2)4
Normalized Film Thickness
1
0.75
0.5
0.25
0
0%
10%
20%
0
4
40
Dose (mJ/cm2)

Fig. 11

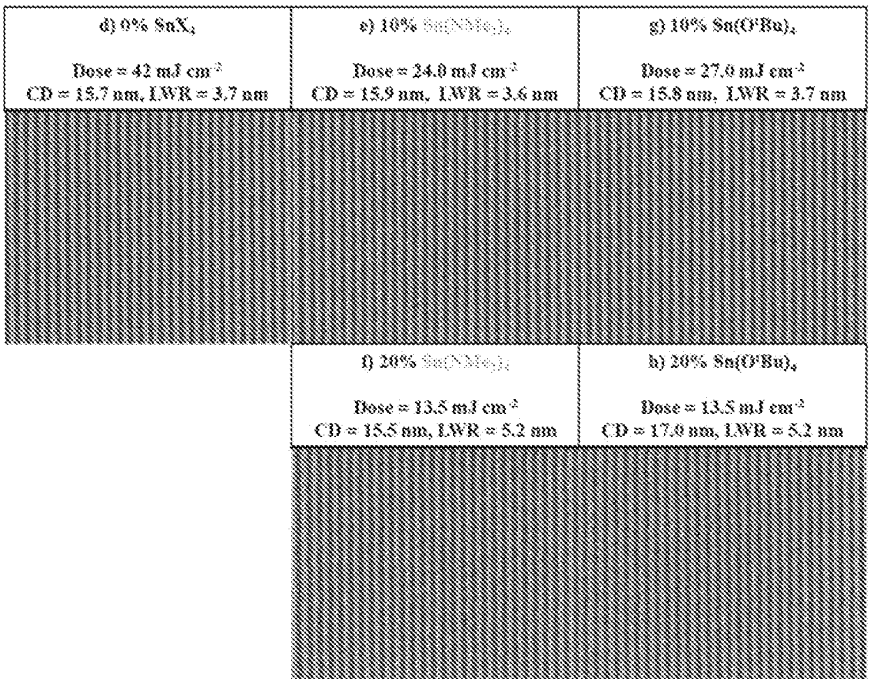

d) 0% $SnX_4$
Dose = 42 mJ cm$^{-2}$
CD = 15.7 nm, LWR = 3.7 nm
e) 10% $Sn(NMe_2)_4$
Dose = 24.0 mJ cm$^{-2}$
CD = 15.9 nm, LWR = 3.6 nm
g) 10% $Sn(O^tBu)_4$
Dose = 27.0 mJ cm$^{-2}$
CD = 15.8 nm, LWR = 3.7 nm
f) 20% $Sn(NMe_2)_4$
Dose = 13.5 mJ cm$^{-2}$
CD = 15.5 nm, LWR = 5.2 nm
h) 20% $Sn(O^tBu)_4$
Dose = 13.5 mJ cm$^{-2}$
CD = 17.0 nm, LWR = 5.2 nm

Fig. 13

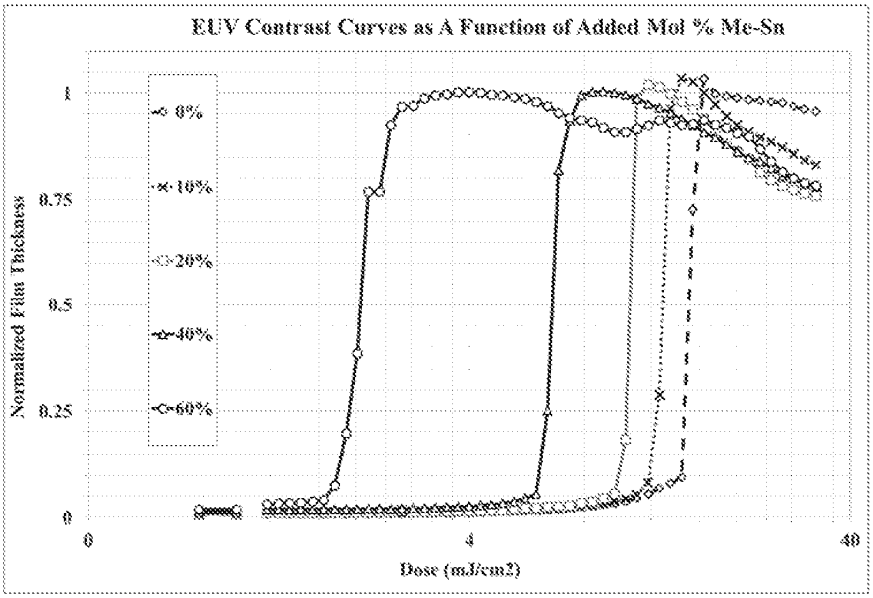

EUV Contrast Curves as A Function of Added Mol % Me-Sn
Normalized Film Thickness
Dose (mJ/cm2)
0%
10%
20%
40%
60%
0
0.25
0.5
0.75
1
0
4
40

Fig. 14

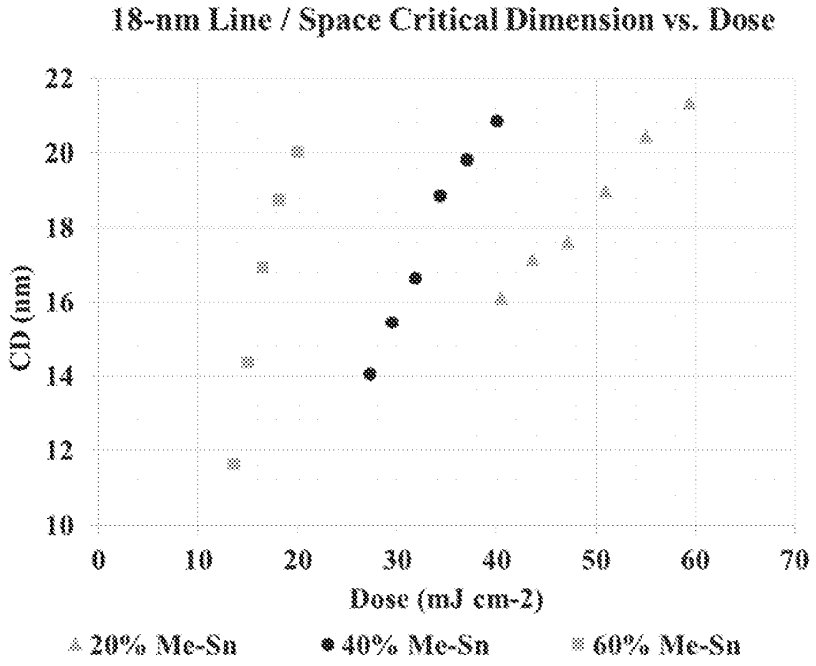

18-nm Line / Space Critical Dimension vs. Dose
CD (nm)
22
20
18
16
14
12
10
0
10
20
30
40
50
60
70
Dose (mJ cm-2)
20% Me-Sn
40% Me-Sn
60% Me-Sn

Fig. 15

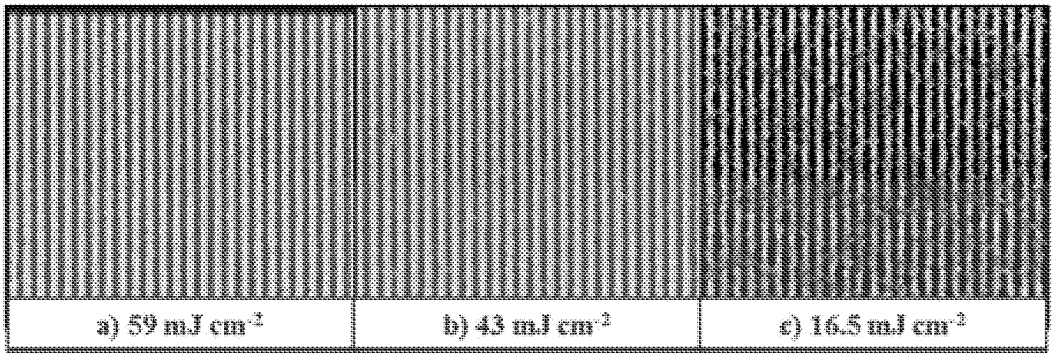

a) 59 mJ cm-2
b) 43 mJ cm-2
c) 16.5 mJ cm-2

Fig. 12

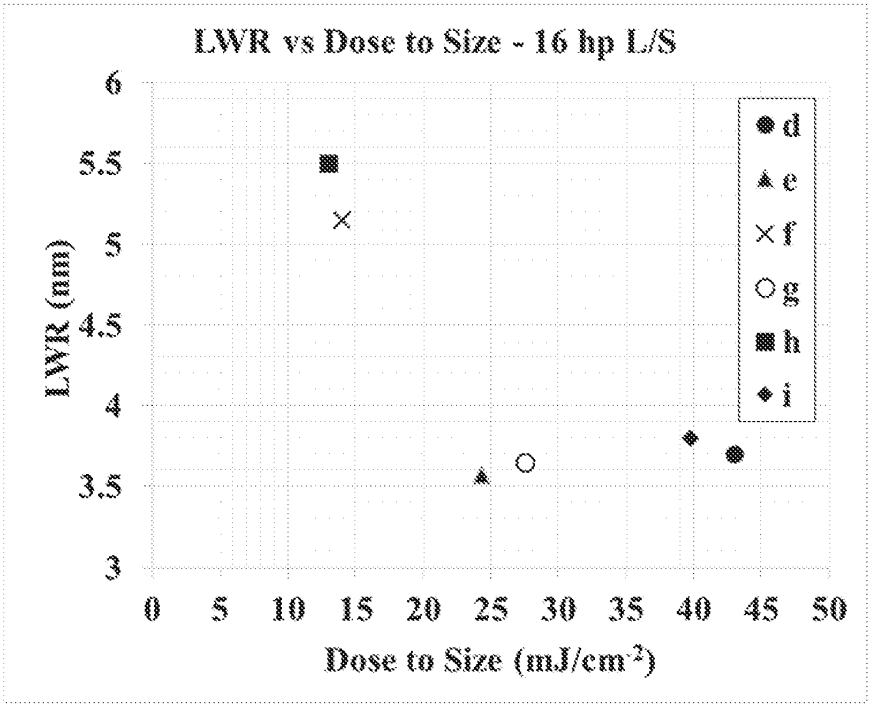
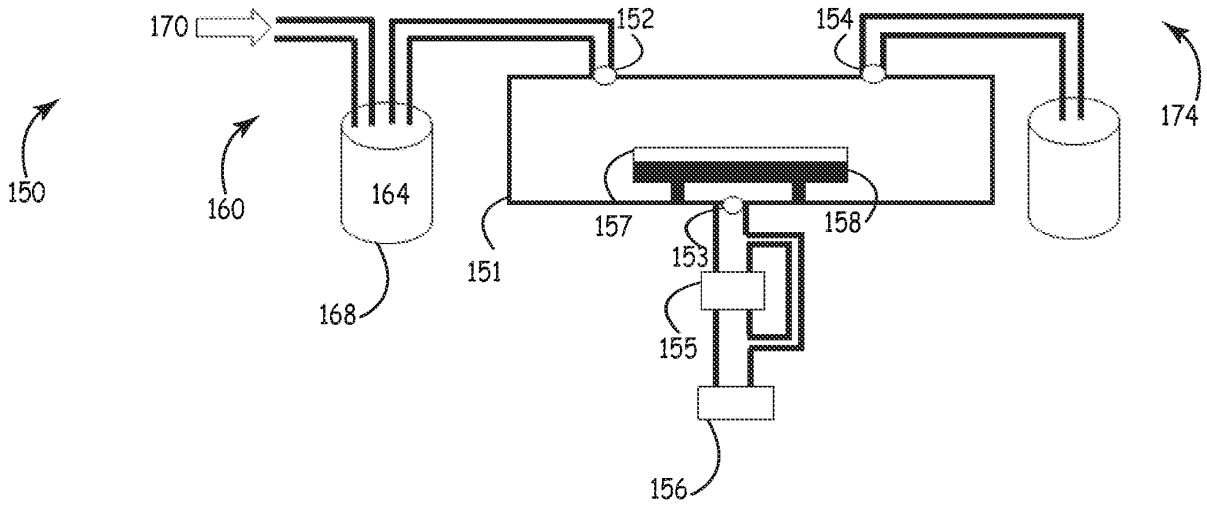

LWR vs Dose to Size - 16 hp L/S
LWR (nm)
6
5.5
5
4.5
4
3.5
3
0
5
10
15
20
25
30
35
40
45
50
Dose to Size (mJ/cm-2)
d
e
f
g
h
i

Fig. 16



PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re the application of: | Attorney Docket No.: 5063.08US05 |
| Meyers et al. | Confirmation No.: 5672 |
| Application No.: 16/987,120 | Examiner: Binu Thomas |
| Filed: August 6, 2020 | Group Art Unit: 1717 |

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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PETITION FOR EXTENSION OF PERIOD FOR RESPONSE
UNDER 37 C.F.R. § 1.136(a)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. § 1.136(a), an extension of time of one (1) month (from January 8, 2021 to February 8, 2021) within which to respond to the Office Action dated October 8, 2020 is requested. The Commissioner is authorized to charge to a credit card in the amount of **$220** for the extension fee. The Commissioner is authorized to charge Deposit Account No. 60-1363 for any underpayments, overpayments or additionally required fees.

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

Customer No. **62274**
Christensen, Fonder, Dardi & Herbert PLLC
11322 86th Avenue N
Maple Grove, MN 55369
Telephone: (612) 315-4322

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

| | |
|---|---|
| January 20, 2021 | /Diane Bennett/ |
| Date | Diane E. Bennett, Ph.D., Reg. #63,240 |

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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| PATENT APPLICATION FEE DETERMINATION RECORD<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/987,120 | Filing Date<br>08/06/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 01/20/2021 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * 25 | Minus | ** 21 | = 4 | | x $100 = | 400 |
| | Independent<br>(37 CFR 1.16(h)) | * 1 | Minus | *** 3 | = 0 | | x $480 = | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 400 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total<br>(37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent<br>(37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /DIANE FLOYD/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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DocCode – SCORE

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Application Number: 16987120 Document Date: 01/20/2021

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 |

CONFIRMATION NO. 5672

62274
CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
11322 86th Ave. N.
Maple Grove, MN 55369

PUBLICATION NOTICE

*OC000000121621446*

**Title:**ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

**Publication No.**US-2020-0371439-A1
**Publication Date:**11/26/2020

## NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

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Lam Research Ex. 1002 - Page 476
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

UNITED STATES PATENT AND TRADEMARK OFFICE

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 10/08/2020

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
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Maple Grove, MN 55369

| EXAMINER | |
|---|---|
| THOMAS, BINU | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1717 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 10/08/2020 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Lam Research Ex. 1002 - Page 477
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| *Office Action Summary* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** Binu Thomas | **Art Unit** 1717 | **AIA (FITF) Status** Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 08/06/2020.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-21 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-21 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 08/06/2020 is/are: a)☐ accepted or b)☑ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



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IPR2025-00309 - U.S. Patent No. 11,537,048

## DETAILED ACTION

### *Drawings*

1. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore,

a. the deposition chamber and structure to deliver flow from a supply of an organotin compound;

b. structure configured to deliver flow from a supply of an inert gas;

c. structure to deliver a second precursor vapor;

d. structure configured to deliver a flow comprising a third precursor vapor;

e. the structure configured to deliver flow comprises one or more vapor inputting structure;

f. a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow

g. a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow and a third vapor inputting structure is configured to deliver a third flow;

must be shown or the feature(s) canceled from the claim(s).

No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing

should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

***Claim Objections***

2. Claims 1-21 are objected to because of the following informalities:

3. Features found in the claims, such as "structure configured to deliver flow from a supply of an organotin compound to provide for formation of an organotin layer on the substrate surface within the deposition chamber" of claim 1 for example, as well as structure(s) found in claims 3, 5, 6, 9, 15-20 are not found in the specification.

4. With regards to claim 6, the wording of the claimed wherein R is an organic ligand with 1-31 carbon atoms bound to Sn with a metal-carbon bond is bit confusing as the wording 1-31 carbon atoms that are bound to Sn could be interpreted incorrectly. It is requested to make clear it is the ligand that is bound to the Sn and the ligand comprises 1-31 carbon atoms.

Appropriate correction is required.

***Claim Rejections - 35 USC § 112***

5. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claim limitation "structure configured to deliver flow from a supply of an organotin compound" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

7. Claim limitation "structure configured to deliver flow from a supply of an inert gas" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

8. Claim limitation "structure to deliver a second precursor vapor" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

9. Claim limitation "structure to deliver a third precursor vapor" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

10. Claim limitation "a configuration providing for selection of the pressure and/or the temperature in the deposition chamber" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

11. Claim limitation "the structure configured to deliver flow comprises one or more vapor inputting structures" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

12. Claim limitation "a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

13. Claim limitation "a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow and a third vapor

inputting structure is configured to deliver a third flow" invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

14. However, the written description fails to disclose the corresponding structure, material, or acts for performing the entire claimed functions and to clearly link the structure, material, or acts to the functions.

15. No clear structure is found in the drawings or specification which delivers a flow of from a supply of an inert gas, deliver a first precursor vapor deliver, a second precursor vapor, deliver a third precursor vapor, deliver flow comprises one or more vapor inputting structures, deliver a first flow, deliver a second flow or deliver a third flow. No clear structure is found in the drawings or specification for selection of the pressure and/or the temperature in the deposition chamber.

16. Therefore, the claim is indefinite and is rejected under 35 U.S.C. 112(b) or pre-AIA 35 U.S.C. 112, second paragraph.

Applicant may:

(a) Amend the claim so that the claim limitation will no longer be interpreted as a limitation under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph;

(b) Amend the written description of the specification such that it expressly recites what structure, material, or acts perform the entire claimed function, without introducing any new matter (35 U.S.C. 132(a)); or

(c) Amend the written description of the specification such that it clearly links the structure, material, or acts disclosed therein to the function recited in the claim, without introducing any new matter (35 U.S.C. 132(a)).

If applicant is of the opinion that the written description of the specification already implicitly or inherently discloses the corresponding structure, material, or acts and clearly links them to the function so that one of ordinary skill in the art would recognize what structure, material, or acts perform the claimed function, applicant should clarify the record by either:

(a) Amending the written description of the specification such that it expressly recites the corresponding structure, material, or acts for performing the claimed function and clearly links or associates the structure, material, or acts to the claimed function, without introducing any new matter (35 U.S.C. 132(a)); or

(b) Stating on the record what the corresponding structure, material, or acts, which are implicitly or inherently set forth in the written description of the specification, perform the claimed function. For more information, see 37 CFR 1.75(d) and MPEP §§ 608.01(o) and 2181.

17. With regards to claim limitation of "structure configured to deliver flow from a supply of an organotin compound", no clear structure is found in the drawings or specification which delivers a flow of organotin compound to the deposition chamber. As claim 5 recites clear structure which delivers flow from a supply of an organotin compound, one of the structural elements found in claim 5 will be interpreted to deliver flow, will be applied for purposes prosecution.

***Claim Rejections - 35 USC § 102***

18. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention.

19. **Claim(s) 1, 5, 12, 14-16 and 21 is/are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Russo (US 4,601,917).**

**In regards to claims 1, 5 and 14-15**, Russo teaches an apparatus comprising:

a deposition chamber (23) with an interior isolated from the ambient atmosphere (fig. 1; col. 3, lines 58-62);

a substrate (25) within the interior of the deposition chamber in order to receive a deposition on a surface of the substrate (fig. 1; col. 3, lines 58-62);

a structure of coating nozzle (24) connected to an evaporator (flash evaporator) delivers a flow of vaporized coating composition made of organotin compound onto the surface of substrate by chemical vapor deposition (fig. 1; col. 3, lines 50-60, col. 4, lines 1-5, col. 74, lines 55-60).

Russo teaches the coating formed from at least the coating composition made of organotin compound is a fluorine doped tin oxide coating (abstract).

**In regards to claims 12 and 21**, Russo teaches a substrate temperature in the range of 150 to 250°C (col. 5, lines 25-30).

**In regards to claim 16**, Russo teaches a syringe pump (20) will control the flow of liquid composition (fig. 1; col. 3, lines 53-58)

***Claim Rejections - 35 USC § 103***

20. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

21. The factual inquiries for establishing a background for determining obviousness under 35 U.S.C. 103 are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

22. **Claims 1-8, 11-16 and 21 are rejected under 35 U.S.C. 103 as being unpatentable over Nishida (US 6,825,131)**.

**In regards to claims 1 and 5**, Nishida teaches an apparatus comprising:

a film forming chamber (A, deposition chamber) with an interior isolated from the ambient atmosphere (fig. 1; col. 5, lines 32-35);

a silicon substrate (1) within the interior of the deposition chamber in order to receive a deposition on a surface of the substrate (fig. 1; col. 5, lines 45-50, col. 6, lines 40-45);

a structure of at least a two fluid nozzle (C) connected to a material feeder and inert gas feeder (D) to atomize a supplied material solution (4) (aerosol generator) delivers a flow of coating composition made of metal element material solution onto the surface of the substrate by chemical vapor deposition (fig. 1-2; col. 3, lines 1-10, col. 5, lines 35-45, 55-65, col. 6, lines 10-15).

Nishida teaches the coating formed is from metal element material solution, but does not explicitly teach an organotin compound to provide for formation of an organotin layer on the substrate surface.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

As Nishida teaches the structural limitations of the claim, one would be capable of using an organotin compound as the material solution.

**In regards to claim 2**, Nishida teaches a thickness of the film deposited is 50-nm or less (col. 3, lines 55-60), but is silent to the thickness variation is no more than about +/- 50% from the average layer thickness.

However, a maximum 50% variation from an average layer thickness would have obvious to a person having ordinary skill in the art as 50% for its suitability with expected results. The selection of something based on its known suitability for its intended use has been held to support a prima facie case of obviousness (MPEP 2144.07).

**In regards to claims 3-4**, Nishida teaches the inert gas feeder (D) which feeds argon gas (fig. 1-2; col. 5, lines 37-40, col. 6, lines 10-15).

**In regards to claims 6-8**, Nishida teaches an oxygen gas feeder (E) which supplies the oxygen to the two fluid nozzle (C) (fig. 1-2; col. 5, lines 40-45, col. 6, lines 15-25) and the coating formed is from metal element material solution.

Nishida does not explicitly teach the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

As Nishida teaches the structural limitations of the claim, one would be capable of using the organotin compound with formula as recited in the claim, as the material solution.

**In regards to claim 11**, Nishida teaches a pressure of 100-torr or less (col. 3, lines 45-50) and example of pressure of 20-torr (col. 6, lines 45-50).

**In regards to claims 12 and 21**, Nishida teaches a film deposition temperature in the range of 100 to 300°C (col. 4, lines 1-25) and example of 170°C (col. 9, lines 5-20).

**In regards to claim 13**, Nishida teaches a control valve (12) to control pressure within the chamber (fig. 1; col. 6, lines 45-55).

**In regards to claim 14-16**, Nishida teaches the flow of material solution through to the two fluid nozzle (C) in the chamber is a vapor, where a valve (7) controls flow of the material solution and valve (7) controls flow of the inert gas to the two fluid nozzle (C) (fig. 1-2; col. 3, lines 1-10, col. 5, lines 35-45, 55-65, col. 6, lines 10-15).

23. **Claims 1, 3, 5, 6-12 and 14-21 are rejected under 35 U.S.C. 103 as being unpatentable over Jursich (US 2005/0266700)**.

**In regards to claims 1, 5 and 14**, Jursich teaches a reactor comprising:

a chamber (25, deposition chamber) with an interior isolated from the ambient atmosphere (fig. 1; para. 87);

a substrate is held on a substrate holder (5) within the interior of the chamber in order to receive a deposition on a surface of the substrate (fig. 1; para. 88);

a source holder 34 supplies a vaporized germanium-containing precursor (vaporization chamber or flash evaporator) to the chamber (fig. 1; para. 83, 89).

Jursich teaches the coating formed comprises from vaporized germanium precursor, but does not explicitly teach an organotin compound to provide for formation of an organotin layer on the substrate surface.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

As Jursich teaches the structural limitations of the claim, one would be capable of using an organotin compound as the material solution.

**In regards to claim 3**, Jursich teaches a conduit (35) which supplies a carrier gas (fig. 1; para. 89).

**In regards to claims 6-10 and 15-20**, Jursich teaches source holder 34 supplies the first vaporized material and a source (95, structure for second precursor vapor) of the precursor not containing germanium (fig. 1; para. 89-90), and a coreactant (100, structure for third precursor vapor)) of moisture (water vapor) is supplied to the chamber (fig. 1; para. 91)

Jursich does not explicitly teach the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula as recited and third precursor vapor comprising a composition represented by the formula as recited in the claims and the function of supplying the precursor vapors with the timing as recited in the claim.

However, the particular type of substrate or processing materials used is a process limitation rather than an apparatus limitation, and the recitation of a particular type of substrate or processing materials do not limit an apparatus claim, see In re Casey, 152 USPQ 235; In re Rishoi, 94 USPQ 71; In re Young, 25 USPQ 69; In re Dulberg, 129 USPQ 348; Ex parte Thibault, 64 USPQ 666; and Ex parte Masham, 2 USPQ2d 1647. (MPEP2115)

Further with regards to operation of supplying the vapor, it has been held that claims directed to apparatus must be distinguished from the prior art in terms of structure rather than function. *In re Danly*, 263 F.2d 844, 847, 120 USPQ 528, 531 (CCPA 1959). Also, a claim containing a "recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus" if the prior art apparatus teaches all the structural limitations of the claim. *Ex parte Masham*, 2 USPQ2d 1647 (Bd. Pat. App. & Inter. 1987) (MPEP2114). As Jursich teaches the structural limitations of the claim, one would be capable of using the organotin compound with a formula as recited in the claim, as the material solution and a third precursor vapor as SnL4 as recited in the clam, and with the flow process as recited in the claim.

**In regards to claims 11-12 and 21**, Jursich teaches a pressure of the reactor in the range of 0.1 to 10-torr and reactor temperature range of 100 to 500°C (para. 81).

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Binu Thomas whose telephone number is (571)270-7684. The examiner can normally be reached on Monday to Thursday, 8:00AM-5:00PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dah-Wei Yuan can be reached on 571-272-1295. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Binu Thomas/
Primary Examiner, Art Unit 1717
October 2, 2020

| Notice of References Cited | Application/Control No. 16/987,120 | Applicant(s)/Patent Under Reexamination Meyers et al. | |
|---|---|---|---|
| | Examiner Binu Thomas | Art Unit 1717 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | CPC Classification | US Classification |
|---|---|---|---|---|---|---|
| * | A | US-4601917-A | 07-1986 | Russo; David A. | C03C17/2453 | 106/287.19 |
| * | B | US-6825131-B2 | 11-2004 | Nishida; Koichi | C23C4/18 | 438/778 |
| * | C | US-20050266700-A1 | 12-2005 | Jursich, Gregory M. | C23C16/45531 | 438/785 |
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**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | CPC Classification |
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Lam Research Ex. 1002 - Page 491
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/987,120 | Meyers et al. |
| | Examiner | Art Unit |
| | Binu Thomas | 1717 |

| CPC - Searched* | | |
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| Symbol | Date | Examiner |
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| CPC Combination Sets - Searched* | | |
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| US Classification - Searched* | | | |
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* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Inventor name search | 09/2020 | BT |
| Reviewed prosecution from parent application | 09/2020 | BT |
| PLUS search | 09/2020 | BT |
| IP.com search using parent application as concept | 09/2020 | BT |
| Keyword search in EAST, see attached | 09/2020 | BT |

| Interference Search | | | |
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| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
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| /Binu Thomas/<br>Primary Examiner, Art Unit 1717 | |
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Lam Research Corp. v. Inpria Corp.
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# Bibliographic Data

Application No: 16/987,120

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /Binu Thomas/ (Examiner's Signature) | (Initials)

Title: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

| FILING or 371(c) DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
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| 08/06/2020 | 118 | 1717 | |
| RULE | | | |

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**CONTINUING DATA**

This application is a CON of 16238779 01/03/2019 PAT 10775696

16238779 is a CON of 15291738 10/12/2016 PAT 10228618

15291738 has PRO of 62297540 02/19/2016

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**FOREIGN APPLICATIONS**

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$5,960

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al.

Application No.: *Continuation of 16/238,779* Examiner: *Not Yet Assigned*

Filed: *Herewith*

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

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INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
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P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. § 1.56, the attention of the Patent and Trademark Office is hereby directed to the references listed on the attached Form PTO-**SB/08a**. It is respectfully requested that the information be expressly considered during the prosecution of this application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom. The listing of a reference herein is not an admission that the reference is prior art or that the reference is material to patentability.

This Information Disclosure Statement is being filed with the application. No certification or fee is required.

Copies of the references were cited by or submitted to the Office in Patent Application No. 16/238,779, filed January 3, 2019, which is relied upon for an earlier filing date under 35 U.S.C. § 120. Thus, copies of these references are not attached. 37 C.F.R. § 1.98(d).

/Binu Thomas/ (09/29/2020)

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

*Continuation of Application No. 16/238,779*

A copy of the co-pending Taiwan Office Action dated June 15, 2020 was not cited in the Parent Application no. 16/238,779. Therefore, this document will be attached to this continuation application herewith.

Copies of cited U.S. patents and U.S. published applications are not included. 37 C.F.R. 1.98(a)(2).

Respectfully submitted,

/Diane Bennett/

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Doc description: Information Disclosure Statement (IDS) Filed

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|---|---|
| Application Number | |
| Filing Date | |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | |
| Examiner Name | Not Yet Assigned |
| Attorney Docket Number | 5063.08US05 |

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| | First Named Inventor | Stephen T. Meyers |
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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
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| | First Named Inventor | Stephen T. Meyers |
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IPR2025-00309 - U.S. Patent No. 11,537,048

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| | First Named Inventor | Stephen T. Meyers |
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| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

Lam Research Ex. 1002 - Page 507
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

| | | | |
|---|---|---|---|
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| | 28 | International Search Report and Written Opinion From Related Application No. PCT/US15/56865 dated February 5, 2016 (12 pages). | |
| | 29 | International Search Report and Written Opinion from related Application No. PCT/US2016/056637 dated May 30, 2017 (19 pages) | |
| | 30 | Supplementary European Search Report from related Application No. 16856109.0 for PCT/US2016/056637 dated September 4, 2019. | |
| | 31 | Office Action from co-pending Taiwan Application No. 105133028 dated September 3, 2019. | × |
| | 32 | Office Action from co-pending Japanese Application No. 2018-518688 dated April 21, 2020. | ☒ |
| | 33 | Office Action from co-pending Taiwan Application No. 105133028 dated June 15, 2020. | ☒ |



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

Lam Research Ex. 1002 - Page 508
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

If you wish to add additional non-patent literature document citation information please click the Add button [Add]

**EXAMINER SIGNATURE**

| Examiner Signature | /Binu Thomas/ (09/29/2020) | Date Considered | 09/29/2020 |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /Diane Bennett/ | Date (YYYY-MM-DD) | 2020-08-06 |
|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /B.T/

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L2 | 76 | ("10025179" \| "10228618" \| "10642153" \| "20020076495" \| "20030124457" \| "20040067444" \| "20060088962" \| "20060234138" \| "20080055597" \| "20080286683" \| "20090155546" \| "20090174036" \| "20100044698" \| "20100184259" \| "20110045406" \| "20110135823" \| "20110166268" \| "20110206599" \| "20110244403" \| "20110293888" \| "20120223418" \| "20130224652" \| "20130253161" \| "20140268062" \| "20140303283" \| "20150056542" \| "20150079393" \| "20150221519" \| "20150253667" \| "20160116839" \| "20170184960" \| "20170184961" \| "20190137870" \| "3385915" \| "3635883" \| "4102683" \| "4104292" \| "4370405" \| "4380559" \| "4601917" \| "4639208" \| "4732841" \| "4851481" \| "4891303" \| "4910122" \| "5025094" \| "5672243" \| "5891985" \| "6020269" \| "6060380" \| "6179922" \| "6183716" \| "6194323" \| "6197896" \| "6268457" \| "6287951" \| "6420088" \| "6566276" \| "6583071" \| "6730454" \| "6844604" \| "6927108" \| "6946677" \| "7001821" \| "7208341" \| "7256129" \| "7709056" \| "7773365" \| "7799503" \| "8030507" \| "8053370" \| "8092703" \| "8366967" \| "8415000" \| "8796483" \| "9310684").PN. | US-PGPUB; USPAT | OR | ON | 2020/09/29 13:57 |
| L3 | 12 | ("20050266700" \| "20060062916" \| "20070092648" \| "5147688" \| "6061117" \| "6503561" \| "7250083").PN. OR ("7709056").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:09 |
| L4 | 107 | ("4059929" \| "5478435" \| "5548159" \| "5558435" \| "5645891" \| "5736425" \| "5747880" \| "5750440" \| "5807607" \| "5814370" \| "5834845" \| "5843602" \| "5847443" \| "5857893" \| "5858457" \| "5858871" \| "5868278" \| "5922299" \| "5948482" \| "5955140" \| "6011123" \| "6015457" \| "6037275" \| "6048256" \| "6066575" \| "6070600" \| "6098843" \| "6107357" \| "6120891" \| "6140252" \| | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:11 |

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|---|---|---|---|---|---|---|
| | | "6159295" \| "6162583" \| "6162838" \| "6163066" \| "6168737" \| "6171645" \| "6171687" \| "6172128" \| "6184260" \| "6187248" \| "6197913" \| "6204202" \| "6208014" \| "6251473" \| "6270846" \| "6277765" \| "6297459").PN. OR ("6583071").URPN. | | | | |
| L6 | 6 | ("10025179" \| "20100099908" \| "20150221519" \| "4014858" \| "4144222" \| "4174346").PN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| L7 | 3 | ("20130253161" \| "4104292" \| "9310684").PN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| L8 | 9 | 6 7 | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:19 |
| L9 | 20 | ("20020048770" \| "20030116091" \| "20030118947" \| "20040087184" \| "5456945" \| "5759923" \| "6116184" \| "6231933" \| "6261373" \| "6358559" \| "6365266" \| "6376634" \| "6406794" \| "6428847" \| "6455443" \| "6472076" \| "6576568" \| "6583071" \| "6592980").PN. OR ("7446055").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:21 |
| L10 | 6 | ("20020033173" \| "5589300" \| "5894064" \| "6048817" \| "6444763" \| "6583071").PN. OR ("6825131").URPN. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:24 |
| L11 | 25 | 9 10 | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:29 |
| L12 | 59,271 | H01L21/02274-02282.cpc. c23c16/$.cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| L13 | 121 | (organotin ) and (H01L21/02274-02282.cpc. c23c16/$.cpc.) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 14:43 |
| L19 | 10 | "20120027937" "20080286448" "20060211271" "20040156987" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:17 |
| L20 | 6 | "15291738" and structure | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:23 |
| L21 | 6 | "15291738" and precursor near2 vapor | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:24 |

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|---|---|---|---|---|---|---|
| L22 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:27 |
| L24 | 6 | "15291738" and thickness near2 variation | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 15:28 |
| L25 | 6 | "15291738" and select$4 near5 (temperature pressure) | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 16:55 |
| L26 | 3 | "20080022896" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 18:07 |
| S1 | 0 | "16987120" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:20 |
| S2 | 6 | "15291738" | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S3 | 1,913 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT | OR | ON | 2020/09/29 09:21 |
| S4 | 1,851 | ((("MEYERS") near3 ("Stephen")) OR (("ANDERSON") near3 ("Jeremy")) OR (("CARDINEAU") near3 ("Brian")) OR (("EDSON") near3 ("Joseph")) OR (("JIANG") near3 ("Kai")) OR (("KESZLER") near3 ("Douglas")) OR (("TELECKY") near3 ("Alan"))).INV. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:21 |
| S5 | 82 | S4 and (c23c14/$ c23c16/$).cpc. | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 09:29 |
| S6 | 6 | "15291738" and deposition near2 chamber | US-PGPUB; USPAT; USOCR | OR | ON | 2020/09/29 11:47 |

**EAST Search History (Interference)**

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9/29/2020 6:38:42 PM
C:\Users\bthomas\Documents\EAST\Workspaces\16987120-vapor deposition organotin.wsp

PLUS Search Results for S/N 16987120, Searched Fri Sep 18 09:12:41 EDT 2020

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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PLUS Search Results for S/N 16987120, Searched Fri Sep 18 09:21:20 EDT 2020

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | Stephen T. Meyers | 5063.08US05 | 5672 |

62274 7590 08/21/2020

CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
33 South Sixth Street
Suite 4540
Minneapolis, MN 55402

| EXAMINER | |
|---|---|

| ART UNIT | PAPER NUMBER |
|---|---|
| 1737 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 08/21/2020 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docket@cfd-ip.com
patents@cfd-ip.com



Lam Research Ex. 1002 - Page 517
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| *Decision Granting Request for Prioritized Examination (Track I)* | **Application No.** 16/987,120 | **Applicant(s)** Meyers et al. | |
|---|---|---|---|
| | **Examiner** CHERYL P GIBSON BAYLOR | **Art Unit** OPET | **AIA (FITF) Status** Yes |

1. THE REQUEST FILED 06 August 2020 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination

A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to CHERYL GIBSON BAYLOR at (571)272-3213. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

| /CHERYL GIBSON BAYLOR/<br>Paralegal Specialist, OPET | |
|---|---|

U.S. Patent and Trademark Office
PTO-2298 (Rev. 02-2012)

## PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/987,120

### APPLICATION AS FILED - PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY FEE($) |
|---|---|---|---|---|---|---|---|
| BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | 300 |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | 660 |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | 760 |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 21 minus 20 = | * 1 | | | OR | x 100 = | 100 |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 1 minus 3 = | * | | | | x 460 = | 0.00 |
| APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | 0.00 |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | 0.00 |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | 1820 |

### APPLICATION AS AMENDED - PART II

| | | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY ADDITIONAL FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|---|
| AMENDMENT A | Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| | Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| | Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

| | | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE($) | ADDITIONAL FEE($) | | RATE($) | ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|---|
| AMENDMENT B | Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| | Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| | Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/987,120 | 08/06/2020 | 1762 | 1820 | 5063.08US05 | 21 | 1 |

**CONFIRMATION NO. 5672**

**FILING RECEIPT**

62274
CHRISTENSEN, FONDER, DARDI & HERBERT PLLC
33 South Sixth Street
Suite 4540
Minneapolis, MN 55402

OC000000119289877

Date Mailed: 08/18/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

**Please verify the accuracy of the data presented on this receipt.** If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

**Inventor(s)**

Stephen T. Meyers, Corvallis, OR;
Jeremy T. Anderson, Corvallis, OR;
Brian J. Cardineau, Corvallis, OR;
Joseph B. Edson, Corvallis, OR;
Kai Jiang, Corvallis, OR;
Douglas A. Keszler, Corvallis, OR;
Alan J. Telecky, Albany, OR;

**Applicant(s)**

Inpria Corporation, Corvallis, OR;

**Power of Attorney:** The patent practitioners associated with Customer Number 62274

**Domestic Priority data as claimed by applicant**

This application is a CON of 16/238,779 01/03/2019
which is a CON of 15/291,738 10/12/2016 PAT 10228618
which claims benefit of 62/297,540 02/19/2016
and claims benefit of 62/240,812 10/13/2015

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

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**If Required, Foreign Filing License Granted:** 08/17/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/987,120**

**Projected Publication Date:** 11/26/2020

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

**Preliminary Class**

524

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US02

Meyers et al. Confirmation No.: 3584

Application No.: 15/291,738 Examiner: *Not Yet Assigned*

Filed: October 12, 2016 Group Art Unit: *Not Yet Assigned*

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

POWER OF ATTORNEY BY APPLICANT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I hereby appoint the Practitioners associated with **Customer Number 62274** as my/our attorneys or agents and to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Address all telephone calls to: Peter S. Dardi, Ph.D. at telephone number (404) 949-5730.

Please recognize or change the correspondence address for this application to:

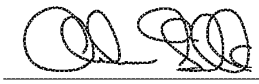
Customer Number 62274
Dardi & Herbert, PLLC
Moore Lake Plaza, Suite 205
1250 East Moore Lake Drive
Fridley, MN 55432

All previous powers of attorney granted in this application are hereby revoked.

The undersigned (whose title is supplied below) is authorized to act on behalf of the Applicant (e.g., where the Applicant is a juristic entity).

Inpria Corporation, Applicant

Date: November 1, 2016



Signature

Andrew Grenville

Name Printed or Typed

CEO

Title

**Doc Code: TRACK1.REQ**
**Document Description**: **TrackOne Request**

PTO/AIA/424 (03-13)

## CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

| | | | |
|---|---|---|---|
| First Named Inventor: | Stephen T. Meyers | Nonprovisional Application Number (if known): | |
| Title of Invention: | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | | |

**APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.**

1. The processing fee set forth in 37 CFR 1.17(i)(1), the prioritized examination fee set forth in 37 CFR 1.17(c), and if not already paid, the publication fee set forth in 37 CFR 1.18(d) have been filed with the request. The basic filing fee, search fee, examination fee, and any required excess claims and application size fees are filed with the request or have been already been paid.

2. The application contains or is amended to contain no more than four independent claims and no more than thirty total claims, and no multiple dependent claims.

3. The applicable box is checked below:

**I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)**

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. The executed inventor's oath or declaration is filed with the application. (37 CFR 1.63 and 1.64)

**II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)**

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

| | |
|---|---|
| Signature /Diane Bennett/ | Date 2020-08-06 |
| Name (Print/Typed) Diane E. Bennett, Ph.D. | Practitioner Registration Number 63,240 |

***Note:*** *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

PTO/SB/08a (03-15)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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**INFORMATION DISCLOSURE STATEMENT BY APPLICANT**
**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | |
| Filing Date | |
| First Named Inventor | Stephen T. Meyers |
| Art Unit | |
| Examiner Name | Not Yet Assigned |
| Attorney Docket Number | 5063.08US05 |

**U.S.PATENTS** Remove

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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Lam Research Ex. 1002 - Page 528
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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Lam Research Ex. 1002 - Page 530
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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|---|---|---|---|---|---|---|
| | 1 | 20020076495 | | 2002-06-20 | Maloney et al. | |
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Lam Research Ex. 1002 - Page 531
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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| | Attorney Docket Number | 5063.08US05 |

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| | Application Number | |
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| | Art Unit | |
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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
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| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
| | Attorney Docket Number | 5063.08US05 |

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IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
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| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
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| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( **Not for submission under 37 CFR 1.99)** | | |
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| | Application Number | |
| | Filing Date | |
| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
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| | First Named Inventor | Stephen T. Meyers |
| | Art Unit | |
| | Examiner Name | Not Yet Assigned |
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|---|---|---|---|
| Name/Print | Diane E. Bennett, Ph.D. | Registration Number | 63,240 |

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T Meyers |
| **Filer:** | Diane Elizabeth Bennett/Allison Goette |
| **Attorney Docket Number:** | 5063.08-US-05 |

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**Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
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| **Basic Filing:** | | | | |
| UTILITY APPLICATION FILING | 1011 | 1 | 300 | 300 |
| UTILITY SEARCH FEE | 1111 | 1 | 660 | 660 |
| UTILITY EXAMINATION FEE | 1311 | 1 | 760 | 760 |
| REQUEST FOR PRIORITIZED EXAMINATION | 1817 | 1 | 4000 | 4000 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| CLAIMS IN EXCESS OF 20 | 1202 | 1 | 100 | 100 |
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| PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL | 1504 | 1 | 0 | 0 |
| PROCESSING FEE, EXCEPT PROV. APPLS. | 1830 | 1 | 140 | 140 |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
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| **EFS ID:** | 40216736 |
| **Application Number:** | 16987120 |
| **International Application Number:** | |
| **Confirmation Number:** | 5672 |
| **Title of Invention:** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING |
| **First Named Inventor/Applicant Name:** | Stephen T Meyers |
| **Customer Number:** | 62274 |
| **Filer:** | Diane Elizabeth Bennett |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 5063.08-US-05 |
| **Receipt Date:** | 06-AUG-2020 |
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| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Preliminary Amendment | PreliminaryRemarks.pdf | 29708<br>865cd30a248734690e9d0c0919966102f943399f | no | 3 |
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| 3 | | CONTINUATION_APPLICATION.pdf | 345462<br>e48090c0ad35237d6100452e08cda24526c17ab2 | yes | 51 |

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| 4 | Drawings-only black and white line drawings | Drawings.pdf | 904574<br>b1759937010f87b64f21a9fd76b8229ada24d21a | no | 7 |
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| 5 | Oath or Declaration filed | Declarations.pdf | 677904<br>f25b39956cbe5f9e30cd2c4dea29ca3c27f12de7 | no | 7 |

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| 6 | TrackOne Request | PrioritizedExamTrack1.pdf | 152742<br>b0a2be6550a23167ed7ba6a5dd22a6c79ab278d1 | no | 2 |
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| 7 | Power of Attorney | PowerOfAttorney.pdf | 87790<br>59483cf7d48563449074d8e55d37c03019010294 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 8 | Transmittal of New Application | ContinuationApplTransmittal.pdf | 26509<br>3fd6f2a39b6f65ec8a71bbe5a44bc7d0183b0d80 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 9 | Information Disclosure Statement (IDS) Form (SB08) | IDSTransmittal.pdf | 24419<br>f2c6274290c3f22db82dc9f4e4144edc04fec916 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied IDS fillable form | | | | | |
| 10 | Information Disclosure Statement (IDS) Form (SB08) | IDS_Form_SB_08a.pdf | 1040808<br>e67b81e50ef9cd4f9e027fb3349ad2533455ea47 | no | 16 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 11 | Non Patent Literature | 6_15_2020_TaiwanOfficeAction1.pdf | 115269<br>83751e0f45aa50be391908672543388191882a98 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 12 | Fee Worksheet (SB06) | fee-info.pdf | 41702<br>a380e96937c751ac8fa5615b780dcf61aa2133b5 | no | 2 |
| **Warnings:** | | | | | |

| Information: | |
|---|---|
| **Total Files Size (in bytes):** | 5270041 |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

## Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

## Inventor Information:

**Inventor 1** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Stephen | T. | Meyers | |

**Residence Information (Select One)** ● US Residency Non US Residency Active US Military Service

| City | Corvallis | State/Province | OR | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 1755 NW Woodland Drive | | |
|---|---|---|---|
| Address 2 | | | |
| City | Corvallis | State/Province | OR |
| Postal Code | 97330 | Country | US |

**Inventor 2** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Jeremy | T. | Anderson | |

**Residence Information (Select One)** ◉ US Residency Non US Residency Active US Military Service

| City | Corvallis | State/Province | OR | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 1845 NW Menlo Drive | | |
|---|---|---|---|
| Address 2 | | | |
| City | Corvallis | State/Province | OR |
| Postal Code | 97330 | Country | US |

**Inventor 3** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Brian | J. | Cardineau | |

**Residence Information (Select One)** ◉ US Residency Non US Residency Active US Military Service



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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

| City | Corvallis | State/Province | OR | Country of Residence i | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 1504 NW Woodland Drive | | |
|---|---|---|---|
| Address 2 | | | |
| City | Corvallis | State/Province | OR |
| Postal Code | 97330 | Country i | US |

**Inventor 4** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Joseph | B. | Edson | |

**Residence Information (Select One)** ◉ US Residency Non US Residency Active US Military Service

| City | Corvallis | State/Province | OR | Country of Residence i | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 908 SE Bayshore Circle | | |
|---|---|---|---|
| Address 2 | | | |
| City | Corvallis | State/Province | OR |
| Postal Code | 97333 | Country i | US |

**Inventor 5** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Kai | | Jiang | |

**Residence Information (Select One)** ◉ US Residency Non US Residency Active US Military Service

| City | Corvallis | State/Province | OR | Country of Residence i | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 1511 SW Birdie Drive | | |
|---|---|---|---|
| Address 2 | | | |
| City | Corvallis | State/Province | OR |
| Postal Code | 97333 | Country i | US |

**Inventor 6** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Douglas | A. | Keszler | |

**Residence Information (Select One)** ◉ US Residency Non US Residency Active US Military Service

| City | Corvallis | State/Province | OR | Country of Residence i | US |
|---|---|---|---|---|---|

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

**Mailing Address of Inventor:**

| | | | |
|---|---|---|---|
| **Address 1** | 3927 NW Lorri Place | | |
| **Address 2** | | | |
| **City** | Corvallis | **State/Province** | OR |
| **Postal Code** | 97330 | **Country** i | US |

**Inventor** 7 Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Alan | J. | Telecky | |

**Residence Information (Select One)** ◉ US Residency ○ Non US Residency ○ Active US Military Service

| | | | | | |
|---|---|---|---|---|---|
| **City** | Albany | **State/Province** | OR | **Country of Residence** i | US |

**Mailing Address of Inventor:**

| | | | |
|---|---|---|---|
| **Address 1** | 2080 NW Cluster Oak Avenue | | |
| **Address 2** | | | |
| **City** | Albany | **State/Province** | OR |
| **Postal Code** | 97321 | **Country** i | US |

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

## Correspondence Information:

**Enter either Customer Number or complete the Correspondence Information section below.**
**For further information see 37 CFR 1.33(a).**

☐ **An Address is being provided for the correspondence Information of this application.**

| | | | |
|---|---|---|---|
| **Customer Number** | 62274 | | |
| **Email Address** | docket@cfd-ip.com | Add Email | Remove Email |

## Application Information:

| | | | |
|---|---|---|---|
| **Title of the Invention** | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | | |
| **Attorney Docket Number** | 5063.08US05 | **Small Entity Status Claimed** | ☐ |
| **Application Type** | Nonprovisional | | |
| **Subject Matter** | Utility | | |
| **Total Number of Drawing Sheets (if any)** | 7 | **Suggested Figure for Publication (if any)** | 12 |

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|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

## Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

| Application number of the previously filed application | Filing date (YYYY-MM-DD) | Intellectual Property Authority or Country |
|---|---|---|
| | | |

## Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

## Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

| Please Select One: | ● Customer Number | US Patent Practitioner | ○ Limited Recognition (37 CFR 11.9) |
|---|---|---|---|
| Customer Number | 62274 | | |

## Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

| Prior Application Status | Pending | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| | Continuation of | 16238779 | 2019-01-03 |

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

| Prior Application Status | Patented | | | Remove | |
|---|---|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD) | Patent Number | Issue Date (YYYY-MM-DD) |
| 16238779 | Continuation of | 15291738 | 2016-10-12 | 10228618 | 2019-03-12 |

| Prior Application Status | Expired | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| 15291738 | Claims benefit of provisional | 62297540 | 2016-02-19 |

| Prior Application Status | Expired | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| 15291738 | Claims benefit of provisional | 62240812 | 2015-10-13 |

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

## Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

| Application Number | Country[i] | Filing Date (YYYY-MM-DD) | Access Code[i] (if applicable) |
|---|---|---|---|
| | | | |

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

## Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

## Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE**: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

**1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)**

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

**2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)**

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

## Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

**Applicant 1** Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

| ● Assignee | Legal Representative under 35 U.S.C. 117 | Joint Inventor |
|---|---|---|
| Person to whom the inventor is obligated to assign. | Person who shows sufficient proprietary interest | |

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

| Organization Name | Inpria Corporation | | |
|---|---|---|---|
| **Mailing Address Information For Applicant:** | | | |
| **Address 1** | 1100 NE Circle Boulevard | | |
| Address 2 | Suite 360 | | |
| **City** | Corvallis | **State/Province** | OR |
| **Country** | US | Postal Code | 97330 |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Applicant Data may be generated within this form by selecting the Add button. Add

## Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

**Assignee 1**

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

| Prefix | **Given Name** | Middle Name | **Family Name** | Suffix |
|---|---|---|---|---|
| | | | | |

**Mailing Address Information For Assignee including Non-Applicant Assignee:**

| | | | |
|---|---|---|---|
| **Address 1** | | | |
| Address 2 | | | |
| **City** | | **State/Province** | |
| **Country** i | | Postal Code | |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

## Signature:

Remove

**NOTE:** This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

| **Signature** | /Diane Bennett/ | | | Date (YYYY-MM-DD) | 2020-08-06 |
|---|---|---|---|---|---|
| First Name | Diane | Last Name | Bennett | Registration Number | 63,240 |

Additional Signature may be generated within this form by selecting the Add button. Add



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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

PTO/AIA/14 (02-18)
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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 5063.08US05 |
|---|---|---|
| | Application Number | |
| Title of Invention | ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING | |

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

# Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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# ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of copending U.S. patent application 16/238,779 filed January 3, 2019 (published as U.S. 2019/0137870) to Meyers et al., entitled "Organotin Oxide Hydroxide Patterning Compositions, Precursors, and Patterning," which claims priority to U.S. patent application 15/291,738, filed October 12, 2016, now U.S. patent 10,228,618, to Meyers et al., entitled "Organotin Oxide Hydroxide Patterning Compositions, Precursors, and Patterning," which claims priority to U.S. provisional patent application 62/240,812 filed October 13, 2015 to Meyers et al., entitled "Organotin Oxide Hydroxide Patterning Compositions With Precursor Vapor Deposition," and to U.S. provisional patent application 62/297,540 filed February 19, 2016 to Cardineau et al., entitled "Precursor Compositions for Organotin Oxide Hydroxide Photoresist Films," all of which are incorporated herein by reference.

## FIELD OF THE INVENTION

The invention relates to precursor compositions that can be coated and in situ hydrolysed to form coatings comprising organotin oxide hydroxide. The invention further relates to radiation sensitive organotin oxide hydroxide coatings that can be patterned effectively with UV light, EUV light or electron-beam radiation to form high resolution patterns with low line width roughness.

## BACKGROUND OF THE INVENTION

For the formation of semiconductor-based devices as well as other electronic devices or other complex fine structures, materials are generally patterned to integrate the structure. Thus, the structures are generally formed through an iterative process of sequential deposition and etching steps through which a pattern is formed of the various materials. In this way, a large number of devices can be formed into a small area. Some advances in the art can involve that reduction of the footprint for devices, which can be desirable to enhance performance.

Organic compositions can be used as radiation patterned resists so that a radiation pattern is used to alter the chemical structure of the organic compositions corresponding with the pattern. For example, processes for the patterning of semiconductor wafers can entail lithographic transfer



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of a desired image from a thin film of organic radiation-sensitive material. The patterning of the resist generally involves several steps including exposing the resist to a selected energy source, such as through a mask, to record a latent image and then developing and removing selected regions of the resist. For a positive-tone resist, the exposed regions are transformed to make such regions selectively removable, while for a negative-tone resist, the unexposed regions are more readily removable.

Generally, the pattern can be developed with radiation, a reactive gas, or liquid solution to remove the selectively sensitive portion of the resist while the other portions of the resist act as a protective etch-resistant layer. Liquid developers can be particularly effective for developing the latent image. The substrate can be selectively etched through the windows or gaps in the remaining areas of the protective resist layer. Alternatively, materials can be deposited into the exposed regions of the underlying substrate through the developed windows or gaps in the remaining areas of the protective resist layer. Ultimately, the protective resist layer is removed. The process can be repeated to form additional layers of patterned material. The materials can be deposited using chemical vapor deposition, physical vapor deposition or other desired approaches. Additional processing steps can be used, such as the deposition of conductive materials or implantation of dopants. In the fields of micro- and nanofabrication, feature sizes in integrated circuits have become very small to achieve high-integration densities and improve circuit function.

## SUMMARY OF THE INVENTION

In a first aspect, the invention pertains to a coating solution comprising an organic solvent, a first organometallic composition, and a metal compound with hydrolysable ligand-metal bonds. In some embodiments, the first organometallic composition can be represented by the formula $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ where $0 < z \leq 2$ and $0 < (z + x) \leq 4$, by the formula $R_nSnX_{4-n}$ where $n = 1$ or 2, or a mixture thereof, in which R is a hydrocarbyl group with 1-31 carbon atoms, and X is a ligand with a hydrolysable M-X bond. The hydrolysable metal compound can be represented by the formula $MX'_n$, where M is a metal chosen from groups 2-16 of the periodic table of elements, X' is a ligand with a hydrolysable M-X' bond or a combination thereof, and n is determined by the valency of the metal and the ligand charge.



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In a further aspect, the invention pertains to a coating solution comprising an organic solvent, at least about 10 mole percent relative to total metal content of a first organometallic composition, and at least 10 mole percent relative to total metal content of a second organometallic composition. In some embodiments, the first organometallic composition can be represented by the formula $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ where $0 < z \leq 2$ and $0 < (z + x) \leq 4$, by the formula $R_nSnX_{4-n}$ where n = 1 or 2, or a mixture thereof, in which R is a hydrocarbyl group, and Sn-X is a hydrolysable chemical bond. The second organometallic composition can be represented by the formula $R'_ySnX'_{4-y}$ where y = 1 or 2, in which R' is a hydrocarbyl group that is different from R, and X' is a ligand having a hydrolysable Sn-X' bond that is the same or different from X.

In another aspect, the invention pertains to a method for forming a radiation patternable coating, the method comprising exposing a precursor coating on a substrate to water vapor, in which the precursor coating comprises a first organometallic composition, and a second hydrolysable composition. The first organometallic composition can be represented by the formula $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ where $0 < z \leq 2$ and $0 < (z + x) \leq 4$, or $R'_nSnX_{4-n}$ where n = 1 or 2 and R and R' are independently hydrocarbyl groups with 1-31 carbon atoms. The second hydrolysable composition can be either a second organometallic composition represented by the formula $R''_ySnX'_{4-y}$ where y = 1 or 2 and R'' is different from R' and X' is a ligand with a hydrolysable Sn-X' bond that is the same or different from X, or an inorganic composition $ML_v$, where v is $2 \leq v \leq 6$ and L is a ligand with a hydrolysable M-L bond that is the same or different from X and X'. In some embodiments, the exposing step results in hydrolysis of the precursor coating compounds to form a coating comprising $((R \text{ or } R')_aR''_b)SnO_{(2-((a+b)/2)-(w/2))}(OH)_w$, where $0 < (a + b) \leq 2$ and $0 < (a + b + w) < 4$; or comprising $y\ ((R \text{ or } R')_aR''_b)SnO_{(2-((a+b)/2)-(w/2))}(OH)_w \cdot z\ MO_{((m/2)-l/2)}(OH)_l$ where $0 < (a + b) \leq 2$, $0 < (a + b + w) < 4$, m = formal valence of $M^{m+}$, $0 \leq l \leq m$, y/z = (0.05 to 0.6), and M = M' or Sn, where M' is a non-tin metal of groups 2-16 of the periodic table. .

In additional aspects, the invention pertains to a method for forming a radiation patternable coating comprising a metal oxo-hydroxo network with metal cations having organic ligands with metal carbon bonds and metal oxygen bonds, the method comprising inputting into a deposition chamber closed from the ambient atmosphere separately a first precursor vapor comprising a compound $R_nSnX_{4-n}$ where n = 1 or 2, wherein R is a hydrocarbyl group with 1-31 carbon atoms, and X is a hydrolysable or oxidizable ligand and a second precursor vapor comprising an oxygen



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containing compound capable of hydrolyzing or oxidizing the first precursor vapor under conditions in the deposition chamber to form a hydrolyzed or oxidized composition. Generally, a substrate can be configured with a surface to receive the hydrolyzed or oxidized composition.

In other aspects, the invention pertains to a coated substrate comprising a substrate with a surface and a coating on the surface comprising an organometallic composition represented by the $y\ (R_zSnO_{(2-(z/2)-(w/2))}(OH)_w \cdot z\ MO_{((m/2)-l/2)}(OH)_l$ where $0 < z \leq 2$, $0 < (z + w) \leq 4$, m = formal valence of $M^{m+}$, $0 \leq l \leq m$, y/z = (0.05 to 0.6), and M = M' or Sn, where M' is a non-tin metal of groups 2-16 of the periodic table , and R is hydrocarbyl groups with 1-31 carbon atoms.

Furthermore, the invention pertains to a substrate and a radiation sensitive coating comprising an alkyl metal oxide hydroxide having a dose-to-gel ($D_g$) of no more than about 6.125 $mJ/cm^2$.

Moreover, the invention pertains to a substrate comprising an inorganic semiconductor layer and a radiation sensitive coating material along a surface. In some embodiments, the radiation coating material can be patterned with EUV light at a wavelength of 13.5nm in a pattern of 16-nm lines on a 32-nm pitch to achieve a critical dimension of 16 nm with a dose from about 8 mJ/cm2 to about 25 mJ/cm2 with a line width roughness of no more than about 4 nm. The radiation sensitive coating material can comprise metal, such as Sn, and can comprise at least 5 weight percent metal and in other embodiments at least about 20 weight percent metal.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of a radiation patterned structure with a latent image.

Fig. 2 is a side plan view of the structure of Fig. 1.

Fig. 3 is a schematic perspective view of the structure of Fig. 1 after development of the latent image to remove un-irradiated coating material to form a patterned structure.

Fig. 4 is a side view of the patterned structure of Fig. 3.

Fig. 5 is a schematic perspective view of the structure of Fig. 1 after development of the latent image to remove irradiated coating material to form a patterned structure.

Fig. 6 is a side view of the patterned structure of Fig. 5.

Fig. 7 is a scanning electron (SEM) micrograph of a regular pattern formed on substrate with a line spacing of 16.7 nm formed with an EUV dose of 56 $mJ/cm^2$.



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Fig. 8 is a plot of film thickness following exposure and development as a function of EUV dose formed for 50 circular pads 500 microns in diameter exposed with stepped doses for substrates coated with radiation resists as described herein with in situ hydrolysis.

Fig. 9 is a plot with two FTIR spectra comparing films formed with solution based hydrolysis versus in situ hydrolysis in the coating.

Fig. 10 is a set of plots with EUV contrast curves involving a function of dose for coatings formed with three different amounts of $Sn(NMe_2)_4$ in the radiation sensitive coating prior to in situ hydrolysis.

Fig. 11 is a set of SEM micrographs for five patterned coatings formed with indicated compositions and irradiation doses.

Fig. 12 is a plot of line width roughness (LWR) as a function of dose-to-size for 6 resist compositions based on patterned with EUV light at a wavelength of 13.5nm in a pattern of 16-nm lines on a 32-nm pitch with the dose-to-size value to achieve a critical dimension of 16 nm.

Fig. 13 is a set of plot of EUV contrast curves involving a function of dose for 5 coatings formed with varying amounts of methyl ligands as a radiation sensitive group.

Fig. 14 is a set of plots of space critical dimensions as a function of irradiation dose for coatings with three different amounts of methyl ligands.

Fig. 15 is set of three SEM micrographs for patterns formed with differing EUV radiation doses.

## DETAILED DESCRIPTION OF THE INVENTION

Improved patterning performance at lower radiation doses can be obtained using organotin patterning compositions with a selected ratio of radiation sensitive alkyl-Sn bonds and/or a selected amount of tin precursors free of radiation sensitive ligands, and improved processing of the radiation patternable coatings can be achieved using in situ solvolysis, e.g., hydrolysis, of the precursor compositions. The radiation patternable coatings generally comprise $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ compositions, where $0 < z \leq 2$ and $0 < (z + x) < 4$, and R is a radiation sensitive alkyl ligand, which in some embodiments can exhibit improved low-dose radiation patterning when formed with a selected amount of $SnX_4$ precursor compounds to modify the value of z for the overall composition. The use of in situ hydrolysis allows for the effective use of precursor compositions through solution based processing that would be difficult or impossible to achieve



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through the direct dissolution and deposition of alkyl tin oxo-hydroxo compositions. As described herein, processing is improved through in situ solvolysis to form the patternable $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ compositions. Vapor deposition can be useful for the deposition of certain precursor coatings as an alternative to solution based processing to form the organotin oxide hydroxide precursors. The patterning compositions are particularly useful for EUV patterning at reduced doses, and low line width roughness can be obtained for small features.

Organotin oxide hydroxides with the general formula $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ where $0 < (x + z) < 4$ and $z > 0$ have been found to offer excellent performance as patterning materials, commonly known as photoresists, when deposited as thin coatings and exposed with Ultraviolet (UV), Extreme Ultraviolet (EUV), or electron-beam radiation and developed with appropriate solvents. Previous work has shown that organotin oxide hydroxides can provide a basis for the formation of stable precursor solutions that can form resist layers providing good radiation absorption and development rate contrast. The organotin compositions are effectively used as negative resists or positive resists. The efficacy of these compounds for EUV and electron-beam resists is described in U.S. patent 9,310,684 B2 to Meyers et al., entitled "Organometallic Solution Based High Resolution Patterning Compositions," incorporated herein by reference. Based on the current synthesis approaches, it seems appropriate to extend these compounds to extend to the value of $(x + z) = 4$ so that $0 < (x + z) \leq 4$ Improved patterning performance found with branched alkyl ligands and blends of alkyl tin oxide hydroxide compositions is described in published U.S. patent application 2016/0116839 A1 to Meyers et al. (hereinafter the '839 application), entitled "Organometallic Solution Based High Resolution Patterning Compositions and Corresponding Methods" incorporated herein by reference.

The foregoing references describe organotin oxide hydroxide photoresist film deposition by coating precursor solutions containing $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ compositions prepared by pre-hydrolysis of one or more $R_nSnX_{(4-n)}$ compositions where (n = 1 or 2), isolation and purification of the organotin hydrolysate(s), and dissolution of the oxide hydroxide(s) in a suitable solvent or mixture thereof. However, the dissolution and coating of pre-hydrolysed organotin oxide hydroxides may have substantial constraints on the accessible ligand identities and stoichiometries mandated by the avoidance of poor solubility of one or more hydrolysates, as well as complex hydrolysis processes for some embodiments which have the potential to introduce undesirable contaminates. Moreover, even if soluble resist precursor solutions can be prepared of the organotin



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oxide hydroxide precursor compositions, undesirable solvents may be required, or film morphology may be impaired.

It has been discovered that many of these constraints may be overcome by the preparation of resist precursor solutions consisting of one or more suitable $R_nSnX_{(4-n)}$ compounds dissolved in an appropriate solvent or mixture of solvents, where X is a ligand with a hydrolysable Sn-X bond. If the precursor $R_nSnX_{(4-n)}$ is sufficiently reactive with water vapor, it can undergo in situ –M-X hydrolysis and condensation in the presence of water to produce the corresponding oxide hydroxide as illustrated in the following general reactions:

$$R_nSnX_x + x\ H_2O \rightarrow R_nSn(OH)_x + x\ HX$$

$$R_nSn(OH)_x \rightarrow R_nSnO_{(2-(n/2)-(x/2))}OH_x + (x/2)\ H_2O$$

where $(0 < (x + z) \leq 4)$. Thus, by the use of coating solutions comprising the $R_nSnX_{(4-n)}$ compounds, a greater range of $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ compositions can be formed in practical procedures as photoresist coatings. In these methods the R-Sn moiety is at least partially preserved through the hydrolysis and condensation process, and the resulting film has both M-C and M-O bonds.

In one embodiment of an in situ hydrolysis process, a precursor $R_nSnX_{(4-n)}$ is dissolved in a solvent, directly coated on a substrate, optionally in the presence of water vapor (such as moist air), to produce a coating, and then additionally or alternatively baked further in the presence of water vapor to form the organotin oxide hydroxide coating. Thus, water vapor for hydrolysis can be present during coating deposition and/or during a pre-patterning bake step to perform the in situ hydrolysis. Additionally, by blending multiple $R_nSnX_{(4-n)}$ compounds where n = 0, 1, or 2 (such as $SnX_4$, $RSnX'_3$, $R'SnX''_3$ and $R''_2SnX_2$, where R, R', and R" are the same or different and X, X', and X" are the same or different) in a suitable solvent an $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ (s) film of selected stoichiometry in the range $0 < z \leq 2$ and $0 < (x + z) \leq 4$ may be readily deposited. Similarly, mixed-ligand hydrolysates comprising a mixture of an organotin oxide hydroxide $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ (where $0 < (x + z) < 4$ and $z > 0$) with one or more different organotin oxides $R'_bSnO_{(2-(b/2)-(a/2))}(OH)_a$ (where $0 < (a + b) < 4$ and $b > 0$) and where $R' \neq R$ can be similarly prepared by this method. Hydrolysable $R_nSnX_{(4-n)}$ and $R'_bSnX_{(4-b)}$ compounds can be dissolved in a common solvent or mixture of solvents and spin-coated on a substrate for in situ hydrolysis. In both cases the high solubility and rapid hydrolyses of suitable molecular organotin precursor compounds



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advantageously sidesteps potential solubility restrictions of the target organotin oxide hydroxide hydrolysates and eliminates the need for complicated and sensitive synthetic procedures to isolate hydrolyzed and partially condensed resist precursors ex situ. In this manner resist precursor preparation can be significantly simplified and desirable compositions with improved performance are enabled.

In another embodiment, the relatively high vapor pressures and reactivity of many molecular $R_nSnX_{(4-n)}$ compounds enable the use of vapor deposition methods for deposition of organotin oxide hydroxide thin-film photoresists. Potential deposition methods include, for example, physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), or modifications thereof. For example, one or more gaseous $R_nSnX_{(4-n)}$ compounds can be introduced to a reaction chamber and reacted with a co-precursor such as $H_2O$ or its associated decomposition products, either in the gas phase or on a substrates surface, thereby producing a radiation sensitive organotin oxide hydroxide coating. If the hydrolysable compound is deposited on the surface with a subsequent hydrolysis reaction, this process can be considered a PVD deposition with in situ hydrolysis, but if the hydrolysis takes place during a continuous deposition process, it can be considered a CVD process. Likewise, if the hydrolysable precursor is sequentially adsorbed, chemisorbed, or decomposed on the substrate surface, and the residual film reacted with a second reactive precursor through multiple deposition/reaction cycles to deposit the corresponding organotin oxide hydroxide it can considered an ALD process. Advantages of vapor deposition methods may include reduced resist film defect density, improved thickness and compositional uniformity, as well as conformal and side-wall coating of substrate topography.

Organotin oxide hydroxide photoresist performance, including for example imaging dose, ultimate resolution, and line-width roughness (LWR), has been found to be dependent upon the composition of the photoresist coating. For these photoresist films with the composition $R_zSnO_{(2-(z/2)-(x/2))}(OH)_x$ where $0 < (x + z) \leq 4$ and $z > 0$, both the identity of the radiation sensitive ligand R, as well as the R:Sn stoichiometry represented by z are significant variables. Generally, the photo resist film can comprise sufficient radiation sensitive ligands R such that the thin film has a molar concentration ratio of radiation sensitive ligands to metal cations (z) from about 0.1 to about 2. Organotin oxide hydroxide resist films with ligand ratios in this range may be prepared by pre-hydrolysis of multiple $R_nSnX_{(4-n)}$ precursors with $z = 1$ or 2 in the appropriate stoichiometry, and



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dissolution of the resulting hydrolysates in a coating solvent, subject to solubility and stability constraints. Certain stoichiometries, particularly those with $0.1<z<1$, the photoresist compositions have been found to exhibit advantageous photoresist properties. However, for photoresist compositions with $z < 1$, the aforementioned processing constraints may be onerous as the solubility of inorganic $SnO_{(2-(x/2))}(OH)_x$ hydrolysates ($z = 0$) is typically extremely low in organic solvents, outside of very limited conditions favoring co-hydrolysis and cluster condensation with specific organotin $RSnX_3$ or $R_2SnX_2$ moieties. Moreover, even when such conditions have been identified and hydrolysates isolated and dissolved, the precursor solution stability, stoichiometry, ligand identity, and solvent may be detrimentally limited relative to desirable values for operation as an EUV photoresist.

These processing and composition constraints can be overcome by adding readily hydrolysable $SnX_4$ compounds directly to precursor coating solutions containing one or more pre-hydrolysed organotin oxide hydroxides, or one or more $RSnX_3$ and/or $R_2SnX_2$ compounds chosen to undergo substantially complete hydrolysis and subsequent condensation along with HX by-product volatization on coating and baking in the presence of water, or another suitable source of oxygen and hydrogen. In this way both the identity and relative stoichiometry of multiple radiation sensitive ligands in both the precursor coating solution and photoresist film may be independently controlled across a wide range of total ligand to metal cation ratios, with relaxed solution stability and solubility constraints and simplified precursor synthesis. Thus, appropriately selected $SnX_4$ compositions may be incorporated into precursor mixtures or processes to enable organotin oxide hydroxide vapor deposition with comparable compositions.

By relaxing the stability and solubility constraints inherent to organometallic compounds with both M-C and M-O bonds, alternate metal species may also be added to the precursor coating solution or reactive gas mixture in the form $MX'_n$ where M is a metal cation chosen from group 2-16 metals, and n is determined by the valency of the metal cation and ligand charge, but is generally 3-6. When $M \neq Sn$, the X' ligand may be the same or different as X in $R_nSnX_{(4-n)}$ compounds used in the same formulation. In both cases these ligands and $MX'_n$ are subject to similar criteria; rapid and substantially complete hydrolysis in the presence of $H_2O$ and diffusion and volatilization of X (X') ligand hydrolysis products from the oxide hydroxide film. Alternate metal cations incorporated into the organotin oxide hydroxide coating in this manner may be advantageous for



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tuning radiation absorption, film density, metal-ligand thermolysis, development rate in preferred developers, or other desired photoresist properties.

The identity and relative stoichiometry of multiple R-Sn moieties present in an organotin oxide hydroxide resist film have been previously found to offer improved patterning performance as described in the '839 application. While the branched alkyl ligands and associated blended compositions described therein are accessible at least in part using pre-hydrolysed organotin oxide hydroxide compounds dissolved in solvents, significant constraints with respect to ligand identity and stoichiometry have been found in the context of practical processing suitable for commercial use. Many of these constraints are associated with hydrolysate solubility. While some mono-organotin hydrolysates such as n-butyltin oxide hydroxide have excellent solubility in a wide range of organic solvents, hydrolysates of mono-*tert*-butyl tin moieties, e.g. $^{t}BuSnO_{(3/2-(x/2))}(OH)_x$ where $(0 < x < 3)$ are often insufficiently soluble in useful solvents and/or desired solution concentrations are difficult to reproduce and/or control. As demonstrated in the '839 application, while it is possible to prepare a solution of $^{t}BuSnO_{(3/2-(x/2))}(OH)_x$ with methanol and solvent blends derived therefrom, the volatility, flashpoint, and toxicity of methanol render it an undesirable solvent for use in semiconductor manufacturing. Moreover, the low maximum concentration limits the range of film thicknesses accessible, and the compositions of blend precursor formulations and coatings possible. These constraints are obviated in an example below, where high-performance $^{t}BuSnO_{(3/2-(x/2))}(OH)_x$ photoresist films are demonstrated via spin coating of a solution of $^{t}BuSn(NEt_2)_3$ in 4-methyl-2-pentanol in the presence of water vapor.

Similarly, the low solubility of hydrolysates, e.g. $MeSnO_{(2-(z/2)-(x/2))}(OH)_x$, of mono-methyl tin moieties limits film thickness and composition ranges of formulations and coatings. However, by preparing resist precursor solutions that comprise readily hydrolysable and highly soluble $MeSnX_3$ compounds resist films comprising the resulting methyl-tin oxide hydroxide in blended formulations with $^{t}BuSnO_{(3/2-(x/2))}(OH)_x$ have been deposited and found to offer advantageous lithographic performance. Significantly, using the methods and precursor solutions disclosed herein, resist precursor solution solvent restrictions are substantially relaxed, and resist film stoichiometry can be more readily adjusted to achieve useful lithographic properties. Desirable photoresist precursor solution and subsequent film compositions comprising a mixture of organotin moieties with different organic ligands (R, R', R'', etc.) in a wide range of molar ratios with respect to each other and the metal cation are thus accessible by mixing multiple hydrolysable



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organotin compounds $R_nSnX_{(4-n)} + R'_zSnX'_{(4-z)} + R''_aSnX''_{(4-a)} + ...$ (where $0 \leq (n, z, a) \leq 2$ and at least one of n, z, a, etc. $> 0$ ).

Alternatively, selected $R_nSnX_{(4-n)}$ compounds where n = 0, 1, or 2 may be added to a precursor coating solution containing one or more separately synthesized organotin oxide hydroxide hydrolysates dissolved in an appropriate solvent. Thus, the added $R_nSnX_{(4-n)}$ compounds can hydrolyse on exposure to water vapor or hydroxide moieties, condensing with the initial organotin oxide hydroxides during coating and baking steps to form a coating with an alkyl ligand to metal ratio determined by the stoichiometry of the precursor compounds originally in the precursor coating solution.

The choice of ligand (X) with a hydrolysable Sn-X bond in the aforementioned compounds is significant for the efficacy of solvation, coating, and successful in situ hydrolysis. Appropriate ligands should form a stable bond with Sn in the absence of Lewis acids and generally be strong nucleophiles that rapidly react with acidic protons to produce species which readily desorb or volatilize from the condensing oxide hydroxide film, thereby reducing voids, domain segregation, or other inhomogeneities. For $R_nSnX_{(4-n)}$ compounds, X may be a single unique ligand, however, in certain embodiments, it may refer to a combination of multiple different ligands, e.g. $R_nSnX^1{}_aX^2{}_bX^3{}_cX^4{}_d$ where $a + b + c + d - n = 4$, and $0 \leq n \leq 2$. Examples of compounds of this type are $^tBuSn(NEt_2)_2(O^tBu)$ $^tBuSn(NEt_2)$ $(NH_2)(O^tBu)$, $^tBuSn(NEt_2)(O^tBu)_2$, $MeSn(NEt_2)(O^tBu)_2$, $MeSn(NEt_2)_2(O^tBu)$, $(^tBu)_2Sn(NEt_2)(O^tBu)$, $Me_2Sn(NEt_2)(O^tBu)$, $(Me)(^tBu)Sn(NEt_2)_2$, $(Me)(^tBu)Sn(NEt_2)(O^tBu)$, $(^iPr)(^tBu)Sn(NMe_2)(O^tBu)$ and mixtures thereof.

The choice of -X ligand(s) may be determined in part by the identity of the hydrocarbyl ligand R, other hydrolysable ligands, and the stoichiometric ratio, R:Sn, as the reactivity of a given Sn-X moiety with respect to hydrolysis or solvolysis will be modified by the total ligand environment around the metal, both in terms of steric (kinetic) and the electrostatic (thermodynamic) effects.

Formulations comprising one or more $R_nSnX_{(4-n)}$ compound where -X is a short-chain aliphatic dialkylamide $-NR'_2$ or alkoxide -OR' ligand and where R' contains < 10 carbon atoms have been found to be particularly suitable for these applications. When exposed to atmospheric moisture during the coating and baking processes, these materials rapidly hydrolyse and condense with other organotin precursor constituents as described above, releasing volatile dialkylamines and alcohols and forming organotin oxide hydroxides with excellent photoresist performance.



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Other useful ligands of this type include, amido, alkylamido, dialkylamido, alkoxo, aryloxo, azido, imido and others known to those skilled in the art.

In some embodiments, such as the dissolution of an organotin dialkylamide in a protic solvent such as an alcohol, the tin precursor compound may react with the solvent. Through solvolysis, such as alcoholysis when the solvent is an alcohol, or similar reactions, full or partial ligand metathesis may occur as illustrated in the reaction below.

$$R_nSn(NR'_2)_{(4-n)} + (4-n)R''OH \rightarrow R_nSn(OR'')_{(4-n)} + (4-n)HNR'_2. \quad (2)$$

Such solvolysis and metathesis reactions in equation 2 are anticipated and acceptable as well as potentially even beneficial provided the product tin species (such as a tin (IV) alkoxide, $R_nSn(OR'')_{(4-n)}$) has the necessary attributes with respect to water reactivity, hydrolysis byproduct volatility, diffusivity, and other attributes discussed herein to produce an appropriate oxide hydroxide film upon coating and baking in an appropriately humid environment.

The improved precursors described herein open up more possibilities for compositions of patternable coatings based on reasonable coating solutions and in situ hydrolysis. In situ hydrolysis provides the capability for a range of vapor phase deposition approaches as appropriate alternatives to solution based processing. Through the ability to adjust the composition of patternable coatings with radiation sensitive ligands, improved patterning with lower radiation doses and good pattern quality has been achieved.

Precursor Compositions

The precursor compositions for forming the resist coatings generally comprise tin cations with appropriate radiation sensitive hydrocarbyl stabilizing ligands and additional ligands with a hydrolysable bond to Sn selected for processing. For processing into a patternable coating, the precursor compositions are generally formed into a solution with a solvent, generally an organic solvent that can be formed into a coating through solution coating or a vapor based deposition process. The ultimate resist coatings are based on metal oxide chemistry, and the precursor solutions of tin cations with alkyl ligands provide stable solutions with good resist properties. The ligands of the precursor solutions are generally selected to facilitate solution formation and related processing functions. As noted above, precursor compositions with a ligand having a hydrolysable bond with Sn can be introduced into the precursor solutions to improve the range of compositions that can be formed into stable solutions with the expectation that subsequent hydrolysis can



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provide for patternable coatings with organotin oxide hydroxide materials. Compositions with blends of alkyl ligands, generally with at least one branched alkyl ligand, have been found to provide desirable patterning properties.

The alkyl ligands provide the radiation sensitivity, and the particular selection of ligands and stoichiometry relative to the metal can influence the radiation sensitivity. Also, the precursor solutions can be designed to achieve desired levels of radiation absorption for a selected radiation energy based on the selection of the metal cations as well as the associated ligands. While the discussion above outlines in significant detail the ranges of precursor compositions suitable for the improved processing described herein, more details are presented on the use of alkyltin amido/alkoxy precursor compositions for in situ hydrolysis. As noted above, various compounds are described that can provide improved solubility in desirable solvents with good processability into radiation sensitive coatings. A wide range of precursor engineering is made possible through the new classes of precursors involving at least some in situ hydrolysis with some vapor hydrolysis/oxidizing reactants, to form the radiation patternable coatings.

In general, precursor solutions can comprise:

$$a1\ R^{1}_{z1}SnO_{(3/2-z1/2-x1/2)}(OH)_{x1} + a2\ R^{2}_{z2}SnO_{(3/2-z2/2-x2/2)}(OH)_{x2} + ... + b1\ R^{1'}_{y1}SnX^{1}_{4-y1} + b2\ R^{2'}_{y2}SnX^{2}_{4-y2} + ... + c1SnX^{1'}_{4} + c2SnX^{2'}_{4} + ... + d1M^{1}X^{1''}_{n1}, d2M^{2}X^{2''}_{n2} + ...\ , \quad (1)$$

where $a1+a2+ ... +b1+b2+ ... +c1+c2+ ... +d1+d2+ ... = 1$, i.e., these parameters correspond with mole fractions of metal in the precursor compositions in the solution, $(0 \leq (a1,a2,...) \leq 0.99)$, $(0 \leq (b1, b2,...) \leq 1)$, $(0 \leq (c1,c2,...) \leq 0.6)$, $(0 \leq (d1,d2,...) \leq 0.5)$ with $0.01 < (b1+b2+...+c1+c2+...)$, R ($R^1$, $R^2$,…) and R' ($R^{1'}$, $R^{2'}$,…) are independently hydrocarbyl groups or a combination thereof, X ($X^1$, $X^2$, . . .), X' ($X^{1'}$, $X^{2'}$,…) and X'' ($X^{1''}$, $X^{2''}$,…) are independently ligands with hydrolysable bonds to the associated metal or combinations thereof, $M^1$, $M^2$, ... are a non-tin metal ions, $(0 < (x1, x2, ...) < 3)$, $(0 < (z1, z2, ...) \leq 2)$, $(1 < (y1, y2, ...) \leq 3)$, and n1, n2, ... are determined by the valency of $M^1$, $M^2$, ... ions and the charge on $X^{1''}$, $X^{2''}$… In general, M is a Group 2-Group 16 metal, and for many metals n ranges from 2 to 6. Desirable metals for M may include Hf, Zr, W, Ta, Co, Ni, In, Sb, Bi, Te or others. Representative suitable $ML''_n$ compounds include, for example, $Zr(OtBu)_4$, $Hf(NMe)_4$, $In(O^iPr)_3$, and $Sb(OEt)_3$, which are available commercially from Sigma-Aldrich, Alfa Aesar, Gelest, Strem Chemical, and other suppliers. In some embodiments,



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all "a" parameter values are zero such that all of the ligands are hydrolysed in situ. In further embodiments, $0.1 \leq (a1,a2,...) \leq 0.90$, or $0.2 \leq (a1,a2,...) \leq 0.85$ or $0.25 \leq (a1,a2,...) \leq 0.75$. In some embodiments, $0.25 \leq (b1,b2,...) \leq 1$ or $0.3 \leq (b1,b2,...) \leq 0.95$ or $0.35 \leq (b1,b2,...) \leq 0.9$. In additional embodiments, $0 \leq (c1,c2,...) \leq 0.4$ or $0.025 \leq (c1,c2,...) \leq 0.4$ or $0.05 \leq (c1,c2,...) \leq 0..35$ or $0.1 \leq (c1,c2,...) \leq 0.3$, and $0 \leq (d1,d2,...) \leq 0.5$ or $0.025 \leq (d1,d2,...) \leq 0.4$ or $0.05 \leq (d1,d2,...) \leq 0.3$. A person of ordinary skill in the art will recognize that additional ranges of "a", "b", "c", and "d" parameters within the explicit ranges above are contemplated and are within the present disclosure. As used herein the symbols "<" and "≤" implicitly carry the concept of the corresponding range limit being "about" the specified value within experimental error.

In summary, precursor compositions can comprise one or more compounds with at least one having ligands with hydrolysable bonds to the metal and one or more having a hydrocarbyl ligand to provide radiation sensitivity. The compositions are generally engineered to be processable using suitable organic solvents for the formation into precursor solutions as described in the following section. The precursors generally are engineered to provide desirable patterning properties as well as good processability.

In some embodiments, the precursor compositions can comprise mixtures of two organotin compounds with different hydrocarbyl ligands, three organotin compounds with different hydrocarbyl ligands, or more than three organotin compounds with different hydrocarbyl ligands. In addition, precursor compositions can comprise a mixture of compounds without metal-carbon bonds and one or more compounds with radiation sensitive alkyl ligands having metal-carbon bonds. Generally, for binary or tertiary mixtures, the mixture comprises at least about 5 mole percent of each component with distinct hydrocarbyl ligands, in some embodiments at least about 10 mole percent and in further embodiments at least about 20 mole percent of each component with distinct hydrocarbyl ligands. A person of ordinary skill in the art will recognize that additional ranges of mole percent of components within the explicit ranges above are contemplated and are within the present disclosure.

In some embodiments the precursor compositions comprise a mixture of R-Sn moieties with hydrocarbyl ligands and inorganic metal $SnX_4$ or $MX_n$ compounds without alkyl ligands bound directly to the metal. Generally, these mixtures comprises at least about 0.5 mole percent of each metal component, in some embodiments at least about 5 mole percent and in further embodiments at least about 10 mole percent of each component. A person of ordinary skill in the



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art will recognize that additional ranges of mixture components within the explicit ranges above are contemplated and are within the present disclosure. The components of the precursor compositions may be combined in solution and are not separately formed as solid blends prior to, for example, formation of a coating.

Whether or not there are one or multiple distinct hydrocarbyl ligands, an R group can be a linear, branched, (i.e., secondary or tertiary at the metal bonded carbon atom) or cyclic hydrocarbyl group. Each R group individually generally has from 1 to 31 carbon atoms with 3 to 31 carbon atoms for the secondary-bonded carbon atom and 4 to 31 carbon atoms for the tertiary-bonded carbon atom embodiments, for example, methyl, ethyl, propyl, butyl, and branched alkyl. In particular, branched alkyl ligands are desirable where the compound can be represented in another representation by $R^1R^2R^3CSnX_3$, where $R^1$ and $R^2$ are independently an alkyl group with 1-10 carbon atoms, and $R^3$ is hydrogen or an alkyl group with 1-10 carbon atoms. In some embodiments $R^1$ and $R^2$ can form a cyclic alkyl moiety, and $R_3$ may also join the other groups in a cyclic moiety. Suitable branched alkyl ligands can be, for example, isopropyl ($R^1$ and $R^2$ are methyl and $R^3$ is hydrogen), tert-butyl ($R^1$, $R^2$and $R^3$ are methyl), tert-amyl ($R^1$ and $R^2$ are methyl and $R^3$ is -$CHCH_3$), sec-butyl ($R^1$ is methyl, $R^2$ is -$CHCH_3$, and $R^3$ is hydrogen), cyclohexyl, cyclopentyl, cyclobutyl, and cyclopropyl. Examples of suitable cyclic groups include, for example, 1-adamantyl (-$C(CH_2)_3(CH)_3(CH_2)_3$ or tricyclo(3.3.1.13,7) decane bonded to the metal at a tertiary carbon) and 2-adamantyl (-$CH(CH)_2(CH_2)_4(CH)_2(CH_2)$ or tricyclo(3.3.1.13,7) decane bonded to the metal at a secondary carbon). In other embodiments hydrocarbyl groups may include aryl, or alkenyl groups, for example benzyl, allyl, or alkynyl groups. In other embodiments the hydrocarbyl ligand R may include any group consisting solely of C and H, and containing 1-31 carbon atoms. For example: linear or branched alkyl ($^i$Pr, $^t$Bu, Me, $^n$Bu), cyclo-alkyl (cyclo-propyl, cyclo-butyl, cyclo-pentyl), olefinic (alkenyl, aryl, allylic), or alkynyl groups, or combinations thereof. In further embodiments suitable R-groups may include hydrocarble groups substituted with hetero-atom functional groups including cyano, thio, silyl, ether, keto, ester, or halogenated groups or combinations thereof.

Some suitable metal compositions with desired ligand structures can be purchased from commercial sources, such as Alfa Aesar (MA, USA) and TCI America (OR, USA), and other metal-ligand compositions can be synthesized as described below. Low metal contaminant



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precursor compositions can be synthesized using the methods described herein based on the use of suitably low contaminated starting materials and appropriate purification.

Desirable patterning results have been obtained using a precursor compound with branched alkyl ligands. But fuller advantage of ligand selection has been achieved through the use of mixed alkyl ligands, as separately advantageous patterning properties such as dose and line-width-roughness imparted by different ligands may be obtained through the teachings herein through blending of multiple alkyl ligands as illustrated in the examples provided. The processing with in situ hydrolysed precursors provides for effective use of tin compounds with methyl ligands in the precursor solutions based on desirable solvents. Effective patterning with a mixture of tert-butyl ligands and methyl ligands is described in the Examples below as well as a precursor comprising a mixture of a hydrolysable compound with t-butyl ligands and hydrolysable $SnX_4$ compounds (X = $NMe_2$ or X = $O^tBu$).

It has been found that the radiation curing doses can scale approximately linearly for mixtures of precursor compounds with different alkyl ligands based on the radiation doses for the respective individual precursor compounds. Due to the lower radiation doses that can be used with the branched alkyl ligands, it is generally desirable for the mixtures to comprise at least one branched organic ligand. But correspondingly it has been discovered that the line width roughness can be improved with mixtures of precursor compounds with different organic ligands. While not wanting to be limited by theory, it is possible that the improved line width roughness values observed for the mixture compositions may be due to facilitated etchings for the mixture compositions without significantly diminishing the contrast in the pattern. In this context, the observations may extend to mixture compositions containing combinations of organotin compounds bearing branched or unbranched alkyls.

X, X', and X'' ligands are generally Lewis bases that can react suitably with acidic protons of water or other Lewis acids via hydrolysis or solvolysis of M-X, M-X' and M-X'' bonds to form readily volatilized products. Alternatively these ligands may react with an appropriate reagent via oxidation or reduction reactions to form readily volatilized products. Ligands may generally be classified by the acid dissociation constant ($pK_a$) of their conjugate acids, where desirable ligands for some embodiments have conjugate acid pKas greater than about 4. Thus, X, X' and X'' generally comprise an atom binding to the metal, e.g., tin, that can undergo nucleophilic



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substitution involving $H_2O$ and-OH. The resulting M–OH or M–$OH_2$ ligands may then react via subsequent condensation or dehydration steps to form an oxide-hydroxide network.

Suitable ligands comprise alkylamido or dialkylamido (-$NR^1R^2$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms or hydrogen), siloxo (-$OSiR^1R^2R^3$, where $R^1$, $R^2$, are independently hydrocarbon groups with 1-10 carbon atoms), silylamido (-$N(SiR^1_3)(R^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), disilylamido (-$N(SiR^1_3)(SiR^2_3)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-10 carbon atoms), alkoxo and aryloxo (-OR, where R is an alkyl or aryl group with 1-10 carbon atoms), azido (-$N_3$), alkynido (-C≡CR, where R is a hydrocarbon group with 1-9 carbon atoms), amidato (-$NR^1(COR^2)$ where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-7 carbon atoms or hydrogen), amidinato (-$NR^1C(NR^2)R^3$) where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), imido (-$N(COR^1)(COR^2)$, where $R^1$ and $R^2$ are independently hydrocarbon groups with 1-8 carbon atoms or hydrogen), or fluorinated analogues thereof.

The metal in an inorganic or organometallic material can significantly influence the absorption of radiation. Tin provides strong absorption of extreme ultraviolet light at 13.5 nm. In combination with alkyl ligands, metals also provide strong absorption of ultraviolet light at 193 nm wavelength. Tin also provides good absorption of electron-beam radiation. The energy absorbed is modulated by the metal-organic interactions, which can result in the rupturing of the metal-ligand bond and the desired control over the material properties. Nevertheless, other metal compositions can be introduced to further influence the absorption properties and overall resist performance. As noted above, other non-tin metals are generally introduced as $MX_n$, where X is a ligand having a hydrolysable bond to the metal.

The use of precursor compounds with ligands having hydrolysable bonds to the metal can simplify the preparation of the precursor solutions since in situ hydrolysis avoids the many synthetic and isolation steps required to produce a defined hydrolysis product. In particular, the solution phase hydrolysis and subsequent condensation and isolation of an organotin oxide hydroxide hydrolysate can involve significant solubility changes during the reaction, so that avoiding this solution based step avoids a potentially difficult process step. To the extent that an ingredient of the precursor composition comprises a separately hydrolysed component, this particular component can be obtained using a solution based hydrolysis, such as using a base



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catalyzed aqueous solution, as described in the '839 application. The components with ligands having hydrolysable bonds to the metal can generally be purchased or synthesized from appropriate starting materials, for example from a tin halide composition or tetrakis(dialkylamido)tin composition, as noted in the Examples.

Precursor Solution Formations and Coating Properties

A range of precursor solutions can be formulated based on the compositions described in the previous section. The precursor compositions generally have the commonality of involving some degree of hydrolytically sensitive metal-ligand bonds. For precursor compounds having sufficient vapor pressure, the hydrolysis can be alternatively performed in situ in a coating or as part of a vapor phase deposition process. The precursor solutions for solution deposition generally comprise tin cations and optionally one or more non-tin metal cations in an organic solvent.

The concentration of ligand stabilized metal cations in the solution can be selected to provide suitable solution properties for a particular solution deposition approach, such as spin coating, slot coating, dip coating, spray or aerosol coating, or printing, and are designed to form a coating composition upon at least partial solvent removal and ultimately an inorganic solid dominated by tin oxides upon irradiation and/or thermal treatment, exposure to a plasma, or similar processing.

With the precursor solutions based on alkyl-stabilization ligands and an organic solvent, progression to the oxide can be controlled as part of the procedure for processing the solution first to a coating material and then to the ultimate metal oxide composition with organic ligands through hydrolysis and condensation reactions with ambient water vapor during coating and/or hydrolysis and condensation following coating. As described herein, alkyl ligands, especially branched alkyl ligands and/or combinations of alkyl ligands in particular stoichiometries relative to the metal, can be used to provide significant control to the processing of the solution to an effective radiation resist composition. Processing with an alcohol based solvent can involve partial or complete substitution of alkoxy ligands from the alcohol for initial ligands with hydrolysable bonds to the metal, but such substitution may not alter downstream processing in any significant way.

A precursor solution concentration can be conveniently specified based on tin ion molar concentration and concentrations of any other metals can be correspondingly specified through the molar fraction values for the metals relative to tin. In general, the precursor solution comprises



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from about 0.005 M to about 1.4 M tin cation, in further embodiments from about 0.02 M to about 1.2 M, and in additional embodiments from about 0.1 M to about 1.0 M tin cation. Total non-tin metal in the precursor solution generally can range from about 0.025 mole % to about 10 mole % of the total metal ions and in further embodiments from about 10 mole % to about 50 mole % of the total metal ions. A person of ordinary skill in the art will recognize that additional ranges of tin cations within the explicit ranges above are contemplated and are within the present disclosure.

In general, the desired hydrolysate compounds can be dissolved in an organic solvent, e.g., alcohols, aromatic and aliphatic hydrocarbons, esters or combinations thereof. In particular, suitable solvents include, for example, aromatic compounds (e.g., xylenes, toluene), ethers (anisole, tetrahydrofuran), esters (propylene glycol monomethyl ether acetate, ethyl acetate, ethyl lactate), alcohols (e.g., 4-methyl-2-propanol, 1-butanol, methanol, isopropyl alcohol, 1-propanol,), ketones (e.g., methyl ethyl ketone), mixtures thereof, and the like. In general, organic solvent selection can be influenced by solubility parameters, volatility, flammability, toxicity, viscosity and potential chemical interactions with other processing materials. After the components of the solution are dissolved and combined, the character of the species may change as a result of partial in-situ hydrolysis, hydration, and/or condensation. When the composition of the solution is referenced herein, the reference is to the components as added to the solution, since complex formulations may undergo solvolysis and ligand metathesis, or produce metal polynuclear species in solution that may not be well characterized. For certain applications it is desirable for the organic solvent to have a flash point of no less than about 10 °C, in further embodiments no less than about 20 °C and in further embodiment no less than about 25 °C and a vapor pressure at 20 °C of no more than about 10 kPa, in some embodiments no more than about 8 kPa and in further embodiments no more than about 6 kPa. A person of ordinary skill in the art will recognize that additional ranges of flash point and vapor pressure within the explicit ranges above are contemplated and are within the present disclosure.

The concentrations of the species in the precursor solutions can be selected to achieve desired physical properties of the solution. In particular, lower concentrations overall can result in desirable properties of the solution for certain coating approaches, such as spin coating, that can achieve thinner coatings using reasonable coating parameters. It can be desirable to use thinner coatings to achieve ultrafine patterning as well as to reduce material costs. In general, the



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concentration can be selected to be appropriate for the selected coating approach. Coating properties are described further below.

In general, precursor solutions can be well mixed using appropriate mixing apparatuses suitable for the volume of material being formed. Suitable filtration can be used to remove any contaminants or other components that do not appropriately dissolve. In some embodiments, it may be desirable to form separate solutions that can be combined to form the precursor solution from the combination. Specifically, separate solutions can be formed comprising one or more of the compounds indicated above in Formula (1). Generally, the separate solutions or the combined solutions can be well mixed. The resulting solution can be referred to as a stabilized metal cation solution.

Stability of the precursor solutions can be evaluated with respect to changes relative to the initial solution. Specifically, a solution has lost stability if phase separation occurs with the production of large sol particles or if the solution loses its ability to perform desired pattern formation. Based on the improved stabilization approaches described herein, the solutions can be stable for at least about a week without additional mixing, in further embodiments at least about 2 weeks, in other embodiments at least about 4 weeks. A person of ordinary skill in the art will recognize that additional ranges of stabilization times are contemplated and are within the present disclosure. Suitable solutions generally can be formulated with sufficient stabilization times that the solutions can be commercially distributed with appropriate shelf lives.

As described herein, processing approaches have been developed that provide for reduction of metal contamination. Thus, the precursor solutions can be formulated that have very low levels of non-tin metal. In general, the unintentional metal concentrations can all be individually reduced to values of no more than about 1 part per million by weight (ppm) in further embodiments, no more than about 200 parts per billion by weight (ppb), in additional embodiments no more than about 50 ppb, and in other embodiments no more than about 10 ppb. In some embodiments, it may be desirable to add other metal elements to influence processing, and generally these can be identified by levels of at least about 1 weight percent and in some embodiments at least about 2 weight percent, and can thus be distinguished from contaminant metals, if appropriate. Metal contaminants to be decreased in particular include alkali metals and alkaline earth metals, Au, Ag, Cu, Fe, Pd, Pt, Co, Mn, and Ni. A person or ordinary skill in the art will recognize that additional



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ranges of metal levels within the explicit levels above are contemplated and are within the present disclosure.

Previous efforts to produce precursor solutions and coatings with low metal contamination are described in the '839 application. Using vapor water for hydrolysis provides a hydrolysis reactant substantially free of metal contaminants that can effectively further the formation of a low contaminant patternable coating based on a low contaminant tin composition. Suitable starting materials with low metal contamination can be obtained commercially or through purification.

Coating Processing and Hydrolysis In Situ

A coating material can be formed through deposition and subsequent processing of the precursor solution onto a selected substrate. Using the precursor solutions described herein, some hydrolysis and condensation generally is performed during coating, and may be completed or furthered post coating via subsequent processing steps such as heating in air. A substrate generally presents a surface onto which the coating material can be deposited, and the substrate may comprise a plurality of layers in which the surface relates to an upper most layer. In some embodiments, the substrate surface can be treated to prepare the surface for adhesion of the coating material. Also, the surface can be cleaned and/or smoothed as appropriate. Suitable substrate surfaces can comprise any reasonable material. Some substrates of particular interest include, for example, silicon wafers, silica substrates, other inorganic materials such as ceramic materials, polymer substrates, such as organic polymers, composites thereof and combinations thereof across a surface and/or in layers of the substrate. Wafers, such as relatively thin cylindrical structures, can be convenient, although any reasonable shaped structure can be used. Polymer substrates or substrates with polymer layers on non-polymer structures can be desirable for certain applications based on their low cost and flexibility, and suitable polymers can be selected based on the relatively low processing temperatures that can be used for the processing of the patternable materials described herein. Suitable polymers can include, for example, polycarbonates, polyimides, polyesters, polyalkenes, copolymers thereof and mixtures thereof. In general, it is desirable for the substrate to have a flat surface, especially for high resolution applications. However, in specific embodiments the substrate may possess substantial topography, where the resist coating is intended to fill or planarize features for particular patterning applications. Alternatively, using the



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vapor deposition methods described herein, existing topography and features may be conformally coated with organotin oxide hydroxide photo resist for particular patterning applications.

In general, any suitable solution coating process can be used to deliver the precursor solution to a substrate in addition to the vapor deposition processes disclosed herein. Suitable coating approaches can include, for example, spin coating, spray coating, dip coating, knife edge coating, printing approaches, such as inkjet printing and screen printing, and the like. Some of these coating approaches form patterns of coating material during the coating process, although the resolution available currently from printing or the like has a significantly lower level of resolution than available from radiation based patterning as described herein.

If patterning is performed using radiation, spin coating can be a desirable approach to cover the substrate relatively uniformly, although there can be edge effects. In some embodiments, a wafer can be spun at rates from about 500 rpm to about 10,000 rpm, in further embodiments from about 1000 rpm to about 7500 rpm and in additional embodiments from about 2000 rpm to about 6000 rpm. The spinning speed can be adjusted to obtain a desired coating thickness. The spin coating can be performed for times from about 5 seconds to about 5 minutes and in further embodiments from about 15 seconds to about 2 minutes. An initial low speed spin, e.g. at 50 rpm to 250 rpm, can be used to perform an initial bulk spreading of the composition across the substrate. A back side rinse, edge bead removal step or the like can be performed with water or other suitable solvent to remove any edge bead. A person or ordinary skill in the art will recognize that additional ranges of spin coating parameters within the explicit ranges above are contemplated and are within the present disclosure.

The thickness of the coating generally can be a function of the precursor solution concentration, viscosity and the spin speed for spin coating. For other coating processes, the thickness can generally also be adjusted through the selection of the coating parameters. In some embodiments, it can be desirable to use a thin coating to facilitate formation of small and highly resolved features in the subsequent patterning process. For example, the coating materials after drying can have an average thickness of no more than about 10 microns, in other embodiments no more than about 1 micron, in further embodiments no more than about 250 nanometers (nm), in additional embodiments from about 1 nanometers (nm) to about 50 nm, in other embodiments from about 2 nm to about 40 nm and in some embodiments from about 3 nm to about 25 nm. A person of ordinary skill in the art will recognize that additional ranges of thicknesses within the



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explicit ranges above are contemplated and are within the present disclosure. The thickness can be evaluated using non-contact methods of x-ray reflectivity and/or ellipsometry based on the optical properties of the film. In general, the coatings are relatively uniform to facilitate processing. In some embodiments, the variation in thickness of the coating varies by no more than ±50% from the average coating thickness, in further embodiments no more than ±40% and in additional embodiments no more than about ±25% relative to the average coating thickness. In some embodiments, such as high uniformity coatings on larger substrates, the evaluation of coating uniformity may be evaluated with a 1 centimeter edge exclusion, i.e., the coating uniformity is not evaluated for portions of the coating within 1 centimeter of the edge. A person of ordinary skill in the art will recognize that additional ranges within the explicit ranges above are contemplated and are within the present disclosure.

The coating process itself can result in the evaporation of a portion of the solvent since many coating processes form droplets or other forms of the coating material with larger surface areas and/or movement of the solution that stimulates evaporation. The loss of solvent tends to increase the viscosity of the coating material as the concentration of the species in the material increases. An objective during the coating process can be to remove sufficient solvent to stabilize the coating material for further processing. Reactive species may condense during coating or subsequent heating to forming a hydrolysate coating material.

In general, the coating material can be exposed to, and optionally heated in, the presence of atmospheric moisture prior to radiation exposure to hydrolyse the hydrolysable bonds to the metal in the precursor compositions, and/or further drive off solvent and promote densification of the coating material. The coating material following in situ hydrolysis may generally form a polymeric metal oxo-hydroxo network based on the binding oxo-hydroxo ligands to the metals in which the metals also have some alkyl ligands, or a molecular solid comprised of polynuclear metal oxo/hydroxo species with alkyl ligands.

The hydrolysis/solvent removal process may or may not be quantitatively controlled with respect to precise stoichiometry of the heated coating material and/or specific amounts of solvent remaining in the coating material. Additionally, the formulas and compositions expressed herein may contain some additional water, whether directly bound to Sn, or as hydrogen-bonded component of the network. Empirical evaluation of the resulting coating material properties generally can be performed to select processing conditions that are effective for the patterning



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process. While heating may not be needed for successful application of the process, it can be desirable to heat the coated substrate to speed the processing and/or to increase the reproducibility of the process and/or to facilitate vaporization of the hydrolysis by products, such as amines and/or alcohols. In embodiments in which heat is applied to remove solvent, the coating material can be heated to temperatures from about 45 °C to about 250 °C and in further embodiments from about 55 °C to about 225 °C. The heating for solvent removal can generally be performed for at least about 0.1 minute, in further embodiments from about 0.5 minutes to about 30 minutes and in additional embodiments from about 0.75 minutes to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges of heating temperature and times within the explicit ranges above are contemplated and are within the present disclosure. As a result of the heat treatment, hydrolysis, and densification of the coating material, the coating material can exhibit an increase in index of refraction and in absorption of radiation without significant loss of contrast.

Vapor Based Coating Formation

The development of precursor compounds comprising of both R-groups with substantially non-hydrolysable bonds to Sn, and X ligands with hydrolysable bonds to Sn has been exploited for the development of vapor phase deposition of radiation patternable organotin oxide hydroxide coatings. In particular, the relatively high vapor pressures and reactivity of many $R_nSnX_{(4-n)}$ compounds such as those listed in Table 1, make possible the use of vapor deposition methods for deposition of organotin oxide hydroxide thin-film photoresists. Through the introduction the hydrolysable precursors in the vapor phase in a reactor closed from the ambient atmosphere, the hydrolysis can be performed as part of the deposition process, i.e., a chemical vapor deposition. Potential vapor deposition methods include chemical vapor deposition (CVD), atomic layer deposition (ALD), and modifications thereof, many of which have previously been employed to deposit inorganic metal oxide and nitride films with metal alkylamide, alkoxide, and halide precursors, [1-4] including $SnO_2$ from $Sn(NMe_2)_4$.[5]. To perform the vapor deposition, generally one or more metal-containing precursors are reacted on or more with small molecule gas-phase reagents such as $H_2O$, $H_2O_2$, $O_3$, $O_2$, or $CH_3OH$, which serve as O and H sources for production of oxides and oxide hydroxides. If desired, physical vapor deposition approaches can also be performed in which the precursor compositions with ligands having hydrolysable bonds to Sn are deposited from the vapor phase and the bonds subsequently hydrolysed after coating formation,



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but for vapor phase processing, hydrolysis/oxidation during the deposition generally may be more efficient.

**TABLE 1**

| Compound | Vapor Pressure (torr) | Temperature (°C) |
|---|---|---|
| $^{t}BuSn(NEt_2)_3$ | **0.3** | **95** |
| $^{t}BuSn(NMe_2)_3$ | **0.3** | **55** |
| $^{t}BuSn(O^{t}Bu)3$ | **3.5** | **~82** |
| $^{i}PrSn(NMe_2)_3$ | **1.4** | **53** |
| $Sn(NEt_2)_4$ | **0.5** | **110** |
| $Sn(NMe_2)_4$ | **0.1** | **~54** |
| $Sn(O^{t}Bu)_4$ | **0.3** | **65** |
| $Sn(O^{t}Am)4$ | **2** | **120** |
| $MeSn(O^{t}Bu)_3$ | **0.1** | **~57** |
| $^{n}BuSn(O^{t}Bu)_3$ | **0.9** | **100** |
| $^{n}BuSn(NMe_2)_3$ | **0.05** | **80** |

In CVD methods, two or more reactant gases are generally mixed in the chamber in the vicinity of the substrate surface. Therefore, sufficient stability can be designed into the reaction conditions to control undesirable vapor-phase reactions and nucleation. ALD precursors, introduced separately and sequentially to the reaction chamber, typically react with chemisorbed co-precursor or decomposition products saturating the substrate surface. Desirable features of $R_nSnX_{(4-n)}$ precursors include, for example, sufficient volatility for vapor-phase transport in the system, thermal stability to prevent premature decomposition, and appropriate reactivity with co-precursors to produce the target product under prescribed process conditions. The pressure and temperature in the reaction chamber can be selected to control the reaction process.

In general, precursors with relatively low vapor pressures may be introduced using flow of vapor, aerosol, and/or direct liquid injection into a vaporization chamber. Flash evaporators can be used to introduce a controlled amount of precursor vapors into the reaction chamber to correspondingly control the reaction process in the chamber. The secondary reactant to drive hydrolysis/oxidation can be introduced through a separate inlet into the chamber. Commercial CVD apparatuses can be adapted for this use or specific equipment can be used. To facilitate deposition the substrate may be heated or may be cooled depending on the precursor properties. Inert gases such as $N_2$, Ar or the like may be used in appropriate capacities as carrier gases, purge gases, or pressure modulating gases in both sequential and continuous flow regimes.



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A range of $R_nSnX_{(4-n)}$ compounds where n = 0, 1, or 2, or combinations thereof, as demonstrated to produce organotin oxide hydroxide photoresists by hydrolysis in solution or in-situ hydrolysis as discussed herein, may also be suitable for vapor deposition of organotin oxide hydroxide photoresists with desirable properties. Useful X ligands include alkylamido and dialkylamido, chloro, alkoxo, or alkynido, siloxo, silylamido, disilylamido, aryloxo, azido, amidato, amidinato, or fluorinated analogues thereof in combination with hydrocarbyl R groups that include both straight-chain and branched-chain alkyl, cyclo-alkyl, aryl, alkenyl, alkynyl benzyl, and their fluorinated derivatives. Suitable precursors may include, for example, $(CH_3)_3CSn(NMe_2)_3$, $(CH_3)_2CHSn(NMe_2)_3$, $(CH_3)_2(CH_3CH_2)CSn(NMe_2)_3$, $(CH_2)_2CHSn(NMe_2)_3$, $CH_3Sn(NMe_2)_3$, $(CH_2)_3CHSn(NMe_2)_3$, $(CH_2)_4CHSn(NMe_2)_3$, $(C_6H_5)CH_2Sn(NMe_2)_3$, $(C_6H_5)(CH_3)CHSn(NMe_2)_3$, $(C_6H_5)(CH_3)CHSn(NMe_2)_3$, $(CH_3)_2(CN)CSn(NMe_2)_3$, $(CH_3)(CN)CHSn(NMe_2)_3$, or $(CH_3)_3CSn(O^tBu)_3$, $(CH_3)_2CHSn(O^tBu)_3$, $(CH_3)_2(CH_3CH_2)CSn(O^tBu)_3$, $(CH_2)_2CHSn(O^tBu)_3$, $CH_3Sn(O^tBu)_3$, $(CH_2)_3CHSn(O^tBu)_3$, $(CH_2)_4CHSn(O^tBu)_3$, $(C_6H_5)CH_2Sn(O^tBu)_3$, $(C_6H_5)(CH_3)CHSn(O^tBu)_3$, $(C_6H_5)(CH_3)CHSn(O^tBu)_3$, $(CH_3)_2(CN)CSn(O^tBu)_3$, $(CH_3)(CN)CHSn(O^tBu)_3$ or others known to those skilled in the art. Additionally, one or more vapor-phase precursor compounds with = 0 such as $Sn(NMe2)_4$, or $Sn(OtBu)_4$ may be reacted sequentially or concurrently with the organotin-containing precursors to alter the R:Sn ratio in the film to achieve desirable patterning attributes.

Thus hydrolysable compounds can be directly deposited via vapor phase hydrolysis as the corresponding alkyl tin oxide hydroxide coating, which can then be appropriately patterned. Advantages of vapor deposition may include, for example, reduced resist film defect density, improved thickness and compositional uniformity, as well as conformal and side-wall coating of substrate topography.

A vapor deposition method for direct deposition of organotin oxide hydroxides with the general formulae $RSnO_{(3/2-x/2)}(OH)_x$ ($0 < x < 3$) and can comprise in some embodiments an inert gas source connected to separate heated bubbler vessels. A first vessel contains a liquid alkyl tris(dialkylamido)tin compound of sufficient vapor pressure to produce suitable partial pressures for transport in the inert carrier gas. A second vessel contains liquid water or a water/alcohol mix. By controlling vessel temperatures, inert gas flow rate, and total system pressure, vapor-phase $RSn(NR'_2)_3$ and $H_2O$ are transported independently to a chamber evacuated to < ~ 0.1 Torr, more generally from about 0.01 Torr to about 25 Torr, and in some atmospheric pressure CVD pressures



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> 25 Torr. The precursors therein mix and react to deposit an organotin oxide hydroxide on the substrate. The substrate and/or chamber and/or vapors may be heated to promote reaction and deposition on the substrate surface. Reaction temperatures below about 200 °C can be desirable in some embodiments to limit de-alkylation of the tin compound and/or to prevent excessive dehydration and condensation of the oxide hydroxide. Such oxide hydroxide formation may reduce photoresist dissolution-rate contrast between exposed and unexposed regions. The gases, the chamber walls and/or the substrate can be heated in various embodiments, generally to a temperature from about 40°C to about 175°C and in further embodiments from about 50°C to about 160°C. A person of ordinary skill in the art will recognize that additional ranges of pressure and temperature within the explicit ranges above are contemplated and re within the present disclosure. In a similar, related process, pulses of water vapor, inert gas, and $RSn(NR'_2)_3$ of appropriate duration and frequency may be alternated to enable a surface-limited adsorption and reaction regime common to ALD methodologies.

Patterning and Patterned Structure Properties

Following hydrolysis, condensation, and drying, the coating material can be finely patterned using radiation. As noted above, the composition of the precursor solution and thereby the corresponding coating material can be designed for sufficient absorption of a desired form of radiation. The absorption of the radiation results in energy that can break the bonds between the metal and alkyl ligands so that at least some of the alkyl ligands are no longer available to stabilize the material. Radiolysis products, including alkyl ligands or fragments may diffuse out of the film, or not, depending on process variables and the identity of such products. With the absorption of a sufficient amount of radiation, the exposed coating material condenses, i.e. forms an enhanced metal oxo-hydroxo network, which may involve additional water absorbed from the ambient atmosphere. The radiation generally can be delivered according to a selected pattern. The radiation pattern is transferred to a corresponding pattern or latent image in the coating material with irradiated areas and un-irradiated areas. The irradiated areas comprise chemically altered coating material, and the un-irradiated areas comprise generally the as-formed coating material. As noted below, very smooth edges can be formed upon development of the coating material with the removal of the un-irradiated coating material or alternatively with selective removal of the irradiated coating material.



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Radiation generally can be directed to the coated substrate through a mask or a radiation beam can be controllably scanned across the substrate. In general, the radiation can comprise electromagnetic radiation, an electron-beam (beta radiation), or other suitable radiation. In general, electromagnetic radiation can have a desired wavelength or range of wavelengths, such as visible radiation, ultraviolet radiation or x-ray radiation. The resolution achievable for the radiation pattern is generally dependent on the radiation wavelength, and a higher resolution pattern generally can be achieved with shorter wavelength radiation. Thus, it can be desirable to use ultraviolet light, x-ray radiation or an electron-beam to achieve particularly high resolution patterns.

Following International Standard ISO 21348 (2007) incorporated herein by reference, ultraviolet light extends between wavelengths of greater than or equal 100 nm and less than 400 nm. A krypton fluoride laser can be used as a source for 248 nm ultraviolet light. The ultraviolet range can be subdivided in several ways under accepted Standards, such as extreme ultraviolet (EUV) from greater than or equal 10 nm to less than 121 nm and far ultraviolet (FUV) from greater than or equal to 122 nm to less than 200 nm A 193 nm line from an argon fluoride laser can be used as a radiation source in the FUV. EUV light has been used for lithography at 13.5 nm, and this light is generated from a Xe or Sn plasma source excited using high energy lasers or discharge pulses. Soft x-rays can be defined from greater than or equal 0.1 nm to less than 10 nm.

The amount of electromagnetic radiation can be characterized by a fluence or dose which is defined by the integrated radiative flux over the exposure time. Suitable radiation fluences can be from about 1 $mJ/cm^2$ to about 150 $mJ/cm^2$, in further embodiments from about 2 $mJ/cm^2$ to about 100 $mJ/cm^2$, and in further embodiments from about 3 $mJ/cm^2$ to about 50 $mJ/cm^2$. A person of ordinary skill in the art will recognize that additional ranges of radiation fluences within the explicit ranges above are contemplated and are within the present disclosure.

With electron-beam lithography, the electron beam generally induces secondary electrons which generally modify the irradiated material. The resolution can be a function at least in part of the range of the secondary electrons in the material in which a higher resolution is generally believed to result from a shorter range of the secondary electrons. Based on high resolution achievable with electron-beam lithography using the inorganic coating materials described herein, the range of the secondary electrons in the inorganic material is limited. Electron beams can be characterized by the energy of the beam, and suitable energies can range from about 5 V to about



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200 kV (kilovolt) and in further embodiments from about 7.5 V to about 100 kV. Proximity-corrected beam doses at 30 kV can range from about 0.1 microcoulombs per centimeter squared to about 5 millicoulombs per centimeter squared ($mC/cm^2$), in further embodiments from about 0.5 $\mu C/cm^2$ to about 1 $mC/cm^2$ and in other embodiments from about 1 $\mu C/cm^2$ to about 100 $\mu C/cm^2$. A person of ordinary skill in the art can compute corresponding doses at other beam energies based on the teachings herein and will recognize that additional ranges of electron beam properties within the explicit ranges above are contemplated and are within the present disclosure.

Based on the design of the coating material, there can be a large contrast of material properties between the irradiated regions that have condensed coating material and the un-irradiated, coating material with substantially intact organic ligands. It has been found that the contrast at a given dose can be improved with a post-irradiation heat treatment, although satisfactory results can be achieved in some embodiments without post-irradiation heat treatment. The post-exposure heat treatment seems to anneal the irradiated coating material to increase its condensation without significantly condensing the un-irradiated regions of coating material based on thermal breaking of the organic ligand-metal bonds. For embodiments in which a post irradiation heat treatment is used, the post-irradiation heat treatment can be performed at temperatures from about 45 °C to about 250 °C, in additional embodiments from about 50 °C to about 190 °C and in further embodiments from about 60 °C to about 175 °C. The post exposure heating can generally be performed for at least about 0.1 minute, in further embodiments from about 0.5 minutes to about 30 minutes and in additional embodiments from about 0.75 minutes to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges of post-irradiation heating temperature and times within the explicit ranges above are contemplated and are within the present disclosure. This high contrast in material properties further facilitates the formation of high-resolution lines with smooth edges in the pattern following development as described in the following section.

Following exposure with radiation, the coating material is patterned with irradiated regions and un-irradiated regions. Referring to Figs. 1 and 2, a patterned structure 100 is shown comprising a substrate 102, a thin film 103 and patterned coating material 104. Patterned coating material 104 comprises regions 110, 112, 114, 116 of irradiated coating material and uncondensed regions 118, 120, 122 of un-irradiated coating material. The pattern formed by condensed regions



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110, 112, 114, 116 and uncondensed regions 118, 120, 122 represent a latent image into the coating material, and the development of the latent image is discussed in the following section.

Development and Patterned Structure

Development of the image involves the contact of the patterned coating material including the latent image to a developer composition to remove either the un-irradiated coating material to form the negative image or the irradiated coating to form the positive image. Using the resist materials described herein, effective negative patterning or positive patterning generally can be performed with desirable resolution using appropriate developing solutions, and generally based on the same coating. In particular, the irradiated regions are at least partially condensed to increase the metal oxide character so that the irradiated material is resistant to dissolving by organic solvents while the un-irradiated compositions remain soluble in the organic solvents. Reference to a condensed coating material refers to at least partial condensation in the sense of increasing the oxide character of the material relative to an initial material. On the other hand, the un-irradiated material is less soluble in weak aqueous bases or acids due to the hydrophobic nature of the material so that aqueous bases can be used to remove the irradiated material while maintaining the non-irradiated material for positive patterning.

The coating compositions with organic-stabilization ligands produce a material that is inherently hydrophobic. Irradiation to break at least some of the organic metal bonds converts the material into a less hydrophobic, i.e., more hydrophilic, material. This change in character provides for a significant contrast between the irradiated coating and non-irradiated coating that provides for the ability to do both positive tone patterning and negative tone patterning with the same resist composition. Specifically, the irradiated coating material condenses to some degree into a more of a metal oxide composition; however, the degree of condensation generally is moderate without significant heating so that the irradiated material is relatively straightforward to develop with convenient developing agents.

With respect to negative tone imaging, referring to Figs. 3 and 4, the latent image of the structure shown in Figs. 1 and 2 has been developed through contact with a developer to form patterned structure 130. After development of the image, substrate 102 is exposed along the top surface through openings 132, 134, 135. Openings 132, 134, 135 are located at the positions of



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uncondensed regions 118, 120, 122 respectively. With respect to positive tone imaging, referring to Figs. 5 and 6, the latent image of the structure shown in Figs. 1 and 2 has been developed to form patterned structure 140. Patterned structure 140 has the conjugate image of patterned structure 130. Patterned structure 140 has substrate 102 exposed at positions of irradiated regions 110, 112, 114, 116 that are developed to form openings 142, 144, 146, 148.

For the negative tone imaging, the developer can be an organic solvent, such as the solvents used to form the precursor solutions. In general, developer selection can be influenced by solubility parameters with respect to the coating material, both irradiated and non-irradiated, as well as developer volatility, flammability, toxicity, viscosity and potential chemical interactions with other process material. In particular, suitable developers include, for example, aromatic compounds (e.g., benzene, xylenes, toluene), esters (e.g., propylene glycol monomethyl ester acetate, ethyl acetate, ethyl lactate, n-butyl acetate, butyrolactone), alcohols (e.g., 4-methyl-2-pentanol, 1-butanol, isopropanol, 1-propanol, methanol), ketones (e.g., methyl ethyl ketone, acetone, cyclohexanone, 2-heptanone, 2-octanone), ethers (e.g., tetrahydrofuran, dioxane, anisole) and the like. The development can be performed for about 5 seconds to about 30 minutes, in further embodiments from about 8 seconds to about 15 minutes and in addition embodiments from about 10 seconds to about 10 minutes. A person of ordinary skill in the art will recognize that additional ranges within the explicit ranges above are contemplated and are within the present disclosure.

For positive tone imaging, the developer generally can be aqueous acids or bases. In some embodiments, aqueous bases can be used to obtain sharper images. To reduce contamination from the developer, it can be desirable to use a developer that does not have metal atoms. Thus, quaternary ammonium hydroxide compositions, such as tetraethylammonium hydroxide, tetrapropylammonium hydroxide, tetrabutylammonium hydroxide or combinations thereof, are desirable as developers. In general, the quaternary ammonium hydroxides of particular interest can be represented with the formula $R_4NOH$, where R = a methyl group, an ethyl group, a propyl group, a butyl group, or combinations thereof. The coating materials described herein generally can be developed with the same developer commonly used presently for polymer resists, specifically tetramethyl ammonium hydroxide (TMAH). Commercial TMAH is available at 2.38 weight percent, and this concentration can be used for the processing described herein. Furthermore, mixed quaternary tetraalkyl- ammonium hydroxides can be used. In general, the



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developer can comprise from about 0.5 to about 30 weight percent, in further embodiments from about 1 to about 25 weight percent and in other embodiments from about 1.25 to about 20 weight percent tetra-alkylammonium hydroxide or similar quaternary ammonium hydroxides. A person of ordinary skill in the art will recognize that additional ranges of developer concentrations within the explicit ranges above are contemplated and are within the present disclosure.

In addition to the primary developer composition, the developer can comprise additional compositions to facilitate the development process. Suitable additives include, for example, dissolved salts with cations selected from the group consisting of ammonium, d-block metal cations (hafnium, zirconium, lanthanum, or the like), f-block metal cations (cerium, lutetium or the like), p-block metal cations (aluminum, tin, or the like), alkali metals (lithium, sodium, potassium or the like), and combinations thereof, and with anions selected from the group consisting of fluoride, chloride, bromide, iodide, nitrate, sulfate, phosphate, silicate, borate, peroxide, butoxide, formate, oxalate, ethylenediamine-tetraacetic acid (EDTA), tungstate, molybdate, or the like and combinations thereof. Other potentially useful additives include, for example, molecular chelating agents, such as polyamines, alcohol amines, amino acids, carboxylic acids, or combinations thereof. If the optional additives are present, the developer can comprise no more than about 10 weight percent additive and in further embodiments no more than about 5 weight percent additive. A person of ordinary skill in the art will recognize that additional ranges of additive concentrations within the explicit ranges above are contemplated and are within the present disclosure. The additives can be selected to improve contrast, sensitivity and line width roughness. The additives in the developer can also inhibit formation and precipitation of metal oxide particles.

With a weaker developer, e.g., lower concentration aqueous developer, diluted organic developer or compositions in which the coating has a lower development rate, a higher temperature development process can be used to increase the rate of the process. With a stronger developer, the temperature of the development process can be lower to reduce the rate and/or control the kinetics of the development. In general, the temperature of the development can be adjusted between the appropriate values consistent with the volatility of the solvents. Additionally, developer with dissolved coating material near the developer-coating interface can be dispersed with ultrasonication during development.



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The developer can be applied to the patterned coating material using any reasonable approach. For example, the developer can be sprayed onto the patterned coating material. Also, spin coating can be used. For automated processing, a puddle method can be used involving the pouring of the developer onto the coating material in a stationary format. If desired spin rinsing and/or drying can be used to complete the development process. Suitable rinsing solutions include, for example, ultrapure water, methyl alcohol, ethyl alcohol, propyl alcohol and combinations thereof for negative patterning and ultrapure water for positive patterning. After the image is developed, the coating material is disposed on the substrate as a pattern.

After completion of the development step, the coating materials can be heat treated to further condense the material and to further dehydrate, densify, or remove residual developer from the material. This heat treatment can be particularly desirable for embodiments in which the oxide coating material is incorporated into the ultimate device, although it may be desirable to perform the heat treatment for some embodiments in which the coating material is used as a resist and ultimately removed if the stabilization of the coating material is desirable to facilitate further patterning. In particular, the bake of the patterned coating material can be performed under conditions in which the patterned coating material exhibits desired levels of etch selectivity. In some embodiments, the patterned coating material can be heated to a temperature from about 100ºC to about 600ºC, in further embodiments from about 175ºC to about 500ºC and in additional embodiments from about 200ºC to about 400ºC. The heating can be performed for at least about 1 minute, in other embodiment for about 2 minutes to about 1 hour, in further embodiments from about 2.5 minutes to about 25 minutes. The heating may be performed in air, vacuum, or an inert gas ambient, such as Ar or $N_2$. A person of ordinary skill in the art will recognize that additional ranges of temperatures and time for the heat treatment within the explicit ranges above are contemplated and are within the present disclosure. Likewise, non-thermal treatments, including blanket UV exposure, or exposure to an oxidizing plasma such as $O_2$ may also be employed for similar purposes.

With conventional organic resists, structures are susceptible to pattern collapse if the aspect ratio, height divided by width, of a structure becomes too large. Pattern collapse can be associated with mechanical instability of a high aspect ratio structure such that forces, e.g., surface tension, associated with the processing steps distort the structural elements. Low aspect ratio structures are more stable with respect to potential distorting forces. With the patternable coating materials



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described herein, due to their high etch resistance and the ability to process effectively the structures with thinner layers of coating material, improved patterning can be accomplished without the need for high aspect ratio patterned coating material. Thus, very high resolution features have been formed without resorting to high aspect ratio features in the patterned coating material.

The resulting structures can have sharp edges with very low line-width roughness. In particular, in addition to the ability to reduce line-width roughness, the high contrast also allows for the formation of small features and spaces between features as well as the ability to form very well resolved two-dimensional patterns (e.g., sharp corners). Thus, in some embodiments, adjacent linear segments of neighboring structures can have an average pitch (half-pitch) of no more than about 60 nm (30 nm half-pitch), in some embodiments no more than about 50 nm (25 nm half-pitch) and in further embodiments no more than about 34 nm (17 nm half-pitch). Pitch can be evaluated by design and confirmed with scanning electron microscopy (SEM), such as with a top-down image. As used herein, pitch refers to the spatial period, or the center-to-center distances of repeating structural elements, and as generally used in the art a half-pitch is a half of the pitch. Feature dimensions of a pattern can also be described with respect to the average width of the feature, which is generally evaluated away from corners or the like. Also, features can refer to gaps between material elements and/or to material elements. In some embodiments, average widths can be no more than about 25 nm, in further embodiments no more than about 20 nm, and in additional embodiments no more than about 15 nm. Average line-width roughness can be no more than about 5 nm, in some embodiments no more than about 4.5 nm and in further embodiments from about 2.5 nm to about 4 nm. Evaluating line-width roughness is performed by analysis of top-down SEM images to derive a $3\sigma$ deviation from the mean line-width. The mean contains both high-frequency and low-frequency roughness, i.e., short correlation lengths and long correlation lengths, respectively. The line-width roughness of organic resists is characterized primarily by long correlation lengths, while the present organometallic coating materials exhibit significantly shorter correlation lengths. In a pattern transfer process, short correlation roughness can be smoothed during the etching process, producing a much higher fidelity pattern. A person of ordinary skill in the art will recognize that additional ranges of pitch, average widths and line-width roughness within the explicit ranges above are contemplated and are within the present disclosure. Based on these processes, the patterning can be adapted to the formation of various



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devices such as electronic integrated circuits, generally through the repeated patterning process to form appropriately layered structures, such as transistors or other components.

Wafer throughput is a substantially limiting factor for implementation of EUV lithography in high-volume semiconductor manufacturing, and is directly related to the dose required to pattern a given feature. However, while chemical strategies exist to reduce imaging dose, a negative correlation between the imaging dose required to print a target feature, and feature size uniformity (such as LWR) is commonly observed for EUV photoresists at feature sizes and pitches < 50 nm, thereby limiting final device operability and wafer yields. However, the precursors, precursor solutions, and photoresist film described herein have been found avoid this limitation and enable reduced EUV imaging dose without concomitant increase in LWR over a substantial dose range. By utilizing precursor solutions comprising blends of $R_nSnX_{(4-n)}$ and $SnX_4$ hydrolyzed in-situ during coating and bake steps as detailed in the following examples, a dose reduction of > 30 % with equivalent or lower LWR is observed relative to photoresist films derived from a mixture of pre-hydrolyzed organotin oxide hydroxide compounds (prepared as described in the '839 application) when processed under similar conditions.

Based on the improved process described in the Examples below, the improved properties of the coating material can be correspondingly characterized. For example, a substrate comprising an inorganic semiconductor layer and a radiation sensitive coating material along a surface can be subjected to patterning with EUV light at a wavelength of 13.5nm in a pattern of 16-nm lines on a 32-nm pitch. To evaluate the coating material the dose to achieve a critical dimension of 16 nm can be evaluated along with the achievable line width roughness (LWR). The improved coatings can achieve a critical dimension of 16 nm with a dose from about 8 mJ/cm2 to about 25 mJ/cm2 with a line width roughness of no more than about 4 nm. SuMMIT analysis software (EUV Technology Corporation) was used to extract resist critical dimension (CD) and line-width-roughness (LWR) from SEM images.

In further embodiments, the improved patterning capability can be expressed in terms of the dose-to-gel value. A structure comprising a substrate and a radiation sensitive coating comprising an alkyl metal oxide hydroxide can have a dose-to-gel ($D_g$) of no more than about 6.125 mJ/cm$^2$ and in further embodiments from about 5.5 mJ/cm$^2$ to about 6 mJ/cm$^2$. Evaluation of dose-to-gel is explained in the Examples below.



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## EXAMPLES

Example 1 - Preparation of Precursors for In Situ Hydrolysis

This example is directed to the formation of organotin amido compounds that are suitable for in situ hydrolysis to form coatings of organotin oxide hydroxides.

The precursor, tert-butyl tris(diethylamido)tin, ($tBuSn(NEt_2)_3$, hereinafter P-**1**) was synthesized after the method reported in Hänssgen, D.; Puff, H.; Beckerman, N. *J. Organomet. Chem.* 1985, **293**, 191, incorporated herein by reference. Tetrakis(diethylamido)tin and tBuLi reagents were purchased from Sigma-Aldrich and used without further purification. Reagents were reacted in stoichiometric quantities at -78 ºC in anhydrous hexanes (Sigma-Aldrich). Precipitated lithium amide salts were removed via filtration and the product rinsed with hexanes, and the solvent stripped under vacuum. The crude product was distilled under vacuum (~0.3 torr at 95 °C).

A solution was prepared in an Ar-filled glove box by weighing 1.177 g (3.0 mmol) of P-**1** in a 30-mL amber glass vial and then adding 15 mL of anhydrous 4-methyl-2-pentanol (dried 24 h over 3A molecular sieves). The vial was capped and agitated. This stock solution was diluted 1 part in 2.85 parts (volume) anhydrous 4-methyl-2-pentanol prior to coating.

The precursor, isopropyl tris(dimethylamido)tin, ($iPrSn(NMe_2)_3$, hereinafter P- **2**) was synthesized under inert atmosphere and subsequently dissolved in toluene to form a resist precursor solution. Under argon, a 1-L Schlenk-adapted round bottom flask was charged with $LiNMe_2$ (81.75 g, 1.6 mol, Sigma-Aldrich) and anhydrous hexanes (700 mL, Sigma-Aldrich) to form a slurry. A large stir bar was added and the vessel sealed. An addition funnel under positive



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argon pressure was charged with $iPrSnCl_3$ (134.3 g, 0.5 mol, Gelest) via syringe and then attached to the reaction flask. The reaction flask was cooled to -78 °C and the $iPrSnCl_3$ was then added dropwise over a period of 2 hours. The reaction was warmed to room temperature overnight while stirring. The reaction produces a by-product solid. After settling, the solid was filtered under positive argon pressure through an in-line cannula filter. The solvent was then removed under vacuum, and the residue distilled under reduced pressure (50-52 °C, 1.4 mmHg) to give a pale yellow liquid (110 g, 75 % yield). $^{1}H$ and $^{119}Sn$ NMR spectra of the distillate in a $C_6D_6$ solvent were collected on a Bruker DPX-400 (400 MHz, BBO probe) spectrometer. Observed $^{1}H$ resonances (s, 2.82 ppm, $-N(CH_3)_2$; d 1.26 ppm, $-CH_3$; m, 1.60 ppm, -CH) match the predicted spectrum for $iPrSn(NMe_2)_3$. The primary $^{119}Sn$ resonance at -65.4 ppm is consistent with a major product having a single tin environment; the chemical shift is comparable to reported monoalkyl tris(dialkylamido)tin compounds.

A solution was prepared in an Ar-filled glove box by weighing 0.662 g (2.25 mmol) of P-**2** in a 30 mL amber glass vial. A 15-mL volume of anhydrous toluene (dried 24 h over 3A molecular sieves) were then added to make a stock solution (SOL-**2**). The vial was then capped and agitated. This stock solution was diluted 1 part in 3 parts (volume) anhydrous toluene prior to coating.

Example 2 - Patterning of In Situ Hydrolysed Photoresist Coatings

This example demonstrates the successful in situ hydrolysis of coatings formed from the compositions of Example 1 and the subsequent EUV patterning.

Thin films were deposited on silicon wafers (100-mm diameter) with a native-oxide surface. The Si wafers were treated with a hexamethyldisilazane (HMDS) vapor prime prior to deposition of the amido precursor. Solutions of P-**1** in 4-methyl-2-pentanol were spin-coated on substrates in air at 1500 rpm and baked on a hotplate in air for 2 min at 100 °C to evaporate residual solvent and volatile hydrolysis products. Film thickness following coating and baking was measured via ellipsometry to be ~31 nm.

The coated substrates were exposed to extreme ultraviolet radiation (Lawrence Berkeley National Laboratory Micro Exposure Tool). A pattern of 17-nm lines on a 34-nm pitch was projected onto the wafer using 13.5-nm wavelength radiation, dipole illumination, and a numerical aperture of 0.3. The patterned resists and substrates were then subjected to a post-exposure bake



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(PEB) on a hotplate for 2 min at 170 °C in air. The exposed film was then dipped in 2-heptanone for 15 seconds, then rinsed an additional 15 seconds with the same developer to form a negative tone image, i.e., unexposed portions of the coating were removed. A final 5-min hotplate bake at 150 °C in air was performed after development. Fig. 7 exhibits an SEM image of 16.7-nm resist lines produced from P-**1** cast from 4-methyl-2-pentanol on a 34-nm pitch at a EUV dose of 56mJ/cm$^2$ with a calculated LWR of 2.6 nm.

A second film was cast from the solution of P-**2** in toluene using identical coating and bake conditions as above. A linear array of 50 circular pads ~500 um in diameter were projected on the wafer using EUV light. Pad exposure times were modulated to step the delivered EUV dose for each pad from 1.38 to 37.99 mJ cm$^{-2}$ with an exponential 7% step. Following the PEB, development, and final bake processes described above, a J. A. Woollam M-2000 Spectroscopic ellipsometer was used to measure the residual thickness of the exposed pads. The thickness of each pad is plotted as a function of delivered EUV dose in Fig. 8. The resulting curve clearly illustrates the negative tone contrast generated on exposure, as residual film thickness starts at ~0 and reaches a maximum (dose to gel, $D_g$) at approximately 15.8 mJ cm$^{-2}$ delivered dose.

Example 3 - Evaluation of In Situ Hydrolyzed Coatings

This example provides evidence of the substantially complete hydrolysis through the in situ hydrolysis approach for precursors having hydrolysable bonds to Sn.

For comparison, isopropyl tin oxide hydroxide was prepared for formation of a radiation sensitive coating. A solid hydrolysate of isopropyltin trichloride ($iPrSnCl_3$, Gelest) was prepared by rapidly adding 6.5 g (24 mmol) of isopropyltin trichloride to 150 mL of 0.5-M NaOH (aq) with vigorous stirring, immediately producing a precipitate. The resulting mixture was stirred for 1 h at room temperature and then filtered with suction through no. 1 filter paper (Whatman). The retained solids were washed three times with ~ 25-mL portions of DI $H_2O$ and then dried for 12 h under vacuum (~5 torr) at room temperature. Elemental analyses (18.04% C, 3.76% H, 1.38% Cl; Microanalysis, Inc.; Wilmington, DE) of the dried powder, indicated substantial removal of chloride ions upon hydrolysis of isopropyltin trichloride and an approximate hydrolysate empirical formula of $^{i}PrSnO_{(3/2-(x/2))}(OH)_x$ where $x \approx 1$ (hereinafter P-**3**). (Calculated for $C_3H_8O_2Sn$: 18.50% C, 4.14% H, 0.00% Cl).



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A solution of the solid hydrolysate $iPrSnO_{(3/2-(x/2))}(OH)_{x\ was}$ prepared by dissolving the dried powder in 2-butanone to a total Sn concentration of ~0.25 M. A solution of P-**2** in anhydrous 4-methyl-2-pentanol was prepared by adding 1.47 g (5.0 mmol) P-**2** to 10 mL 4-methyl-2-pentanol as previously described. Thin films were cast by spin coating each solution on a 25 mm x 25 mm Si wafer. The solution of P-**2** was coated at 2000 rpm, while the solution of P-3 was coated at 1250 rpm. Following coating, each film was baked at 150 °C in air for 2 minutes. The alcohol may react with P-**2** to form alkoxide ligands, but in any case, if alkoxide ligands form, these seem to be further hydrolysed to form the oxide hydroxide composition.

Fourier Transform Infrared (FTIR) transmission spectra of the two films were collected on a Nicolet 6700 spectrometer using a bare substrate as a background. Representative spectra for the two films (Fig. 8) are qualitatively very similar, suggesting substantial hydrolysis and elimination of amido/alkoxo ligands from the solution of P-**2** and deposition of the oxide hydroxide in both cases. In particular, the regions from 2800-3000 $cm^{-1}$ and 1100-1500 $cm^{-1}$ are almost identical, indicating a similar $CH_x$ composition between the two films, as well as the absence of substantial C-N species.

Example 4 - Preparation of Hydrolysable Precursors with Tetrakis-dialkylamido or -tert-butoxo tin Compounds

This example describes formation of mixed hydrolysable precursor compounds to provide for control of the stoichiometry of radiation sensitive ligands relative to metal in the radiation sensitive coatings.

Tert-butyl tris(diethylamido)tin was synthesized as described in Example 1. Tetrakis(dimethylamido)tin, ($Sn(NMe_2)_4$, FW=295.01) was purchased from Sigma-Aldrich and used without further purification.

Tin (IV) tert-butoxide, ($Sn(O^tBu)_4$, FW = 411.16, hereinafter P-**5**) was prepared after the method of Hampden-Smith et al. *Canadian Journal of Chemistry*, 1991, **69**, 121., incorporated herein by reference: Stannous chloride (152 g / 0.8 mol) and pentane (1 L) were added to a 3-L oven-dried round-bottom flask equipped with a magnetic stir-bar and purged with nitrogen. A 1-L pressure-equalizing addition funnel fitted with a nitrogen pressure inlet was charged with diethylamine (402 mL / 3.9 mol) and pentane (600 mL) and then attached to the flask, and the flask submerged in an ice bath. The amine solution was then added dropwise such that a gentle



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reflux was maintained. Upon completion of the amine addition, 2-methyl-2-propanol (290 g / 3.9 mol) in pentane (50 mL) was added to the addition funnel and thence dropwise to the flask. After stirring for 18 hours, the slurry was transferred into an air-free fritted filter flask and precipitated salts removed. The solvent was removed under reduced pressure and the target compound distilled (B.P. = 60-62 C @ 1 torr). $^{1}H$ NMR ($C_6D_6$): 1.45 ppm (s); $^{119}Sn$ NMR ($C_6D_6$): -371.4 ppm (s).

Stock solutions of P-**1** ($^{t}BuSn(NEt_2)_3$, hereinafter S-**1**), P-**4** ($Sn(NMe_2)_4$, hereinafter S-**2**), and P-**5** ($Sn(O^{t}Bu)_4$, hereinafter S-**3**) were prepared by transferring each of the corresponding compounds via cannula into separate flasks containing anhydrous 4-methyl-2-pentanol (dried 24 h over 4A molecular sieves). Additional dry 4-methyl-2-pentanol was then added to dilute the solutions to 0.25 M (Sn) final concentration.

A further stock solution, S-**4,** was prepared by cannulating 41 g of P-**1** into a round bottom flask immersed in an iso-propanol / dry ice bath and containing 250 mL of methanol while stirring on a magnetic stir plate. After the transfer of the $^{t}BuSn(NEt_2)_3$ aliquot, the flask containing the mixture was removed from the ice bath and allowed to reach room temperature. Next, the flask containing the mixture was brought to 50 °C in a water bath attached to a rotary evaporator and the solvent stripped at reduced pressure (10 mtorr) until solvent evaporation was substantially complete and a viscous yellow oil obtained. Finally, the yellow oil was dissolved in 1.0 L of 4-methy-2-pentanol. The resulting solution was determined to have a molarity of 0.097 M [Sn] based on the residual mass of the solution following solvent evaporation and subsequent thermal decomposition of the residual solids to $SnO_2$.

Precursor coating solutions CS-**a,** CS-**b**, and CS-**c** were prepared by mixing stock solution S-**1** with S-**2** in 0, 5:1, and 9:1 volume ratios to produce coating solutions where 0 (**a**), 10 (**b**), and 20 (**c**) mol % of the total Sn concentration in the mixture was derived from $Sn(NMe_2)_4$. These solutions were then further diluted with 4-methyl-2-pentanol to 0.070 M (total Sn) prior to spin coating. For example, to prepare 200 mL of CS-**b,** 5.6 mL of the stock solution prepared from $Sn(NMe_2)_4$ (S-**2**) was added to 50.4 mL of the solution prepared from $^{t}BuSn(NEt_2)_3$ (S-**1**), mixed vigorously, and diluted to 200 mL total volume with dry 4-methyl-2-pentanol. A summary of precursor coating solutions, concentrations, and compositions is presented in Table 2**.**

Precursor coating solutions CS-**e-h** were prepared with a total Sn concentration of 0.044 M by mixing stock solution S-**4** with stock solutions S-**2** and S-**3** in appropriate volume ratios such that 10 and 20 mol % of the total Sn concentration was derived from $Sn(NMe_2)_4$ (CS-**e**, **CS-f,**



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respectively), and $Sn(O^tBu)_4$ (CS-**g**, CS-**h**) and diluting with dry 4-methyl-2-pentanol. Precursor coating solution CS-**d** was prepared by directly diluting stock solution S-**4** with dry 4-methyl-2-pentanol to a final concentration of 0.042 M Sn. As an example, 200 mL of precursor coating solution CS-**e** is prepared by mixing 72.6 mL of S-**4** with 7.04 mL of S-**3,** and diluting to 200 mL total volume with dry 4-methyl-2-pentanol.

**TABLE 2**

| Precursor Coating Solution | $^t$Bu-Sn Stock Solution | Total Conc. [Sn] (M) | mol% Sn from $Sn(NMe)_4$ | mol% Sn from $Sn(O^tBu)_4$ |
|---|---|---|---|---|
| **a** | 1 | 0.070 | 0 | 0 |
| **b** | 1 | 0.070 | 10 | 0 |
| **c** | 1 | 0.070 | 20 | 0 |
| **d** | 4 | 0.042 | 0 | 0 |
| **e** | 4 | 0.044 | 10 | 0 |
| **f** | 4 | 0.044 | 20 | 0 |
| **g** | 4 | 0.044 | 0 | 10 |
| **h** | 4 | 0.044 | 0 | 20 |

Precursor coating solution CS-**i** was prepared by mixing a methanol solution containing a pre-hydrolysed t-butyl tin oxide hydroxide hydrolysate with a 4-methyl-2-pentanol solution of a prehydrolysed i-propyl tin oxide hydroxide hydrolysate, and diluting the resulting mixture to 0.03 M [Sn] with pure solvents as described in the '839 application. The resulting solutions are characterized as a blend of $^i$PrSnO$_{(3/2-(x/2))}$(OH)$_x$ and $^t$BuSnO$_{(3/2-(x/2))}$(OH)$_x$ hydrolysates, where the fraction of t-BuSnO$_{(3/2-(x/2))}$(OH)$_x$ is 40 % relative to the total moles of Sn.

Example 5 - Patterning with Engineered Coatings with Selected Degree of Radiation Sensitive Ligands

This example presents results obtain by patterning of coatings formed with the coating solutions prepared as described in Example 4 demonstrating improved patterning with lower radiation doses.



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Tert-butyltin oxide hydroxide photoresist films were deposited from precursor coating solutions from Example 4 prepared from $^{t}BuSn(NEt_2)_3$ and, for some coating solutions, $Sn(NMe_2)_4$ or $Sn(O^{t}Bu)_4$, and then exposed with EUV radiation. Thin films for EUV contrast curves were deposited on silicon wafers (100-mm diameter) with a native-oxide surface. The Si wafers were treated with a hexamethyldisilazane (HMDS) vapor prime prior to deposition. Precursor coating solutions CS-**a**, CS-**b**, and CS-**c** (0.070 M Sn) prepared according to specification in Table 1 from $^{t}BuSn(NEt_2)_3$ and 0, 10, and 20 mol % $Sn(NMe_2)_4$ were spin-coated the Si substrates in air at 1500 rpm and baked on a hotplate in air for 2 min at 100 °C to eliminate residual solvent and volatile hydrolysis products. Film thicknesses following coating and baking were measured via ellipsometry to be ~25-28 nm.

A linear array of 50 circular pads ~500 μm in diameter were exposed on each wafer with EUV light using the Lawrence Berkeley National Laboratory Micro Exposure Tool. Pad exposure times were modulated to step the delivered EUV dose for each pad from 1.38 to 37.99 mJ $cm^{-2}$ with an exponential 7% step. After exposure, wafers were subjected to a post-exposure bake (PEB) on a hotplate in air at 170 °C for 2 min. The exposed film was then dipped in 2-heptanone for 15 seconds and rinsed an additional 15 seconds with the same developer to form a negative tone image, i.e., unexposed portions of the coating were removed. A final 5-min hotplate bake at 150 °C in air was performed after development. A J. A. Woollam M-2000 spectroscopic ellipsometer was used to measure the residual thickness of the exposed pads. The measured thicknesses were normalized to the maximum measured resist thickness and plotted versus the logarithm of exposure dose to form characteristic curves for each resist at a series of post exposure bake temperatures. See Fig. 10. The maximum slope of the normalized thickness vs log dose curve is defined as the photoresist contrast ($\gamma$) and the dose value at which a tangent line drawn through this point equals 1 is defined as the photoresist dose-to-gel, ($D_g$). In this way common parameters used for photoresist characterization may be approximated following Mack, C. *Fundamental Principles of Optical Lithography*, John Wiley & Sons, Chichester, U.K; pp 271-272, 2007.

The resulting curves clearly illustrate the negative-tone contrast generated on exposure, as residual pad thickness for each resist film starts at ~0 and reaches a maximum near $D_g$. The dose required to initiate the development rate change is clearly observed to decrease as the mol fraction of Sn in the precursor coating solutions corresponding to $Sn(NMe_2)_4$ is increased from 0 ($D_g$ = 13.8 mJ $cm^{-2}$), to 10 % ($D_g$ = 10.6 mJ $cm^{-2}$), and finally 20 % ($D_g$ = 5.8 mJ $cm^{-2}$).



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High-resolution line-space patterns were likewise printed using a EUV scanner and tert-butyltin oxide hydroxide photoresist films cast from precursor coating solutions CS-**d**, CS-**e**, and CS-**f**. Silicon wafers (300-mm diameter) with a native-oxide surface were used as substrates without additional surface treatment. Precursor coating solutions CS-**d-h** prepared from $^{t}BuSn(NEt_2)_3$ and 0, 10, or 20 mol % $Sn(NMe_2)_4$ or $Sn(O^{t}Bu)_4$ as described above, as well as CS-**i**, were spin-coated on the Si substrates in air at 1000 or 1500 rpm (CS-**d** only) and baked on a hotplate in air for 2 min at 100 °C.

The coated substrates were exposed to extreme ultraviolet radiation using a NXE:3300B EUV scanner with dipole 60x illumination and a numerical aperture of 0.33. A pattern of 16-nm lines on a 32-nm pitch was projected on the coated wafer following 2 minute, 100 °C post-apply bake (PAB). The exposed resist films and substrates were then subjected to a PEB on a hotplate for 2 min at 170 °C in air. The exposed films were then developed in 2-heptanone for 15 seconds, then rinsed an additional 15 seconds with the same developer to form a negative tone image, i.e., unexposed portions of the coating were removed. A final 5-min hotplate bake at 150 °C in air was performed after development. Fig. 11 exhibits SEM images of the resulting resist lines developed from tert-butyltin oxide hydroxide photoresist films. The imaging dose, critical dimension, and line-width roughness are shown for each film cast from precursor coating solutions prepared from $^{t}BuSn(NEt_2)_3$ (CS-**d),** and 10 or 20 mol% $Sn(NMe_2)_4$ (CS-**e,** CS-**f**, respectively), or $Sn(O^{t}Bu)_4$ (CS-**g**, CS-**h**). Again, imaging dose is observed to decrease with increasing fraction of $SnX_4$ added to the precursor coating solution. The imaging dose required to achieve a critical dimension of 16 nm is plotted versus the calculated LWR each film cast from precursor coating solutions d-i is plotted in Figure 12. Significantly, a > 30% reduction in the required imaging dose in is obtained for the films cast from CS-**e** and **-f**, relative to **-i** without a concomitant increase in line-width-roughness (LWR), indicating a substantial improvement over the pre-hydrolysed mixed alkyl ligand formulation and an important circumvention (over that dose range) of the commonly observed inverse relationship between patterning dose and LWR.

Example 6 -

Pattering performance is evaluated for coatings prepared with a mixture of tert-butyl and methyl radiation sensitive ligands.



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Specifically, precursor solution preparation, film coating, and lithographic performance were examined in the context of organotin oxide hydroxide photoresist films comprising a mixture of $^{t}BuSnO_{(3/2-(x/2))}(OH)_x$ and $MeSnO_{(3/2-(x/2))}(OH)_x$ prepared via in situ hydrolysis of a precursor solution comprising $^{t}BuSnX_3$ and $MeSnX_3$ compounds.

$MeSn(O^{t}Bu)_3$ (FW = 353.1, hereinafter P-**6**) was synthesized as follows from $MeSnCl_3$ (Gelest), an oven-dried RBF equipped with an addition funnel and magnetic stir-bar was charged with 0.8 M $MeSnCl_3$ in pentane. While cooling with an ice bath, 4 molar equivalents of diethylamine in pentane (5.5 M) were added dropwise through the addition funnel. Upon complete addition, 4 molar equivalents of tert-butyl alcohol mixed 3.25:1 (vol) in pentane were added, and the solution is allowed to stir at room temperature for 30 min. The reaction mixture was then filtered and volatiles removed under vacuum leaving a product as a light oil. The product was then distilled at 55-60 °C at ~0.1 torr.

A stock solution of P-**6** was prepared by dissolution in dry 4-methyl-2-pentanol. This solution of $MeSn(O^{t}Bu)_3$ was mixed at various volume ratios with a second stock solution of prepared from $^{t}BuSn(NEt_2)_3$ in 4-methyl-2-pentanol in an identical manner to solution S-**4** above and diluted with the same solvent to achieve a total Sn concentration of 0.05 M. By this method a series of precursor solutions were prepared with a range of 0-60 mol % of the total alkyl-Sn concentration added as $MeSn(OtBu)_3$. These precursor solutions were coated on 100-mm Si substrates, baked at 100 °C, and then exposed to EUV radiation at varying doses creating a contrast array as previously described.

Following exposure the coated wafers were baked at 170 °C in air and developed for 15 s in 2-heptanone, rinsed for 15 s with a wash-bottle containing the same solvent, then dried under $N_2$ and baked in air at 150 °C for 5 min. The residual thickness of each exposure pad was measured and plotted as a function of dose in Fig. 13**.** Extracted resist metrics (see Example 5) are tabulated in Table 3. It is observed from Fig. 13 that Dg decreases markedly as the mol % of $MeSn(OtBu)_3$ in the precursor solution increases, while the contrast remains high, even at relatively low values of $D_g$. Importantly, the residual thickness $<<D_g$ is consistently near zero, indicating the resist is cleared in the unexposed region with minimal residue (scum).



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**TABLE 3**

| Mol % $MeSn(OtBu)_3$ | $D_g$ ($mJ/cm^2$) | γ Contrast |
|---|---|---|
| 0 | 16.1 | 15.8 |
| 10 | 14.1 | 14.8 |
| 20 | 11.6 | 15.6 |
| 40 | 7.3 | 12.7 |
| 60 | 2.3 | 9.4 |

A pattern of 18-nm lines on a 36-nm pitch was exposed on similarly processed wafers, using the Lawrence Berkeley National Laboratory Micro Exposure Tool using 13.5-nm wavelength radiation, dipole illumination, and a numerical aperture of 0.3. The line width (CD) measured with a SEM and plotted versus imaging dose in Fig. 14. Again the imaging dose required to achieve a given line-width is found to strongly decrease as the mol-fraction of $MeSn(O^tBu)_3$ in the precursor solution is increased. Representative SEM images from the same wafers are shown in Figure Fig. 15 for precursor solutions containing a) 20%, b) 40%, and c) 60% P-**6**.

The embodiments above are intended to be illustrative and not limiting. Additional embodiments are within the claims and additional inventive concepts. In addition, although the present invention has been described with reference to particular embodiments, those skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention. Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein. To the extent that specific structures, compositions and/or processes are described herein with components, elements, ingredients or other partitions, it is to be understand that the disclosure herein covers the specific embodiments, embodiments comprising the specific components, elements, ingredients, other partitions or combinations thereof as well as embodiments consisting essentially of such specific components, ingredients or other partitions or combinations thereof that can include additional features that do not change the fundamental nature of the subject matter, as suggested in the discussion, unless otherwise specifically indicated.



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Additional Inventive Concepts

1. A method for forming a radiation patternable coating comprising an oxo-hydroxo network with metal cations having organic ligands with metal carbon bonds and metal oxygen bonds, the method comprising:

inputting into a deposition chamber closed from the ambient atmosphere a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ where n = 1 or 2, wherein R is an organic ligand with 1-31 carbon atoms bound to Sn with a metal-carbon bond, n = 1 or 2, and X is a ligand having a hydrolysable bond with Sn and

inputting sequentially or at the same time a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with X ligand or ligands, wherein a substrate is configured with a surface to receive the non-volatile components of the composition.

2. The method of additional inventive concept 1 wherein the second precursor vapor comprises water vapor.

3. The method of additional inventive concept 1 wherein the deposition chamber has a pressure from about 0.01 Torr to about 25 Torr.

4. The method of additional inventive concept 1 wherein the deposition chamber has a temperature from about 40°C to about 175°C.

5. The method of additional inventive concept 1 further including a step of inputting an inert purge gas between each cycle of inputting precursor vapors.

6. The method of additional inventive concept 1 where a third precursor is separately inputted to the chamber the precursor comprising $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidixable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.



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7. A coated substrate comprising a substrate with a surface and a coating on the surface comprising:

an organometallic composition represented by the formula y $(R_zSnO_{(2-(z/2)-(w/2))}(OH)_w \cdot z\ MO_{((m/2)-l/2)}(OH)_l$ where R is a hydrocarbyl group with 1-31 carbon atoms or a combination thereof, $0 < z \leq 2$, $0 < (z + w) \leq 4$, m = formal valence of $M^{m+}$, $0 \leq l \leq m$, y/z = (0.05 to 0.6), and M = M' or Sn, where M' is a non-tin metal of groups 2-16 of the periodic table.

8. A structure comprising a substrate and a radiation sensitive coating comprising an alkyl metal oxide hydroxide having a dose-to-gel ($D_g$) of no more than about 6.125 mJ/cm$^2$.

9. A structure comprising a substrate comprising an inorganic semiconductor layer and a radiation sensitive coating material along a surface, wherein the radiation coating material can be patterned with EUV light at a wavelength of 13.5nm in a pattern of 16-nm lines on a 32-nm pitch to achieve a critical dimension of 16 nm with a dose from about 8 mJ/cm2 to about 25 mJ/cm2 with a line width roughness of no more than about 4 nm.

10. The structure of additional inventive concept 9 wherein the radiation sensitive coating material has at least 5 weight percent of metal.

11. The structure of additional inventive concept 9 wherein the radiation sensitive coating material has at least 20 weight percent of metal.



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What is claimed is:

1. An apparatus comprising:

a deposition chamber having an interior isolated from the ambient atmosphere;

a substrate within the interior of the deposition chamber configured to receive a deposition on a surface of the substrate; and

structure configured to deliver flow from a supply of an organotin compound to provide for formation of an organotin layer on the substrate surface within the deposition chamber.

2. The apparatus of claim 1 wherein the substrate comprises a silicon wafer and wherein the organotin layer has a thickness from about 2 nm to about 50 nm and the thickness variation is no more than about +/- 50% from the average layer thickness.

3. The apparatus of claim 1 further comprising structure configured to deliver flow from a supply of an inert gas.

4. The apparatus of claim 2 wherein the inert gas comprises nitrogen or argon.

5. The apparatus of claim 1 wherein the structure configured to deliver flow comprises an aerosol generator configured to generate an aerosol from a liquid comprising the organotin compound, a vaporization chamber configured to receive an injection of organotin compound, a flash evaporator configured to evaporate the organotin compound, or a bubbler configured for bubbling an inert carrier gas through a liquid comprising the organotin compound, and wherein the deposition on the surface of the substrate comprises chemical vapor deposition.

6. The apparatus of claim 1 wherein the flow from a supply of an organotin compound comprises a first precursor vapor comprising a composition represented by the formula $R_nSnX_{4-n}$ wherein R is an organic ligand with 1-31 carbon atoms bound to Sn with a metal-carbon bond, n = 1 - 3 and X is a ligand having a hydrolysable bond with Sn; and the apparatus further comprising structure to deliver a second precursor vapor comprising an oxygen-containing compound capable of reacting with the composition in the first precursor vapor under conditions in the deposition



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chamber to form a composition with non-volatile components and a volatile component comprising a reaction product with X ligand or ligands, wherein the substrate is configured with a surface to receive the non-volatile components of the composition.

7. The apparatus of claim 6 wherein the oxygen containing compound comprises water vapor, hydrogen peroxide, ozone, oxygen, an alcohol, or combinations thereof.

8. The apparatus of claim 6 wherein the second precursor vapor comprises water vapor.

9. The apparatus of claim 6 further comprising structure configured to deliver a flow comprising a third precursor vapor comprising a composition represented by the formula $ML_v$, where v is $2 \leq v \leq 6$ and L is an oxidizable ligand or a ligand having a hydrolysable M-L bond or a combination thereof, and M is a metal selected from groups 2-16 of the periodic table.

10. The apparatus of claim 9 wherein the third precursor vapor comprises $SnL_4$.

11. The apparatus of claim 1 wherein the interior has a pressure from about 0.01 Torr to about 25 Torr.

12. The apparatus of claim 1 wherein the interior has a temperature from about 40°C to about 175°C.

13. The apparatus of claim 1 comprising a configuration providing for selection of the pressure and/or the temperature in the deposition chamber.

14. The apparatus of claim 1 wherein the flow comprises a vapor.

15. The apparatus of claim 1 wherein the structure configured to deliver flow comprises one or more vapor inputting structures.



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16. The apparatus of claim 1 wherein the vapor inputting structures provide for control of the flow.

17. The apparatus of claim 15 wherein a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow at the same time.

18. The apparatus of claim 15 wherein a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow, wherein the first flow and the second flow are sequential.

19. The apparatus of claim 15 wherein a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow and a third vapor inputting structure is configured to deliver a third flow, wherein the first flow, the second flow, and the third flow are sequential.

20. The apparatus of claim 15 wherein a first vapor inputting structure is configured to deliver a first flow and a second vapor inputting structure is configured to deliver a second flow and a third vapor inputting structure is configured to deliver a third flow, wherein the first flow and the second flow are at the same time and the third flow is sequential.

21. The apparatus of claim 1 wherein the interior has a temperature from about 45°C to about 250°C.



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IPR2025-00309 - U.S. Patent No. 11,537,048

ABSTRACT

Organometallic precursors are described for the formation of high resolution lithography patterning coatings based on metal oxide hydroxide chemistry. The precursor compositions generally comprise ligands readily hydrolysable by water vapor or other OH source composition under modest conditions. The organometallic precursors generally comprise a radiation sensitive organo ligand to tin that can result in a coating that can be effective for high resolution patterning at relatively low radiation doses and is particularly useful for EUV patterning. The precursors compositions are readily processable under commercially suitable conditions. Solution phase processing with in situ hydrolysis or vapor based deposition can be used to form the coatings.



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Lam Research Corp. v. Inpria Corp.
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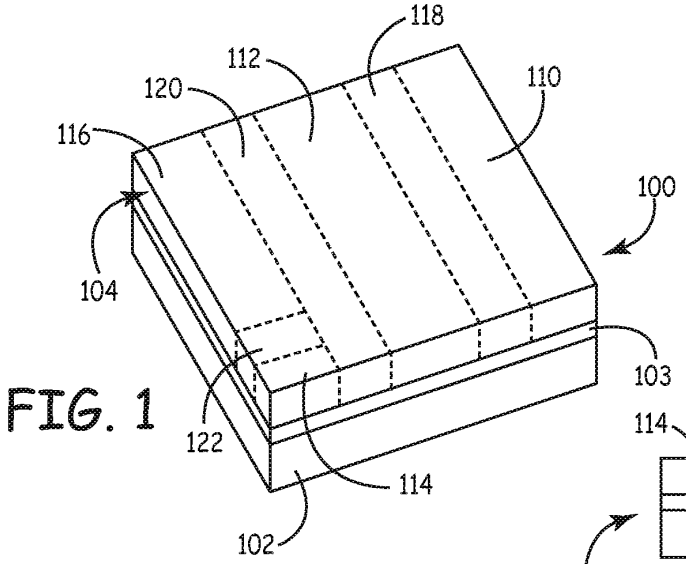



FIG. 1

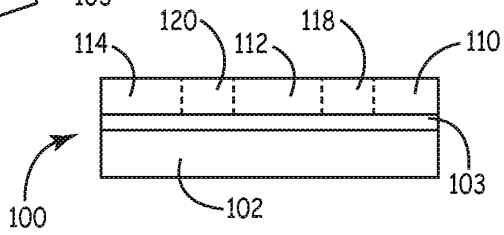



FIG. 2

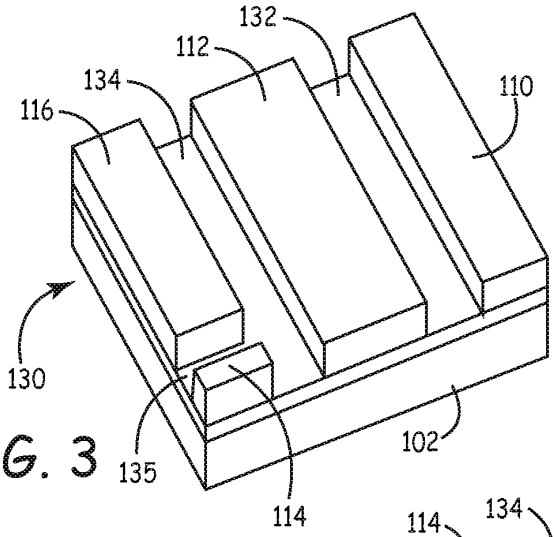



FIG. 3

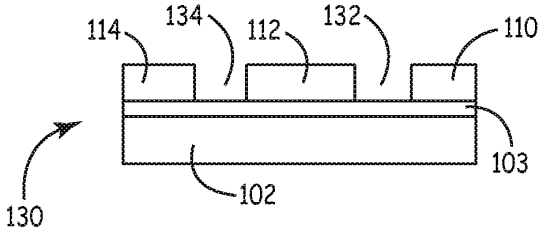



FIG. 4

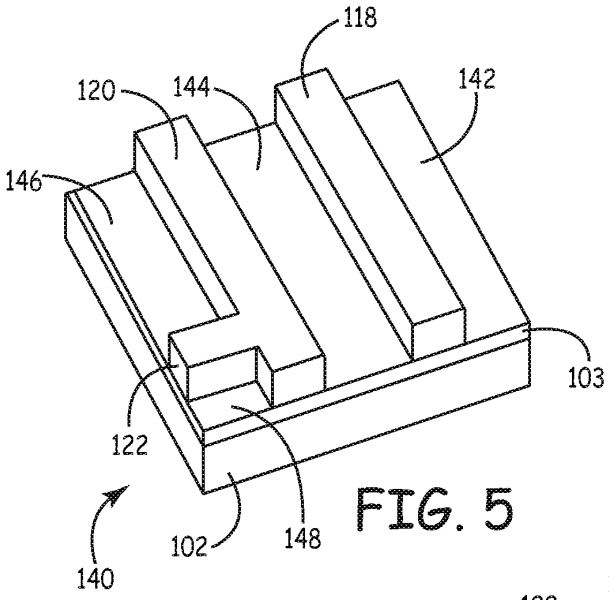

118
120
144
142
146
103
122
102
148
140

FIG. 5

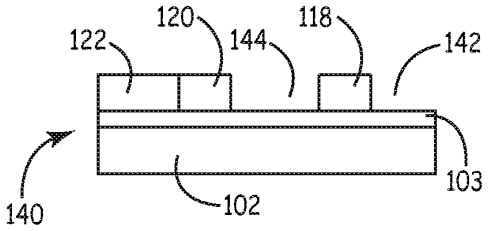

120
118
122
144
142
103
140
102

FIG. 6

Fig. 7

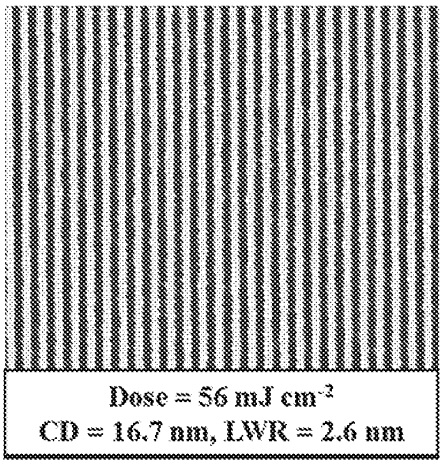

Dose = 56 mJ cm-2
CD = 16.7 nm, LWR = 2.6 nm

Fig. 8

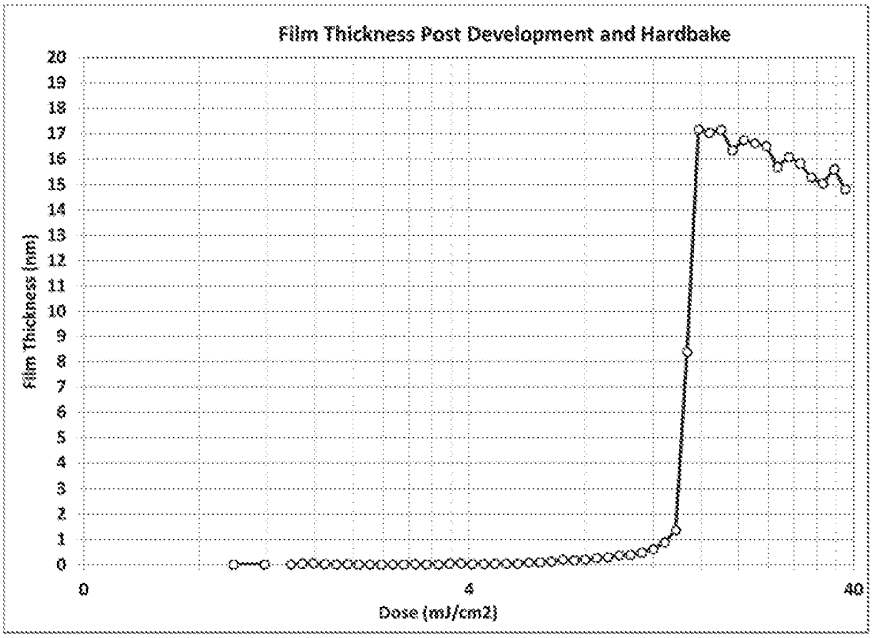

Film Thickness Post Development and Hardbake
Film Thickness (nm)
Dose (mJ/cm2)
0
4
40

Fig. 9

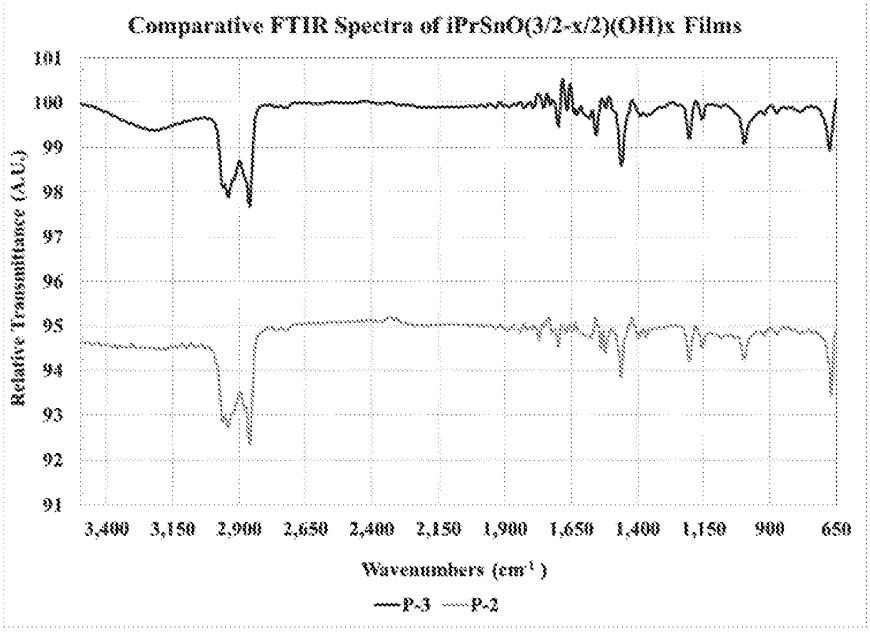

Comparative FTIR Spectra of iPrSnO(3/2-x/2)(OH)x Films
Relative Transmittance (A.U.)
101
100
99
98
97
96
95
94
93
92
91
3,400
3,150
2,900
2,650
2,400
2,150
1,900
1,650
1,400
1,150
900
650
Wavenumbers (cm-1)
P-3
P-2

Fig. 10

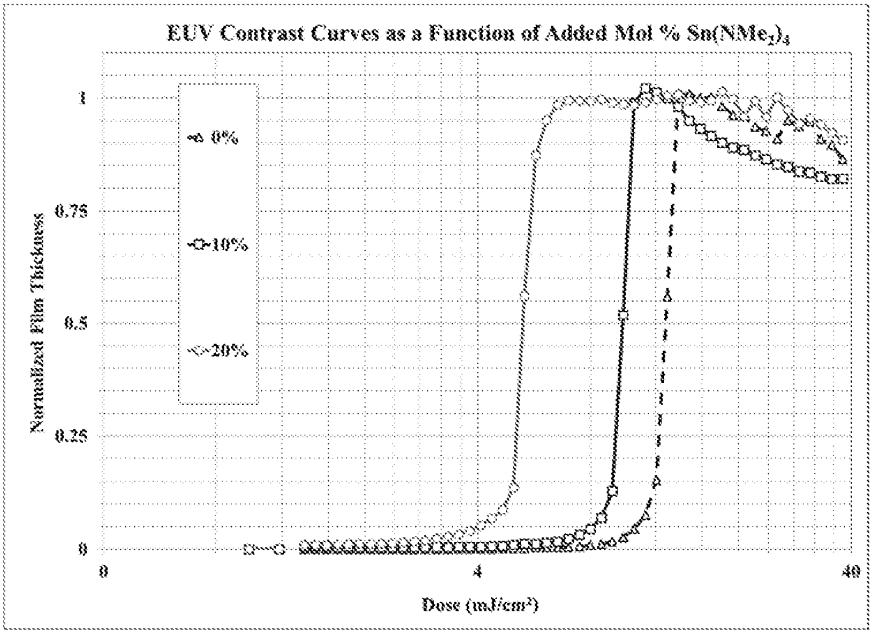

EUV Contrast Curves as a Function of Added Mol % Sn(NMe2)4
Normalized Film Thickness
1
0.75
0.5
0.25
0
0%
10%
20%
0
4
40
Dose (mJ/cm2)

Fig. 11

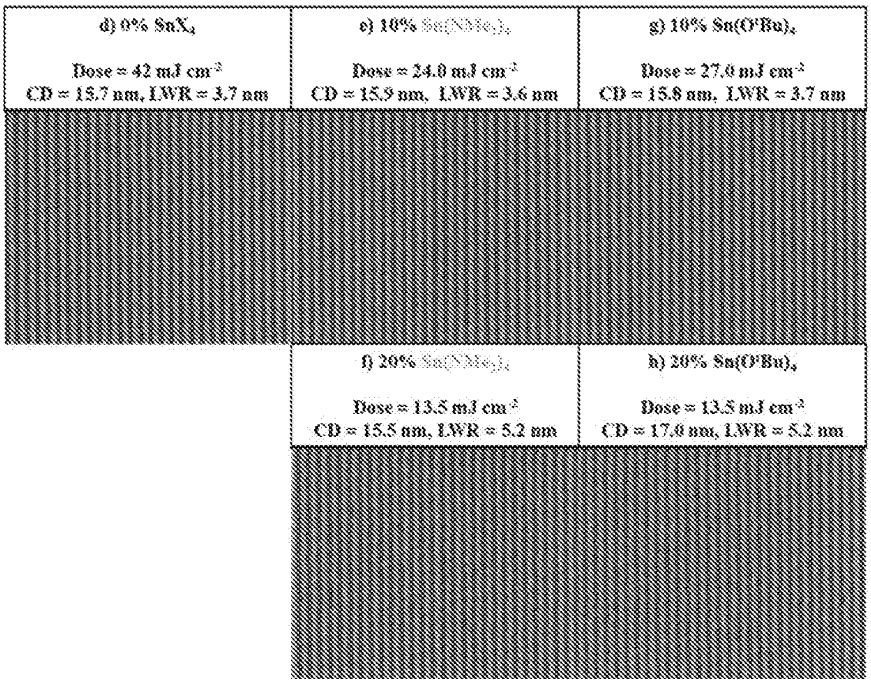

d) 0% SnX4
Dose = 42 mJ cm-2
CD = 18.7 nm, LWR = 3.7 nm
e) 10% Sn(NMe2)4
Dose = 24.0 mJ cm-2
CD = 15.9 nm, LWR = 3.6 nm
g) 10% Sn(OtBu)4
Dose = 27.0 mJ cm-2
CD = 15.8 nm, LWR = 3.7 nm
f) 20% Sn(NMe2)4
Dose = 13.5 mJ cm-2
CD = 15.5 nm, LWR = 5.2 nm
h) 20% Sn(OtBu)4
Dose = 13.5 mJ cm-2
CD = 17.0 nm, LWR = 5.2 nm

Fig. 13

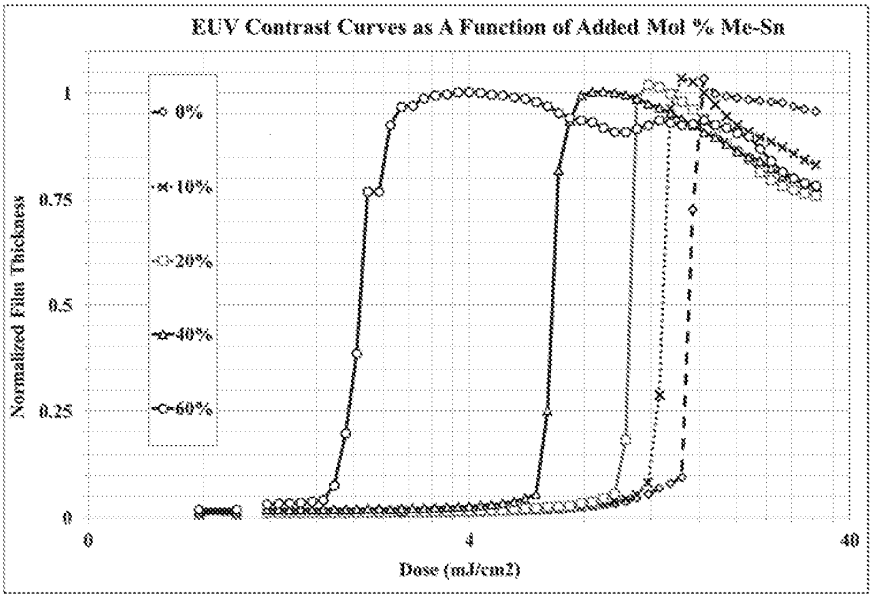

EUV Contrast Curves as A Function of Added Mol % Me-Sn
Normalized Film Thickness
1
0.75
0.5
0.25
0
0
4
40
Dose (mJ/cm2)
0%
10%
20%
40%
60%

Fig. 14

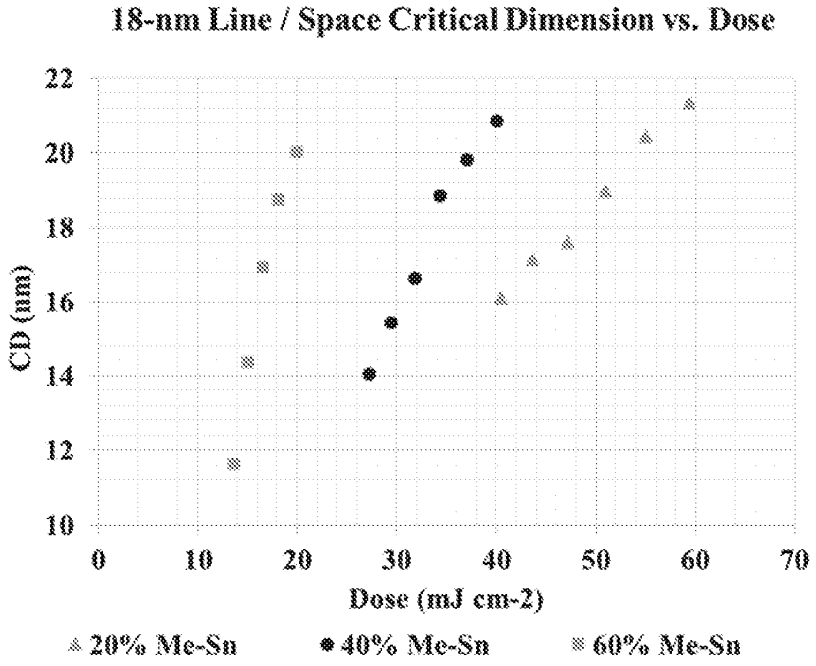

18-nm Line / Space Critical Dimension vs. Dose
CD (nm)
22
20
18
16
14
12
10
0
10
20
30
40
50
60
70
Dose (mJ cm-2)
20% Me-Sn
40% Me-Sn
60% Me-Sn

Fig. 15

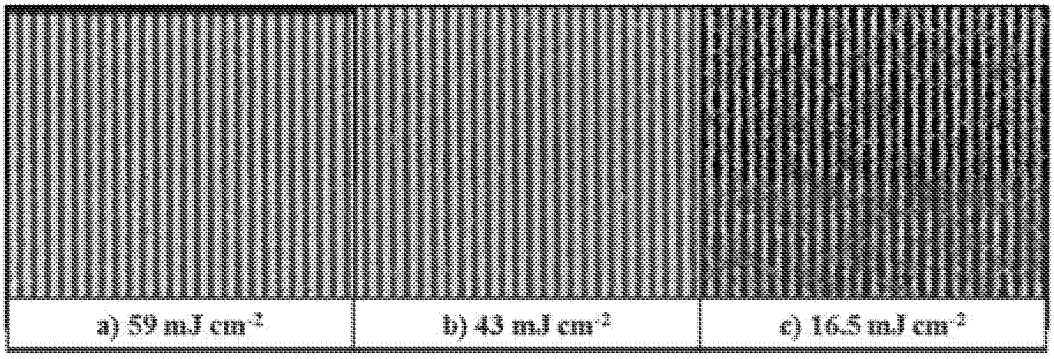
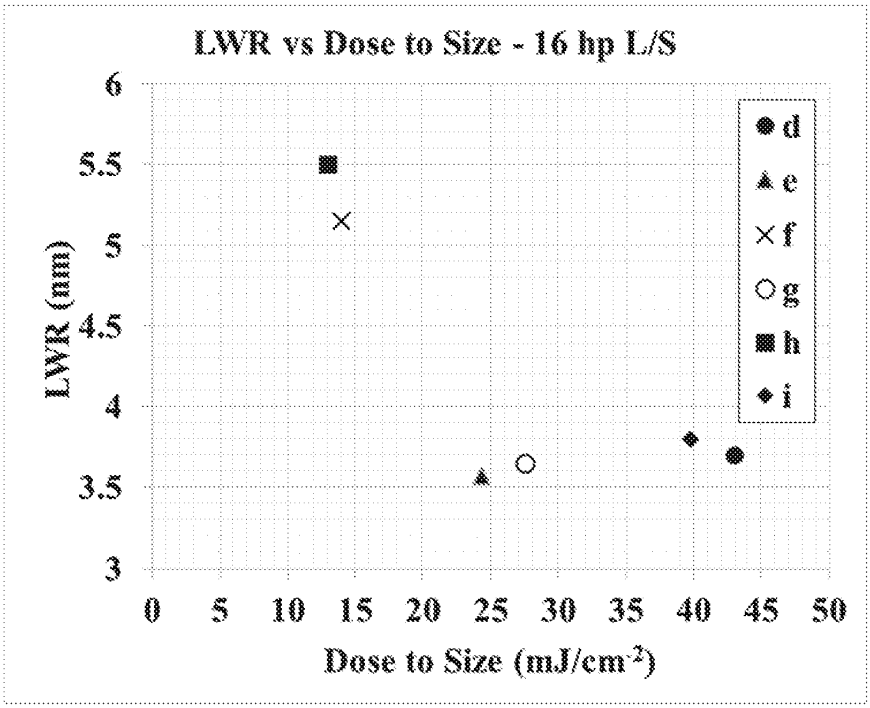

a) 59 mJ cm-2
b) 43 mJ cm-2
c) 16.5 mJ cm-2

Fig. 12


LWR vs Dose to Size - 16 hp L/S
LWR (nm)
6
5.5
5
4.5
4
3.5
3
0
5
10
15
20
25
30
35
40
45
50
Dose to Size (mJ/cm-2)
d
e
f
g
h
i

Attorney Docket No.: 5063.08US02

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATIONS USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

As a below named inventor, I hereby declare that:

This Declaration is directed to:

[ ] The attached application, or

[X] United States or PCT international application number 15/291,738 filed on October 12, 2016.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have read and understand the contents of the above-identified application, including the claims.

I acknowledge the duty to disclose to the United States Patent Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Stephen T. Meyers
Full name of inventor (given name, family name)

Inventor's signature

10/13/16
Date

Attorney Docket No.: 5063.08US02

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Jeremy T. Anderson
Full name of inventor (given name, family name)

Inventor's signature

October 21, 2016
Date

Attorney Docket No.: 5063.08US02

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Brian J. Cardineau
Full name of inventor (given name, family name)

Inventor's signature

10-21-16
Date

Attorney Docket No.: 5063.08US02

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Joseph B. Edson
Full name of inventor (given name, family name)

Inventor's signature

10/20/16
Date

Attorney Docket No.: 5063.08US02

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATIONS USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

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Kai Jiang
Full name of inventor (given name, family name)

Inventor's signature

16/10/20.
Date

Attorney Docket No.: 5063.08US02

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Douglas A. Keszler
Full name of inventor (given name, family name)

Douglas A Keszler — 13 OCT 16
Inventor's signature — Date

Attorney Docket No.: 5063.08US02

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Alan J. Telecky
Full name of inventor (given name, family name)

Inventor's signature

10/21/2016
Date

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al.

Application No.: *Continuation of 16/238,779* Examiner: *Not Yet Assigned*

Filed: *Herewith*

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

PRELIMINARY REMARKS

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

Prior to examination, please amend the above-identified application as follows:

The present amendment comprises the following sections:

A. Remarks

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

August 6, 2020 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240

## REMARKS

Claims 1-21 are pending. The specification is the same as the parent specification except for the updating of the cross reference to related applications. Claim 1 is supported by the specification, for example, at page 3, line 24 to page 4, line 2; page 18, lines 7-11; page 24, line 15 to page 25, line 22; and page 26, lines 19-23. Claim 2 is supported by the specification, for example, at page 22, lines 24-29; page 23, lines 3-5; and page 26, lines 18-20. Claims 3-4 are supported by the specification, for example, at page 25, lines 21-22. Claim 5 is supported by the specification, for example, at page 25, lines 14-22. Claim 6 is supported by claim 11 of the parent application. Claim 6 is further supported by the specification, for example, at page 3, line 24 to page 4, line 2; page 7, line 4 to page 8, line 23; page 13, line 26; page 24, lines 15-20; page 25, lines 9-17; and page 26, line 26 to page 27, line 13. Claim 7 is supported by claim 12 of the parent application. Claim 7 is further supported by the specification, for example, at page 12, lines 3-12; page 24, lines 26-29; and page 39, lines 1-8. Claim 8 is supported by the specification, for example, at page 46, additional inventive concept 2. Claim 9 is supported by the specification, for example, at page 46, additional inventive concept 6. Claim 10 is supported by the specification, for example, at page 7, lines 23-26 and page 13, lines 15-28. Claim 11 is supported by claim 13 of the parent application. Claim 11 is further supported by the specification, for example, at page 26, line 30 to page 27, line 1. Claim 12 is supported by claim 14 of the parent application. Claim 12 is further supported by the specification, for example, at page 27, lines 6-8. Claim 13 is supported by the specification, for example, at page 25, line 12-22 and page 26, line 29 to page 27, line 5. Claims 14-18 are supported by the specification, for example, at page 24, line 15 to page 27, line 13. Claims 19-20 are supported by the specification, for example, at page 46, additional inventive concept 6. Claim 21 is supported by the specification, for example, at page 24, line 5. No new matter is introduced.



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IPR2025-00309 - U.S. Patent No. 11,537,048

Favorable consideration and prompt allowance of the application are respectfully requested. The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

Customer No. 62274
Christensen, Fonder, Dardi & Herbert PLLC
33 South Sixth Street
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Minneapolis, MN 55402
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Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 5063.08US05

Meyers et al.

Application No.: *Continuation of 16/238,779* Examiner: *Not Yet Assigned*

Filed: *Herewith*

For: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING

---

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. § 1.56, the attention of the Patent and Trademark Office is hereby directed to the references listed on the attached Form PTO-**SB/08a**. It is respectfully requested that the information be expressly considered during the prosecution of this application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom. The listing of a reference herein is not an admission that the reference is prior art or that the reference is material to patentability.

This Information Disclosure Statement is being filed with the application. No certification or fee is required.

Copies of the references were cited by or submitted to the Office in Patent Application No. 16/238,779, filed January 3, 2019, which is relied upon for an earlier filing date under 35 U.S.C. § 120. Thus, copies of these references are not attached. 37 C.F.R. § 1.98(d).

A copy of the co-pending Taiwan Office Action dated June 15, 2020 was not cited in the Parent Application no. 16/238,779. Therefore, this document will be attached to this continuation application herewith.

Copies of cited U.S. patents and U.S. published applications are not included. 37 C.F.R. 1.98(a)(2).

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

Customer No. 62274
Christensen, Fonder, Dardi & Herbert PLLC
33 South Sixth Street
Suite 4540
Minneapolis, MN 55402
Telephone: (612) 315-4322

*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 60-1363.*

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

| August 6, 2020 | /Diane Bennett/ |
|---|---|
| Date | Diane E. Bennett, Ph.D., Reg. #63,240 |



Lam Research Ex. 1002 - Page 628
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048

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Attorney Docket No.: 5063.08US05

CONTINUATION APPLICATION TRANSMITTAL

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is a request for filing a

[X] Continuation [ ] Divisional

application, under 37 C.F.R. § 1.53(b), of pending prior Application No. 16/238,779, filed January 3, 2019 for: ORGANOTIN OXIDE HYDROXIDE PATTERNING COMPOSITIONS, PRECURSORS, AND PATTERNING by: Stephen T. Meyers, Jeremy T. Anderson, Brian J. Cardineau, Joseph B. Edson, Kai Jiang, Douglas A. Keszler, and Alan J. Telecky. The entire disclosure of the prior application is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

Enclosed are:

[X] Specification, Claims and Abstract - 51 pages.

[X] Drawings - 7 sheets (Figs. 1-15).

[X] Application Data Sheet.

[X] Preliminary Remarks - 3 pages.

[X] Power of Attorney and Declarations - copies from prior application.

[X] Track 1 Request.

| The filing fee has been calculated as shown below: | | | | | |
|---|---|---|---|---|---|
| | No. Filed | No. Extra | ~~Small Entity Rate~~ | OR | **Large Entity Rate** |
| Basic Filing Fee | | | ~~$75~~ | OR | **$300** |
| Utility Search Fee | | | ~~$330~~ | OR | **$660** |
| Utility Examination Fee | | | ~~$380~~ | OR | **$760** |
| Track 1 Processing Fee | | | ~~$70~~ | OR | **$140** |
| Track 1 Request | | | ~~$2000~~ | OR | **$4000** |
| Total Claims | 21 - 20 | = 1 | ~~x 50 = $~~ | OR | **x 100 = $100** |
| Independent Claims | 1 - 3 | = 0 | ~~x 230 = $~~ | OR | **x 460 = $0** |
| Surcharge - Late Oath/Declaration [If applicable] | | | ~~[+ 80]~~ | OR | **[+ 160]** |
| Presence of Multiple Dependent Claim [If applicable] | | | ~~[+ 410]~~ | OR | **[+ 820]** |
| Submission of Sequence Listing of 300MB to 800MB | | | ~~[$500]~~ | OR | **[$1,000]** |
| Submission of Sequence Listing of more than 800MB | | | ~~[$5,000]~~ | OR | **[$10,000]** |
| Utility Application Size Fee - per each additional 50 sheets that exceeds 100 sheets: | | | ~~* x 200 = $~~ | OR | *** x 400 = $** |
| | | **TOTAL** | **~~$~~** | **TOTAL** | **$5960.00** |
| **If the difference is less than zero, enter "0". Total # of sheets = (Spec and Abst pgs)+Dwg Sheets<br>*** For e-filing Total # of sheets = (Spec and Abst pages)+Dwg Sheets = [__] * 0.75 – 100 = [__] / 50 | | | | | |

1. [X] The Commissioner is hereby authorized to charge a credit card referenced in the electronic filing in the amount of **$5960.00**. The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 60-1363.

2. [ ] Priority of country application(s) No. _____ filed _____ is claimed under 35 U.S.C. § 119. The certified copy was filed in prior Application No. _____ on _____.

3. [X] The prior application is assigned of record to Inpria Corporation recorded at Reel 040409, Frame 0171.

4. [X] An Information Disclosure Statement and Transmittal Letter are enclosed.

5. [ ] Applicant is entitled to small entity status in accordance with 37 CFR 1.27.

6. [ ] CD-ROM or CD-R in duplicate, and Compact Disc Transmittal are enclosed.

7. [ ] Request and Certification Under 35 U.S.C. 122(b)(2)(B)(i) (non-publication).

8. [X] Address all future communications to:

Christensen, Fonder, Dardi & Herbert PLLC
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Suite 4540
Minneapolis, MN 55402

Respectfully submitted,

/Diane Bennett/

Diane E. Bennett, Ph.D.
Registration No. 63,240

CERTIFICATE OF ELECTRONIC TRANSMISSION

I hereby certify that this paper is being transmitted electronically to the U.S. Patent and Trademark Office on the date shown below.

August 6, 2020 /Diane Bennett/
Date Diane E. Bennett, Ph.D., Reg. #63,240



Lam Research Ex. 1002 - Page 630
Lam Research Corp. v. Inpria Corp.
IPR2025-00309 - U.S. Patent No. 11,537,048