UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,899	06/05/2013	Boyan Boyanov	42P38794

CONFIRMATION NO. 8341

POWER OF ATTORNEY NOTICE

31817
SCHWABE, WILLIAMSON & WYATT, P.C.
1211 SW 5th Avenue, Suite 1600
Portland, OR 97204

OC000000131218955

Date Mailed: 01/20/2022

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/14/2022.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/vostuart/

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United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,899	06/05/2013	Boyan Boyanov	D0480-PA-13290-US-01

CONFIRMATION NO. 8341

164
KINNEY & LANGE, P.A.
312 SOUTH THIRD STREET
MINNEAPOLIS, MN 55415-1002

POA ACCEPTANCE LETTER

OC000000131219118

Date Mailed: 01/20/2022

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/14/2022.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/vostuart/

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor	Boyan Boyanov
Title	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
Art Unit	2898
Examiner Name	Rodolfo D. Fortich
Attorney Docket Number	D0480-PA-13290-US-01

SIGNATURE of Applicant or Patent Practitioner

Signature	/Ian D. MacKinnon/	Date (Optional)	January 14, 2022
Name	Ian D. MacKinnon	Registration Number	34,660
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 1.11 and 1.14. This collection is estimated to take 3 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.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
13/991,899	June 5, 2013

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 164

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Intel Corporation

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

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).

Signature	/Lisa Hopkinson/	Date (Optional)	
Name	Lisa Hopkinson		
Title	Administrator of Patents		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 1.11 and 1.14. This collection is estimated to take 3 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.

Electronic Acknowledgement Receipt	
EFS ID:	44748644
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	31817
Filer:	Ian David MacKinnon
Filer Authorized By:	
Attorney Docket Number:	42P38794
Receipt Date:	14-JAN-2022
Filing Date:	05-JUN-2013
Time Stamp:	13:06:39
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	2022-01-14_POA_D0480-PA-13290-US-01.pdf	1798589 44fc695661732d095950b83a09232d6cd14eec9b	no	2

Warnings:

Information:	
Total Files Size (in bytes):	1798589

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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,899	06/05/2013	Boyan Boyanov	42P38794

CONFIRMATION NO. 8341

POWER OF ATTORNEY NOTICE



45209
WOMBLE BOND DICKINSON (US) LLP/Mission
Attn: IP Docketing
P.O. Box 7037
Atlanta, GA 30357-0037

Date Mailed: 03/06/2019

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/22/2019.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mnguyen/

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
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,899	06/05/2013	Boyan Boyanov	42P38794

CONFIRMATION NO. 8341

31817
SCHWABE, WILLIAMSON & WYATT, P.C.
1211 SW 5th Avenue, Suite 1600
Portland, OR 97204

POA ACCEPTANCE LETTER

OC000000106331199

Date Mailed: 03/06/2019

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/22/2019.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mnguyen/

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
13/991,899	June 5, 2013

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 31817

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Intel Corporation

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

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).

Signature	Lisa Hopkinson	Date (Optional)	
Name	Lisa Hopkinson		
Title	Administrator of Patents		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 1.11 and 1.14. This collection is estimated to take 3 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.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor	Boyan Boyanov
Title	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
Art Unit	2898
Examiner Name	Rodolfo D. FORTICH
Attorney Docket Number	42P38794

SIGNATURE of Applicant or Patent Practitioner

Signature	/Justin K. Brask/	Date (Optional)	
Name	Justin K. Brask	Registration Number	61080
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

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

Electronic Acknowledgement Receipt	
EFS ID:	35231683
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Justin K. Brask/Sheri Villarreal
Filer Authorized By:	Justin K. Brask
Attorney Docket Number:	42P38794
Receipt Date:	22-FEB-2019
Filing Date:	05-JUN-2013
Time Stamp:	20:48:44
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	P38794US_Transmittal_02_22_19.pdf	252049 daca2f38472be9ac0fe95b313b365d9cbedcaa2f	no	2

Warnings:

Information:					
2	Assignee showing of ownership per 37 CFR 3.73	P38794US_Statement_373c_02_22_19.pdf	118410 64ac79d1241870025b40ef3a67ab915c67c0b5c3	no	3
Warnings:					
Information:					
3	Power of Attorney	P38794US_POA_82B.pdf	793446 abf3dbdb053808142c2107db64b1b4702fe7b8e7	no	1
Warnings:					
Information:					
4	Power of Attorney	P38794US_POA_aia0082A.pdf	155719 07f63c613585ab86acfbe65530d1170ec8952687	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	1319624		

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.

Doc Code: TRAN.LET
Document Description: Transmittal Letter

PTO/SB/21 (07-09)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission	7

Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor	Boyan Boyanov
Art Unit	2898
Examiner Name	Rodolfo D. FORTICH
Attorney Docket Number	42P38794

ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☑ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☑ Other Enclosure(s) (please Identify below):
  Statement 373C

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Schwabe, Williamson & Wyatt P.C.		
Signature	/Justin K. Brask/		
Printed name	Justin K. Brask		
Date	February 22, 2019	Reg. No.	61,080

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	/Sheri Villarreal/		
Typed or printed name	Sheri Villarreal	Date	February 22, 2019

This collection of information is required by 37 CFR 1.5. 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 1.11 and1.14. This collection is estimated to 2 hours 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.

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.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. 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 displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Intel Corporation

Application No./Patent No.: 9,373,584 Filed/Issue Date: June 21, 2016

Titled: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

Intel Corporation, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 031022, Frame 0160, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). 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 1.11 and 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.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Justin K. Brask/	February 22, 2019
Signature	Date
Justin K. Brask	61080
Printed or Typed Name	Title or Registration Number

[Page 2 of 2]

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.

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.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/21/2016	9373584	42P38794	8341

45209 7590 06/01/2016

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
900 2nd Avenue South, Suite 600
Minneapolis, MN 55402

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 Data Management (ODM) at (571)-272-4200.

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

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, 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.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

45209 7590 03/01/2016
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Tammy Lin	(Depositor's name)
	(Signature)
5/18/16	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

TITLE OF INVENTION: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/01/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
FORTICH, RODOLFO D	2898	257-773000

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/SB/122) attached.
- ☒ "Fee Address" indication (or "Fee Address" Indication form 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 Blakely, Sokoloff, Taylor & Zafman LLP
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 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.

(A) NAME OF ASSIGNEE: Intel Corporation
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Santa Clara, California

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

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-4537 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29 — 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.
- ☐ 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.

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 3/24/16
Typed or printed name Michael J. Mallie Registration No. 36,591

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PTO/SB/47 (03-09)
Approved for use through 03/31/2012. OMB 0651-0016
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
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"FEE ADDRESS" INDICATION FORM

Address to:
Mail Stop M Correspondence
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Fax to:
571-273-6500

- OR -

INSTRUCTIONS: The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below:** If you have a Customer Number to represent the fee address. **When to check the second box below:** If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

☑ Customer Number: 000197

OR

☐ The attached Request for Customer Number (PTO/SB/125) form.

PATENT NUMBER (if known)	APPLICATION NUMBER
	13/991,899

Completed by (check one):

☐ Applicant/Inventor

☑ Attorney or Agent of record 36,591 (Reg. No.)

☐ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

☐ Assignee recorded at Reel _____ Frame_____

Signature

Michael J. Mallie
Typed or printed name

408-720-8300
Requester's telephone number

3/24/16
Date

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.363. 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. 11 and 1.14. This collection is estimated to take 5 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 COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Mail Stop M Correspondence, 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.

Attorney's Docket No. 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Boyan Boyanov

Application No.: 13/991,899

Filed: June 5, 2013

For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

Examiner: Fortich, Rodolfo D.

Art Unit: 2898

Confirmation No.: 8341

CERTIFICATE OF TRANSMISSION
I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below.

/ /
Signature **Date**

Filed via EFS-Web
Commissioner for Patents
Alexandria, VA 22313-1450

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Dear Sir:

Applicant is assuming that the Examiner's statement of reasons for allowance is to be taken in light of the structure and interaction recited in the claims. Applicant notes that the Examiner's comments may have paraphrased the language of the claims and it should be understood that the language of the claims themselves set out the scope of the claims.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: April 29, 2016

/Tatiana Rossin/
Tatiana Rossin
Reg. No. 56,833

1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
(408) 720-8300
Fax (408) 720-8383

Customer No. 45209

Electronic Patent Application Fee Transmittal

Application Number:	13991899
Filing Date:	05-Jun-2013
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Filer:	Michael Mallie/Tammy Hu
Attorney Docket Number:	42P38794

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

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:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt	
EFS ID:	25812193
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Michael Mallie/Tammy Hu
Filer Authorized By:	Michael Mallie
Attorney Docket Number:	42P38794
Receipt Date:	18-MAY-2016
Filing Date:	05-JUN-2013
Time Stamp:	13:07:58
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$960
RAM confirmation Number	10946
Deposit Account	504238
Authorized User	MALLIE, MICHAEL J.
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

Charge any Additional Fees required under 37 CFR 1.20 (Post Issuance fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		P38794_ISSUE_FEE.pdf	901749 8b14d08490da5e33c92ac713a86ccb439a2da5c5	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Issue Fee Payment (PTO-85B)	1	1
	Change of Address	2	2

Warnings:					
Information:					
2	Miscellaneous Incoming Letter	42P38794_Comments_on_Statement.pdf	37498 348b61da4d85693e9ef736db9b810d7664a9e0d9	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30802 51758a49ac9d7bdac7c2f155e47beecfeacfaff9	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	970049		

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.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 03/23/2016

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	

ART UNIT	PAPER NUMBER
2898	

NOTIFICATION DATE	DELIVERY MODE
03/23/2016	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):

inteldocs_docketing@cpaglobal.com
Database_Group@bstz.com

Response to Rule 312 Communication	Application No. 13/991899	Applicant(s)
	Examiner	Art Unit

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

1. ☒ The amendment filed on *18 March 2016* under 37 CFR 1.312 has been considered, and has been:

a) ☒ entered.

b) ☐ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.

DF

PUBLISHING DIVISION

Attorney's Docket No. 42P38794 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Boyan Boyanov

Application No.: 13/991,899

Filed: June 5, 2013

For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

Examiner: Fortich, Rodolfo D.

Art Unit: 2898

Confirmation No.: 8341

CERTIFICATE OF TRANSMISSION
I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below.

/Theresa Asmus/ March 18, 2016
Signature **Date**

E-Filed via EFS Web
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS
(Notice of Allowance Mailed)

Sir:

In response to the Notice to File Corrected Application Papers mailed March 14, 2016 ("Notice"), please find enclosed:

1. an Amendment to the specification in compliance with 37 CFR 1.121.

2. a copy of the Notice.

The enclosed Amendment does not contain new matter.

Amendment to the Specification

Please add in "Brief Description of the Drawings" at line 4 on page 3 of the specification before "DETAILED DESCRIPTION OF THE PRESENT INVENTION" the following new paragraph:

> Figure 5 shows a block diagram of an exemplary embodiment of a data processing system.

REMARKS

Applicant has amended the Brief Description of the Drawings at line 3, page 4 of the specification to add a new paragraph "Figure 5 shows a block diagram of an exemplary embodiment of a data processing system." No new matter has been added.

If there are any additional charges, please charge Deposit Account No. 504238.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: March 18, 2016

/Tatiana Rossin/
Tatiana Rossin
Reg. No. 56,833

1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
(408) 720-8300

Customer No. 45209

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
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NOTICE TO FILE CORRECTED PAPERS

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 03/14/2016

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER
FORTICH, RODOLFO D

ART UNIT	PAPER NUMBER
2898	

NOTIFICATION DATE	DELIVERY MODE
03/14/2016	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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Database_Group@bstz.com

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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www.uspto.gov

Application No. : 13991899
Applicant : Boyanov
Filing Date : 06/05/2013
Date Mailed : 03/14/2016

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Notice of Allowance Mailed

This application has been accorded an Allowance Date and is being prepared for issuance. The application, however, is incomplete for the reasons below.

Applicant is given two (2) months from the mail date of this Notice within which to respond. This time period for reply is extendable under 37 CFR 1.136(a) for only TWO additional MONTHS.

The informalities requiring correction are indicated in the attachment(s). If the informality pertains to the abstract, specification (including claims) or drawings, the informality must be corrected with an amendment in compliance with 37 CFR 1.121 (or, if the application is a reissue application, 37 CFR 1.173). Such an amendment may be filed after payment of the issue fee if limited to correction of informalities noted herein. See Waiver of 37 CFR 1.312 for Documents Required by the Office of Patent Publication, 1280 Off. Gaz. Patent Office 918 (March 23, 2004). In addition, if the informality is not corrected until after payment of the issue fee, for purposes of 35 U.S.C. 154(b)(1)(iv), "all outstanding requirements" will be considered to have been satisfied when the informality has been corrected. A failure to respond within the above-identified time period will result in the application being ABANDONED.

See attachment(s).

A copy of this notice MUST be returned with the reply. Please address response to "Mail Stop Issue Fee, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450".

/Chris Harmon/
Publication Branch
Office of Data Management
(571) 272-4200

Application No. 13991899

IDENTIFICATION OF SPECIFICATION/DRAWING INCONSISTENCIES

☐ On Page of the specification there is a brief description of FIG. , but the drawings filed do not include a drawing with that designation. Applicant must respond either by supplying the omitted drawing or by amending the specification to remove all references to that drawing.

☒ The drawings filed 06/05/2013 include FIG. 5, but the specification's brief description of the drawings does not describe a drawing with that designation. Applicant must respond either by amending the specification to add a brief description of that drawing or by correcting the drawings to remove the drawing in question.

☐ Drawings are present in the application and are referred to in the detailed description of the invention, but the specification does not contain a brief description of the drawings as required by 37 CFR 1.74 and 37 CFR 1.77(b)(8).

☐ Page of the specification refers to FIG. , but no drawing with that designation is described in the brief description of the drawings and no drawing with that designation is present in the application. Applicant must respond either by amending the specification to remove all references to that drawing, or by supplying that drawing and amending the specification to add a brief description of it.

☐ In the reissue application, FIG. , is labeled as "New" but is not described in the reissue specification's brief description of the drawings. Applicant must respond by amending the reissue specification's brief description of the drawings to add a brief description of the new drawing.

☐ OTHER:

☐ COMMENTS:

Electronic Acknowledgement Receipt	
EFS ID:	25244646
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Theresa Asmus
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	18-MAR-2016
Filing Date:	05-JUN-2013
Time Stamp:	16:44:17
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	42P38794_RNFCAP_efile.pdf	47097 c1869a9f6571bd0bcf9a75c18b2904c65374119e	no	3
Warnings:					
Information:					

2	Miscellaneous Incoming Letter	42P38794_Notice_File_Corrected_Papers_efile.pdf	145368 31ca56f376fa6efb5c6c7c6660b4facbc33ea2d3	no	3
Warnings:					
Information:					
			Total Files Size (in bytes):	192465	

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 NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 03/14/2016

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	

ART UNIT	PAPER NUMBER
2898	

NOTIFICATION DATE	DELIVERY MODE
03/14/2016	ELECTRONIC

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Application No. : 13991899
Applicant : Boyanov
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See attachment(s).

A copy of this notice MUST be returned with the reply. Please address response to "Mail Stop Issue Fee, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450".

/Chris Harmon/
Publication Branch
Office of Data Management
(571) 272-4200

Application No. 13991899

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☐ On Page of the specification there is a brief description of FIG. , but the drawings filed do not include a drawing with that designation. Applicant must respond either by supplying the omitted drawing or by amending the specification to remove all references to that drawing.

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☐ OTHER:

☐ COMMENTS:

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NOTICE OF ALLOWANCE AND FEE(S) DUE

45209 7590 03/01/2016

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	
ART UNIT	PAPER NUMBER
2898	

DATE MAILED: 03/01/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

TITLE OF INVENTION: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/01/2016

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 and an extra copy of the form should be submitted. 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: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

45209 7590 03/01/2016

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c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

TITLE OF INVENTION: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/01/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
FORTICH, RODOLFO D	2898	257-773000

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/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form 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 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.

(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. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

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

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

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

❑ Applicant certifying micro entity status. See 37 CFR 1.29

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.

❑ 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.

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. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

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45209 7590 03/01/2016

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Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	

ART UNIT	PAPER NUMBER
2898	

DATE MAILED: 03/01/2016

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.

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 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, 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. 13/991,899	Applicant(s) BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	AIA (First Inventor to File) Status No

-- 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 *Claims amendments filed on 12/21/2015* .
   ☐ 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 *1-8 and 10-12*. 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 See Continuation Sheet
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 *EAST Search, Bib form*.

Continuation of Attachment(s) 2. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 06/05/2013, 08/15/2014, 02/03/2015 and 12/21/2015.

The present application is being examined under the pre-AIA first to invent provisions.

Detailed Action

Applicant's claims amendments filed on 12/16/2015 is acknowledged. Claims 1, 8 and 10 were amended. Claim 10 was canceled.

EXAMINER'S AMENDMENT

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.

TO CLAIMS

This application is in condition for allowance except for the presence of claims 13-20 non-elected without traverse in the reply filed on October 20, 2014. Accordingly, claims 13-20 have been cancelled.

Allowable Subject Matter

Claims 1-7 have been allowed.

The following is an examiner's statement of reasons for allowance: the best prior art of record does not teach or fairly suggest the claimed method to manufacture an electronic device, comprising: recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using a first chemistry comprising between about 0.1 % to about 70% by mass of an etchant, between about 0.1 % to about 10% by mass of an oxidizer, between about 50ppm to about 1 % by mass of an inhibitor and between about 1 % to about 60% by mass of a solvent to provide an etching uniformity independent of a crystallographic orientation; and depositing a capping layer on the recessed conductive line and on the dielectric sidewall of the channel to prevent electromigration.

Claims 8 and 10-12 have been allowed.

The following is an examiner's statement of reasons for allowance: the best prior art of record does not teach or fairly suggest the method to control line edge roughness, comprising: etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising a dielectric sidewall self-aligned to the at least one conductive line, wherein the first chemistry comprises between about 0.1 % to about 70% by mass of an etchant, between about 0.1 % to about 10% by mass of an oxidizer, between about 50ppm to about 1 % by mass of an inhibitor and between about 1 % to about 60% by mass of a solvent to provide uniformity of etching independent of a crystallographic orientation; and depositing a capping layer on the at least one conductive line and on the dielectric sidewall of the channel.

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."

Conclusion

Any inquiry concerning this communication or earlier communications from an Examiner should be directed to Examiner Rodolfo Fortich, at (571) 272-3461, on Monday through Thursday, 7:30 am - 5:30 pm ET. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Julio Maldonado can be reached on (571) 272-1864. 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 only through Private PAIR.

For more information about the PAIR system, see http://pair-direct.uspto.gov. The Electronic Business Center (EBC) at (866) 217 -9197 (toll-free) may answer questions on how to access the Private PAIR system.

/RODOLFO FORTICH/
Examiner, Art Unit 2898

/CHUONG A LUU/
Primary Examiner, Art Unit 2898

Notice of References Cited	Application/Control No. 13/991,899	Applicant(s)/Patent Under Reexamination BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,470,789	11-1995	Misawa, Nobuhiro	438/643
*	B	US-7,338,908	03-2008	Koos et al.	438/745
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	Art Unit
	RODOLFO FORTICH	2898

CPC- SEARCHED		
Symbol	Date	Examiner
H01L21/7685 OR H01L23/485	2/8/2016	R. F

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner
(H01L2924/00014 ORH01L2924/00 OR H01L2924/0002 ORH01L2224/13147 ORH01L2224/48247)	2/8/2016	R. F

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
257	773, 762, 767, 741, 750	2/8/2016	R. F

SEARCH NOTES		
Search Notes	Date	Examiner
See EAST search	2/8/2016	R. F
Consultation with Chuong Luu (2898)	2/5/2016	R. F
Assignee/Inventor search	10/28/2014	R. F

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
438	627, 669, 687, 597, 618	2/8/2016	R. F

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*	**Application Number**	13/991,899
	Filing Date	06/05/2013
	First Named Inventor	Boyan BOYANOV
	Group Art Unit	2898
e-filed December 21, 2015	**Examiner Name**	FORTICH, Rodolfo D.
Sheet 1 of 1	**Attorney Docket No: 42P38794**	

US PATENT DOCUMENTS					
Examiner Initial *	Cite No [1]	USP Document Number	Publication or Issue Date MM-DD-YYYY	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No [1]	Foreign Patent Document Country Code/Number/Kind Code (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T [2]

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No [1]	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, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
/R. F/	NPL1	Chih-Kai Hsu "Electromigration Study on Sn capped Air-gap Cu Damascenes Structure", 2006.	
/R. F/	NPL2	Korean Patent Application No. 10-2014-7015212, Office Action (with English translation), dated August 3, 2015 (14 pages) [P38794KR].	
/R. F/	NPL3	Taiwan (R.O.C.) Patent Application No. 101140536, Office Action (with English translation), dated August 13, 2015, (17 pages) [P38794TW].	
/R. F/	NPL4	China Patent Application No. 201180074611.5, Office Action, dated November 16, 2014, (9 pages) [P38794CN].	

EXAMINER /Rodolfo Fortich/ **DATE CONSIDERED** 02/08/2016

Based on PTO/SB/08A(09-06) - Substitute Disclosure Statement Form (PTO-1449) as modified by BSTZ 03/26/07
* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional) 2 Applicant is to place a check mark here if English language Translation is attached

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH /R. F/

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	15	(inhibitor and (solvent or water) and etch$3 and (smooth or uniform$3 or even or rough$4)) AND ((H01L21/7685 OR H01L23/485).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2016/02/08 15:31
L5	7	(L1) AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2016/02/08 15:44
L6	50	"257/773".CCLS. and (channel and cap$4) and (solvent and etch$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2016/02/08 15:45
L7	13	"438/627".CCLS. and (channel and cap$4) and (solvent and etch$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2016/02/08 16:15
S1	7	"257/773".CCLS. and (recess$3 same (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S2	23	"257/773".CCLS. and (recess$3 same2 (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S4	595	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 13:43
S5	4	((13/991903) or (13/914637) or (13/915158) or (13/921436)).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/08/12 14:12
S6	78	((Boyan) near2 (Boyanov)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2014/08/12 14:38
S7	2483	(recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S8	724	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S9	683	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3 and dielectric)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:40

S10	647	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:41
S11	55	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:42
S12	38	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:08
S13	40	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same6 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:09
S14	448	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:08
S15	143	S14 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:09
S16	4	(("20100109131") or ("20080026487") or ("20040245637") or ("20010045651")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 08:31
S17	160	"438/627".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:53
S18	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 09:12
S19	155	"438/669".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 10:11
S20	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:28
S21	1	("20050001325").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:33
S22	2	(("6,375,693") or ("6,503,834")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:38
S29	59	("257/762".CCLS. or "257/767".CCLS. or "257/741".CCLS. or "257/750".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 11:33
S30	65	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or	US-PGPUB; USPAT;	AND	ON	2014/10/28 12:36

		etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	USOCR			
S31	9	(recess$3 or etch$3) same2 (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3) and inhibitor)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/28 13:54
S32	1	(10/690084).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 13:56
S33	1	("5535230").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 10:22
S34	1	("8502247").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:05
S35	2	(("7488432") or ("20140152637")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:57
S36	615	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/09 15:25
S37	462	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S38	276	S37 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S39	1	("5741626").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/20 16:39
S40	66	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2015/03/20 17:10
S41	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:40
S42	1	("6,696,758").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:51
S43	13	(("6,395,607") or ("6,670,274") or ("5,374,454") or ("5,380,546") or ("5,723,387") or ("6,274,499") or ("6,258,713") or ("6,261,963") or ("6,281,127") or ("6,171,960") or ("6,350,687") or ("6,017,803") or ("6,251,774")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:58
S44	6	(("6,441,492") or ("6,368,484") or ("6,339,258") or ("6,333,560") or ("5,865,984") or ("5,486,282")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 15:38

S45	5	(("6387800") or ("6391776") or ("6506668") or ("6893541") or ("7199052")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:37
S46	3	(("6,607,977") or ("6,642,146") or ("7,659,197") or ("7,901,5451")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:40
S47	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:44
S48	950	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/24 08:03
S49	518	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity))	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:04
S50	273	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity) and etch$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:06
S51	7	(("6706625") or ("6342733") or ("5695810") or ("5585673") or ("6323554") or ("20040113279") or ("5,470,790")).PN. or (2007/0202689).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:46
S52	2	(("6323554") or ("20070202689")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:49
S53	3	(("6,110,648") or ("5,470,789") or ("5,350,484")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 09:10
S54	65	((electromigration or electromigrating) same ((cap or capping) and dielectric and (conductive or conducting or metal or metallic) and (trench or opening or recess or channel or hole or cavity) and etch or etching)) same4 (inhibiting or inhibitor or azole or amine or amino or phosphate or phosphonate)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 10:37
S56	2	(("20090283499") or ("20060128144")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/08/14 12:52
S58	7	(inhibitor and solvent and etch$3 and (smooth or uniform$3 or even or rough$4) and cap$4) AND ((H01L21/7685 OR H01L23/485).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2015/08/14 13:37

2/8/2016 4:17:47 PM
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BIB DATA SHEET

CONFIRMATION NO. 8341

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/991,899	06/05/2013	257	2898	42P38794

APPLICANTS

INVENTORS

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2011/059453 11/04/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

06/19/2013

Foreign Priority claimed	❑ Yes ☑ No	❑ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	❑ Yes ☑ No		OR	10	20	3
Verified and Acknowledged	/RODOLFO D FORTICH/ Examiner's Signature	Initials				

ADDRESS

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402
UNITED STATES

TITLE

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FILING FEE RECEIVED	FEES: Authority has been given in Paper	❑ All Fees
1480	No._____ to charge/credit DEPOSIT ACCOUNT	❑ 1.16 Fees (Filing)
	No._____ for following:	❑ 1.17 Fees (Processing Ext. of time)
		❑ 1.18 Fees (Issue)
		❑ Other _____
		❑ Credit

BIB (Rev. 05/07).

Receipt date: 02/03/2015

Substitute for Form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Sheet	1	of	1

Complete if Known

Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor:	Boyan Boyanov
Art Unit	2898
Confirmation No.	8341
Examiner Name	Fortich, Rodolfo D.
Attorney Docket No.	**42P38794**

13991899 GAU: 2898

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

***Abstract in English and English Translation**

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published
/R.F./	**NPL1**	Taiwan Patent Application No. 101140536, Office Action and Taiwan IPO Search Report (with English translation), dated November 27, 2014, (15 pages) [P38794TW].
	NPL2	

Examiner Signature	/Rodolfo Fortich/	Date Considered	3/24/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Based on Form PTO/SB/08B (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	
Sheet	1	of	2	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/R.F./		US-	7,396,759 B1	07-08-2008	Van Schravendijk Bart et al.	
/R.F./		US-	2006/0128144 A1	06-15-2006	Hyun-Mog Park et al.	
/R.F./		US-	2009/0127097 A1	05-21-2009	Chen Kei-Wei et al.	
/R.F./		US-	2009/0283499 A1	11-19-2009	Mayer Steven T. et al.	
		US-				
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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,

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

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SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.
If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Substitute for Form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	/Rodolfo Fortich/
Sheet	2	**of**	2	Attorney Docket Number	42P38794

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		OTA, Takashi, et al., "Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle," Proc. Of SPIE Vol. 6921, 69213S, (2008)	
/R.F./		M.M ANTONIJEVIC et al., "Copper Corrosion Inhibitors. A review", Int. J. Electrochem Sci., Vol. 3, 2008, 28 pages.	
/R.F./		T. SAITO et al., 'A Robust, Deep-Submicron Copper Interconnect Structure using Self-Aligned Metal Capping Method", IEEE, 2004, 3 pages.	
/R.F./		PCT International Search Report and Written Opinion for PCT/US2011/059453, mailed July 16, 2012 (14 pp.).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

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[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English Translation is attached.
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Examiner Name	Fortich, Rodolfo D.
Sheet	1	**of**	1	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-				
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		International Preliminary Report on Patentability (Chapter 1 of the Patent Cooperation Treaty) for PCT/US2011/059453, mailed May 6, 2014 (8 pages).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

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SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

CPC								
Symbol							**Type**	**Version**
H01L		23	/	53238			F	2013-01-01
H01L		21	/	7685			I	2013-01-01
H01L		23	/	485			I	2013-01-01
H01L		21	/	76883			I	2013-01-01
H01L		21	/	76849			I	2013-01-01
H01L		2924	/	0002			A	2013-01-01
H01L		23	/	528			I	2013-01-01
H01L		23	/	53209			I	2013-01-01
H01L		23	/	53295			I	2013-01-01
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CPC Combination Sets								
Symbol							**Type**	**Set**	**Ranking**	**Version**
H01L		2924	/	0002			A	1	1	2013-01-01
H01L		2924	/	00			A	1	2	2013-01-01

/RODOLFO FORTICH/ Examiner.Art Unit 2898	02/08/2016	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	11	
/CHUONG A LUU/ Primary Examiner.Art Unit 2898	02/20/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	3B

U.S. Patent and Trademark Office

Part of Paper No. 20160208

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
257	773	H	0	1	L	21 / 76 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
438	627	669	687	597	618

/RODOLFO FORTICH/ Examiner.Art Unit 2898	02/08/2016	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	11	
/CHUONG A LUU/ Primary Examiner.Art Unit 2898	02/20/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	3B

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

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

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	-	17												
2	2	-	18												
3	3	-	19												
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-	13														
-	14														
-	15														
-	16														

/RODOLFO FORTICH/ Examiner.Art Unit 2898 (Assistant Examiner)	02/08/2016 (Date)	**Total Claims Allowed:** 11	
/CHUONG A LUU/ Primary Examiner.Art Unit 2898 (Primary Examiner)	02/20/2016 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 3B

Substitute for form 1449A/PTO	*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*	**Application Number**	13/991,899
	Filing Date	06/05/2013
	First Named Inventor	Boyan BOYANOV
	Group Art Unit	2898
	Examiner Name	FORTICH, Rodolfo D.
e-filed December 21, 2015		
Sheet 1 of 1	**Attorney Docket No: 42P38794**	

US PATENT DOCUMENTS					
Examiner Initial *	**Cite No [1]**	**USP Document Number**	**Publication or Issue Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	**Cite No [1]**	**Foreign Patent Document** Country Code/Number/Kind Code (if known)	**Publication Date MM-DD-YYYY**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**	**T [2]**

OTHER DOCUMENTS -- NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No [1]**	**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, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T [2]**
	NPL1	Chih-Kai Hsu "Electromigration Study on Sn capped Air-gap Cu Damascenes Structure", 2006.	
	NPL2	Korean Patent Application No. 10-2014-7015212, Office Action (with English translation), dated August 3, 2015 (14 pages) [P38794KR].	
	NPL3	Taiwan (R.O.C.) Patent Application No. 101140536, Office Action (with English translation), dated August 13, 2015, (17 pages) [P38794TW].	
	NPL4	China Patent Application No. 201180074611.5, Office Action, dated November 16, 2014, (9 pages) [P38794CN].	

EXAMINER **DATE CONSIDERED**

Based on PTO/SB/08A(09-06) - Substitute Disclosure Statement Form (PTO-1449) as modified by BSTZ 03/26/07

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Electronic Patent Application Fee Transmittal	
Application Number:	13991899
Filing Date:	05-Jun-2013
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Filer:	Tatiana Rossin/Theresa Asmus
Attorney Docket Number:	42P38794
Filed as Large Entity	
Filing Fees for U.S. National Stage under 35 USC 371	

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($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	24434436
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Theresa Asmus
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	21-DEC-2015
Filing Date:	05-JUN-2013
Time Stamp:	19:53:36
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	7466
Deposit Account	504238
Authorized User	ROSSIN, TATIANA
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 CFR 1.492 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)	

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Charge any Additional Fees required under 37 CFR 1.21 (Miscellaneous fees and charges)

Charge any Additional Fees required under 37 CFR 1.492(a) (basic national fee only)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Other Reference-Patent/App/Search documents	P38794_IDS_Transmittal_Letter_efile.pdf	48690 a1ccfa0f58f73b7c76441caa91700140f67df4c7	no	2
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	P38794_IDS_Form_1449_efile.pdf	32004 d2a36387bc5d5b221a4e5f5018c32203488bfa3b	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Non Patent Literature	NPL1_Chih-Kai_Hsu_P38794TW_P68948.pdf	125831 b6748f1cbb104638b2bc208ca75b6ecaea517587	no	3
Warnings:					
Information:					
4	Non Patent Literature	NPL2_Korea_OA_P38794_2015-08-03.pdf	2504447 77b700379ec6a3ac3c7d718a759f7b053087f0d5	no	14
Warnings:					
Information:					
5	Non Patent Literature	NPL3_Taiwan_OA_P38794_2015-09-02.pdf	320732 fe5fcdbcbc99516049108fb2744a5825a2cde873	no	14
Warnings:					
Information:					
6	Non Patent Literature	NPL4_China_OA_P38794_2015-11-23.pdf	433667 c724db1c24f568a1260891580835b85537cb29ad	no	9
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	30775 686f6eb969a1d80d253ee8380a4607cf9c39649a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	3496146		

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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
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New International Application Filed with the USPTO as a Receiving Office
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Attorney Docket No: 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:	Examiner: Fortich, Rodolfo D.
Boyan Boyanov	Art Unit: 2898
Application No.: 13/991,899	Confirmation No.: 8341
Filed: June 5, 2013	**CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below.
For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	/Theresa Asmus/ December 21, 2015 ***Signature*** ***Date***

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

INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08 together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed). It is respectfully requested that the cited documents be considered and that the enclosed copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

Pursuant to 37 C.F.R. § 1.97, the submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made and is not to be construed as an admission that the information cited in this statement is material to patentability.

Pursuant to 37 C.F.R. § 1.97, this Information Disclosure Statement is being submitted under one of the following (as indicated by an "X" to the left of the appropriate paragraph):

_____ 37 C.F.R. §1.97(b).

__X__ 37 C.F.R. §1.97(c). If so, then enclosed with this Information Disclosure Statement is one of the following:

_____ A statement pursuant to 37 C.F.R. §1.97(e) or

__X__ Authorization for $180.00 for the fee under 37 C.F.R. § 1.17(p).

_____ 37 C.F.R. §1.97(d). If so, then enclosed with this Information Disclosure Statement are the following:

(1) A statement pursuant to 37 C.F.R. §1.97(e); and

(2) Authorization for $180.00 for the fee under 37 C.F.R. §1.17(p) for submission of the Information Disclosure Statement.

If there are any additional charges, you are hereby authorized to charge Deposit Account No. 504238.

Respectfully submitted,

BLAKELY SOKOLOFF TAYLOR ZAFMAN LLP

Date: December 21, 2015

/Tatiana Rossin/
Tatiana Rossin
Reg. No. 56,833

1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
(408) 720-8300

Attorney's Docket No. 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan Boyanov Application No.: 13/991,899 Filed: June 5, 2013 For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	Examiner: Fortich, Rodolfo D. Art Unit: 2898 Confirmation No.: 8341 **CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below. /Theresa Asmus/ December 21, 2015 **Signature** **Date**

Filed via EFS-Web
Commissioner for Patents
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Non-Final Office Action mailed August 28, 2015, applicant submits the following amendment and remarks for consideration.

IN THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method to manufacture an electronic device, comprising:
recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using a first chemistry comprising between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, between about 50ppm to about 1% by mass of an inhibitor and between about 1% to about 60% by mass of a solvent to provide an etching uniformity independent of a crystallographic orientation; and
depositing a capping layer on the recessed conductive line and on the dielectric sidewall of the channel to prevent electromigration.

2. (Previously Presented) The method of claim 1, wherein the recessing includes forming a passivation layer on the at least one conductive line during etching using the inhibitor and the solvent, wherein the passivation layer is to ensure that the at least one conductive line is etched uniformly independent of a crystallographic orientation.

3. (Original) The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. (Original) The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. (Original) The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. (Original) The method of claim 1, further comprising

forming a dielectric layer over the substrate;

forming at least one opening in the dielectric layer; and

filling the at least one opening with a conductive material to form the at least one conductive line.

7. (Original) The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. (Currently Amended) A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising a dielectric sidewall self-aligned to the at least one conductive line, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, between about 50ppm to about 1% by mass of an inhibitor and between about 1% to about 60% by mass of a solvent to provide uniformity of etching independent of a crystallographic orientation; and

depositing a capping layer on the at least one conductive line and on the dielectric sidewall of the channel.

9. (Canceled).

10. (Currently Amended) The method of claim [[9]] 8, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof, and the solvent includes water, propylene carbonate, sulfolane, glycol ethers, methylene chloride, or any combination thereof.

11. (Original) The method of claim 8, further comprising

depositing the capping layer onto the etched conductive line in the channel.

12. (Original) The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. (Withdrawn) An apparatus, comprising:

at least one first conductive line in a dielectric layer over a substrate,

and

a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. (Withdrawn) The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. (Withdrawn) The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. (Withdrawn) The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. (Withdrawn) The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. (Withdrawn) The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. (Withdrawn)The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. (Withdrawn) The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

REMARKS

Reconsideration of this application, as amended, is respectfully requested.

Claims 1-8, and 11-12 stand rejected. Claims 9 and 10 stand objected to.

In this response, claims 1, 8, and 10 have been amended. Claim 9 has been canceled. No claims have been added. Support for the amendments is found in the specification, the drawings, and in the claims as originally filed. Applicant submits that the amendments do not add new matter.

Applicant acknowledges with appreciation the Examiner's indication of allowance of claims 9 and 10 if claim 9 is re-written in independent form including all limitations of the base claim and any intervening claims.

Claims 1-8 and 11-12 are rejected under pre-AIA 35 U.S.C 103(a) as being unpatentable over Misawa et al., U.S. Patent No. 5,470,789 (hereinafter "Misawa"), in view of Mayers et al., U.S. Publication No. 2009/0283499 (hereinafter "Mayers")

The Examiner noted that Misawa fails to explicitly teach that the first chemistry comprises an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation. (Office Action, page 4).

Amended claim 1 recites, in part, "recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using ***a first chemistry comprising between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, between about 50ppm to about 1% by mass of an inhibitor and between about 1% to about 60% by mass of a solvent***." (emphasis added).

The Examiner stated that claim 9 that recites "the first chemistry compris[ing] between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, between about 50ppm to about 1% by mass of an inhibitor and between about 1% to about 60% by mass of a solvent" would be allowable if re-written in independent form including all limitations of the base claim and any intervening claims.

Given that amended claim 1 contains some limitations that are similar to those limitations discussed with respect to claim 9, applicant respectfully submits that claim 1, as amended, is now allowable.

Applicant has amended claim 8 to include all limitations of claim 9. Therefore, applicant respectfully submits that claim 8, as amended is now allowable.

Applicant has canceled claim 9.

The Examiner indicated that claim 10 would be allowable if claim 9 were re-written in independent form including all limitations of the base claim and any intervening claims.

Therefore, applicant respectfully submits that claim 10 is now allowable.

Given that claims 2-7 and 11-12 depend from amended claims 1 and 8 respectively, and add additional limitations, applicant respectfully submits that claims 2-7 and 11-12 are now allowable.

It is respectfully submitted that in view of the amendments and arguments set forth herein, the applicable rejections and objections have been overcome. If the Examiner believes a telephone conference would expedite the prosecution of the present application, the Examiner is invited to call the undersigned at (408) 720-8300.

If there are any additional charges, please charge Deposit Account No. 504238.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: December 21, 2015

/Tatiana Rossin/
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PTO/AIA/22 (03-13)
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) 42P38794
Application Number 13/991,899	Filed June 5, 2013
For METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	
Art Unit 2898	Examiner FORTICH, Rodolfo D.

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	Micro Entity Fee	
☑	One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 200.00
☐	Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐	Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐	Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐	Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 02-2666.

☑ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 56,833.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Tatiana Rossin/	December 21, 2015
Signature	Date
Tatiana Rossin	408-720-8300
Typed or printed name	Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☐ * Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). 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 1.11 and 1.14. This collection is estimated to take 6 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: Mail Stop PCT, 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 disclosure of these records is required by the Freedom of Information Act.
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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.

Electronic Patent Application Fee Transmittal	
Application Number:	13991899
Filing Date:	05-Jun-2013
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Filer:	Tatiana Rossin/Theresa Asmus
Attorney Docket Number:	42P38794
Filed as Large Entity	
Filing Fees for U.S. National Stage under 35 USC 371	

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($)
Extension - 1 month with $0 paid	1251	1	200	200
Miscellaneous:				
			Total in USD ($)	**200**

Electronic Acknowledgement Receipt	
EFS ID:	24434547
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Theresa Asmus
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	21-DEC-2015
Filing Date:	05-JUN-2013
Time Stamp:	20:05:20
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$200
RAM confirmation Number	8144
Deposit Account	022666
Authorized User	ROSSIN, TATIANA V.
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 CFR 1.492 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 CFR 1.19 (Document supply fees)

Charge any Additional Fees required under 37 CFR 1.21 (Miscellaneous fees and charges)

Charge any Additional Fees required under 37 CFR 1.492(a) (basic national fee only)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		P38794_ROA_efile.pdf	63355 34119504f23489207e943039ff237420e5206407	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	5
	Applicant Arguments/Remarks Made in an Amendment	6	8

Warnings:					
Information:					
2	Extension of Time	P38794_EOT_efile.pdf	182972 435bfd974596ca13c3be95688a2891989c5c8de7	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30827 5e1849dba650dcbcf6bceff99343042618bb1267	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	277154		

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)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/991,899	Filing Date 06/05/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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 **12/21/2015**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	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) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ 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.
** 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 number found in the appropriate box in column 1.

LIE
/LINDA A. WASHINGTON/

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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 08/28/2015

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	

ART UNIT	PAPER NUMBER
2898	

NOTIFICATION DATE	DELIVERY MODE
08/28/2015	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):

inteldocs_docketing@cpaglobal.com
Database_Group@bstz.com

Office Action Summary	Application No. 13/991,899	Applicant(s) BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	AIA (First Inventor to File) Status No

-- 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 *07/29/2015*.

☐ 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) *1-20* is/are pending in the application.

5a) Of the above claim(s) *13-20* is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-8,11 and 12* is/are rejected.

8)☒ Claim(s) *9 and 10* 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 *06/05/2013* 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 *06/05/2013, 08/15/2014, 02/03/2015*.

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

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Request for Continued Examination

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 07/29/2015 has been entered.

2. Applicant's amendments/arguments with respect to claims 1 and 8 have been considered but are moot because the arguments do not apply to the references being used in the current rejection. Claims 13-20 are withdrawn from further consideration in the reply filed on October 20, 2014.

Claim Rejections - 35 USC § 103

3. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented 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 having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. **Claims 1-8 and 11-12 is rejected under pre-AIA 35 U.S.C 103(a) as being unpatentable over Misawa et al (US 5,470,789; hereinafter "Misawa") in view of Mayers et al (US 2009/0283499 A1; hereinafter "Mayers").**

5. **Regarding claim 1**, Misawa (figures 6A-6E and Column 5-6) teaches a method to manufacture an electronic device, comprising: recessing (buff-abrading) at least one conductive line (36 made of Cu as per column 5-line 50) in a dielectric layer (32, made of silicon nitride, as per column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over a substrate (30) to form a channel (top central opening in figure 6C) comprising a dielectric sidewall (upper central sides of 32) and depositing a capping layer (38, figure 6D) on the recessed conductive line (36) in the channel (top central opening shown in figure 6C) to prevent electro-migration (diffusion of the copper can be precluded and wiring layers of high electro-migration resistances and low resistances can be formed, column 6-lines 28-30).

Misawa fails to explicitly teach the using of a first chemistry comprising an inhibitor and a solvent to provide an etching uniformity independent of a crystallographic orientation.

Mayers (figure 1B and paragraphs 60-64) teaches the using of a first chemistry (dilute aqueous solutions of peroxides, persulfates, ozone and/or permanganates, paragraph 60) comprising an inhibitor (paragraph 64-line 2) and a solvent (water is the solvent in any aqueous solution) to provide an etching uniformity independent of a crystallographic orientation (minimize grain attacks and surface roughening, paragraph 64-lines 2-3).

It would have been obvious to one of ordinary skill in the art, at the time of the invention, to use an inhibitor in Misawa's first chemistry, as taught by Mayers, in order to control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

6. **Regarding claim 2**, Misawa as modified by Mayers teaches the method of claim 1, wherein the recessing includes forming a passivation layer (dilute aqueous solutions film of peroxides, persulfates, ozone and/or permanganates, Mayers paragraph 60) on the at least one conductive line during etching using the inhibitor (paragraph 64-line 2) and the solvent (water), wherein the passivation layer is to ensure that the at least one conductive line is etched uniformly independent of a crystallographic orientation (minimize grain attacks and surface roughening, Mayers paragraph 64-lines 2-3).

7. **Regarding claim 3**, Misawa as modified by Mayers teaches the method of claim 1, wherein the channel (top central opening in Misawa's figure 6C) is self-aligned (lined up) to the conductive line (36).

8. **Regarding claim 4**, Misawa as modified by Mayers teaches the method of claim 1, wherein the at least one conductive line (36) is recessed to a depth (figure 6C) determined based on a thickness of the capping layer (38, see Misawa's figure 6E).

9. **Regarding claim 5**, Misawa as modified by Mayers teaches the method of claim 1, wherein the capping layer (38) is deposited on the recessed conductive line 36 (Misawa's figure 6D) by an electroless plating, a chemical vapor deposition, or a physical vapor deposition (Misawa's column 6-lines 7-8).

10. **Regarding claim 6**, Misawa as modified by Mayers teaches the method of claim 1, further comprising forming a dielectric layer (32, made of silicon nitride, as per Misawa's column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over the substrate (30); forming at least one opening (33 in Misawa's figure 6A) in the dielectric layer (32); and filling the at least one opening with a conductive material (36, Misawa's figure 6B) to form the at least one conductive line (36 in Misawa's figure 6C).

11. **Regarding claim 7**, Misawa as modified by Mayers teaches the method of claim 1, wherein the at least one conductive line (36) comprises a first metal (Cu, as per Misawa's column 5-line 47-48), and the capping layer (38) comprises a second metal (Ti, Misawa's column 5-line 49) other than the first metal (Cu).

12. **Regarding claim 8**, Misawa (figures 6A-6E and Column 5-6) teaches a method to control line edge roughness, comprising: etching (buff-abrading) at least one conductive line (36 made of Cu as per Misawa's column 5-line 50) in a dielectric layer (32, made of silicon nitride, as per column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over a substrate (30) with a first chemistry (potassium iodine, iodine, and an abrasive agent, Misawa's column 5-line 67 and column 6-lines 1-6) to a predetermined depth to form a channel (top central opening shown in Misawa's figure 6C) comprising a dielectric sidewall (upper vertical walls of 32) self-aligned to the at least one conductive line 36 (Misawa's figure 6C), and depositing a capping layer (38) on the at least one conductive line (36), and on the dielectric sidewall of the channel (Misawa's figure 6D).

Misawa fails to explicitly teach that the first chemistry comprises an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation.

Mayers (figure 1B and paragraphs 60-64) teaches the using of a first chemistry (dilute aqueous solutions of peroxides, persulfates, ozone and/or permanganates, paragraph 60) comprising an inhibitor (paragraph 64-line 2) and a solvent (water is the solvent in any aqueous solution) to provide an etching uniformity independent of a crystallographic orientation (minimize grain attacks and surface roughening, paragraph 64-lines 2-3).

It would have been obvious to one of ordinary skill in the art, at the time of the invention, to use an inhibitor in Misawa's first chemistry, as taught by Mayers, in order to control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

13. **Regarding claim 11**, Misawa as modified by Mayers teaches the method of claim 8, further comprising depositing the capping layer (38) onto the etched conductive line (36) in the channel (top central opening shown in Misawa's figure 6C).

14. **Regarding claim 12**, Misawa as modified by Mayers teaches the method of claim 8, wherein the depth is determined based on a thickness of the capping layer 38 (Misawa's figure 6E).

Allowable Subject Matter

15. **Claims 9-10 are objected to as being dependent upon a rejected base claim, but would be allowable if claim 9 is rewritten in independent form including all of the limitations of the base claim and any intervening claims.**

16. The following is a statement of reasons for the indication of allowable subject matter: the prior art neither discloses nor suggests that:

- The first chemistry comprises between about 0.1 % to about 70% by mass of an etchant, between about 0.1 % to about 10% by mass of an oxidizer, between about 50ppm to about 1 % by mass of the inhibitor, and between about 1 % to about 60% by mass of the solvent.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RODOLFO FORTICH whose telephone number is (571)272-3461. The examiner can normally be reached on weekdays, 8AM-5PM. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Julio Maldonado can be reached on (571)272-1864. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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For more information about the PAIR system, see http://pair-direct.uspto.gov. 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.

/RODOLFO FORTICH/
Examiner, Art Unit 2898

/CHUONG A LUU/
Primary Examiner, Art Unit 2898

Notice of References Cited	Application/Control No. 13/991,899	Applicant(s)/Patent Under Reexamination BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,470,789	11-1995	Misawa, Nobuhiro	438/643
*	B	US-2009/0283499	11-2009	Mayer et al.	216/90
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Examiner Name	Fortich, Rodolfo D.
Sheet	1	**of**	1	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-				
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		International Preliminary Report on Patentability (Chapter 1 of the Patent Cooperation Treaty) for PCT/US2011/059453, mailed May 6, 2014 (8 pages).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Receipt date: 02/03/2015 13991899 GAU: 2898

Substitute for Form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Complete if Known	
Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor:	Boyan Boyanov
Art Unit	2898
Confirmation No.	8341
Examiner Name	Fortich, Rodolfo D.
Attorney Docket No.	**42P38794**

Sheet	**1**	**of**	**1**

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

***Abstract in English and English Translation**

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published
/R.F./	**NPL1**	Taiwan Patent Application No. 101140536, Office Action and Taiwan IPO Search Report (with English translation), dated November 27, 2014, (15 pages) [P38794TW].
	NPL2	

Examiner Signature	/Rodolfo Fortich/	Date Considered	3/24/2015

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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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	Art Unit
	RODOLFO FORTICH	2898

CPC- SEARCHED		
Symbol	Date	Examiner
H01L21/7685 OR H01L23/485	8/14/2015	R. F

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner
(H01L2924/00014 ORH01L2924/00 OR H01L2924/0002 ORH01L2224/13147 ORH01L2224/48247)	8/14/2015	R. F

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
257	773, 762, 767, 741, 750	8/14/2015	R. F

SEARCH NOTES		
Search Notes	Date	Examiner
See EAST search	8/18/2015	R. F
Consultation with Chuong Luu (2898)	8/18/2015	R. F
Assignee/Inventor search	10/28/2014	R. F

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
438	627, 669, 6876, 597, 618	8/14/2015	R. F

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	7	"257/773".CCLS. and (recess$3 same (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S2	23	"257/773".CCLS. and (recess$3 same2 (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S4	595	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 13:43
S5	4	((13/991903) or (13/914637) or (13/915158) or (13/921436)).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/08/12 14:12
S6	78	((Boyan) near2 (Boyanov)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2014/08/12 14:38
S7	2483	(recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S8	724	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S9	683	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3 and dielectric)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:40
S10	647	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:41
S11	55	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:42
S12	38	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:08
S13	40	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same6 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:09

S14	448	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:08
S15	143	S14 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:09
S16	4	(("20100109131") or ("20080026487") or ("20040245637") or ("20010045651")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 08:31
S17	160	"438/627".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:53
S18	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 09:12
S19	155	"438/669".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 10:11
S20	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:28
S21	1	("20050001325").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:33
S22	2	(("6,375,693") or ("6,503,834")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:38
S29	59	("257/762".CCLS. or "257/767".CCLS. or "257/741".CCLS. or "257/750".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 11:33
S30	65	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 12:36
S31	9	(recess$3 or etch$3) same2 (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3) and inhibitor)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/28 13:54
S32	1	(10/690084).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 13:56
S33	1	("5535230").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 10:22
S34	1	("8502247").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:05

S35	2	(("7488432") or ("20140152637")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:57
S36	615	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/09 15:25
S37	462	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S38	276	S37 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S39	1	("5741626").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/20 16:39
S40	66	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2015/03/20 17:10
S41	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:40
S42	1	("6,696,758").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:51
S43	13	(("6,395,607") or ("6,670,274") or ("5,374,454") or ("5,380,546") or ("5,723,387") or ("6,274,499") or ("6,258,713") or ("6,261,963") or ("6,281,127") or ("6,171,960") or ("6,350,687") or ("6,017,803") or ("6,251,774")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:58
S44	6	(("6,441,492") or ("6,368,484") or ("6,339,258") or ("6,333,560") or ("5,865,984") or ("5,486,282")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 15:38
S45	5	(("6387800") or ("6391776") or ("6506668") or ("6893541") or ("7199052")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:37
S46	3	(("6,607,977") or ("6,642,146") or ("7,659,197") or ("7,901,5451")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:40
S47	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:44
S48	950	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/24 08:03
S49	518	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity))	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:04

S50	273	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity) and etch$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:06
S51	7	(("6706625") or ("6342733") or ("5695810") or ("5585673") or ("6323554") or ("20040113279") or ("5,470,790")).PN. or (2007/0202689).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:46
S52	2	(("6323554") or ("20070202689")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:49
S53	3	(("6,110,648") or ("5,470,789") or ("5,350,484")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 09:10
S54	65	((electromigration or electromigrating) same ((cap or capping) and dielectric and (conductive or conducting or metal or metallic) and (trench or opening or recess or channel or hole or cavity) and etch or etching)) same4 (inhibiting or inhibitor or azole or amine or amino or phosphate or phosphonate)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 10:37
S55	5	(inhibitor and solvent and etch$3 and crystal$9 and (smooth or uniform$3 or even or rough$4) and cap$4) AND ((H01L21/7685 OR H01L23/485).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2015/08/14 11:59
S56	2	(("20090283499") or ("20060128144")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/08/14 12:52
S58	7	(inhibitor and solvent and etch$3 and (smooth or uniform$3 or even or rough$4) and cap$4) AND ((H01L21/7685 OR H01L23/485).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2015/08/14 13:37
S59	11	(inhibitor and (solvent or water) and etch$3 and (smooth or uniform$3 or even or rough$4)) AND ((H01L21/7685 OR H01L23/485).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2015/08/14 14:13

8/18/2015 12:13:18 PM
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Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	Rodolfo D. Fortich
Sheet	1	of	2	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/R.F./		US-	7,396,759 B1	07-08-2008	Van Schravendijk Bart et al.	
/R.F./		US-	2006/0128144 A1	06-15-2006	Hyun-Mog Park et al.	
/R.F./		US-	2009/0127097 A1	05-21-2009	Chen Kei-Wei et al.	
/R.F./		US-	2009/0283499 A1	11-19-2009	Mayer Steven T. et al.	
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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,

Based on Form PTO/SB/08A (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

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Substitute for Form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	/Rodolfo Fortich/
Sheet	2	**of**	2	Attorney Docket Number	42P38794

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		OTA, Takashi, et al., "Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle," Proc. Of SPIE Vol. 6921, 69213S, (2008)	
/R.F./		M.M ANTONIJEVIC et al., "Copper Corrosion Inhibitors. A review", Int. J. Electrochem Sci., Vol. 3, 2008, 28 pages.	
/R.F./		T. SAITO et al., 'A Robust, Deep-Submicron Copper Interconnect Structure using Self-Aligned Metal Capping Method", IEEE, 2004, 3 pages.	
/R.F./		PCT International Search Report and Written Opinion for PCT/US2011/059453, mailed July 16, 2012 (14 pp.).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English Translation is attached.
This collection of information is required by 37 CFR 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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.**
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

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

CLAIM		DATE								
Final	Original	08/12/2014	10/28/2014	03/24/2015	08/18/2015					
	1	÷	✓	✓	✓					
	2	÷	✓	✓	✓					
	3	÷	✓	✓	✓					
	4	÷	✓	✓	✓					
	5	÷	✓	✓	✓					
	6	÷	✓	✓	✓					
	7	÷	✓	✓	✓					
	8	÷	✓	✓	✓					
	9	÷	✓	✓	O					
	10	÷	✓	✓	O					
	11	÷	✓	✓	✓					
	12	÷	✓	✓	✓					
	13	÷	N	N	N					
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	19	÷	N	N	N					
	20	÷	N	N	N					

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BIB DATA SHEET

CONFIRMATION NO. 8341

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/991,899	06/05/2013	257	2898	42P38794

APPLICANTS

INVENTORS

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2011/059453 11/04/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

06/19/2013

Foreign Priority claimed	☐ Yes ☑ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☑ No		OR	10	20	3
Verified and Acknowledged	/RODOLFO D FORTICH/ Examiner's Signature	Initials				

ADDRESS

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402
UNITED STATES

TITLE

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FILING FEE RECEIVED	FEES: Authority has been given in Paper	☐ All Fees
1480	No._____ to charge/credit DEPOSIT ACCOUNT	☐ 1.16 Fees (Filing)
	No._____ for following:	☐ 1.17 Fees (Processing Ext. of time)
		☐ 1.18 Fees (Issue)
		☐ Other _____
		☐ Credit

BIB (Rev. 05/07).

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	13/991,899	Filing Date	2013-06-05	Docket Number (if applicable)	42P38794	Art Unit	2898
First Named Inventor	Boyan Boyanov			Examiner Name	FORTICH, Rodolfo D.		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☒ Other PETITION FOR EXTENSION OF TIME PURSUANT TO 37 C.F.R. § 1.136 (a)

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 504238

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Signature of Registered U.S. Patent Practitioner			
Signature	/Tatiana Rossin/	Date (YYYY-MM-DD)	2015-07-29
Name	Tatiana Rossin	Registration Number	56833

This collection of information is required by 37 CFR 1.114. 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 1.11 and 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.

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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 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 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.

PATENT

Attorney's Docket No. 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:	Examiner: Fortich, Rodolfo D.
Boyan Boyanov	Art Unit: 2898
Application No.: 13/991,899	Confirmation No.: 8341
Filed: June 5, 2013	**CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below. /Tatiana Rossin/ July 29, 2015 *Tatiana Rossin* *Date*
For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

Filed via EFS-Web
Commissioner for Patents
Alexandria, VA 22313-1450

PETITION FOR EXTENSION OF TIME PURSUANT TO 37 C.F.R. § 1.136 (a)

Sir:

Applicant respectfully petitions pursuant to 37 CFR 1.136(a) for an one month extension of time to file this response to the Final Office Action mailed April 10, 2015. The extended period is set to expire on August 10, 2015. The Director is authorized to charge our Deposit Account No. 504238 in the amount of $200.00 for the fee under 37 C.F.R. § 1.17 (a) for an one month extension of time.

Please charge any shortages and credit any overages to our Deposit Account No. 504238.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: July 29, 2015

/Tatiana Rossin/
Tatiana Rossin
Reg. No. 56,833

1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
(408) 720-8300

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan Boyanov Application No.: 13/991,899 Filed: June 5, 2013 For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	Examiner: Fortich, Rodolfo D. Art Unit: 2898 Confirmation No.: 8341 **CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below. /Tatiana Rossin/ July 29, 2015 ***Tatiana Rossin*** ***Date***

Filed via EFS-Web
Commissioner for Patents
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Final Office Action mailed April 10, 2015, applicant submits the following amendment and remarks for consideration. A Request for Continued Examination is submitted herewith.

IN THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method to manufacture an electronic device, comprising:
recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using a first chemistry comprising an inhibitor and a solvent to provide an etching uniformity independent of a crystallographic orientation; and
depositing a capping layer on the recessed conductive line and on the dielectric sidewall of the channel to prevent electromigration.

2. (Currently Amended) The method of claim 1, wherein the recessing includes ~~etching~~ forming a passivation layer on the at least one conductive line during etching using the inhibitor and the solvent, wherein the passivation layer is to ensure that the at least one conductive line is etched uniformly independent of a crystallographic orientation.

3. (Original) The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. (Original) The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. (Original) The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. (Original) The method of claim 1, further comprising
forming a dielectric layer over the substrate;
forming at least one opening in the dielectric layer; and

filling the at least one opening with a conductive material to form the at least one conductive line.

7. (Original) The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. (Currently Amended) A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising a dielectric sidewall self-aligned to the at least one conductive line, wherein the first chemistry comprises an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation; and

depositing a capping layer on the at least one conductive line and on the dielectric sidewall of the channel.

9. (Currently Amended) The method of claim 8, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, ~~and~~ between about 50ppm to about 1% by mass of the inhibitor, and between about 1% to about 60% by mass of the solvent.

10. (Currently Amended) The method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof, and the solvent includes water, propylene carbonate, sulfolane, glycol ethers, methylene chloride, or any combination thereof.

11. (Original) The method of claim 8, further comprising

depositing the capping layer onto the etched conductive line in the channel.

12. (Original) The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. (Withdrawn) An apparatus, comprising:

at least one first conductive line in a dielectric layer over a substrate,

and

a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. (Withdrawn) The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. (Withdrawn) The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. (Withdrawn) The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. (Withdrawn) The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. (Withdrawn) The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. (Withdrawn)The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. (Withdrawn) The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

REMARKS

Reconsideration of this application, as amended, is respectfully requested.

Claims 1-12 stand rejected.

In this response, claims 1, 2, and 8-10 have been amended. No claims have been canceled. No claims have been added. Support for the amendments is found in the specification, the drawings, and in the claims as originally filed. Applicant submits that the amendments do not add new matter.

Amended claim 1 reads as follows:

A method to manufacture an electronic device, comprising:

recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using a first chemistry comprising an inhibitor and a solvent to provide an etching uniformity independent of a crystallographic orientation; and

depositing a capping layer on the recessed conductive line and on the dielectric sidewall of the channel to prevent electromigration. (emphasis added)

Claims 1-7 were rejected under pre-AIA 35 U.S.C 102(b) as being anticipated by Misawa et al., U.S. Patent No. 5, 470,789 (hereinafter "Misawa").

The Examiner noted that Misawa fails to explicitly teach that the first chemistry comprises an inhibitor to provide uniformity of etching independent of a crystallographic orientation. (Office Action, page 4).

Misawa discloses process for fabricating integrated circuit devices. More specifically, Misawa discloses that wiring layer 36 of copper formed in an opening in the

insulating layer 32 is buff-abraded with a mixed aqueous solution (5%) of potassium iodine (KI) and iodine (I_2), and an abrasive agent (col. 5, line 47-col. 6, line 2).

Thus, Misawa discloses buff-abrading of the copper wiring layer with a mixed aqueous solution (5%) of potassium iodine (KI) and iodine (I_2), and an abrasive agent. In contrast, amended claim 1 refers to using a first chemistry comprising ***an inhibitor and a solvent to provide an etching uniformity independent of a crystallographic orientation***.

Misawa fails to teach or suggest recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall using a first chemistry comprising an inhibitor and a solvent to provide an etching uniformity independent of a crystallographic orientation, as recited in amended claim 1.

Because Misawa fails to disclose all limitations of amended claim 1, applicant respectfully submits that claim 1, as amended, is not anticipated by Misawa under pre-AIA 35 U.S.C 102(b).

Given that claims 2-7 depend from amended claim 1, and add additional limitations, applicant respectfully submits that claims 2-7 are not anticipated by Misawa under pre-AIA 35 U.S.C 102(b).

Claims 8-12 have been rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Misawa, in view of U.S. Patent No. 7,338,908 B1 to Koos et al. ("Koos").

As set forth above, Misawa fails to teach or suggest the first chemistry comprising ***an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation,*** as recited in amended claim 8.

Koos does not cure the Misawa deficiencies. Koos discloses that the etching and/or oxidizing solution may additionally contain a corrosion inhibitor to minimize grain attacks and surface roughening of the exposed copper metal. (col. 9, lines 9-13). In contrast, amended claim 8 refers to the first chemistry comprising ***an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation***. Koos fails to teach or suggest the first chemistry comprising an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation, as recited in amended claim 8.

Therefore, one of ordinary skill in the art at the time the invention was made would not use Koos in a combination with Misawa to arrive at etching at least one conductive line in a dielectric layer over a substrate with a first chemistry comprising an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation, as recited in amended claim 8.

Furthermore, even if Misawa and Koos were combined, such a combination would still lack ***the first chemistry comprising an inhibitor and a solvent to provide uniformity of etching independent of a crystallographic orientation***, as recited in amended claim 8.

Therefore, applicant respectfully submits that amended claim 8 is not obvious under pre-AIA 35 U.S.C. 103(a) over Misawa, in view of Koos.

Given that claims 9-12 depend from amended claim 8, and add additional limitations, applicant respectfully submits that claims 9-12 are not obvious under pre-AIA 35 U.S.C. 103(a) over Misawa, in view of Koos.

It is respectfully submitted that in view of the amendments and arguments set forth herein, the applicable rejections and objections have been overcome. If the Examiner believes a telephone conference would expedite the prosecution of the present application, the Examiner is invited to call the undersigned at (408) 720-8300.

If there are any additional charges, please charge Deposit Account No. 504238.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: July 29, 2015

/Tatiana Rossin/
Tatiana Rossin
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1279 Oakmead Parkway
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Fax (408) 720-8383

Customer No. 45209

Electronic Patent Application Fee Transmittal	
Application Number:	13991899
Filing Date:	05-Jun-2013
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Filer:	Tatiana Rossin
Attorney Docket Number:	42P38794
Filed as Large Entity	
Filing Fees for U.S. National Stage under 35 USC 371	

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($)
Extension - 1 month with $0 paid	1251	1	200	200
Miscellaneous:				
Request for Continued Examination	1801	1	1200	1200
		Total in USD ($)		**1400**

Electronic Acknowledgement Receipt	
EFS ID:	23063621
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin
Filer Authorized By:	
Attorney Docket Number:	42P38794
Receipt Date:	29-JUL-2015
Filing Date:	05-JUN-2013
Time Stamp:	18:30:32
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1400
RAM confirmation Number	5092
Deposit Account	504238
Authorized User	ROSSIN, TATIANA
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

Charge any Additional Fees required under 37 C.F.R. Section 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)	42P38794_RCE_072915.pdf	697942 fa284e3ccf0e05e21c7a420814979860f6f7e849	no	3
Warnings:					
Information:					
2	Extension of Time	42P38794_EOT_072915.pdf	17655 709b7880bae8abffa0d9b52a8fa98b1400dd8006	no	1
Warnings:					
Information:					
3		42P38794_Response_to_FOA_072915.pdf	42709 f2c8706542c3d78c4f1cddf7cfdd976977bf334d	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	9

Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	32493 de657fe9694e2f32a97c1b76c83e52845fcb8c92	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	790799		

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
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/991,899	Filing Date 06/05/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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	07/29/2015	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	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) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ 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.
** 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 number found in the appropriate box in column 1.

LIE
/LAJUAN HICKSON/

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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 04/10/2015

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
P.O. Box 52050
Minneapolis, MN 55402

EXAMINER	
FORTICH, RODOLFO D	

ART UNIT	PAPER NUMBER
2898	

NOTIFICATION DATE	DELIVERY MODE
04/10/2015	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):

inteldocs_docketing@cpaglobal.com
Database_Group@bstz.com

Office Action Summary	Application No. 13/991,899	Applicant(s) BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	AIA (First Inventor to File) Status No

-- 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 *02/03/2015*.

☐ 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) *1-20* is/are pending in the application.

5a) Of the above claim(s) *13-20* is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-12* 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 *06/05/2013* 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 *06/05/2013,08/15/2014, 02/03/2015*.

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

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

1. Applicants' amendments filed on 02/03/2015 are acknowledged. Claims 1 and 8 have been amended. Claims 13-20 were withdrawn from further consideration in the reply filed on October 20, 2014.

Applicant's amendments/arguments with respect to claims 1 and 8 have been considered but are moot because the arguments do not apply to the references being used in the current rejection.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of pre-AIA 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 –

(b) The invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. **Claims 1-7 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Misawa et al (US 5,470,789; hereinafter "Misawa").**

4. **Regarding claim 1**, Misawa (figures 6A-6E and Column 5-6) teaches a method to manufacture an electronic device, comprising: recessing (buff-abrading) at least one conductive line (36 made of Cu as per column 5-line 50) in a dielectric layer (32, made of silicon nitride, as per column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over a substrate (30) to form a channel (top central opening in figure 6C); and depositing a capping layer (38, figure 6D) on the recessed conductive line (36) in the channel (top central opening shown in figure 6C) to prevent electro-migration (wiring layers of high electro-migration resistances and low resistances can be formed, column 6-lines 28-30).

5. **Regarding claim 2**, Misawa teaches the method of claim 1, wherein the recessing includes etching (buff-abraded with a mixed aqueous solution of potassium iodine and iodine and an abrasive agent, column 5-line 67 and column 6-lines 1-2) the at least one conductive line (36) uniformly independent of a crystallographic orientation (implied in column 6-lines 1-6).

6. **Regarding claim 3**, Misawa teaches the method of claim 1, wherein the channel (top central opening shown in figure 6C) is self-aligned to the conductive line 36 (figure 6C).

7. **Regarding claim 4**, Misawa teaches the method of claim 1, wherein the at least one conductive line (36) is recessed to a depth (figure 6C) determined based on a thickness of the capping layer (38, see figure 6E).

8. **Regarding claim 5**, Misawa teaches the method of claim 1, wherein the capping layer (38) is deposited on the recessed conductive line 36 (figure 6D) by an electroless plating, a chemical vapor deposition, or a physical vapor deposition (column 6-lines 7-8).

9. **Regarding claim 6**, Misawa teaches the method of claim 1, further comprising forming a dielectric layer (32, made of silicon nitride, as per column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over the substrate (30); forming at least one opening (33 in figure 6A) in the dielectric layer (32); and filling the at least one opening with a conductive material (36, figure 6B) to form the at least one conductive line (36 in figure 6C).

10. **Regarding claim 7**, Misawa teaches the method of claim 1, wherein the at least one conductive line (36) comprises a first metal (Cu, as per column 5-line 47-48), and the capping layer (38) comprises a second metal (Ti, column 5-line 49) other than the first metal (Cu).

Claim Rejections - 35 USC § 103

11. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented 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 having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

12. **Claims 8-12 is rejected under pre-AIA 35 U.S.C 103(a) as being unpatentable over Misawa et al in view of Koos et al (US 7,338,908 B1; hereinafter "Koos").**

13. **Regarding claim 8,** Misawa (figures 6A-6E and Column 5-6) teaches a method to control line edge roughness, comprising: etching (buff-abrading) at least one conductive line (36 made of Cu as per column 5-line 50) in a dielectric layer (32, made of silicon nitride, as per column 5-line 57, where it is well known that silicon nitride has a dielectric constant between 7 to 7.8) over a substrate (30) with a first chemistry (potassium iodine, iodine, and an abrasive agent, column 5-line 67 and column 6-lines 1-6) to a predetermined depth to form a channel (top central opening shown in figure 6C) comprising a dielectric sidewall (upper vertical walls of 32) self-aligned to the at least one conductive line 36 (figure 6C), and depositing a capping layer (38) on the at least one conductive line (36), and on the dielectric sidewall of the channel (figure 6D).

Misawa fails to explicitly teach that the first chemistry comprises an inhibitor to provide uniformity of etching independent of a crystallographic orientation.

Koos teaches different percentages of glycine and peroxide by weight (column 8-lines 55-67) in combination with inhibitors, such as, benotriazole (BTA), thiourea, certain mercaptans, and imidazoles (column 9-lines 9-13), and teaches that by controlling the ratio of copper oxidizing agent and copper oxide etchant in such solutions, one can control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

It would have been obvious to one of ordinary skill in the art, at the time of the invention, to use an inhibitor in Misawa's first chemistry, as taught by Koos, in order to control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

14. **Regarding claim 9**, Misawa teaches the method of claim 8, wherein the first chemistry comprises potassium iodine, iodine, and an abrasive agent, (column 5-line 67 and column 6-lines 1-6).

Missawa fails to explicitly teach that the first chemistry comprises between about 0.1 % to about 70% by mass of an etchant, between about 0.1 % to about 10% by mass of an oxidizer, and between about 50 ppm to about 1 % by mass of the inhibitor.

Koos teaches different percentages of glycine and peroxide by weight (column 8-lines 55-67) in combination with inhibitors, such as, benotriazole (BTA), thiourea, certain mercaptans, and imidazoles (column 9-lines 9-13), and teaches that by controlling the ratio of copper oxidizing agent and copper oxide etchant in such solutions, one can control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

Since the optimization of workable ranges is considered within the skill of the art as it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. It would have been obvious to one of ordinary skill in the art, at the time of the invention, to adjust the quantities of the oxide/inhibitor in the Misawa's teachings as taught by Koos, to obtain the optimum etching rate workable range, controlling the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate. (In re Aller, 105 USPQ 233). See also MPEP 2144.05 I and II.

15. **Regarding claim 10**, Misawa as modified by Koos teaches the method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof (see Koos's column 8-lines 55-67 and column 9-lines 1-13)

16. **Regarding claim 11**, Misawa as modified by Koos teaches the method of claim 8, further comprising depositing the capping layer (38) onto the etched conductive line (36) in the channel (top central opening shown in Misawa's figure 6C).

17. **Regarding claim 12**, Misawa as modified by Koos teaches the method of claim 8, wherein the depth is determined based on a thickness of the capping layer 38 (Misawa's figure 6E).

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly**, 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 TH REE-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.

Correspondence

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RODOLFO FORTICH whose telephone number is (571)272-3461. The examiner can normally be reached on weekdays, 8AM-5PM. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Julio Maldonado can be reached on (571)272-1864. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

/Rodolfo Fortich/
Patent Examiner, Art Unit 2898

/CHUONG A LUU/
Primary Examiner, Art Unit 2898

Notice of References Cited	Application/Control No. 13/991,899	Applicant(s)/Patent Under Reexamination BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,470,789	11-1995	Misawa, Nobuhiro	438/643
*	B	US-7,338,908	03-2008	Koos et al.	438/745
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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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BIB DATA SHEET

CONFIRMATION NO. 8341

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/991,899	06/05/2013	257	2898	42P38794

APPLICANTS

INVENTORS

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2011/059453 11/04/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

06/19/2013

Foreign Priority claimed	☐ Yes ☑ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☑ No		OR	10	20	3
Verified and Acknowledged	/RODOLFO D FORTICH/ Examiner's Signature	Initials				

ADDRESS

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
c/o CPA Global
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Minneapolis, MN 55402
UNITED STATES

TITLE

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FILING FEE RECEIVED	FEES: Authority has been given in Paper	☐ All Fees
1480	No._____ to charge/credit DEPOSIT ACCOUNT	☐ 1.16 Fees (Filing)
	No._____ for following:	☐ 1.17 Fees (Processing Ext. of time)
		☐ 1.18 Fees (Issue)
		☐ Other _____
		☐ Credit

BIB (Rev. 05/07).

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	7	"257/773".CCLS. and (recess$3 same (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S2	23	"257/773".CCLS. and (recess$3 same2 (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S4	595	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 13:43
S5	4	((13/991903) or (13/914637) or (13/915158) or (13/921436)).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/08/12 14:12
S6	78	((Boyan) near2 (Boyanov)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2014/08/12 14:38
S7	2483	(recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S8	724	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S9	683	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3 and dielectric)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:40
S10	647	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:41
S11	55	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:42
S12	38	(INTEL near2 CORPORATION).as. and	US-	AND	ON	2014/10/27

		(recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	PGPUB; USPAT; USOCR; EPO; DERWENT			16:08
S13	40	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same6 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:09
S14	448	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:08
S15	143	S14 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:09
S16	4	(("20100109131") or ("20080026487") or ("20040245637") or ("20010045651")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 08:31
S17	160	"438/627".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:53
S18	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 09:12
S19	155	"438/669".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 10:11
S20	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:28
S21	1	("20050001325").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:33
S22	2	(("6,375,693") or ("6,503,834")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:38
S29	59	("257/762".CCLS. or "257/767".CCLS. or "257/741".CCLS. or "257/750".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 11:33
S30	65	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or	US-PGPUB; USPAT;	AND	ON	2014/10/28 12:36

		capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	USOCR			
S31	9	(recess$3 or etch$3) same2 (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3) and inhibitor)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/28 13:54
S32	1	(10/690084).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 13:56
S33	1	("5535230").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 10:22
S34	1	("8502247").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:05
S35	2	(("7488432") or ("20140152637")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/29 11:57
S36	615	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/09 15:25
S37	462	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S38	276	S37 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/20 15:42
S39	1	("5741626").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/20 16:39
S40	66	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2015/03/20 17:10
S41	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:40
S42	1	("6,696,758").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 14:51
S43	13	(("6,395,607") or ("6,670,274") or	US-	OR	OFF	2015/03/23

		("5,374,454") or ("5,380,546") or ("5,723,387") or ("6,274,499") or ("6,258,713") or ("6,261,963") or ("6,281,127") or ("6,171,960") or ("6,350,687") or ("6,017,803") or ("6,251,774")).PN.	PGPUB; USPAT; USOCR			14:58
S44	6	(("6,441,492") or ("6,368,484") or ("6,339,258") or ("6,333,560") or ("5,865,984") or ("5,486,282")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 15:38
S45	5	(("6387800") or ("6391776") or ("6506668") or ("6893541") or ("7199052")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:37
S46	3	(("6,607,977") or ("6,642,146") or ("7,659,197") or ("7,901,5451")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:40
S47	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/23 16:44
S48	950	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2015/03/24 08:03
S49	518	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity))	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:04
S50	273	electromigrat$3 same ((cap or capping) and dielectric and (conduct$3 or metal$3) and (trench or open$3 or recess or channel or hole or cavity) and etch$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 08:06
S51	7	(("6706625") or ("6342733") or ("5695810") or ("5585673") or ("6323554") or ("20040113279") or ("5,470,790")).PN. or (2007/0202689).CCLS.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:46
S52	2	(("6323554") or ("20070202689")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 08:49
S53	3	(("6,110,648") or ("5,470,789") or ("5,350,484")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2015/03/24 09:10
S54	65	((electromigration or electromigrating) same ((cap or capping) and dielectric and (conductive or conducting or metal or metallic) and (trench or opening or recess or channel or hole or cavity) and etch or etching)) same4 (inhibiting or inhibitor or azole or amine or amino or phosphate or phosphonate)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2015/03/24 10:37

3/24/2015 12:06:17 PM
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Substitute for Form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Complete if Known	
Application Number	13/991,899
Filing Date	June 5, 2013
First Named Inventor:	Boyan Boyanov
Art Unit	2898
Confirmation No.	8341
Examiner Name	Fortich, Rodolfo D.
Attorney Docket No.	**42P38794**

Sheet	**1**	**of**	**1**

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

***Abstract in English and English Translation**

NON PATENT LITERATURE DOCUMENTS

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/R.F./	**NPL1**	Taiwan Patent Application No. 101140536, Office Action and Taiwan IPO Search Report (with English translation), dated November 27, 2014, (15 pages) [P38794TW].
	NPL2	

Examiner Signature	/Rodolfo Fortich/	Date Considered	3/24/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	
Sheet	1	of	2	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/R.F./		US-	7,396,759 B1	07-08-2008	Van Schravendijk Bart et al.	
/R.F./		US-	2006/0128144 A1	06-15-2006	Hyun-Mog Park et al.	
/R.F./		US-	2009/0127097 A1	05-21-2009	Chen Kei-Wei et al.	
/R.F./		US-	2009/0283499 A1	11-19-2009	Mayer Steven T. et al.	
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Substitute for Form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	/Rodolfo Fortich/
Sheet	2	**of**	2	Attorney Docket Number	42P38794

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		OTA, Takashi, et al., "Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle," Proc. Of SPIE Vol. 6921, 69213S, (2008)	
/R.F./		M.M ANTONIJEVIC et al., "Copper Corrosion Inhibitors. A review", Int. J. Electrochem Sci., Vol. 3, 2008, 28 pages.	
/R.F./		T. SAITO et al., 'A Robust, Deep-Submicron Copper Interconnect Structure using Self-Aligned Metal Capping Method", IEEE, 2004, 3 pages.	
/R.F./		PCT International Search Report and Written Opinion for PCT/US2011/059453, mailed July 16, 2012 (14 pp.).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

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[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English Translation is attached.
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

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

CLAIM		DATE								
Final	Original	08/12/2014	10/28/2014	03/24/2015						
	1	÷	✓	✓						
	2	÷	✓	✓						
	3	÷	✓	✓						
	4	÷	✓	✓						
	5	÷	✓	✓						
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	7	÷	✓	✓						
	8	÷	✓	✓						
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	10	÷	✓	✓						
	11	÷	✓	✓						
	12	÷	✓	✓						
	13	÷	N	N						
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	18	÷	N	N						
	19	÷	N	N						
	20	÷	N	N						

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	Art Unit
	RODOLFO FORTICH	2898

CPC- SEARCHED		
Symbol	Date	Examiner
H01L2924/00014, H01L2924/00, H01L2924/0002, H01L2224/13147, H01L2224/48247	3/23/2015	R. F

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner
(H01L2924/00014 ORH01L2924/00 OR H01L2924/0002 ORH01L2224/13147 ORH01L2224/48247)	3/23/2015	R. F

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
257	773, 762, 767, 741, 750	10/28/2014	R. F

SEARCH NOTES		
Search Notes	Date	Examiner
See EAST search	3/23/2015	R. F
Consultation with Chuong Luu (2898)	3/23/2015	R. F
Assignee/Inventor search	10/28/2014	R. F

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
438	627, 669, 6876, 597, 618	3/23/2015	R. F

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Examiner Name	Fortich, Rodolfo D.
Sheet	1	of	1	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-				
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

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/R.F./		International Preliminary Report on Patentability (Chapter 1 of the Patent Cooperation Treaty) for PCT/US2011/059453, mailed May 6, 2014 (8 pages).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Attorney's Docket No. 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan Boyanov Application No.: 13/991,899 Filed: June 5, 2013 For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	Examiner: Fortich, Rodolfo D. Art Unit: 2898 Confirmation No.: 8341 **CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below. */Tuyen Lam/* *February 3, 2015* ***Tuyen Lam*** ***Date***

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Commissioner for Patents
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Office Action mailed November 3, 2014, applicant submits the following amendment and remarks for consideration.

IN THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method to manufacture an electronic device, comprising:
recessing at least one conductive line in a dielectric layer over a substrate to form a channel comprising a dielectric sidewall; and
depositing a capping layer on the recessed conductive line and on the dielectric sidewall ~~in~~ of the channel to prevent electromigration.

2. (Original) The method of claim 1, wherein the recessing includes
etching the at least one conductive line uniformly independent of a crystallographic orientation.

3. (Original) The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. (Original) The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. (Original) The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. (Original) The method of claim 1, further comprising
forming a dielectric layer over the substrate;
forming at least one opening in the dielectric layer; and
filling the at least one opening with a conductive material to form the at least one conductive line.

7. (Original) The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. (Currently Amended) A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising a dielectric sidewall self-aligned to the at least one conductive line, wherein the first chemistry comprises an inhibitor to provide uniformity of etching independent of a crystallographic orientation;~~, wherein the channel is configured to contain~~ and

depositing a capping layer ~~within a width of~~on the at least one conductive line and on the dielectric sidewall of the channel~~, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation~~.

9. (Original) The method of claim 8, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, and between about 50ppm to about 1% by mass of the inhibitor.

10. (Original) The method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof.

11. (Original) The method of claim 8, further comprising

depositing the capping layer onto the etched conductive line in the channel.

12. (Original) The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. (Withdrawn) An apparatus, comprising:

at least one first conductive line in a dielectric layer over a substrate,

and

a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. (Withdrawn) The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. (Withdrawn) The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. (Withdrawn) The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. (Withdrawn) The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. (Withdrawn) The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. (Withdrawn)The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. (Withdrawn) The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

REMARKS

Reconsideration of this application, as amended, is respectfully requested.

Claims 1-20 stand rejected.

In this response, claims 1 and 8 have been amended. No claims have been canceled. No claims have been added. Support for the amendments is found in the specification, the drawings, and in the claims as originally filed. Applicant submits that the amendments do not add new matter.

Amended claim 1 reads as follows:

A method to manufacture an electronic device, comprising:

recessing at least one conductive line in a dielectric layer over a substrate to form a channel ***comprising a dielectric sidewall***; and

depositing a capping layer on the recessed conductive line ***and on the dielectric sidewall of*** the channel to prevent electromigration. (emphasis added)

Claims 1-8 and 11-12 were rejected under pre-AIA 35 U.S.C § 102(b) as being anticipated by Andricacos et al., U.S. Publication No. 2005/0001325 (hereinafter "Andricacos").

Andricacos discloses selective capping of copper wiring. More specifically, Andricacos discloses selectively recessing copper by electroetching in the presence of the liner. In particular, Andricacos discloses that the liner can be Ta, TaN, W, WN or multiple layers of two or more of these materials. (paragraphs [0036]-[0037], Figure 1B). As shown in Figure 1C of Andricacos, the capping layer 18 is deposited on the liner material 12. In contrast, amended claim 1 refers to recessing at least one conductive line in a dielectric layer over a substrate to ***form a channel comprising a dielectric sidewall***.

Andricacos fails to disclose recessing at least one conductive line in a dielectric layer over a substrate to form a channel ***comprising a dielectric sidewall***; and depositing a capping layer on the recessed conductive line ***and on the dielectric sidewall of*** the channel to prevent electromigration, as recited in amended claim 1.

Because Andricacos fails to disclose all limitations of amended claim 1, applicant respectfully submits that claim 1, as amended, is not anticipated by Andricacos under pre-AIA 35 U.S.C § 102(b).

In view of the above discussion, it is respectfully submitted that Andricacos fails to disclose etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising ***a dielectric sidewall*** self-aligned to the at least one conductive line, wherein ***the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation***; and depositing a capping layer on the at least one conductive line ***and on the dielectric sidewall*** of the channel, as recited in amended claim 8.

Because Andricacos fails to disclose all limitations of amended claim 8, applicant respectfully submits that claim 8, as amended, is not anticipated by Andricacos under pre-AIA 35 U.S.C § 102(b).

Claims 9-10 have been rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over Andricacos, in view of U.S. Patent No. 7,338,908 B1 to Koos et al. ("Koos").

As set forth above, Andricacos fails to teach or suggest etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a

predetermined depth to form a channel comprising ***a dielectric sidewall*** self-aligned to the at least one conductive line, wherein ***the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation***; and depositing a capping layer on the at least one conductive line ***and on the dielectric sidewall*** of the channel, as recited in amended claim 8.

Koos addresses a method for fabrication of semiconductor interconnect structure with reduced capacitance, leakage current, and improved breadkdown voltage. Koos fails to teach or suggest etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising ***a dielectric sidewall*** self-aligned to the at least one conductive line, wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation; and depositing a capping layer on the at least one conductive line ***and on the dielectric sidewall*** of the channel, as recited in amended claim 8.

Furthermore, even if Koos and Andricacos were combined, such a combination would still lack etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel comprising ***a dielectric sidewall*** self-aligned to the at least one conductive line, wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation; and depositing a capping layer on the at least one conductive line ***and on the dielectric sidewall*** of the channel, as recited in amended claim 8.

Given that claims 9-10 depend from amended claim 8, and add additional limitations, applicant respectfully submits that claims 9-10 are not obvious under pre-AIA 35 U.S.C. § 103(a) over Andricacos, in view of Koos.

It is respectfully submitted that in view of the amendments and arguments set forth herein, the applicable rejections and objections have been overcome. If the Examiner believes a telephone conference would expedite the prosecution of the present application, the Examiner is invited to call the undersigned at (408) 720-8300.

If there are any additional charges, please charge Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: February 3, 2015

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:	
Boyan Boyanov	Examiner: Fortich, Rodolfo D.
Application No.: 13/991,899	Art Unit: 2898
Filed: June 5, 2013	Confirmation No.: 8341
For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

E-filed via EFS-Web
Commissioner for Patents
Alexandria, Virginia 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed for applications filed after June 30, 2003). It is respectfully requested that the cited documents be considered and that the enclosed copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

CERTIFICATE OF ELECTRONIC FILING

I hereby certify that this correspondence is being deposited with the United States Patent and Trademark Office via electronic filing through the United States Patent and Trademark Electronic Filing System on:

February 3, 2015
Date of Deposit

/Tuyen Lam/
Tuyen Lam

Pursuant to 37 C.F.R. § 1.97, the submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made and is not to be construed as an admission that the information cited in this statement is material to patentability.

Pursuant to 37 C.F.R. § 1.97, this Information Disclosure Statement is being submitted under one of the following (as indicated by an "X" to the left of the appropriate paragraph):

_____ 37 C.F.R. §1.97(b).

__X__ 37 C.F.R. §1.97(c). If so, then enclosed with this Information Disclosure Statement is one of the following:

_____ A statement pursuant to 37 C.F.R. §1.97(e) or

__X__ The Director is Authorized to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. § 1.17(p).

_____ 37 C.F.R. §1.97(d). If so, then enclosed with this Information Disclosure Statement are the following:

(1) A statement pursuant to 37 C.F.R. §1.97(e); and

(2) Authorization to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. §1.17(p) for submission of the Information Disclosure Statement.

If there are any additional charges, please charge Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: February 3, 2015

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Customer No.: 45209

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Confirmation No.	8341
				Examiner Name	Fortich, Rodolfo D.
Sheet	**1**	**of**	**1**	Attorney Docket No.	**42P38794**

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

***Abstract in English and English Translation**

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published
	NPL1	Taiwan Patent Application No. 101140536, Office Action and Taiwan IPO Search Report (with English translation), dated November 27, 2014, (15 pages) [P38794TW].
	NPL2	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.
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Based on Form PTO/SB/08B (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

Electronic Patent Application Fee Transmittal					
Application Number:	13991899				
Filing Date:	05-Jun-2013				
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS				
First Named Inventor/Applicant Name:	Boyan Boyanov				
Filer:	Tatiana Rossin/Tuyen Lam				
Attorney Docket Number:	42P38794				
Filed as Large Entity					
Filing Fees for U.S. National Stage under 35 USC 371					
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($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	21391108
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Tuyen Lam
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	03-FEB-2015
Filing Date:	05-JUN-2013
Time Stamp:	20:35:01
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	16810
Deposit Account	022666
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

Charge any Additional Fees required under 37 C.F.R. Section 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		42P38794_R-OA_2-3-15.pdf	45690 a6fe3fa20ff092ee767d1a7edb456a1138e58dda	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	9

Warnings:

Information:

2	Transmittal Letter	42P38794_IDS_Statement_2-3-15.pdf	22616 f0b100875a91ad3dbb7d0da0ff514542552b535d	no	2

Warnings:

Information:

3	Information Disclosure Statement (IDS) Form (SB08)	42P38794_IDS_SB08_2-3-15.pdf	34820 7624397e0de69395525204d7c3c10987501a736b	no	1

Warnings:

Information:

This is not an USPTO supplied IDS fillable form

4	Non Patent Literature	NPL_TW_OA_dated11-27-14.pdf	738478 f435f234211b3ae95c020ff877609a6fc9267823	no	15

Warnings:

Information:

5	Fee Worksheet (SB06)	fee-info.pdf	30718 d15933e74146bb6037945631f5c9813b997fb86b	no	2

Warnings:

Information:

Total Files Size (in bytes):	872322

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 Substitute for Form PTO-875	Application or Docket Number 13/991,899	Filing Date 06/05/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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	02/03/2015	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $420 =	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) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ 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.
** 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 number found in the appropriate box in column 1.

LIE
/NICOLLE L. SCRIVNER/

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

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 11/03/2014

Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

EXAMINER	
FORTICH, RODOLFO D	
ART UNIT	**PAPER NUMBER**
2898	

MAIL DATE	DELIVERY MODE
11/03/2014	PAPER

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.

Office Action Summary	Application No. 13/991,899	Applicant(s) BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	AIA (First Inventor to File) Status No

-- 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 *10/20/2014*.

☐ 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) *1-20* is/are pending in the application.

5a) Of the above claim(s) *13-20* is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-12* 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 *06/05/2013* 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 *06/05/2013 and 08/15/2014*.

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

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Election/Restrictions

1. Claims 13-20 are withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected inventions, there being no allowable generic or linking claim. Election was made without traverse in the reply filed on October 20, 2014.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of pre-AIA 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 –

(b) The invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. **Claims 1-8 and 11-12 are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Andricacos et al (US 2005/0001325 A1; hereinafter "Andricacos").**

4. **Regarding claim 1**, Andricacos (figures 1A-1D and paragraphs 35-45) teaches a method to manufacture an electronic device, comprising: recessing at least one conductive line (10 made of Cu as per paragraph 37) in a dielectric layer (16, paragraph 35) over a substrate (14) to form a channel (above the upper surface of 10 in figure 1B); and depositing a capping layer (18, 20 containing Ru or CoWP, as per paragraph 42-45 and figure 1C) on the recessed conductive line in the channel (figure 2C) to prevent electromigration (Ru and CoWP are an excellent barrier to Cu diffusion or electromigration as per paragraph 45).

5. **Regarding claim 2,** Andricacos teaches the method of claim 1, wherein the recessing includes etching (paragraph 37) the at least one conductive line (10) uniformly independent of a crystallographic orientation (paragraph 40-lines 1-4).

6. **Regarding claim 3**, Andricacos teaches the method of claim 1, wherein the channel is self-aligned to the conductive line 10 (figure 1B).

7. **Regarding claim 4**, Andricacos teaches the method of claim 1, wherein the at least one conductive line (10) is recessed to a depth (figure 1B) determined based on a thickness of the capping layer (18 and 20, see figure 1D).

8. **Regarding claim 5**, Andricacos teaches the the method of claim 1, wherein the capping layer (18, 20) is deposited on the recessed conductive line (10) by an electroless plating, a chemical vapor deposition, or a physical vapor deposition (paragraphs 42-44).

9. **Regarding claim 6**, Andricacos teaches the method of claim 1, further comprising forming a dielectric layer (16) over the substrate (14); forming at least one opening in the dielectric layer (16); and filling the at least one opening with a conductive material (Cu) to form the at least one conductive line 10 (paragraphs 6 and 35-36).

10. **Regarding claim 7**, Andricacos teaches the method of claim 1, wherein the at least one conductive line (10) comprises a first metal (Cu, as per paragraph 33), and the capping layer (18, 20) comprises a second metal (Ru and Rh, as per paragraphs 42-44) other than the first metal (Cu).

11. **Regarding claim 8**, Andricacos (figures 1A-1D and paragraphs 35-45) teaches a method to control line edge roughness, comprising: etching at least one conductive line (10) in a dielectric layer (16) over a substrate (14) with a first chemistry (paragraph 39) to a predetermined depth to form a channel self-aligned to the conductive line 10 (figure 1B), wherein the channel is configured to contain a capping layer (18, 20) within a width of the at least one conductive line 10 (18, 20 and 10 have the same width as per figure 1C), and wherein the first chemistry comprises an inhibitor (chemical etching in the presence of a liner, as per paragraph 39) configured to provide uniformity of etching independent of a crystallographic orientation (paragraph 40-lines 1-4).

12. **Regarding claim 11**, Andricacos teaches the method of claim 8, further comprising depositing the capping layer (18, 20) onto the etched conductive line (10) in the channel (figures 1C-1D).

13. **Regarding claim 12**, Andricacos teaches the method of claim 8, wherein the depth is determined based on a thickness of the capping layer 18 and 20 (figure 1D).

Claim Rejections - 35 USC § 103

14. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented 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 having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

15. **Claims 9-10 is rejected under pre-AIA 35 U.S.C 103(a) as being unpatentable over Andricacos et al in view of Koos et al (US 7,338,908 B1; hereinafter "Koos").**

16. Regarding claim 9, Andricacos teaches the method of claim 8, wherein the first chemistry comprises between about 0.1 % to about 70% by mass of an etchant (0.5% vol acetic acid), between about 0.1 % to about 10% by mass of an oxidizer (0.3% vol hydrogen peroxide, as per paragraph 39).

Andricacos fails to explicitly teach that the first chemistry comprises between about 50 ppm to about 1 % by mass of the inhibitor.

Koos teaches different percentages of glycine and peroxide by weight (column 8-lines 55-67) in combination with inhibitors, such as, benotriazole (BTA), thiourea, certain mercaptans, and imidazoles (column 9-lines 9-13), and teaches that by controlling the ratio of copper oxidizing agent and copper oxide etchant in such solutions, one can control the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate.

Since the optimization of workable ranges is considered within the skill of the art as it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. It would have been obvious to one of ordinary skill in the art, at the time of the invention, to adjust the quantities of the oxide/inhibitor in the Andricacos's teachings as taught by Koos, to obtain the optimum etching rate workable range, controlling the amount of oxidation and depth of the intermediate copper oxide film that is formed on the surface of the substrate. (In re Aller, 105 USPQ 233). See also MPEP 2144.05 I and II.

17. **Regarding claim 10**, Andricacos as modified by Koos teaches the method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof (see Koos's column 8-lines 55-67 and column 9-lines 1-13)

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RODOLFO FORTICH whose telephone number is (571)272-3461. The examiner can normally be reached on weekdays, 8AM-5PM. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Julio Maldonado can be reached on (571)272-1864. 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 http://pair-direct.uspto.gov.

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.

/Rodolfo Fortich/

Patent Examiner, Art Unit 2898

/WHITNEY T MOORE/

Primary Examiner, Art Unit 2826

Notice of References Cited	Application/Control No. 13/991,899	Applicant(s)/Patent Under Reexamination BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0001325	01-2005	Andricacos et al.	257/762
*	B	US-7,338,908	03-2008	Koos et al.	438/745
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
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	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	Art Unit
	RODOLFO FORTICH	2898

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner
(H01L2924/00014 ORH01L2924/00 OR H01L2924/0002 ORH01L2224/13147 ORH01L2224/48247)	10/28/2014	R. F

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
257	773, 762, 767, 741, 750	10/28/2014	R. F

SEARCH NOTES		
Search Notes	Date	Examiner
See EAST search	10/28/2014	R. F
Consultation with Whitney Moore (2826)	10/24/2014	R. F
Assignee/Inventor search	10/28/2014	R. F

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
438	627, 669, 6876, 597, 618	10/28/2014	R. F

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

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

CLAIM		DATE								
Final	Original	08/12/2014	10/28/2014							
	1	÷	✓							
	2	÷	✓							
	3	÷	✓							
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	18	÷	N							
	19	÷	N							
	20	÷	N							

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Examiner Name	Fortich, Rodolfo D.
Sheet	1	**of**	1	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-				
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		International Preliminary Report on Patentability (Chapter 1 of the Patent Cooperation Treaty) for PCT/US2011/059453, mailed May 6, 2014 (8 pages).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.
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Based on Form PTO/SB/08A (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L4	9	(recess$3 or etch$3) same2 (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3) and inhibitor)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/28 13:54
L6	1	(10/690084).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 13:56
S1	7	"257/773".CCLS. and (recess$3 same (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S2	23	"257/773".CCLS. and (recess$3 same2 (channel and cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 12:44
S4	595	(recess$3 near4 (channel near4 cap$4))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/08/12 13:43
S5	4	((13/991903) or (13/914637) or (13/915158) or (13/921436)).APP.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/08/12 14:12
S6	78	((Boyan) near2 (Boyanov)).INV.	US-PGPUB; USPAT; USOCR	AND	ON	2014/08/12 14:38
S7	2483	(recess$3 or etch$3) same4 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S8	724	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:39
S9	683	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and deposit$3 and dielectric)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:40
S10	647	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:41
S11	55	(recess$3 or etch$3) same (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3))	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/27 15:42
S12	38	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same4	US-PGPUB; USPAT;	AND	ON	2014/10/27 16:08

		(electromigrat$3 and (cap or capping) and deposit$3)	USOCR; EPO; DERWENT			
S13	40	(INTEL near2 CORPORATION).as. and (recess$3 or etch$3) same6 (electromigrat$3 and (cap or capping) and deposit$3)	US-PGPUB; USPAT; USOCR; EPO; DERWENT	AND	ON	2014/10/27 16:09
S14	448	"257/773".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:08
S15	143	S14 AND ((H01L2924/00014 OR H01L2924/00 OR H01L2924/0002 OR H01L2224/13147 OR H01L2224/48247).CPC.)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:09
S16	4	(("20100109131") or ("20080026487") or ("20040245637") or ("20010045651")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 08:31
S17	160	"438/627".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 08:53
S18	4	(("20090283499") or ("20060128144") or ("7396759") or ("20090127097")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 09:12
S19	155	"438/669".CCLS. and (channel and cap$4)	US-PGPUB; USPAT; USOCR; EPO	AND	ON	2014/10/28 10:11
S20	2	(("6630741") or ("7008871")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:28
S21	1	("20050001325").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:33
S22	2	(("6,375,693") or ("6,503,834")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/10/28 10:38
S29	59	("257/762".CCLS. or "257/767".CCLS. or "257/741".CCLS. or "257/750".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 11:33
S30	65	("438/687".CCLS. or "438/597".CCLS. or "438/618".CCLS.) and ((recess$3 or etch$3) and (electromigrat$3 and (cap or capping) and channel and (depositing or deposition) and dielectric and (conduct$3 or metal$3)))	US-PGPUB; USPAT; USOCR	AND	ON	2014/10/28 12:36

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BIB DATA SHEET

CONFIRMATION NO. 8341

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/991,899	06/05/2013	257	2898	42P38794

APPLICANTS

INVENTORS

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/US2011/059453 11/04/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

06/19/2013

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /RODOLFO D FORTICH/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		OR	10	20	3

ADDRESS

Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
UNITED STATES

TITLE

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FILING FEE RECEIVED	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit
1480		

BIB (Rev. 05/07).

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	
Sheet	1	**of**	2	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/R.F./		US-	7,396,759 B1	07-08-2008	Van Schravendijk Bart et al.	
/R.F./		US-	2006/0128144 A1	06-15-2006	Hyun-Mog Park et al.	
/R.F./		US-	2009/0127097 A1	05-21-2009	Chen Kei-Wei et al.	
/R.F./		US-	2009/0283499 A1	11-19-2009	Mayer Steven T. et al.	
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Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

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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 2 hours 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,

Based on Form PTO/SB/08A (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

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Substitute for Form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit 2898	
				Examiner Name	/Rodolfo Fortich/
Sheet	2	**of**	2	Attorney Docket Number	42P38794

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/R.F./		OTA, Takashi, et al., "Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle," Proc. Of SPIE Vol. 6921, 69213S, (2008)	
/R.F./		M.M ANTONIJEVIC et al., "Copper Corrosion Inhibitors. A review", Int. J. Electrochem Sci., Vol. 3, 2008, 28 pages.	
/R.F./		T. SAITO et al., 'A Robust, Deep-Submicron Copper Interconnect Structure using Self-Aligned Metal Capping Method", IEEE, 2004, 3 pages.	
/R.F./		PCT International Search Report and Written Opinion for PCT/US2011/059453, mailed July 16, 2012 (14 pp.).	

Examiner Signature	/Rodolfo Fortich/	Date Considered	10/28/2014

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English Translation is attached.
This collection of information is required by 37 CFR 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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Based on Form PTO/SB/08B (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.
ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.F./

Attorney's Docket No. 42P38794 Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan Boyanov Application No.: 13/991,899 Filed: June 5,, 2013 For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	Examiner: Fortich, Rodolfo D. Art Unit: 2898 Confirmation No.: 8341 **CERTIFICATE OF TRANSMISSION** I hereby certify that this correspondence is being submitted electronically via EFS Web on the date shown below. */Tuyen Lam/* *October 20, 2014* ***Tuyen Lam*** ***Date***

Filed via EFS-Web
Commissioner for Patents
Alexandria, VA 22313-1450

RESPONSE TO RESTRICTION REQUIREMENT

Sir:

In response to the Office Action mailed August 20, 2014, applicant submits the following amendment and remarks for consideration.

IN THE CLAIMS

Please amend the claims as follows:

1. (Original) A method to manufacture an electronic device, comprising:
recessing at least one conductive line in a dielectric layer over a substrate to form a channel; and
depositing a capping layer on the recessed conductive line in the channel to prevent electromigration.

2. (Original) The method of claim 1, wherein the recessing includes
etching the at least one conductive line uniformly independent of a crystallographic orientation.

3. (Original) The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. (Original) The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. (Original) The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. (Original) The method of claim 1, further comprising
forming a dielectric layer over the substrate;
forming at least one opening in the dielectric layer; and
filling the at least one opening with a conductive material to form the at least one conductive line.

7. (Original) The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. (Original) A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel self-aligned to the conductive line, wherein the channel is configured to contain a capping layer within a width of the at least one conductive line, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation.

9. (Original) The method of claim 8, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, and between about 50ppm to about 1% by mass of the inhibitor.

10. (Original) The method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof.

11. (Original) The method of claim 8, further comprising

depositing the capping layer onto the etched conductive line in the channel.

12. (Original) The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. (Withdrawn) An apparatus, comprising:

at least one first conductive line in a dielectric layer over a substrate,

and

a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. (Withdrawn) The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. (Withdrawn) The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. (Withdrawn) The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. (Withdrawn) The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. (Withdrawn) The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. (Withdrawn)The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. (Withdrawn) The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

REMARKS

In response to the restriction requirement set forth in the Office Action, applicant hereby without traverse elects claims 1-12 of Group I for examination. Applicant reserves the right to pursue the withdrawn claims in one or more divisional applications.

If there are any additional charges, please charge Deposit Account No. 02-2666 for any fee deficiency that may be due.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: October 20, 2014

/Tatiana Rossin/
Tatiana Rossin
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Fax (408) 720-8383

Electronic Acknowledgement Receipt	
EFS ID:	20464605
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Tuyen Lam
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	20-OCT-2014
Filing Date:	05-JUN-2013
Time Stamp:	16:56:08
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		42P38794_RestrictionRequirement_Response_10-20-14.pdf	39297 3ee8b8d0499538d9ede297359232c6dda762d3d9	yes	5

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Response to Election / Restriction Filed	1	1
	Claims	2	4
	Applicant Arguments/Remarks Made in an Amendment	5	5
Warnings:			
Information:			
	Total Files Size (in bytes):	39297	

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 Substitute for Form PTO-875	Application or Docket Number 13/991,899	Filing Date 06/05/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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 **10/20/2014**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 13	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	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) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ 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.
** 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 number found in the appropriate box in column 1.

LIE
/BONNIE COLE/

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.
13/991,899	06/05/2013	Boyan Boyanov	42P38794	8341

45209 7590 08/20/2014

Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

EXAMINER	
FORTICH, RODOLFO D	
ART UNIT	**PAPER NUMBER**
2898	

MAIL DATE	DELIVERY MODE
08/20/2014	PAPER

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.

Office Action Summary	Application No. 13/991,899	Applicant(s) BOYANOV ET AL.	
	Examiner RODOLFO FORTICH	Art Unit 2898	AIA (First Inventor to File) Status No

-- 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 2 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 *06/05/2013*.

☐ 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) *1-20* 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) _____ is/are rejected.

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

9)☒ Claim(s) *1-20* 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: _____.

DETAILED ACTION

Election/ Restrictions

1. **REQUIREMENT FOR UNITY OF INVENTION**

As provided in 37 CFR 1.475(a), a national stage application shall relate to one invention only or to a group of inventions so linked as to form a single general inventive concept ("requirement of unity of invention"). Where a group of inventions is claimed in a national stage application, the requirement of unity of invention shall be fulfilled only when there is a technical relationship among those inventions involving one or more of the same or corresponding special technical features. The expression "special technical features" shall mean those technical features that define a contribution which each of the claimed inventions, considered as a whole, makes over the prior art.

The determination whether a group of inventions is so linked as to form a single general inventive concept shall be made without regard to whether the inventions are claimed in separate claims or as alternatives within a single claim. See 37 CFR 1.475(e).

WHEN CLAIMS ARE DIRECTED TO MULTIPLE CATEGORIES OF INVENTIONS

As provided in 37 CFR 1.475(b), a national stage application containing claims to different categories of invention will be considered to have unity of invention if the claims are drawn only to one of the following combinations of categories:

(1) A product and a process specially adapted for the manufacture of said product; or

(2) A product and process of use of said product; or

(3) A product, a process specially adapted for the manufacture of the said product, and a use of the said product; or

(4) A process and an apparatus or means specifically designed for carrying out the said process; or

(5) A product, a process specially adapted for the manufacture of the said product, and an apparatus or means specifically designed for carrying out the said process.

Otherwise, unity of invention might not be present. See 37 CFR 1.475(c).

2. Restriction is required under 35 U.S.C. 121 and 372.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

In accordance with 37 CFR 1.499, applicant is required, in reply to this action, to elect a single invention to which the claims must be restricted.

Group I. Claims 1-12 drawn to a semiconductor apparatus combined with electrical contacts or leads, classified in class 257, subclass 773.

Group II. Claims 12-20 drawn to a coating method of an electronic device where at least one layer forms a diffusion barrier, classified in class 438, and subclass 627.

3. The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Inventions I and ll lack unity of invention because the groups do not share the same or corresponding technical feature.

4. Restriction for examination purposes as indicated is proper because all these inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and/or examination burden if restriction were not required because at least the following reason(s) apply:

a. The inventions have acquired a separate status in the art in view of their different classification.

b. The inventions have acquired a separate status in the art due to their recognized divergent subject matter.

c. The inventions require a different field of search (e.g., searching different classes /subclasses or electronic resources, or employing different search strategies or search queries).

5. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

6. Applicant is advised that the reply to this requirement to be complete must include (i) an election of a invention to be examined even though the requirement may be traversed (37 CFR 1.143) and (ii) identification of the claims encompassing the elected invention.

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

The examiner has required restriction between product or apparatus claims and process claims. Where applicant elects claims directed to the product/apparatus, and all product/apparatus claims are subsequently found allowable, withdrawn process claims that include all the limitations of the allowable product/apparatus claims should be considered for rejoinder. All claims directed to a nonelected process invention must include all the limitations of an allowable product/apparatus claim for that process invention to be rejoined.

In the event of rejoinder, the requirement for restriction between the product/apparatus claims and the rejoined process claims will be withdrawn, and the rejoined process claims will be fully examined for patentability in accordance with 37 CFR 1.104. Thus, to be allowable, the rejoined claims must meet all criteria for patentability including the requirements of 35 U.S.C. 101, 102, 103 and 112. Until all claims to the elected product/apparatus are found allowable, an otherwise proper restriction requirement between product/apparatus claims and process claims may be maintained. Withdrawn process claims that are not commensurate in scope with an allowable product/apparatus claim will not be rejoined. See MPEP § 821.04.

Additionally, in order for rejoinder to occur, applicant is advised that the process claims should be amended during prosecution to require the limitations of the product/apparatus claims. Failure to do so may result in no rejoinder. Further, note that the prohibition against double patenting rejections of 35 U.S.C. 121 does not apply where the restriction requirement is withdrawn by the examiner before the patent issues. See MPEP § 804.01.

Conclusion

Any inquiry concerning this communication or earlier communications from an Examiner should be directed to Examiner Rodolfo Fortich, at (571) 272-3461, on Monday through Friday, 8:00 am - 5:00 pm ET. 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 only through Private PAIR.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Julio Maldonado can be reached on (571) 272-1864. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

For more information about the PAIR system, see http://pair-direct.uspto.gov. The Electronic Business Center (EBC) at (866) 217 -9197 (toll-free) may answer questions on how to access the Private PAIR system.

/Rodolfo D. Fortich/
Patent Examiner, Art Unit 2898

/WHITNEY T MOORE/
Primary Examiner, Art Unit 2826

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991899	BOYANOV ET AL.
	Examiner	**Art Unit**
	RODOLFO FORTICH	2898

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

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

CLAIM		DATE								
Final	Original	08/12/2014								
	1	÷								
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	3	÷								
	4	÷								
	5	÷								
	6	÷								
	7	÷								
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	20	÷								

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	13/991,899
				Filing Date	June 5, 2013
				First Named Inventor:	Boyan Boyanov
				Art Unit	2898
				Examiner Name	Fortich, Rodolfo D.
Sheet	1	**of**	1	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-				
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
		International Preliminary Report on Patentability (Chapter 1 of the Patent Cooperation Treaty) for PCT/US2011/059453, mailed May 6, 2014 (8 pages).	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Based on Form PTO/SB/08A (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 42P38794PCT	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2011/059453	International filing date *(day/month/year)* 04 November 2011 (04.11.2011)	Priority date *(day/month/year)*
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant INTEL CORPORATION		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☒	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 06 May 2014 (06.05.2014)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Yukari Nakamura e-mail: pt07.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
ROSSIN TATIANA

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP 1279
OAKMEAD PARKWAY SUNNYVALE CA 94085 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**16 JULY 2012 (16.07.2012)**
Applicant's or agent's file reference 42P38794PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2011/059453	**04 NOVEMBER 2011 (04.11.2011)**	

International Patent Classification (IPC) or both national classification and IPC

H01L 21/28(2006.01)i

Applicant

INTEL CORPORATION et al

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	13 JULY 2012 (13.07.2012)	Kim, Young Jin Telephone No.042 481 5771

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:
   - ☒ paid additional fees
   - ☐ paid additional fees under protest and, where applicable, the protest fee
   - ☐ paid additional fees under protest but the applicable protest fee was not paid
   - ☐ not paid additional fees
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
   - ☐ complied with
   - ☒ not complied with for the following reasons:

   Group I (claims 1-7, 13-20) is directed to an apparatus and its manufacturing method. Group II (claims 8-12) is directed to a method to control line edge roughness. The common technical feature between Group I and Group II is a channel of conductive line in a dielectric layer over a substrate, wherein the channel is configured to contain a capping layer. However, this feature lacks novelty and an inventive step in view of the following document : US 2006-0128144 A1. Thus, there is no technical relationship left over the prior art among the claimed inventions, leaving the claims without a single general inventive concept.

4. Consequently, this opinion has been established in respect of the following parts of the international application :
   - ☒ all parts.
   - ☐ the parts relating to claims Nos. _____

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	9-10,17-18,20	YES
	Claims	1-8,11-16,19	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2009-0283499 A1 (MAYER STEVEN T. et al.) 19 November 2009
D2: US 2006-0128144 A1 (HYUN-MOG PARK et al.) 15 June 2006

1. Novelty and Inventive Step

1.1. Concerning claims [1-20]

1.1.1. Independent claims [1, 8, 13]

D1, which is considered to represent the most relevant state of the art, discloses an apparatus and its fabricating method, the method comprising: recessing at least one conductive line(115) in a dielectric layer(119) over a substrate with a first chemistry to a predetermined depth to form a channel self-aligned to the conductive line, wherein the channel is configured to contain a capping layer(121) within a width(127) of the at least one conductive line, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation; and depositing a capping layer selectively on the recessed conductive line in the channel to prevent electromigration (see abstract; figures 1B, 2; paragraphs [0046]-[0064]).

*As all of the features of **claims** [1, 8, 13] are disclosed in **D1**, these **claims** are anticipated by **D1**. Therefore, **claims** [1, 8, 13] lack novelty under PCT Article 33(2).*

1.1.2. Dependent claims [2-7, 11-12, 14-16]

Claims [2-7], [11-12] and [14-16] are dependent on **claims** [1], [8] and [13], respectively.

The additional feature of **claim** [2] is identical to the feature of **D1** that the recessing includes etching the at least one conductive line uniformly independent of a crystallographic orientation (see paragraphs [0058], [0061]-[0062]).

The additional feature of **claims** [3, 11, 14] is identical to the feature of **D1** that the capping layer(121) is selectively deposited on the selectively etched conductive line(115) (see paragraphs [0046], [0054]).

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Box V

The additional feature of **claims** [4, 12] is identical to the feature of **D1** that the amount of the conductive line(115) etched is equal to the target thickness of the capping layer(121) (see paragraph [0054]).

The additional feature of **claim** [5] is identical to the feature of **D1** that the capping layer(121) is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition (see paragraphs [0042], [0050]).

The additional feature of **claim** [6] is identical to the feature of **D1** that the conductive line(115) is damascene structure (see figure 1B; paragraph [0050]).

The additional feature of **claims** [7, 15] is identical to the feature of **D1** that the conductive line(115) comprises a first metal, and the capping layer(121) comprises a second metal other than the first metal (see paragraphs [0049]-[0050]).

The additional feature of **claim** [16] is identical to the feature of **D1** that the distances between the conductive capping layers(121) are substantially the same as the distances between the conductive lines(115) (see paragraph [0045]).

*Accordingly, **claims** [2-7, 11-12, 14-16] are substantially the same as **D1**. Therefore, **claims** [2-7, 11-12, 14-16] lack novelty under PCT Article 33(2).*

1.1.3. Dependent claims [9-10, 17-20]

Claims [9-10] and [17-20] are dependent on **claims** [8] and [13], respectively.

The additional features of **claims** [9-10] are merely variations of the disclosures of the cited document **D1** (paragraphs [0062]-[0064]) and a person skilled in the art would arrive at the **claimed** inventions by general experimentation alone without exercising any ingenuity.

Claims [17-20] relate to dimensions or an applicable system that are merely matters of design option when the general technical knowledge about the state of the art is used.

*Therefore, **claims** [9-10, 17-20] lack an inventive step under PCT Article 33(3).*

1.2. Concerning claims [1, 3-7, 13-20]

1.2.1. Independent claims [1, 13]

D2, which is considered to represent the most relevant state of the art, discloses an apparatus and its fabricating method, the method comprising: recessing at least one conductive line(126) in a dielectric layer(104) over a substrate to form a channel(124); and depositing a capping layer(128) selectively on the recessed conductive line in the channel to prevent electromigration (see abstract; figures 1-8; paragraphs [0024]-[0029]).

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Box V

*As all of the features of **claims** [1, 13] are disclosed in **D2**, these **claims** are anticipated by **D2**. Therefore, **claims** [1, 13] lack novelty under PCT Article 33(2).*

1.2.2. Dependent claims [3-7, 14-15, 19]

Claims [3-7] and [14-15, 19] are dependent on **claims** [1] and [13], respectively.

The additional feature of **claims** [3, 14] is identical to the feature of **D2** that the capping layer(128) is selectively deposited on the selectively etched conductive line(126) (see figures 5-8).

The additional feature of **claim** [4] is identical to the feature of **D2** that the recessed depth(144) is equal to the thickness of the capping layer(128) (see figures 7-8; paragraphs [0026]-[0027]).

The additional feature of **claim** [5] is identical to the feature of **D2** that the capping layer(128) is deposited on the recessed conductive line by an electroless plating (see paragraph [0027]).

The additional feature of **claim** [6] is identical to the feature of **D2** that the method further comprises: forming a dielectric layer(104) over the substrate; forming at least one opening(106) in the dielectric layer; and filling the at least one opening with a conductive material(118) to form the at least one conductive line (see figures 1-5).

The additional feature of **claims** [7, 15] is identical to the feature of **D2** that the conductive line(126) comprises copper, and the capping layer(128) comprises cobalt (see paragraphs [0021], [0027]).

The additional feature of **claim** [19] is identical to the feature of **D2** that the conductive line(126) is an interconnect incorporated into a computer system (see paragraphs [0028]-[0029]).

*Accordingly, **claims** [3-7, 14-15, 19] are substantially the same as **D2**. Therefore, **claims** [3-7, 14-15, 19] lack novelty under PCT Article 33(2).*

1.2.3. Dependent claims [16-18, 20]

Claims [16-18, 20] are dependent on **claim** [13].

Claim [16] differs from **D2** in that the apparatus further comprises a second capping layer selectively deposited on a second conductive line, the second conductive line being at a first spacing from the first conductive line. However, the feature added by **claim** [16] is considered to be a minor difference over the disclosure of **D2**, that falls under the general knowledge by a person skilled in the art.

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Box V

Claims [17-18, 20] relate to dimensions that are merely matters of design option when the general technical knowledge about the state of the art is used.

Therefore, ***claims*** *[16-18, 20] lack an inventive step under PCT Article 33(3).*

2. Industrial Applicability

Claims [1-20] are industrially applicable under PCT Article 33(4).

Electronic Acknowledgement Receipt	
EFS ID:	19883761
Application Number:	13991899
International Application Number:	
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan Boyanov
Customer Number:	45209
Filer:	Tatiana Rossin/Tuyen Lam
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	15-AUG-2014
Filing Date:	05-JUN-2013
Time Stamp:	21:10:13
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	42P38794_IDS_LTR_8-15-14.pdf	22900 5ed5318ee2441192e2863cd00a6504c731f9635e	no	2

Warnings:
Information:

2	Information Disclosure Statement (IDS) Form (SB08)	42P38794_IDS_SB08_8-15-14.pdf	50929 b4d49041a5e92b959721cd97cf7016f99799b647	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Non Patent Literature	42P38794_NPL_IPRP_Chapter1_Mailed5-6-14.pdf	321333 508627fbc0961a036acacd3c11f609d61d9ef070	no	8
Warnings:					
Information:					
		Total Files Size (in bytes):	395162		

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.

<u>New Applications Under 35 U.S.C. 111</u>
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.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:	
Boyan Boyanov	Examiner: Fortich, Rodolfo D.
Application No.: 13/991,899	Art Unit: 2898
Filed: June 5, 2013	Confirmation No.: 8341
For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

E-filed via EFS-Web
Commissioner for Patents
Alexandria, Virginia 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed for applications filed after June 30, 2003). It is respectfully requested that the cited documents be considered and that the enclosed copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

CERTIFICATE OF ELECTRONIC FILING

I hereby certify that this correspondence is being deposited with the United States Patent and Trademark Office via electronic filing through the United States Patent and Trademark Electronic Filing System on:

August 15, 2014
Date of Deposit

/Tuyen Lam/
Tuyen Lam

Pursuant to 37 C.F.R. § 1.97, the submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made and is not to be construed as an admission that the information cited in this statement is material to patentability.

Pursuant to 37 C.F.R. § 1.97, this Information Disclosure Statement is being submitted under one of the following (as indicated by an "X" to the left of the appropriate paragraph):

__X__ 37 C.F.R. §1.97(b).

_____ 37 C.F.R. §1.97(c). If so, then enclosed with this Information Disclosure Statement is one of the following:

_____ A statement pursuant to 37 C.F.R. §1.97(e) or

_____ The Director is Authorized to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. § 1.17(p).

_____ 37 C.F.R. §1.97(d). If so, then enclosed with this Information Disclosure Statement are the following:

(1) A statement pursuant to 37 C.F.R. §1.97(e); and

(2) Authorization to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. §1.17(p) for submission of the Information Disclosure Statement.

If there are any additional charges, please charge Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: August 15, 2014

/Tatiana Rossin/
Tatiana Rossin
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,899	06/05/2013	Boyan Boyanov	42P38794

CONFIRMATION NO. 8341

45209
Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

PUBLICATION NOTICE

OC000000064176970

Title:METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

Publication No.US-2013-0256899-A1
Publication Date:10/03/2013

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 Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/991,899	Boyan Boyanov	42P38794

45209
Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

INTERNATIONAL APPLICATION NO.	
PCT/US2011/059453	
I.A. FILING DATE	PRIORITY DATE
11/04/2011	

CONFIRMATION NO. 8341
371 ACCEPTANCE LETTER

OC000000062090299

Date Mailed: 06/21/2013

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

06/05/2013	06/05/2013
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Copy of the International Application filed on 06/05/2013
- Copy of the International Search Report filed on 06/05/2013
- Preliminary Amendments filed on 06/05/2013
- Information Disclosure Statements filed on 06/05/2013
- Oath or Declaration filed on 06/05/2013
- Request for Immediate Examination filed on 06/05/2013
- U.S. Basic National Fees filed on 06/05/2013

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

VALERIE A JACKSON

Telephone: (703) 756-1443

FORM PCT/DO/EO/903 (371 Acceptance Notice)

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/991,899

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	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	480
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	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	1480

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(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($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
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	

AMENDMENT B

	(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($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
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.

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
13991899	

Applicant(s) Boyan BOYANOV

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1					
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Total Indep	3		0		0	
Total Depend	17	↵	0	↵	0	↵
Total Claims	20		0		0	

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	Indep	Depend	Indep	Depend	Indep	Depend
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UNITED STATES PATENT AND TRADEMARK OFFICE

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/991,899	06/05/2013		1480	42P38794	20	3

CONFIRMATION NO. 8341

45209
Mission/BSTZ
BLAKELY SOKOLOFF TAYLOR & ZAFMAN
1279 Oakmead Parkway
Sunnyvale, CA 94085-4040

FILING RECEIPT

OC000000062090298

Date Mailed: 06/21/2013

Receipt is acknowledged of this non-provisional 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 APPLICANT, 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 Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections 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**

Inventor(s)

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

Applicant(s)

Boyan Boyanov, Portland, OR;
Kanwal Jit Singh, Hillsboro, OR;

Power of Attorney: The patent practitioners associated with Customer Number 45209

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/US2011/059453 11/04/2011

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.

If Required, Foreign Filing License Granted: 06/19/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/991,899**

Projected Publication Date: 10/03/2013

Non-Publication Request: No

Early Publication Request: No

Title

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where

the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

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 U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PTO-1390 (03-13)
Approved for use through 4/30/2013. OMB 0651-0021
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.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	
42P38794	
U.S. Application No. (if known, see 37 CFR 1.5)	

International Application No.	International Filing Date	Priority Date Claimed
PCT/US2011/059453	November 4, 2011	November 4 2011

Title of Invention
METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

First Named Inventor
Boyan BOYANOV

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☑ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☑ is attached.
   b. ☑ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. 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 1.11 and 1.14. This collection is estimated to take 15 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: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/US2011/059453	42P38782

17. ☑ Other items or information:

WO 2013/066356 A1 (Publication Date: May 10, 2013)

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480	
TOTAL OF 18, 19, and 20 =	$ 1480	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof **$400**		

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/ 50 =		x **$400**	$
Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).				$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	20 - 20 =	0	x **$80**	$ 0	
Independent claims	3 - 3 =	0	x **$420**	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$780**	$	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
TOTAL OF ABOVE CALCULATIONS =				$ 1480	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
TOTAL NATIONAL FEE =				$ 1480	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. +				$	
TOTAL FEES ENCLOSED =				$ 1480	
				Amount to be refunded:	$
				Amount to be charged:	$ 1480

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 02-2666 in the amount of $ 1480.00 to cover the above fees.

c. ☑ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 02-2666 as follows:

i. ☑ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

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: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☑ The address associated with Customer Number: 45209 **OR** ☐ Correspondence address below

Name	Tatiana Rossin, BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP				
Address	1279 Oakmead Parkway				
City	Sunnyvale	State	California	Zip Code	94085
Country	U.S.A.	Telephone	(408) 720-8300		
Email	intel_foreign_docs@bstz.com				

Signature	/Tatiana Rossin/	Date	June 5, 2013
Name (Print/Type)	Tatiana Rossin	Registration No. (Attorney/Agent)	56,833

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.

PTO/SB/14 (11-08)
Approved for use through 01/31/2014. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	42P38794
	Application Number	
Title of Invention	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

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.)

Applicant Information:

Applicant 1

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Boyan		BOYANOV	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Portland	State/Province	OR	Country of Residence	US

Citizenship under 37 CFR 1.41(b) US

Mailing Address of Applicant:

Address 1	15760 NW Rondos Drive		
Address 2			
City	Portland	State/Province	OR
Postal Code	97229	Country	US

Applicant 2

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kanwal	Jit	SINGH	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Hillsboro	State/Province	OR	Country of Residence	US

Citizenship under 37 CFR 1.41(b) IN

Mailing Address of Applicant:

Address 1	1055 NE Creeksedge Drive		
Address 2			
City	Hillsboro	State/Province	OR
Postal Code	97124	Country	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.**

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	42P38794
	Application Number	
Title of Invention	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

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Application Information:

Title of the Invention	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS		
Attorney Docket Number	42P38794	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
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Total Number of Drawing Sheets (if any)	10	Suggested Figure for Publication (if any)	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

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Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/US2011/059453	2011-11-04

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	42P38794
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This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. 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(a).

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Application Number	Country[i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
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Assignee 1

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Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

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A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Tatiana Rossin/			Date (YYYY-MM-DD)	2013-06-05
First Name	Tatiana	Last Name	Rossin	Registration Number	56833

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.**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan BOYANOV	)	Examiner: Not yet assigned
Application No.: Not Yet Assigned (US National Phase filing of PCT/US2011/059453 under 35 U.S.C. 371)	)	Art Unit: Not yet assigned
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Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450

PRELIMINARY AMENDMENT

Sir:

Prior to examination of the above-referenced application, applicant respectfully requests the Examiner to enter the following amendments and to consider the following remarks. The Examiner is requested to enter this amendment before calculating the fee.

CERTIFICATE OF ELECTRONIC FILING

I hereby certify that this correspondence is being deposited with the United States Patent and Trademark Office via electronic filing through the United States Patent and Trademark Electronic Filing System on:

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IN THE SPECIFICATION

At page 1, line 2, please add the following:

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a U.S. National Phase application under 35 U.S.C. § 371 of International Application No. PCT/US2011/059453, filed November 4, 2011, entitled "METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS".

REMARKS

Consideration of this application as amended is respectfully requested.

The specification has been amended to reflect that the present application is a U.S. National Phase application under 35 U.S.C. § 371.

It is respectfully submitted that no new mater has been added.

If there are any additional charges, please charge them to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: June 5, 2013

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[Continued on next page]

(54) Title: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

(57) Abstract: At least one conductive line in a dielectric layer over a substrate is recessed to form a channel. The channel is self-aligned to the conductive line. The channel can be formed by etching the conductive line to a predetermined depth using a chemistry comprising an inhibitor to provide uniformity of etching independent of a crystallographic orientation. A capping layer to prevent electromigration is deposited on the recessed conductive line in the channel. The channel is configured to contain the capping layer within the width of the conductive line.

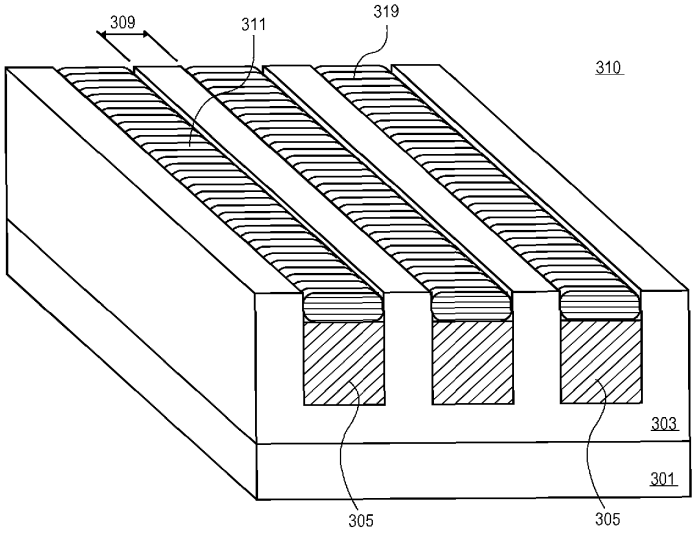


FIG. 3B

WO 2013/066356 A1

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Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

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METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FIELD

Embodiments of the present invention relate to the field of electronic device manufacturing, and in particular, to forming interconnect structures.

BACKGROUND

As the feature size of electronic devices shrinks, reliability of interconnects becomes critical to integrated circuit performance. Generally, electromigration refers to the transport of material caused by the movement of the ions in a conductor due to the momentum transfer between conducting electrons and diffusing metal atoms. The effect is especially important in applications where high current densities are used, for example, in microelectronics structures involving logic devices. Typically, a metal capping technology is used to prevent electromigration.

Figure 1A is a cross-sectional view of a typical interconnect structure having metal electromigration caps. As shown in Figure 1A, metal interconnect lines, for example lines 103 and 104, formed on a dielectric substrate 101 are originally spaced apart at a line spacing 105. The electromigration caps, for example, caps 111-113, can be grown on the respective interconnect lines above a flat surface of the substrate using electroless plating. Generally, the growth of the electromigration caps on the interconnect lines is isotropic. The electromigration cap can grow on the interconnect metal line vertically as well as laterally above the substrate. The lateral growth of the metal electromigration caps may generate overhang structures, for example, an overhang 109 that protrude over the substrate 101 outside the width of the interconnect lines. As shown in Figure 1A, the lateral growth of the metal caps reduces a line-to-line spacing from spacing 105 to spacing 107.

Typically, the size of the overhang 109, is about 50% of the cap thickness. For example, if the two neighboring metal caps have the thickness of about 10 nanometers ("nm"), the total size of their overhangs can be about 2x5nm. As such, the line-to-line spacing can be reduced, for example, by a factor of two from about 20 (nm) to about 10 nm.

Figure 1B is a top view of a typical interconnect structure having metal electromigration caps electrolessly grown over a flat surface of substrate 121 having interconnect lines, such as an interconnect line 123. As shown in Figure 1B, the lateral growth of the metal caps above the substrate increases the line edge roughness ("LER") and reduces line-to-line spacing. As shown in Figure 1B, the line-to-line spacing, for example, a line-to-line spacing 125, varies uncontrollably. Both the increased LER and reduced line-to-line spacing negatively impact on

the reliability of the interconnect structures, increase the risk of current shorting that may lead to the failure of the entire integrated circuit device.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements, in which:

Figure 1A is a cross-sectional view of a typical interconnect structure having metal electromigration caps.

Figure 1B is a top view of a typical interconnect structure having metal electromigration caps.

Figure 2A shows a cross-sectional view of a substrate to fabricate an interconnect structure according to one embodiment of the invention.

Figure 2B is a view similar to Figure 2A, after a dielectric layer is formed over the substrate according to one embodiment of the invention.

Figure 2C is a view similar to Figure 2B, after a photoresist layer is deposited over the dielectric layer to form one or more openings in the dielectric layer according to one embodiment of the invention.

Figure 2D is a view similar to Figure 2C, after one or more openings are formed in the dielectric layer according to one embodiment of the invention.

Figure 2E is a view similar to Figure 2D, after a conductive layer is deposited over the dielectric layer according to one embodiment of the invention.

Figure 2F is a view similar to Figure 2E, after portions of conductive layer and the base layer are removed from the top surface of the dielectric layer outside the openings to form patterned conductive lines according to one embodiment of the invention.

Figure 2G is a view similar to Figure 2F, after conductive lines in a dielectric layer over a substrate are recessed according to one embodiment of the invention.

Figure 2H is a view similar to Figure 2G, after capping layers are selectively deposited onto the respective recessed conductive lines in the channels to prevent electromigration according to one embodiment of the invention.

Figure 3A is a three-dimensional view 300 of an interconnect structure after recessing the conductive lines in a dielectric layer over a substrate according to one embodiment of the invention.

Figure 3B is a view 310 similar to Figure 3A, after capping layers are deposited into the respective channels formed by the recessed conductive lines according to one embodiment of the invention.

Figure 4 is a top view of an interconnect structure 400 having capping layers selectively deposited within channels formed by the recessed conductive lines in a dielectric layer over a substrate according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

In the following description, numerous specific details, such as specific materials, dimensions of the elements, etc. are set forth in order to provide thorough understanding of one or more of the embodiments of the present invention. It will be apparent, however, to one of ordinary skill in the art that the one or more embodiments of the present invention may be practiced without these specific details. In other instances, semiconductor fabrication processes, techniques, materials, equipment, etc., have not been described in great details to avoid unnecessarily obscuring of this description. Those of ordinary skill in the art, with the included description, will be able to implement appropriate functionality without undue experimentation.

While certain exemplary embodiments of the invention are described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative and not restrictive of the current invention, and that this invention is not restricted to the specific constructions and arrangements shown and described because modifications may occur to those ordinarily skilled in the art.

Reference throughout the specification to "one embodiment", "another embodiment", or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "for an embodiment" in various places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

Moreover, inventive aspects lie in less than all the features of a single disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention. While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described, but can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative rather than limiting.

Methods and apparatuses to control a line edge roughness ("LER") and line-to-line spacing in deposition of self-aligned metal caps are described herein. At least one conductive

line is recessed to form a channel in a dielectric layer over a substrate. A capping layer to prevent electromigration is deposited on the recessed conductive line in the channel. The channel is self-aligned to the conductive line. The channel is configured to contain the capping layer within the width of the conductive line. That is, the interconnect line is recessed to contain the cap growth within a channel self aligned to the interconnect line. The channel can be formed by etching the conductive line to a predetermined depth using a chemistry comprising an inhibitor to provide uniformity of etching independent of a crystallographic orientation, as described in further detail below. Methods and apparatuses described herein can be used to control the increase in LER associated with selectively deposited electromigration caps, for example, electroless cobalt caps. That is, an increase in LER and reduction in line-to-line spacing typically associated with the electromigration caps selectively deposited on the metal interconnect lines can be prevented by containing an electroless cap within a recess that is self-aligned to an interconnect line. Eliminating an increase in LER and preventing from reducing of the line-to-line spacing can decrease the risk of failure and increase the manufacturing yield of the electronic devices having reduced (e.g., nanometer scale) dimensions. The electronic devices can be, for example, computer system architecture devices, e.g., transistors, memories, logic devices, and any other integrated circuit and microelectronic devices.

Figure 2A shows a cross-sectional view 200 of a substrate to fabricate an interconnect structure according to one embodiment of the invention. In one embodiment, substrate 201 includes a monocrystalline silicon. In one embodiment, substrate 201 includes a silicon-on-insulator ("SOI"). For alternate embodiments, substrate may comprise compound semiconductors, e.g., indium phosphide, gallium arsenide, gallium nitride, silicon germanium, and silicon carbide. In another embodiment, substrate 201 may include e.g., glass, and quartz. Substrate 201 may include one or more metallization layers of integrated circuits having active and passive devices, e.g., transistors, switches, optoelectronic devices, capacitors, resistors, interconnects (not shown). The one or more metallization layers of integrated circuits of substrate 201 may be separated from adjacent metallization layers by a dielectric material (not shown), e.g., interlayer dielectric. The adjacent metallization layers may be electrically interconnected by vias (not shown).

Figure 2B is a view similar to Figure 2A, after a dielectric layer 203 is formed over the substrate 201 according to one embodiment of the invention. In one embodiment, dielectric layer 203 is an interlayer dielectric ("ILD"). In one embodiment, dielectric layer 203 is a low-k dielectric, e.g., silicon dioxide, silicon oxide, and carbon doped oxide ("CDO"), or any combination thereof. In one embodiment, Dielectric layer 203 includes a nitride, oxide, a polymer, phosphosilicate glass, fluorosilicate ("SiOF") glass, organosilicate glass ("SiOCH"), or

any combination thereof. In one embodiment, dielectric layer 203 includes a spin-on low-k dielectric material. In one embodiment, dielectric layer 203 is silicon dioxide. In another embodiment, dielectric layer 203 is silicon nitride. dielectric layer 203 may be deposited using any suitable deposition technique. In one embodiment, dielectric layer 203 may be deposited using blanket deposition technique, for example, chemical vapor deposition ("CVD"), sputtering, spin-on, or another thin film deposition technique. In one embodiment, dielectric layer 203 is deposited to the thickness in the approximate range of 50nm to 2μm.

Figure 2C is a view similar to Figure 2B, after a photoresist layer 204 is deposited over dielectric layer 203 to form one or more openings in dielectric layer 203 according to one embodiment of the invention. In one embodiment, photoresist layer 204 is deposited on a hard mask layer 202 formed on dielectric layer 203, as shown in Figure 2C. In another embodiment, photoresist layer 204 is deposited directly onto dielectric layer 203. As shown in Figure 2C, photoresist layer 204 and hard mask layer 202 are patterned and etched to form openings, such as an opening 220. Patterning and etching of the photoresist and hard mask is known to one of ordinary skill in the art of microelectronic device manufacturing. Patterning and etching of the photoresist may be performed using one of the techniques known to one of ordinary skill in the art of microelectronic device manufacturing. The technique may include masking the photoresist layer, exposing the masked layer to light, and then developing the unexposed portions to remove the portions of the photoresist layer that are exposed to light to form a window in the photoresist layer. In one embodiment, the process of exposing to light and removing the photoresist layer may be performed in a plasma reactor. The opening in hard mask 202 may be etched to expose a portion of dielectric layer 203 using a dry etching, e.g., reactive ion etching ("RIE"), wet etching, or any combination thereof techniques.

Figure 2D is a view similar to Figure 2C, after one or more openings, such as an opening 206, are formed in dielectric layer 203 according to one embodiment of the invention. In one embodiment, the openings are, such as opening 206, is etched through openings in hard mask 203, such as opening 220. In another embodiment, the openings are formed by etching the dielectric layer through the openings in patterned photoresist 204 deposited directly onto dielectric layer 203. In one embodiment, the openings in the dielectric layer 203, for example, trenches, are formed using an anisotropic dry etching, e.g., plasma etching. In another embodiment, the openings in the dielectric layer 203 are formed using dry etching, wet etching, or a combination thereof techniques known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the openings in dielectric layer 203 has the width in the approximate range of 0.005microns ("μm ") to 5 μm, and the depth in the approximate range

of 0.005 μm to 10 μm. In one embodiment, the size of openings is determined by the size of a conductive line formed within ILD 203 later on in the process.

After forming the openings, such as opening 206, the photoresist and hard mask are removed. Removing of the photoresist and the hard mask from dielectric layer 203 is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the photoresist and hard mask may be removed using a chemical technique, mechanical technique, or both.

Figure 2E is a view similar to Figure 2D, after a conductive layer 205 is deposited over dielectric layer 203 according to one embodiment of the invention. As shown in Figure 2E, forming of the conductive layer 205 involves filling the one or more openings in dielectric layer 203 with a conductive material to form one or more conductive lines. In one embodiment, a base layer (not shown) is first deposited on dielectric layer 203 covering the internal sidewalls and bottom of the openings, and then a conductive layer 205 is deposited on the base layer. In one embodiment, the base layer includes a conductive seed layer (not shown) deposited on a conductive barrier layer (not shown). The seed layer can include copper, and the conductive barrier layer can include aluminum, titanium, tantalum, tantalum nitride, and the like metals. The conductive barrier layer can be used to prevent diffusion of the conductive material from the seed layer, e.g., copper, into ILD 203. Additionally, the conductive barrier layer can be used to provide adhesion for the seed layer (e.g., copper). In one embodiment, to form the base layer, the conductive barrier layer is deposited onto the dielectric layer 203 covering the sidewalls and bottom of the opening, and then the seed layer is deposited on the conductive barrier layer. In another embodiment, the conductive base layer includes the seed layer that is directly deposited onto dielectric layer 203 covering the sidewalls and bottom of the openings. Each of the conductive barrier layer and seed layer may be deposited using any thin film deposition technique known to one of ordinary skill in the art of semiconductor manufacturing, e.g., by sputtering, blanket deposition, and the like. In one embodiment, each of the conductive barrier layer and the seed layer has the thickness in the approximate range of 1 to 100 nm. In one embodiment, the barrier layer may be a thin dielectric that has been etched to establish conductivity to the metal layer below. In one embodiment, the barrier layer may be omitted altogether and appropriate doping of the copper line may be used to make a "self-forming barrier".

Conductive layer 205 fills the openings, such as an opening 206, and covers portions of the base layer (not shown) outside of the openings that are on top of dielectric layer 203. In one embodiment, conductive layer 205 e.g., copper, is deposited onto the seed layer of base layer of copper, by an electroplating process. In one embodiment, conductive layer 205 is deposited into

the openings using a damascene process that is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, conductive layer 205 is deposited onto the seed layer using one of selective deposition techniques known to one of ordinary skill in the art of semiconductor manufacturing, e.g., electroplating, electroless plating, and the like. In one embodiment, the choice of a material for conductive layer 205 determines the choice of a material for the seed layer. For example, if the material for conductive layer 205 includes copper, the material for the seed layer also includes copper. In one embodiment, conductive layer 205 includes e.g., copper (Cu), ruthenium (Ru), nickel (Ni), cobalt (Co), chromium (Cr), iron (Fe), manganese (Mn), titanium (Ti), aluminum (Al), hafnium (Hf), tantalum (Ta), tungsten (W), Vanadium (V), Molybdenum (Mo), palladium (Pd), gold (Au), silver (Au), platinum Pt, or any combination thereof.

Figure 2F is a view similar to Figure 2E, after portions of conductive layer 205 and the base layer are removed from the top surface of dielectric layer 203 outside the openings to form patterned conductive lines, such as a conductive line 208 according to one embodiment of the invention. Portions of conductive layer 205 may be removed chemically, e.g., using etching, mechanically, e.g., using polishing, or by a combination of thereof techniques, e.g., using a chemical-mechanical polishing ("CMP") technique known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, one or more patterned conductive lines are formed within dielectric layer 203 using methods described above. In another embodiment, the conductive lines are formed by patterning and etching of the conductive layer deposited on the top surface of dielectric layer 203. Patterning and etching of the conductive layer deposited on the top surface of the dielectric layer 203 is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the thickness of the conductive line, for example, a thickness 211 is in the approximate range of 0.015μm to 1μm. In one embodiment, the width of the conductive line, for example, a width 209 is in the approximate range of 5nm to about 500nm. In one embodiment, the spacing between the conductive lines, for example, a spacing 207, is from about 5nm to about 500nm. In one embodiment, the spacing between the conductive lines is from about 2nm to about 100nm.

Figure 2G is a view similar to Figure 2F, after the conductive lines, for example, a conductive line 208, in a dielectric layer over a substrate are recessed according to one embodiment of the invention. As shown in Figure 2G, channels, such as a channel 212, are formed in dielectric layer 203. As shown in Figure 2G, channels, such as channel 212, have sidewalls made of dielectric layer 203, such as sidewalls 214 and 216, and a bottom made of a respective conductive line, such as a bottom 218 made of conductive line 208.

In one embodiment, the channel has depth, such as a depth 213 from about 5 nm to about 50nm. In one embodiment, the depth of the channel is from about 2 nm to about 20nm. In one embodiment, the channel has depth that is from about 10% to about 50% of the thickness of the conductive line, such as a thickness 211 shown in Figure 2F. In one embodiment, the conductive lines are recessed to the depth, which is determined based on the thickness of a capping layer, as described in further detail below.

Figure 3A is a three-dimensional view 300 of an interconnect structure after recessing the conductive lines, such as a conductive line 305 and a conductive line 304, in a dielectric layer 303 over a substrate 301 according to one embodiment of the invention. Substrate 301, dielectric layer 303, and the conductive lines 305 and 304, can be, for example, any of the respective substrates, dielectric layers, and conductive lines, as described above. As shown in Figure 3A, channels, such as a channel 302 and a channel 307, are formed in a dielectric layer 303 over substrate 301 by recessing the conductive lines. As shown in Figure 3A, the channels are self-aligned to the respective conductive lines. For example, channel 307 is self-aligned to conductive line 305 and channel 302 is self-aligned to conductive line 304. As shown in Figure 3A, the length of the channel, e.g., a length 315 is along the length of the conductive line, and the width of the channel, e.g., a width 307 is along the width of the conductive line. In one embodiment, the length of the channel is substantially longer that the width of the channel. In one embodiment, the width of the channel is less than 100nm, and the length of the channel is at least 500nm. In one embodiment, the width of the channel is from about 5 nm to about 500nm, and the length of the channel is from about a few hundred nanometers to about a few hundred microns. As shown in Figure 3A, the conductive lines, such as conductive lines 305 and 304 are separated by a distance, such as a spacing 309. In one embodiment, the spacing between the conductive lines, such as lines 305 and 304 is from about 5nm to about 500nm. In one embodiment, the spacing between the conductive lines, such as lines 305 and 304 is from about 2nm to about 100nm.

In one embodiment, recessing the conductive lines, such as line 208, lines 304 and 305, involves wet etching the conductive lines uniformly independent of a crystallographic orientation using a chemistry containing an etchant, an oxidizer, an inhibitor, and a solvent. That is, adding an inhibitor and a solvent to the etchant provides uniform etching of the conductive material independent of a crystallographic orientation, by forming, during etching, a passivation layer (not shown) on the conductive material. The wet etch chemistry containing an etchant, an oxidizer, an inhibitor, and solvent provides control over the depth of the etching of the conductive line, so that only a portion (e.g., 5% to 50%) of the conductive line can be recessed.

In one embodiment, the chemistry to wet etch the conductive lines to provide a channel that is free from a pattern dependence and a crystallographic preference comprises between about 1% to about 40% by mass of an etchant, between about 1% to about 10% by mass of an oxidizer, and between about 0.1% to about 1% by mass of an inhibitor, and between about 1 to about 60% by mass of an organic solvent. In one embodiment, the chemistry to wet etch the conductive lines comprises an etchant from about 0.1% to about 70% by mass (depending on the etch rate of the etchant), an oxidizer from about 0.1% to about 10% by mass (depending on the strength of the oxidizer), an inhibitor from about 50 parts per million (ppm) to about 1% by mass; and a solvent between about 1 to about 60% by mass.

In one embodiment, the chemistry to etch the conductive lines can include an etchant, for example, a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer, for example, a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, an inhibitor, for example, an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof, and a solvent. The solvent can be an aqueous system (preferred), e.g., water, or an organic solvent. The examples of an organic solvents are propylene carbonate, sulfolane, glycol ethers, methylene chloride, and the like.

For example, regarding the etchant in the chemistry to etch copper conductive lines, Cu metal is typically in a zero oxidation state. In order to etch copper, the copper needs to be oxidized into a 0+n oxidation state where 'n' can be any of 1, 2 , 3 or 4. Typically, 1st state and 2^{d} state are more common oxidation states of copper. For any molecule to act as an etchant, it needs to be able to bind copper in one of its oxidation states 1, 2, 3 or 4. This binding typically occurs through the use of group 15 (Nitrogen family), group 16 (Oxygen family) or group 17 (Halogen family) atoms in a molecule. In one embodiment, the etchant to etch copper conductive lines is an organic etchant, for example, any of glycine, ethylenediaminetetraacetic, alpha-amino acids, polycarboxylic acids (for example, citric acid that is a tricarboxylic acid), oxalic and malonic acids.

For example, an oxidizer in the chemistry to etch copper conductive lines is used to change the copper oxidation state from an insoluble copper metal to a soluble copper ion. The oxidizer can be chosen from any of the oxidizers, for example, any of peroxides (e.g., hydrogen peroxide), ozone, permanganates, chromates, perborates and hypohalites, and the like.

For example, to etch the copper constituting the current carrying line in a uniform and non-crystallographic orientation, it is important to add an inhibitor to the chemistry. The role of an inhibitor is to form a passivation layer (a polymeric compound formed from the molecules of the inhibitor binding copper in a specific and periodic manner). The formation of this passivation

layer during the controlled etch of copper is critical to ensure uniformity of etching and preventing etching attacks (e.g., forming voids) along crystallographic (e.g., grain) boundaries. For example, any inhibitor that is not decomposed in the chosen oxidizer and etchant combination may be used in the chemistry to etch copper conductive lines. The classes of inhibitors are known to one of ordinary skill in the art of electronic device manufacturing. For example, any of organic inhibitors including azoles, amines, amino acids, phosphates and phosphonates can be used in the chemistry to etch the copper conductive lines.

In another embodiment, the conductive copper lines are recessed by wet etching using a chemistry comprising a citric acid and peroxide. A chemistry comprising citric acid and peroxide, however, typically has high etching rate that can be difficult to control. Additionally, an etching rate of the chemistry comprising citric acid and peroxide depends on a crystallographic orientation that may produce rough etched surface. Addition of a corrosion inhibitor, for example, benzotriazole ("BTA") to the chemistry, and dilution of the citric acid and peroxide in organic solvent can slow down the etching rate dramatically and eliminate the crystallographic nature of the etch, such as etching the voids in Cu along the grain boundaries producing a smooth surface.

In one embodiment, the conductive lines are recessed by wet etching that involves any of spraying, and pouring the etching chemistry onto the conductive lines. In one embodiment, the conductive lines are recessed by wet etching that involves immersing the conductive lines into the etching chemistry solution. In one embodiment, the conductive lines are recessed by wet etching at a temperature from about 15°C to about 50°C for a predetermined time. In at least some embodiments, the conductive lines are recessed by dry etching, e.g., plasma etching.

Figure 2H is a view similar to Figure 2G, after the capping layers are selectively deposited onto the respective recessed conductive lines in the channels to prevent electromigration according to one embodiment of the invention. The conductive lines etched using the chemistry as described above, have a smooth uniform top surface to adhere the capping layer. As shown in Figure 2H, a capping layer 215 is deposited onto recessed conductive line 208 within channel 212. In one embodiment, the channel, such as channel 212, is configured to contain a capping layer within the width of the conductive line, e.g., width 209 shown in Figure 2F. That is, the recessed conductive line creates a channel which contains the growth of the capping layer within the channel that mitigates the reduction in line-to-line spacing and increase in LER. As shown in Figure 2H the capping layer 215 is located on the conductive line 208 within the sidewalls of the channel 212. In one embodiment, the capping layer is deposited on the recessed conductive line by an electroless deposition (e.g., plating), a chemical vapor deposition ("CVD"), a physical vapor deposition ("PVD"), or any other selective deposition

techniques known to one of ordinary skill in the art of electronic device manufacturing. In one embodiment, a conductive line, such as line 208, comprises a first metal, and the capping layer comprises a second metal other than the first metal to prevent electromigration of the first metal from the conductive line. In one embodiment, the metal for the capping layer is heavier than the metal for the conductive line to prevent electromigration.

For example, the conductive line can be made of any of the metals including copper, aluminum. In one embodiment, the capping layer, such as capping layer 215, is made of cobalt ("Co"), cobalt electroless alloys, e.g., CoBP, CoWBP, CoWP, CoWB, CoWP, or a combination thereof. In another embodiment, a capping layer, such as capping layer 215, is made of nickel ("Ni"), Ni electroless alloys, e.g., NiBP, NiWBP, NiWP, NiWB, NiWP, or a combination thereof. In another embodiment, a capping layer, such as capping layer 215, is made of platinum ("Pt") group metals, for example, Pt, Pd, Ru, Ir, Rh as pure elements or alloys. The typical alloy elements for Pt group metals are W, B, P. In yet another embodiment, a capping layer, such as capping layer 215, is made of refractory metals, for example, Ta, W, Mo, or a combination thereof.

In one embodiment, the Co capping layer is deposited within a channel onto the recessed Cu conductive layer. In one embodiment, Ni capping layer is deposited within a channel onto the recessed Cu conductive layer. In one embodiment, refractory metal capping layer is deposited within a channel onto the recessed Cu conductive layer.

In one embodiment, the capping layers comprising a Pt group metal, Co, Ni, or a combination thereof, are deposited onto the conductive layers, e.g., copper, aluminum, using any of an electroless deposition, and a vapor phase deposition, e.g., CVD. In one embodiment, the capping layers including refractory metals are deposited onto the conductive layers, e.g., copper, aluminum, using any of a CVD and PVD techniques known to one of ordinary skill in the art of electronic device manufacturing. In one embodiment, the thickness of the capping layer, e.g., a thickness 221, is from about 2 nm to about 50 nm. In one embodiment, the thickness of the capping metal layer is sufficient to prevent electromigration from the underlying conductive layer. In one embodiment, the capping layer has the thickness that is no greater than the depth of the channel within which the capping layer is deposited.

Figure 3B is a view 310 similar to Figure 3A, after capping layers are deposited into the respective channels formed by the recessed conductive lines according to one embodiment of the invention. As shown in Figure 3B, capping layers, such as a capping layer 311 and 319 are selectively deposited into respective channels, such as channel 302 and channel 307, as described above. As shown in Figure 3A, the capping layers are contained within their respective channels. As shown in Figure 3B, the capping layer 319 is separated from capping layer 311 by

spacing 309. In one embodiment, the spacing between conductive lines 305 and 304 and the spacing between the capping layers 319 and 311 is the same.

Figure 4 is a top view of an interconnect structure 400 having capping layers selectively deposited within channels formed by the recessed conductive lines in a dielectric layer 401 over a substrate according to one embodiment of the invention. As shown in Figure 4, the LER of the interconnect lines, such as an interconnect line 403 is substantially reduced, the edges of the interconnect lines are smooth, and a line-to-line spacing, such as a line-to-line spacing 405 is increased and maintained between the lines. In one embodiment, the line-to-line spacing is increased by 2x cap thickness. This can result in rather dramatic decreases in electric field and time to dielectric breakdown, especially, for a future technology node having 20nm lines and 20nm spaces. The minimum cap thickness known to work today is 5nm. This means that with a conventional approach the line-line space would be 10nm instead of the 20nm drawn on a mask. Furthermore, currently, the size of the protrusions in the overhang tends to be about 50% of the cap thickness. For a typical cap thickness of 5-10nm using methods described above LER can be decreased by 3-5nm independent of line width. For a future 20 nm technology node, decrease in LER by 3-5nm can result in 15-20% increase in line-to-line spacing of an interconnect structure.

Figure 5 shows a block diagram of an exemplary embodiment of a data processing system 500 having one or more electronic devices, e.g., transistors, memories, such as a memory 504, and a memory 518, processing logic devices, such a processing logic device 526, and any other integrated circuit and microelectronic devices that are built using methods described herein. As shown in Figure 5, data processing system 500 includes a processor 502 having processing logic 526. In at least some embodiments, processing logic 526 contains at least one conductive line in a dielectric layer over a substrate, a channel in the dielectric layer over the one conductive line; and a capping layer on the at least one conductive line in the channel to prevent electromigration, as described herein. In at least some embodiments, each of the memories 504 and 518 contains at least one conductive line in a dielectric layer over a substrate, a channel in the dielectric layer over the one conductive line; and a capping layer on the at least one conductive line in the channel to prevent electromigration, as described herein

In alternative embodiments, the data processing system may be connected (e.g., networked) to other machines in a Local Area Network (LAN), an intranet, an extranet, or the Internet. The data processing system may operate in the capacity of a server or a client machine in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The data processing system may be a personal computer (PC), a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web

appliance, a server, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that data processing system. Further, while only a single data processing system is illustrated, the term "data processing system" shall also be taken to include any collection of data processing systems that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies described herein.

The exemplary data processing system 500 includes a processor 502, a main memory 504 (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM) or Rambus DRAM (RDRAM), etc.), a static memory 506 (e.g., flash memory, static random access memory (SRAM), etc.), and a secondary memory 518 (e.g., a data storage device), which communicate with each other via a bus 530.

Processor 502 represents one or more general-purpose processing devices such as a microprocessor, central processing unit, or the like. More particularly, the processor 502 may be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, processor implementing other instruction sets, or processors implementing a combination of instruction sets. Processor 502 may also be one or more special-purpose processing devices such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. Processor 502 is configured to execute the processing logic 526 for performing the operations described herein.

The computer system 500 may further include a network interface device 508. The computer system 500 also may include a video display unit 510 (e.g., a liquid crystal display (LCD), a light emitting diode display (LED), or a cathode ray tube (CRT)), an alphanumeric input device 512 (e.g., a keyboard), a cursor control device 514 (e.g., a mouse), and a signal generation device 516 (e.g., a speaker).

The secondary memory 518 may include a machine-accessible storage medium (or more specifically a computer-readable storage medium) 531 on which is stored one or more sets of instructions (e.g., software 522) embodying any one or more of the methodologies or functions described herein. The software 522 may also reside, completely or at least partially, within the main memory 504 and/or within the processor 502 during execution thereof by the computer system 500, the main memory 504 and the processor 502 also constituting machine-readable storage media. The software 522 may further be transmitted or received over a network 520 via the network interface device 508.

While the machine-accessible storage medium 531 is shown in an exemplary embodiment to be a single medium, the term "machine-readable storage medium" should be

taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "machine-readable storage medium" shall also be taken to include any medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention. The term "machine-readable storage medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media.

In alternative embodiments, Figure 5 illustrates a computing device 500. The computing device 500 houses a board 530. The board may include a number of components, including but not limited to a processor 502 and at least one communication chip 508. The processor 502 is physically and electrically coupled to the board 530. In some implementations the at least one communication chip 508 is also physically and electrically coupled to the board 530. In further implementations, the communication chip 508 is integrated within the processor 502.

Depending on its applications, computing device 500 may include other components that may or may not be physically and electrically coupled to the board 530. These other components include, but are not limited to, volatile memory (e.g., DRAM), non-volatile memory (e.g., ROM), flash memory, a graphics processor, a digital signal processor, a crypto processor, a chipset, an antenna, a display, a touchscreen display, a touchscreen controller, a battery, an audio codec, a video codec, a power amplifier, a global positioning system (GPS) device, a compass, an accelerometer, a gyroscope, a speaker, a camera, and a mass storage device (such as hard disk drive, a solid state drive, a compact disk (CD) drive, a digital versatile disk (DVD) drive, and so forth).

The communication chip 508 enables wireless communications for the transfer of data to and from the computing device 500. The term "wireless" and its derivatives may be used to describe circuits, devices, systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a non-solid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. The communication chip 508 may implement any of a number of wireless standards or protocols, including but not limited to Wi-Fi (IEEE 802.11 family), WiMAX (IEEE 802.16 family), IEEE 802.20, long term evolution (LTE), Ev-DO, HSPA+, HSDPA+, HSUPA+, EDGE, GSM, GPRS, CDMA, TDMA, DECT, Bluetooth, derivatives thereof, as well as any other wireless protocols that are designated as 3G, 4G, 5G, andbeyond. The computing device 500 may include a plurality of communication chips 508. For instance, a first communication chip 508 may be dedicated to shorter range wireless

communications such as Wi-Fi andBluetooth and a second communication chip 1006 may be dedicated to longer range wireless communications such as GPS, EDGE, GPRS, CDMA, WiMAX, LTE, Ev-DO, and others.

The processor 502 of the computing device 500 includes an integrated circuit die packaged within the processor 502. In some implementations of the invention, the integrated circuit die of the processor includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein. The term "processor" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory.

The communication chip 508 also includes an integrated circuit die packaged within the communication chip 508. In accordance with another implementation of the invention, the integrated circuit die of the communication chip includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein.

In further implementations, another component housed within the computing device 600 may contain an integrated circuit die that includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein.

In various implementations, the computing device 500 may be a laptop, a netbook, a notebook, an ultrabook, a smartphone, a tablet, a personal digital assistant (PDA), an ultra mobile PC, a mobile phone, a desktop computer, a server, a printer, a scanner, a monitor, a set-top box, an entertainment control unit, a digital camera, a portable music player, or a digital video recorder. In further implementations, the computing device 500 may be any other electronic device that processes data.

In the foregoing specification, embodiments of the invention have been described with reference to specific exemplary embodiments thereof. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of embodiments of the invention as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method to manufacture an electronic device, comprising:

recessing at least one conductive line in a dielectric layer over a substrate to form a channel; and

depositing a capping layer on the recessed conductive line in the channel to prevent electromigration.

2. The method of claim 1, wherein the recessing includes

etching the at least one conductive line uniformly independent of a crystallographic orientation.

3. The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. The method of claim 1, further comprising

forming a dielectric layer over the substrate;

forming at least one opening in the dielectric layer; and

filling the at least one opening with a conductive material to form the at least one conductive line.

7. The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel self-aligned to the conductive line, wherein the channel is configured to contain a capping layer within a width of the at least one

conductive line, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation.

9. The method of claim 8, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, and between about 50ppm to about 1% by mass of the inhibitor.

10. The method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof.

11. The method of claim 8, further comprising
depositing the capping layer onto the etched conductive line in the channel.

12. The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. An apparatus, comprising:
at least one first conductive line in a dielectric layer over a substrate,
and
a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the

at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

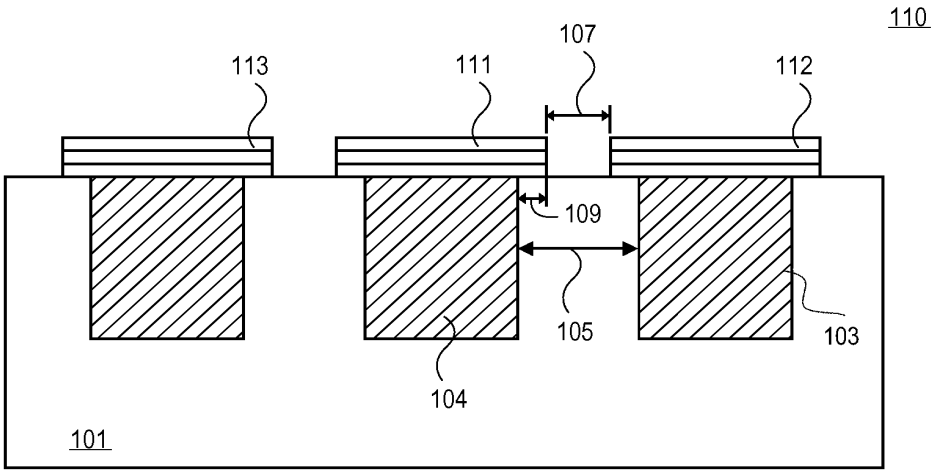


FIG. 1A
(PRIOR ART)

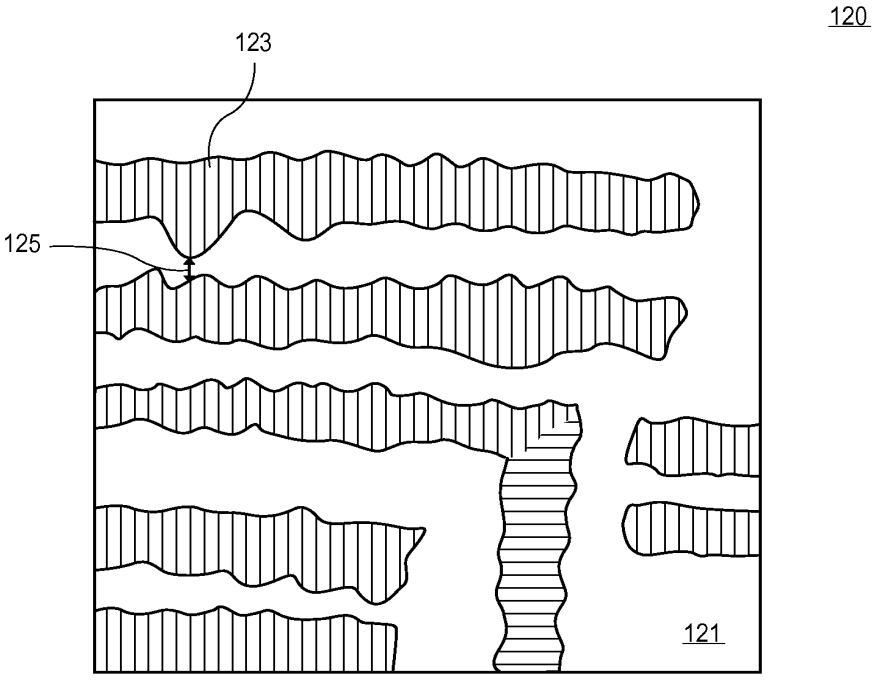


FIG. 1B
(PRIOR ART)

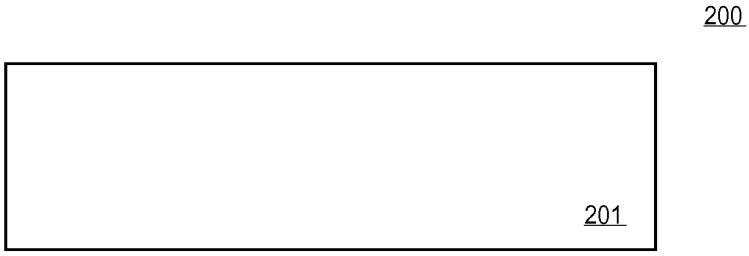


FIG. 2A

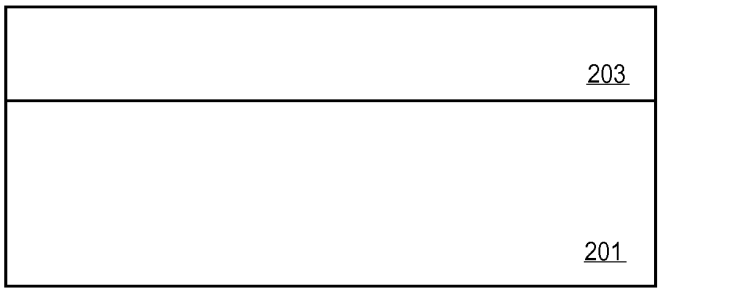


FIG. 2B

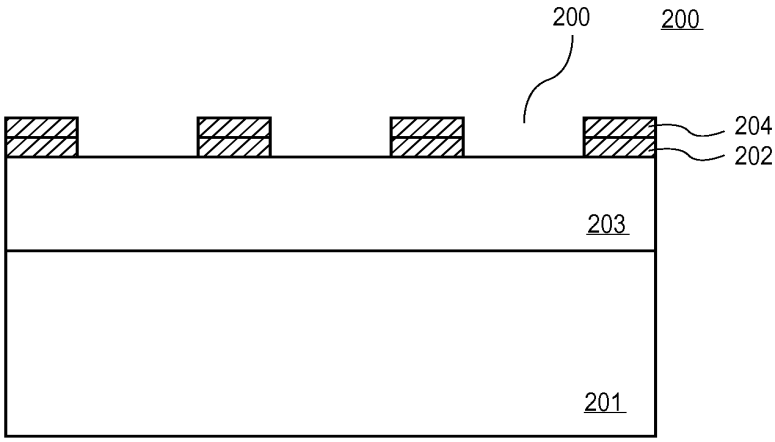


FIG. 2C

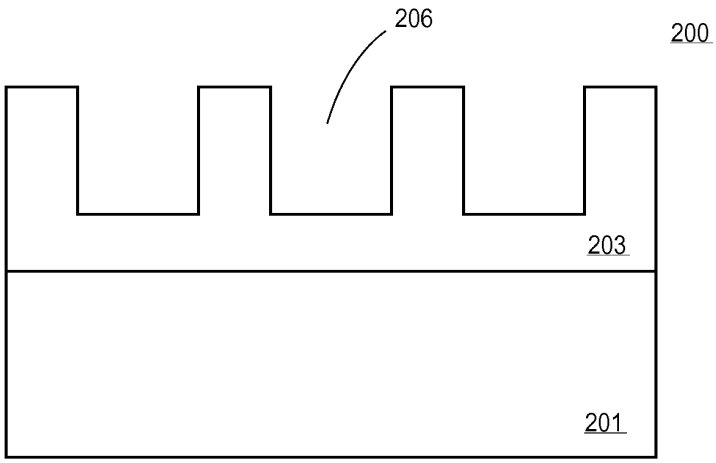


FIG. 2D

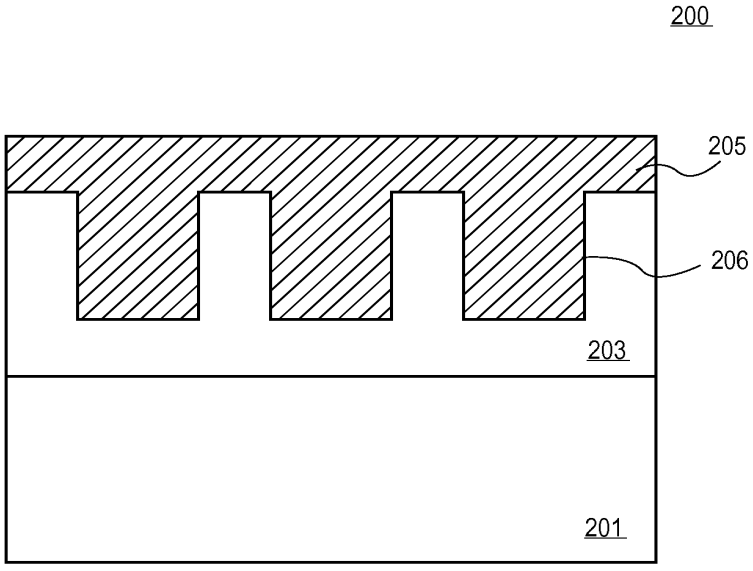


FIG. 2E

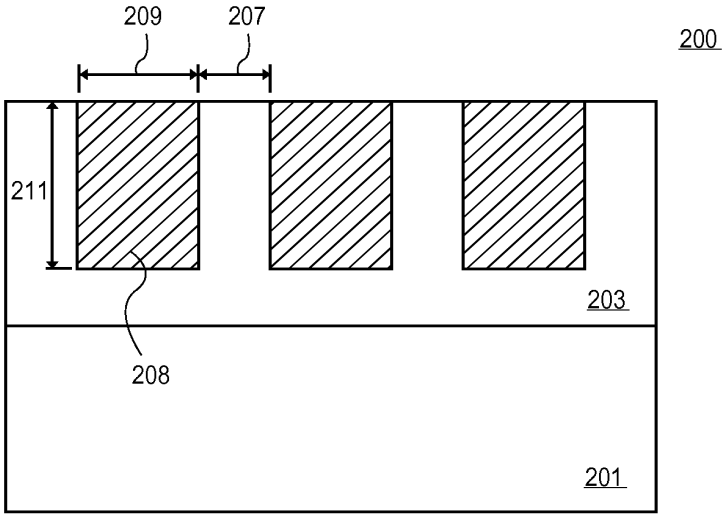


FIG. 2F

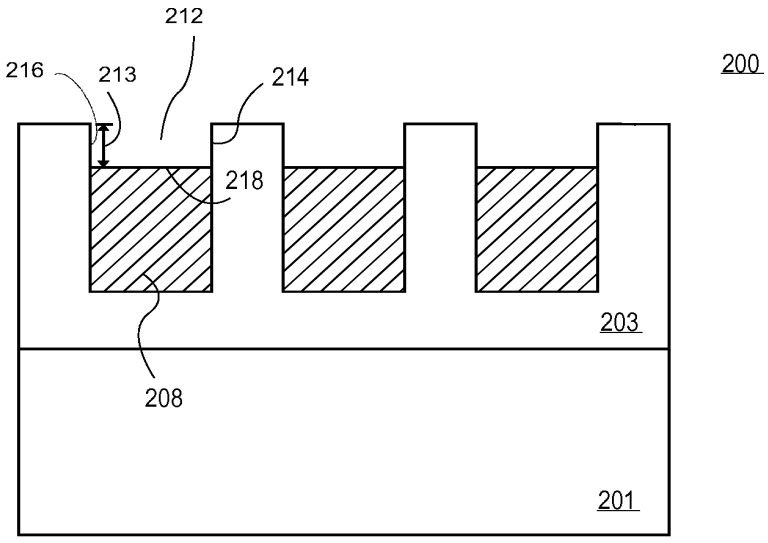


FIG. 2G

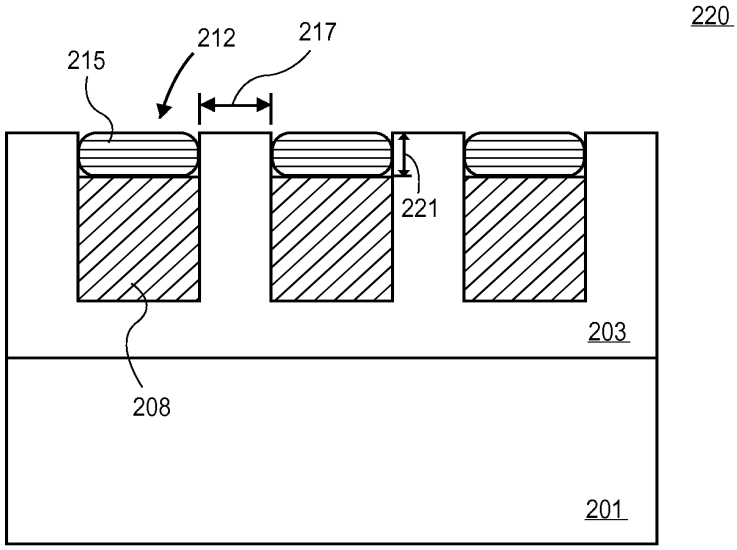


FIG. 2H

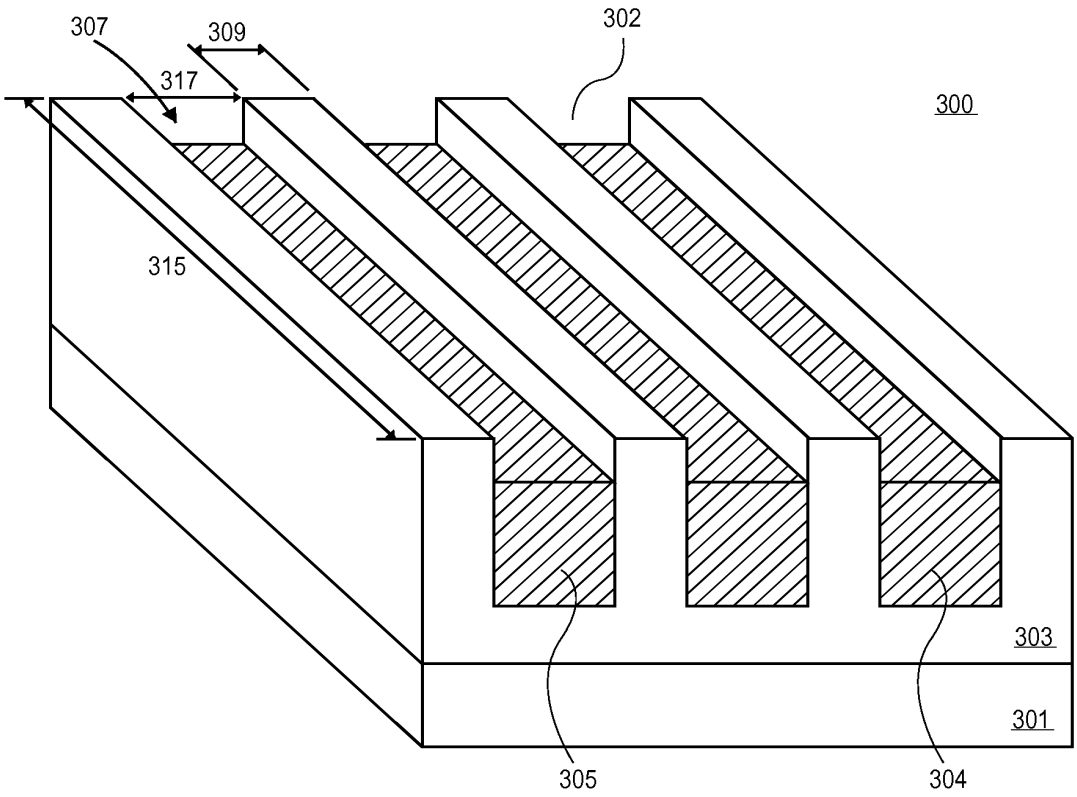


FIG. 3A

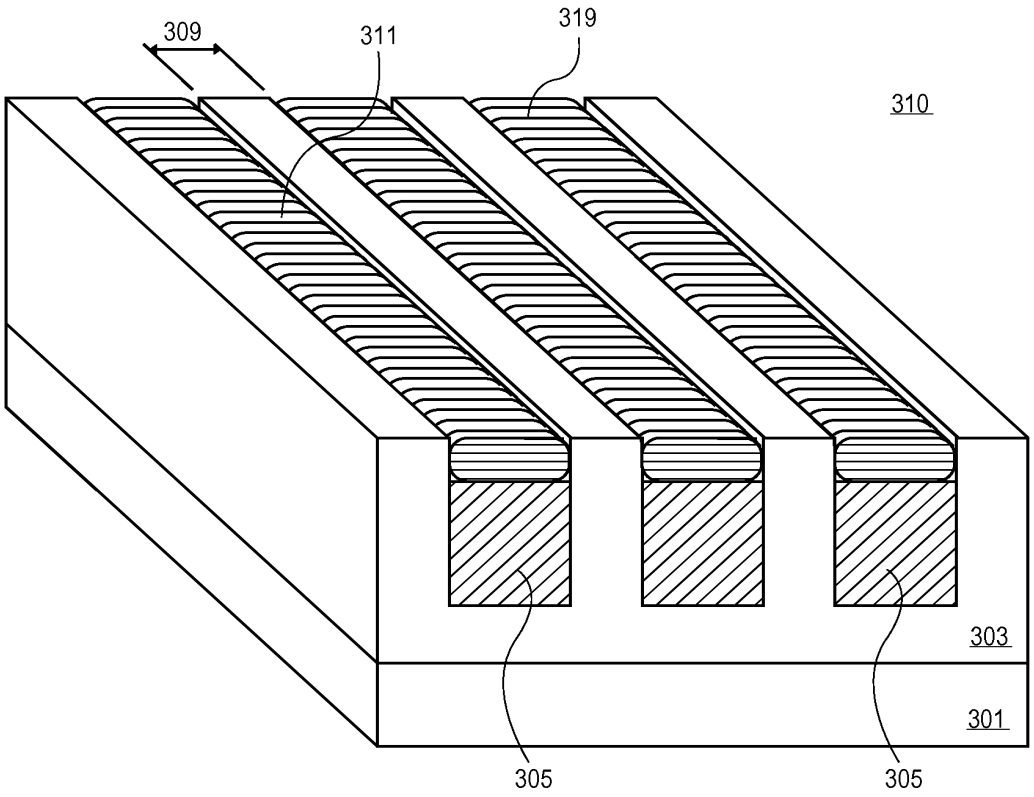


FIG. 3B

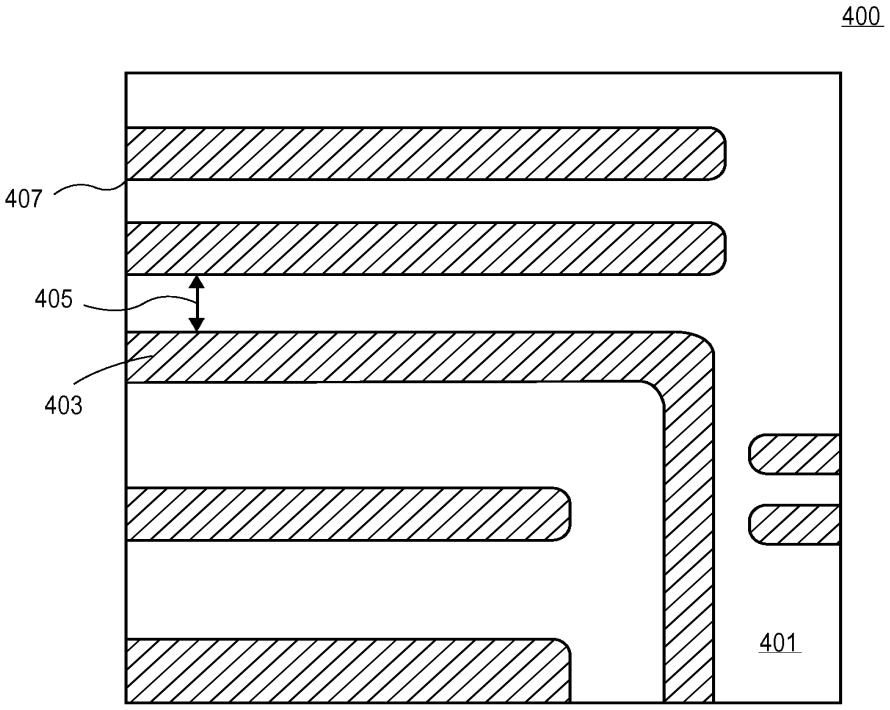


FIG. 4

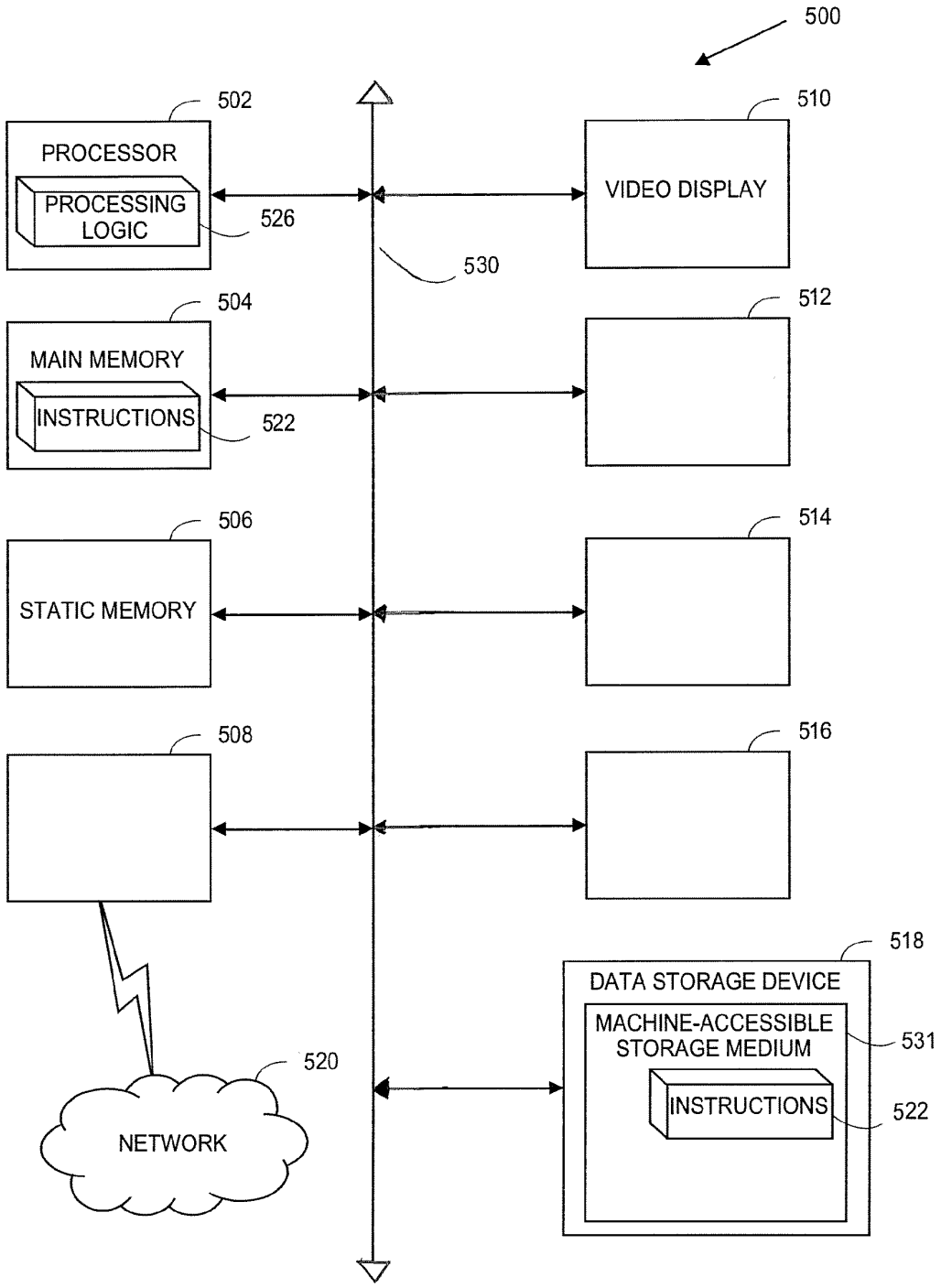

500
502
PROCESSOR
PROCESSING LOGIC
526
530
504
MAIN MEMORY
INSTRUCTIONS
522
506
STATIC MEMORY
508
510
VIDEO DISPLAY
512
514
516
518
DATA STORAGE DEVICE
MACHINE-ACCESSIBLE STORAGE MEDIUM
531
INSTRUCTIONS
522
520
NETWORK

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/059453

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L 21/28; C23C 14/00; C23F 1/00; H01L 21/4763

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: damascene,cap,recess,self align,selective

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0283499 A1 (MAYER STEVEN T. et al.) 19 November 2009 See abstract; figures 1B, 2; paragraphs [0046]-[0064]	1-20
X	US 2006-0128144 A1 (HYUN-MOG PARK et al.) 15 June 2006 See abstract; figures 1-8; paragraphs [0024]-[0029]	1,3-7,13-20
A	US 7396759 B1 (VAN SCHRAVENDIJK BART et al.) 08 July 2008 See abstract; figure 8; column 8 line 14 - column 10 line 27	1-20
A	US 2009-0127097 A1 (CHEN KEI-WEI et al.) 21 May 2009 See abstract; figures 7-8; paragraphs [0029]-[0031]	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 JULY 2012 (13.07.2012)	**16 JULY 2012 (16.07.2012)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Kim, Young Jin Telephone No. 042 481 5771

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/059453

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group Ⅰ (claims 1-7, 13-20) is directed to an apparatus and its manufacturing method.
Group Ⅱ (claims 8-12) is directed to a method to control line edge roughness.

1. ☒ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/059453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0283499 A1	19.11.2009	CN 101736376 A	16.06.2010
		KR 10-2011-0028446 A	18.03.2011
		KR 10-2012-0024844 A	14.03.2012
		US 2002-0074238 A1	20.06.2002
		US 2002-0195352 A1	26.12.2002
		US 2003-0079995 A1	01.05.2003
		US 2004-0065540 A1	08.04.2004
		US 2005-0282371 A1	22.12.2005
		US 2007-0105377 A1	10.05.2007
		US 2009-0266707 A1	29.10.2009
		US 2009-0277802 A1	12.11.2009
		US 2009-0277867 A1	12.11.2009
		US 2009-0280649 A1	12.11.2009
		US 2010-0015805 A1	21.01.2010
		US 2010-0029088 A1	04.02.2010
		US 2010-0032303 A1	11.02.2010
		US 2010-0032310 A1	11.02.2010
		US 2010-0044236 A1	25.02.2010
		US 2010-0116672 A1	13.05.2010
		US 2011-223772 A1	15.09.2011
		US 6315883 B1	13.11.2001
		US 6402923 B1	11.06.2002
		US 6514393 B1	04.02.2003
		US 6653226 B1	25.11.2003
		US 6709565 B2	23.03.2004
		US 6755954 B2	29.06.2004
		US 6756307 B1	29.06.2004
		US 6773571 B1	10.08.2004
		US 6919010 B1	19.07.2005
		US 7070686 B2	04.07.2006
		US 7189647 B2	13.03.2007
		US 7338908 B1	04.03.2008
		US 7405163 B1	29.07.2008
		US 7449098 B1	11.11.2008
		US 7449099 B1	11.11.2008
		US 7531079 B1	12.05.2009
		US 7531463 B2	12.05.2009
		US 7560016 B1	14.07.2009
		US 7682498 B1	23.03.2010
		US 7686935 B2	30.03.2010
		US 7690324 B1	06.04.2010
		US 7799200 B1	21.09.2010
		US 7854828 B2	21.12.2010
		US 7972970 B2	05.07.2011
		US 8158532 B2	17.04.2012
		WO 2010-144330 A2	16.12.2010
		WO 2010-144330 A3	16.12.2010
		WO 2011-017119 A2	10.02.2011
		WO 2011-017119 A3	10.02.2011

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/059453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-0128144 A1	15.06.2006	None	
US 7396759 B1	08.07.2008	US 7576006 B1	18.08.2009
		US 7704873 B1	27.04.2010
		US 7727880 B1	01.06.2010
		US 7727881 B1	01.06.2010
		US 8030777 B1	04.10.2011
US 2009-0127097 A1	21.05.2009	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

Docket No.: P38794PCT
PATENT

Declaration of inventorship (Rules 4.17(iv) and 51*bis*.1(a)(iv)) for the purposes of the designation of the United States of America:

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/ . . . . . (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: . . . . . .
. . . . . .

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: Boyan Boyanov

Residence: Portland, Oregon
(city and either US state, if applicable, or country)

Mailing Address: 15760 NW Rondos Drive
Portland, OR, US 97229
Citizenship: United States of America

Inventor's Signature: _____ Date: 11/03/11
(The signature must be that of the inventor, not that of the agent)

INTEL CORPORATION
LCA/PAL FORMS

Name: Kanwal Jit Singh

Residence: Hillsboro, Oregon
(city and either US state, if applicable, or country)

Mailing Address: 6897 NE Vinings Way, Apt 124
Hillsboro, OR 97124

Citizenship: India

Inventor's Signature: _____ Date: _____
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

**Declaration of inventorship (Rules 4.17(iv) and 51*bis*.1(a)(iv))
for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/ . . . . . (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: . . . . . .
. . . . . .

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: Boyan Boyanov

Residence: Portland, Oregon
(city and either US state, if applicable, or country)

Mailing Address: 15760 NW Rondos Drive
Portland, OR, US 97229

Citizenship: United States of America

Inventor's Signature: _____ Date: _____
(The signature must be that of the inventor, not that of the agent)

Docket No.: P38794PCT
PATENT

Name: Kanwal Jit Singh

KS (Kanwal Singh) Nov 29, 2011

Residence: Hillsboro, Oregon
(city and either US state, if applicable, or country)

Mailing Address: ~~6867 NE Vinings Way, Apt 124~~ 1055 NE CREEKSIDE DR
Hillsboro, OR 97124

Citizenship: India

Inventor's Signature: _____ Date: Nov 29, 2011
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor: Boyan BOYANOV	Examiner: Not yet assigned
Application No.: Not Yet Assigned (US National Phase filing of PCT/US2011/059453 under 35 U.S.C. 371)	Art Unit: Not yet assigned
Filed: Herewith	Confirmation No.: Not yet assigned
For: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS	

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

INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed for applications filed after June 30, 2003). It is respectfully requested that the cited documents be considered and that the enclosed copy of Information Disclosure Citation Form PTO-1449 or PTO/SB/08a be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

CERTIFICATE OF ELECTRONIC FILING

I hereby certify that this correspondence is being deposited with the United States Patent and Trademark Office via electronic filing through the United States Patent and Trademark Electronic Filing System on:

June 5, 2013
Date of Deposit

/Tuyen Lam/
Tuyen Lam

Pursuant to 37 C.F.R. § 1.97, the submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made and is not to be construed as an admission that the information cited in this statement is material to patentability.

Pursuant to 37 C.F.R. § 1.97, this Information Disclosure Statement is being submitted under one of the following (as indicated by an "X" to the left of the appropriate paragraph):

x_____ 37 C.F.R. §1.97(b).

_____ 37 C.F.R. §1.97(c). If so, then enclosed with this Information Disclosure Statement is one of the following:

_____ A statement pursuant to 37 C.F.R. §1.97(e) or

_____ The Director is Authorized to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. § 1.17(p).

_____ 37 C.F.R. §1.97(d). If so, then enclosed with this Information Disclosure Statement are the following:

(1) A statement pursuant to 37 C.F.R. §1.97(e); and

(2) Authorization to charge our Deposit Acct. No. 02-2666 in the amount of $180.00 for the fee under 37 C.F.R. §1.17(p) for submission of the Information Disclosure Statement.

If there are any additional charges, please charge Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Dated: June 5, 2013 /Tatiana Rossin/
Tatiana Rossin
Reg. No. 56,833

1279 Oakmead Parkway
Sunnyvale, CA 94085-4040
(408) 720-8300

Customer No.: 45209

Substitute for Form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit	Not yet assigned
				Examiner Name	Not yet assigned
Sheet	1	**of**	2	Attorney Docket Number	42P38794

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (If known)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-	7,396,759 B1	07-08-2008	Van Schravendijk Bart et al.	
		US-	2006/0128144 A1	06-15-2006	Hyun-Mog Park et al.	
		US-	2009/0127097 A1	05-21-2009	Chen Kei-Wei et al.	
		US-	2009/0283499 A1	11-19-2009	Mayer Steven T. et al.	
		US-				
		US-				
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FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language translation is attached.

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 2 hours 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,

Based on Form PTO/SB/08A (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.
If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Substitute for Form 1449/PTO				***Complete if Known***	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)*				Application Number	Not yet assigned
				Filing Date	Herewith
				First Named Inventor:	Boyan BOYANOV
				Art Unit	Not yet assigned
				Examiner Name	Not yet assigned
Sheet	2	**of**	2	Attorney Docket Number	42P38794

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No[1]	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, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
		OTA, Takashi, et al., "Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle," Proc. Of SPIE Vol. 6921, 69213S, (2008)	
		M.M ANTONIJEVIC et al., "Copper Corrosion Inhibitors. A review", Int. J. Electrochem Sci., Vol. 3, 2008, 28 pages.	
		T. SAITO et al., 'A Robust, Deep-Submicron Copper Interconnect Structure using Self-Aligned Metal Capping Method", IEEE, 2004, 3 pages.	
		PCT International Search Report and Written Opinion for PCT/US2011/059453, mailed July 16, 2012 (14 pp.).	

Examiner Signature		Date Considered	

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English Translation is attached.
This collection of information is required by 37 CFR 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 2 hours 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, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SENT FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Based on Form PTO/SB/08B (08-03) as modified by BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP on 09/10/03.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

TVR/SV

To:

ROSSIN TATIANA

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP 1279
OAKMEAD PARKWAY SUNNYVALE CA 94085 USA

RECEIVED
SUNNYVALE
JUL 25 2012

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing *(day/month/year)*	16 JULY 2012 (16.07.2012)
Applicant's or agent's file reference: 42P38794PCT BLAKELY SOKOLOFF TAYLOR ZAFMAN	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. **PCT/US2011/059453**	International filing date *(day/month/year)* **04 NOVEMBER 2011 (04.11.2011)**
Applicant **INTEL CORPORATION et al**	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:

   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 . 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90bis.1 and 90bis.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the PCT Applicant's Guide, National Chapters.

Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-8715

ENTERED
JUL 26 2012
INTO DATABASE
Entered into FIP
By:
Entered into FIP

Form PCT/ISA/220 (July 2010)

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Services => PCT Services

ID : PCT international application number
PW : **9Y55XCY6**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com
Email: ipkc@ipkcenter.com
Phone: +1 703 388 1066
Fax: +1 703 388 1084

Notes to Form PCT/ISA/220 (July 2010)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
42P38794PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2011/059453	**04 NOVEMBER 2011 (04.11.2011)**	
Applicant		
INTEL CORPORATION et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☒ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **3B**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/059453

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I (claims 1-7, 13-20) is directed to an apparatus and its manufacturing method.
Group II (claims 8-12) is directed to a method to control line edge roughness.

1. ☒ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/059453

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L 21/28; C23C 14/00; C23F 1/00; H01L 21/4763

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: damascene,cap,recess,self align,selective

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0283499 A1 (MAYER STEVEN T. et al.) 19 November 2009 See abstract; figures 1B, 2; paragraphs [0046]-[0064]	1-20
X	US 2006-0128144 A1 (HYUN-MOG PARK et al.) 15 June 2006 See abstract; figures 1-8; paragraphs [0024]-[0029]	1,3-7,13-20
A	US 7396759 B1 (VAN SCHRAVENDIJK BART et al.) 08 July 2008 See abstract; figure 8; column 8 line 14 - column 10 line 27	1-20
A	US 2009-0127097 A1 (CHEN KEI-WEI et al.) 21 May 2009 See abstract; figures 7-8; paragraphs [0029]-[0031]	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 JULY 2012 (13.07.2012)	**16 JULY 2012 (16.07.2012)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Kim, Young Jin Telephone No. 042 481 5771

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/059453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0283499 A1	19.11.2009	CN 101736376 A	16.06.2010
		KR 10-2011-0028446 A	18.03.2011
		KR 10-2012-0024844 A	14.03.2012
		US 2002-0074238 A1	20.06.2002
		US 2002-0195352 A1	26.12.2002
		US 2003-0079995 A1	01.05.2003
		US 2004-0065540 A1	08.04.2004
		US 2005-0282371 A1	22.12.2005
		US 2007-0105377 A1	10.05.2007
		US 2009-0266707 A1	29.10.2009
		US 2009-0277802 A1	12.11.2009
		US 2009-0277867 A1	12.11.2009
		US 2009-0280649 A1	12.11.2009
		US 2010-0015805 A1	21.01.2010
		US 2010-0029088 A1	04.02.2010
		US 2010-0032303 A1	11.02.2010
		US 2010-0032310 A1	11.02.2010
		US 2010-0044236 A1	25.02.2010
		US 2010-0116672 A1	13.05.2010
		US 2011-223772 A1	15.09.2011
		US 6315883 B1	13.11.2001
		US 6402923 B1	11.06.2002
		US 6514393 B1	04.02.2003
		US 6653226 B1	25.11.2003
		US 6709565 B2	23.03.2004
		US 6755954 B2	29.06.2004
		US 6756307 B1	29.06.2004
		US 6773571 B1	10.08.2004
		US 6919010 B1	19.07.2005
		US 7070686 B2	04.07.2006
		US 7189647 B2	13.03.2007
		US 7338908 B1	04.03.2008
		US 7405163 B1	29.07.2008
		US 7449098 B1	11.11.2008
		US 7449099 B1	11.11.2008
		US 7531079 B1	12.05.2009
		US 7531463 B2	12.05.2009
		US 7560016 B1	14.07.2009
		US 7682498 B1	23.03.2010
		US 7686935 B2	30.03.2010
		US 7690324 B1	06.04.2010
		US 7799200 B1	21.09.2010
		US 7854828 B2	21.12.2010
		US 7972970 B2	05.07.2011
		US 8158532 B2	17.04.2012
		WO 2010-144330 A2	16.12.2010
		WO 2010-144330 A3	16.12.2010
		WO 2011-017119 A2	10.02.2011
		WO 2011-017119 A3	10.02.2011

Form PCT/ISA/210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2011/059453

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-0128144 A1	15.06.2006	None	
US 7396759 B1	08.07.2008	US 7576006 B1	18.08.2009
		US 7704873 B1	27.04.2010
		US 7727880 B1	01.06.2010
		US 7727881 B1	01.06.2010
		US 8030777 B1	04.10.2011
US 2009-0127097 A1	21.05.2009	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
ROSSIN TATIANA

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP 1279
OAKMEAD PARKWAY SUNNYVALE CA 94085 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**16 JULY 2012 (16.07.2012)**
Applicant's or agent's file reference 42P38794PCT	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2011/059453	**04 NOVEMBER 2011 (04.11.2011)**	

International Patent Classification (IPC) or both national classification and IPC

H01L 21/28(2006.01)i

Applicant

INTEL CORPORATION et al

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [x] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	13 JULY 2012 (13.07.2012)	Kim, Young Jin Telephone No.042 481 5771

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:
   - ☒ paid additional fees
   - ☐ paid additional fees under protest and, where applicable, the protest fee
   - ☐ paid additional fees under protest but the applicable protest fee was not paid
   - ☐ not paid additional fees
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
   - ☐ complied with
   - ☒ not complied with for the following reasons:

Group I (claims 1-7, 13-20) is directed to an apparatus and its manufacturing method. Group II (claims 8-12) is directed to a method to control line edge roughness. The common technical feature between Group I and Group II is a channel of conductive line in a dielectric layer over a substrate, wherein the channel is configured to contain a capping layer. However, this feature lacks novelty and an inventive step in view of the following document : US 2006-0128144 A1. Thus, there is no technical relationship left over the prior art among the claimed inventions, leaving the claims without a single general inventive concept.

4. Consequently, this opinion has been established in respect of the following parts of the international application :
   - ☒ all parts.
   - ☐ the parts relating to claims Nos. _____

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2011/059453

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	9-10,17-18,20	YES
	Claims	1-8,11-16,19	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2009-0283499 A1 (MAYER STEVEN T. et al.) 19 November 2009
D2: US 2006-0128144 A1 (HYUN-MOG PARK et al.) 15 June 2006

1. Novelty and Inventive Step

1.1. Concerning claims [1-20]

1.1.1. Independent claims [1, 8, 13]

D1, which is considered to represent the most relevant state of the art, discloses an apparatus and its fabricating method, the method comprising: recessing at least one conductive line(115) in a dielectric layer(119) over a substrate with a first chemistry to a predetermined depth to form a channel self-aligned to the conductive line, wherein the channel is configured to contain a capping layer(121) within a width(127) of the at least one conductive line, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation; and depositing a capping layer selectively on the recessed conductive line in the channel to prevent electromigration (see abstract; figures 1B, 2; paragraphs [0046]-[0064]).

*As all of the features of **claims** [1, 8, 13] are disclosed in **D1**, these **claims** are anticipated by **D1**. Therefore, **claims** [1, 8, 13] lack novelty under PCT Article 33(2).*

1.1.2. Dependent claims [2-7, 11-12, 14-16]

Claims [2-7], [11-12] and [14-16] are dependent on **claims** [1], [8] and [13], respectively.

The additional feature of **claim** [2] is identical to the feature of **D1** that the recessing includes etching the at least one conductive line uniformly independent of a crystallographic orientation (see paragraphs [0058], [0061]-[0062]).

The additional feature of **claims** [3, 11, 14] is identical to the feature of **D1** that the capping layer(121) is selectively deposited on the selectively etched conductive line(115) (see paragraphs [0046], [0054]).

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Box V

The additional feature of **claims** [4, 12] is identical to the feature of **D1** that the amount of the conductive line(115) etched is equal to the target thickness of the capping layer(121) (see paragraph [0054]).

The additional feature of **claim** [5] is identical to the feature of **D1** that the capping layer(121) is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition (see paragraphs [0042], [0050]).

The additional feature of **claim** [6] is identical to the feature of **D1** that the conductive line(115) is damascene structure (see figure 1B; paragraph [0050]).

The additional feature of **claims** [7, 15] is identical to the feature of **D1** that the conductive line(115) comprises a first metal, and the capping layer(121) comprises a second metal other than the first metal (see paragraphs [0049]-[0050]).

The additional feature of **claim** [16] is identical to the feature of **D1** that the distances between the conductive capping layers(121) are substantially the same as the distances between the conductive lines(115) (see paragraph [0045]).

*Accordingly, **claims** [2-7, 11-12, 14-16] are substantially the same as **D1**. Therefore, **claims** [2-7, 11-12, 14-16] lack novelty under PCT Article 33(2).*

1.1.3. Dependent claims [9-10, 17-20]

Claims [9-10] and [17-20] are dependent on **claims** [8] and [13], respectively.

The additional features of **claims** [9-10] are merely variations of the disclosures of the cited document **D1** (paragraphs [0062]-[0064]) and a person skilled in the art would arrive at the **claim**ed inventions by general experimentation alone without exercising any ingenuity.

Claims [17-20] relate to dimensions or an applicable system that are merely matters of design option when the general technical knowledge about the state of the art is used.

*Therefore, **claims** [9-10, 17-20] lack an inventive step under PCT Article 33(3).*

1.2. Concerning claims [1, 3-7, 13-20]

1.2.1. Independent claims [1, 13]

D2, which is considered to represent the most relevant state of the art, discloses an apparatus and its fabricating method, the method comprising: recessing at least one conductive line(126) in a dielectric layer(104) over a substrate to form a channel(124); and depositing a capping layer(128) selectively on the recessed conductive line in the channel to prevent electromigration (see abstract; figures 1-8; paragraphs [0024]-[0029]).

Continued on Supplemental Box

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Box V

*As all of the features of **claims** [1, 13] are disclosed in **D2**, these **claims** are anticipated by **D2**. Therefore, **claims** [1, 13] lack novelty under PCT Article 33(2).*

1.2.2. Dependent claims [3-7, 14-15, 19]

Claims [3-7] and [14-15, 19] are dependent on **claims** [1] and [13], respectively.

The additional feature of **claims** [3, 14] is identical to the feature of **D2** that the capping layer(128) is selectively deposited on the selectively etched conductive line(126) (see figures 5-8).

The additional feature of **claim** [4] is identical to the feature of **D2** that the recessed depth(144) is equal to the thickness of the capping layer(128) (see figures 7-8; paragraphs [0026]-[0027]).

The additional feature of **claim** [5] is identical to the feature of **D2** that the capping layer(128) is deposited on the recessed conductive line by an electroless plating (see paragraph [0027]).

The additional feature of **claim** [6] is identical to the feature of **D2** that the method further comprises: forming a dielectric layer(104) over the substrate; forming at least one opening(106) in the dielectric layer; and filling the at least one opening with a conductive material(118) to form the at least one conductive line (see figures 1-5).

The additional feature of **claims** [7, 15] is identical to the feature of **D2** that the conductive line(126) comprises copper, and the capping layer(128) comprises cobalt (see paragraphs [0021], [0027]).

The additional feature of **claim** [19] is identical to the feature of **D2** that the conductive line(126) is an interconnect incorporated into a computer system (see paragraphs [0028]-[0029]).

*Accordingly, **claims** [3-7, 14-15, 19] are substantially the same as **D2**. Therefore, **claims** [3-7, 14-15, 19] lack novelty under PCT Article 33(2).*

1.2.3. Dependent claims [16-18, 20]

Claims [16-18, 20] are dependent on **claim** [13].

Claim [16] differs from **D2** in that the apparatus further comprises a second capping layer selectively deposited on a second conductive line, the second conductive line being at a first spacing from the first conductive line. However, the feature added by **claim** [16] is considered to be a minor difference over the disclosure of **D2**, that falls under the general knowledge by a person skilled in the art.

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of :

Box V

Claims [17-18, 20] relate to dimensions that are merely matters of design option when the general technical knowledge about the state of the art is used.

*Therefore, **claims** [16-18, 20] lack an inventive step under PCT Article 33(3).*

2. Industrial Applicability

Claims [1-20] are industrially applicable under PCT Article 33(4).

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan BOYANOV
Filer:	Tatiana Rossin/Tuyen Lam
Attorney Docket Number:	42P38794

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	280	280
Natl Stage Search Fee - Report provided	1642	1	480	480
National Stage Exam - all other cases	1633	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1480**

Electronic Acknowledgement Receipt	
EFS ID:	15962741
Application Number:	13991899
International Application Number:	PCT/US11/59453
Confirmation Number:	8341
Title of Invention:	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
First Named Inventor/Applicant Name:	Boyan BOYANOV
Customer Number:	45209
Filer:	Tatiana Rossin/Tuyen Lam
Filer Authorized By:	Tatiana Rossin
Attorney Docket Number:	42P38794
Receipt Date:	05-JUN-2013
Filing Date:	
Time Stamp:	22:58:29
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1480
RAM confirmation Number	7591
Deposit Account	022666
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1	Transmittal of New Application	42P38794_371_Transmittal_6-5-13.pdf	194618 22ffb6eb664f5accfb2dfa96b1766ca54494cc0c	no	4
Warnings:					
Information:					
2	Application Data Sheet	42P38794_ADS_6-5-13.pdf	45394 833ce2eae29ef37379f4d9d41e1c8885dac82828	no	3
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3		42P38794_PrelimAmend_6-5-13.pdf	26631 27d060b965b0fc509f92f6b9a0a96f734b9fb6ed	yes	3
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Preliminary Amendment		1	1	
	Specification		2	2	
	Claims		3	3	
Warnings:					
Information:					
4	Documents submitted with 371 Applications	42P38794_Pub_ISR_6-5-13.pdf	1383956 94c5d73a702565bc06986efd94e9d03baae60510	no	34
Warnings:					
Information:					
5	Oath or Declaration filed	42P38794_Declaration_Boyanov_6-5-13.pdf	43650 bf0cc14d40c9f8a1225d1b00208cef74f1d46ca1	no	2
Warnings:					
Information:					
6	Oath or Declaration filed	42P38794_Declaration_Kanwal_6-5-13.pdf	321289 dc9a330e6a53202ffadd4920d0a02790629f71b2	no	2
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					

Information:					
7	Transmittal Letter	42P38794_IDS_LTR_6-5-13.pdf	18352 f33d050550a22fe789970676b43468c4a2f40c17	no	2
Warnings:					
Information:					
8	Information Disclosure Statement (IDS) Form (SB08)	42P38794_IDS_SB08_6-5-13.pdf	64147 6369440452242aa9b65a5d68db5014147a768f70	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
9	Non Patent Literature	NPL_Antonijevic_CopperCorrosionInhibitors.pdf	273289 689f60d669893f0944cc851294200c5eb6dd06ca	no	28
Warnings:					
Information:					
10	Non Patent Literature	NPL_Experimental_evaluation_of_OPD_of_electrostatically_chucked_EUV_reticle.pdf	727477 7d1ec0258550bb7245f4524b67f6db5646bdb8c1	no	8
Warnings:					
Information:					
11	Non Patent Literature	NPL_ISR_WrittenOpinion.pdf	577685 021d9f95e91ea2a53b3cd990516c1eb18bf6d362	no	14
Warnings:					
Information:					
12	Non Patent Literature	NPL_Saito.pdf	362280 93e37487977ff4600e156d66f63cf4237dfde230	no	3
Warnings:					
Information:					
13	Fee Worksheet (SB06)	fee-info.pdf	33315 4637c68c0a37475de3cf6a28ca1d2c231523c7cc	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4072083		

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.

Docket No.: P38794PCT
PATENT

Declaration of inventorship (Rules 4.17(iv) and 51*bis*.1(a)(iv)) for the purposes of the designation of the United States of America:

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/ . . PCT/US2011/059453 . . . . . (if furnishing declaration pursuant to Rule 26*ter*).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: . . . . . .

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Citizenship: United States of America

Inventor's Signature: _____ Date: 11/03/11
(The signature must be that of the inventor, not that of the agent)

INTEL CORPORATION
LCA/PAL FORMS

Docket No.: P38794PCT
PATENT

Name: Kanwal Jit Singh

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Hillsboro, OR 97124

Citizenship: India

Inventor's Signature: _____ Date: _____
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

Docket No.: P38794PCT
PATENT

**Declaration of inventorship (Rules 4.17(iv) and 51*bis*.1(a)(iv))
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I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/ . PCT/US2011/059453 . . . . . (if furnishing declaration pursuant to Rule 26*ter*).

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I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: . . . . . .
. . . . . .

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: Boyan Boyanov

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Inventor's Signature: _____ Date: _____
(The signature must be that of the inventor, not that of the agent)

INTEL CORPORATION
LCA/PAL FORMS

Docket No.: P38794PCT
PATENT

Name: Kanwal Jit Singh

KS (Kanwal Singh) Nov 29, 2011

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Citizenship: India

Inventor's Signature: _____ Date: Nov 29, 2011
(The signature must be that of the inventor, not that of the agent)

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

PCT REQUEST

Original (for **SUBMISSION**)

0	**For receiving Office use only**	
0-1	International Application No.	PCT/US11/59453
0-2	International Filing Date	04-11-2011
0-3	Name of receiving Office and "PCT International Application"	RO/US

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT-SAFE [EASY/EFS-Web mode] Version 3.51.051.227 MT/FOP 20111001/0.20.5.19
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	United States Patent and Trademark Office (USPTO) (RO/US)
0-7	**Applicant's or agent's file reference**	42P38794PCT
I	**Title of Invention**	METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS
II	**Applicant**	
II-1	This person is	Applicant only
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II-7	State of residence	US
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PCT REQUEST

Original (for **SUBMISSION**)

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	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	Agent
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IV-1-5	e-mail	Intel_Foreign_Docs@bstz.com
IV-1-5(a)	E-mail authorization The receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority are authorized to use this e-mail address, if the Office or Authority so wishes, to send notifications issued in respect of this international application:	as advance copies followed by paper notifications
IV-1-6	Agent's registration No.	56,833
IV-2	**Additional agent(s)**	additional agent(s) with same address as first named agent
IV-2-1	Name(s)	TAYLOR, Edwin H.(25,129); MALLIE, Michael J.(36,591); VINCENT, Lester J.(31,460)
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	
VI-1	**Priority Claim**	NONE
VII-1	**International Searching Authority Chosen**	Korean Intellectual Property Office (ISA/KR)

PCT REQUEST

Original (for **SUBMISSION**)

VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	–	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	–	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	–	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	–	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	–	
IX	**Check list**	Number of sheets	Electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	15	–
IX-3	Claims	3	–
IX-4	Abstract	1	✓
IX-5	Drawings	10	–
IX-7	TOTAL	33	
	Accompanying Items	Paper document(s) attached	Electronic file(s) attached
IX-8	Fee calculation sheet	✓	–
IX-19	Other	PCT-Transmittal	
IX-20	**Figure of the drawings which should accompany the abstract**	3B	
IX-21	**Language of filing of the international application**	English	
X-1	**Signature of applicant, agent or common representative**	/Tatiana Rossin/	
X-1-1	Name (LAST, First)	ROSSIN, Tatiana	
X-1-2	Name of signatory		
X-1-3	Capacity (if such capacity is not obvious from reading the request)	REG. 56,833	

PCT REQUEST

Original (for **SUBMISSION**)

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	04-11-2011
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/KR
10-6	**Transmittal of search copy delayed until search fee is paid**	

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11-1	**Date of receipt of the record copy by the International Bureau**	

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on next page]

(54) Title: METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

(57) Abstract: At least one conductive line in a dielectric layer over a substrate is recessed to form a channel. The channel is self-aligned to the conductive line. The channel can be formed by etching the conductive line to a predetermined depth using a chemistry comprising an inhibitor to provide uniformity of etching independent of a crystallographic orientation. A capping layer to prevent electromigration is deposited on the recessed conductive line in the channel. The channel is configured to contain the capping layer within the width of the conductive line.

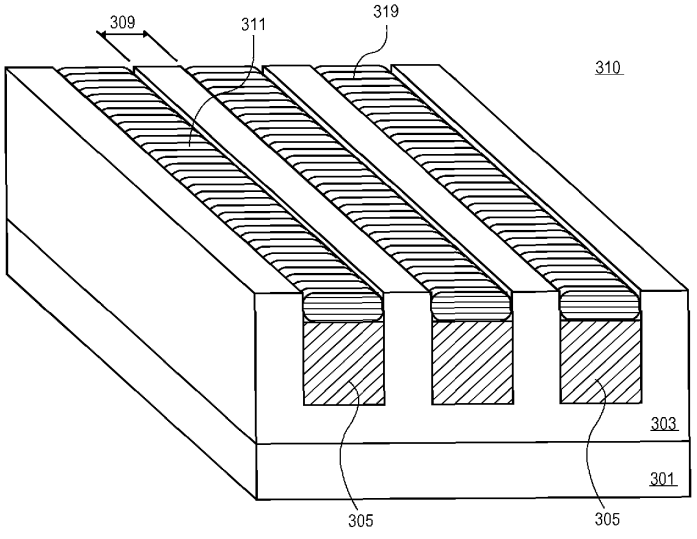


FIG. 3B

WO 2013/066356 A1

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

METHODS AND APPARATUSES TO FORM SELF-ALIGNED CAPS

FIELD

Embodiments of the present invention relate to the field of electronic device manufacturing, and in particular, to forming interconnect structures.

BACKGROUND

As the feature size of electronic devices shrinks, reliability of interconnects becomes critical to integrated circuit performance. Generally, electromigration refers to the transport of material caused by the movement of the ions in a conductor due to the momentum transfer between conducting electrons and diffusing metal atoms. The effect is especially important in applications where high current densities are used, for example, in microelectronics structures involving logic devices. Typically, a metal capping technology is used to prevent electromigration.

Figure 1A is a cross-sectional view of a typical interconnect structure having metal electromigration caps. As shown in Figure 1A, metal interconnect lines, for example lines 103 and 104, formed on a dielectric substrate 101 are originally spaced apart at a line spacing 105. The electromigration caps, for example, caps 111-113, can be grown on the respective interconnect lines above a flat surface of the substrate using electroless plating. Generally, the growth of the electromigration caps on the interconnect lines is isotropic. The electromigration cap can grow on the interconnect metal line vertically as well as laterally above the substrate. The lateral growth of the metal electromigration caps may generate overhang structures, for example, an overhang 109 that protrude over the substrate 101 outside the width of the interconnect lines. As shown in Figure 1A, the lateral growth of the metal caps reduces a line-to-line spacing from spacing 105 to spacing 107.

Typically, the size of the overhang 109, is about 50% of the cap thickness. For example, if the two neighboring metal caps have the thickness of about 10 nanometers ("nm"), the total size of their overhangs can be about 2x5nm. As such, the line-to-line spacing can be reduced, for example, by a factor of two from about 20 (nm) to about 10 nm.

Figure 1B is a top view of a typical interconnect structure having metal electromigration caps electrolessly grown over a flat surface of substrate 121 having interconnect lines, such as an interconnect line 123. As shown in Figure 1B, the lateral growth of the metal caps above the substrate increases the line edge roughness ("LER") and reduces line-to-line spacing. As shown in Figure 1B, the line-to-line spacing, for example, a line-to-line spacing 125, varies uncontrollably. Both the increased LER and reduced line-to-line spacing negatively impact on

the reliability of the interconnect structures, increase the risk of current shorting that may lead to the failure of the entire integrated circuit device.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements, in which:

Figure 1A is a cross-sectional view of a typical interconnect structure having metal electromigration caps.

Figure 1B is a top view of a typical interconnect structure having metal electromigration caps.

Figure 2A shows a cross-sectional view of a substrate to fabricate an interconnect structure according to one embodiment of the invention.

Figure 2B is a view similar to Figure 2A, after a dielectric layer is formed over the substrate according to one embodiment of the invention.

Figure 2C is a view similar to Figure 2B, after a photoresist layer is deposited over the dielectric layer to form one or more openings in the dielectric layer according to one embodiment of the invention.

Figure 2D is a view similar to Figure 2C, after one or more openings are formed in the dielectric layer according to one embodiment of the invention.

Figure 2E is a view similar to Figure 2D, after a conductive layer is deposited over the dielectric layer according to one embodiment of the invention.

Figure 2F is a view similar to Figure 2E, after portions of conductive layer and the base layer are removed from the top surface of the dielectric layer outside the openings to form patterned conductive lines according to one embodiment of the invention.

Figure 2G is a view similar to Figure 2F, after conductive lines in a dielectric layer over a substrate are recessed according to one embodiment of the invention.

Figure 2H is a view similar to Figure 2G, after capping layers are selectively deposited onto the respective recessed conductive lines in the channels to prevent electromigration according to one embodiment of the invention.

Figure 3A is a three-dimensional view 300 of an interconnect structure after recessing the conductive lines in a dielectric layer over a substrate according to one embodiment of the invention.

Figure 3B is a view 310 similar to Figure 3A, after capping layers are deposited into the respective channels formed by the recessed conductive lines according to one embodiment of the invention.

Figure 4 is a top view of an interconnect structure 400 having capping layers selectively deposited within channels formed by the recessed conductive lines in a dielectric layer over a substrate according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

In the following description, numerous specific details, such as specific materials, dimensions of the elements, etc. are set forth in order to provide thorough understanding of one or more of the embodiments of the present invention. It will be apparent, however, to one of ordinary skill in the art that the one or more embodiments of the present invention may be practiced without these specific details. In other instances, semiconductor fabrication processes, techniques, materials, equipment, etc., have not been described in great details to avoid unnecessarily obscuring of this description. Those of ordinary skill in the art, with the included description, will be able to implement appropriate functionality without undue experimentation.

While certain exemplary embodiments of the invention are described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative and not restrictive of the current invention, and that this invention is not restricted to the specific constructions and arrangements shown and described because modifications may occur to those ordinarily skilled in the art.

Reference throughout the specification to "one embodiment", "another embodiment", or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "for an embodiment" in various places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

Moreover, inventive aspects lie in less than all the features of a single disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention. While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described, but can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative rather than limiting.

Methods and apparatuses to control a line edge roughness ("LER") and line-to-line spacing in deposition of self-aligned metal caps are described herein. At least one conductive

line is recessed to form a channel in a dielectric layer over a substrate. A capping layer to prevent electromigration is deposited on the recessed conductive line in the channel. The channel is self-aligned to the conductive line. The channel is configured to contain the capping layer within the width of the conductive line. That is, the interconnect line is recessed to contain the cap growth within a channel self aligned to the interconnect line. The channel can be formed by etching the conductive line to a predetermined depth using a chemistry comprising an inhibitor to provide uniformity of etching independent of a crystallographic orientation, as described in further detail below. Methods and apparatuses described herein can be used to control the increase in LER associated with selectively deposited electromigration caps, for example, electroless cobalt caps. That is, an increase in LER and reduction in line-to-line spacing typically associated with the electromigration caps selectively deposited on the metal interconnect lines can be prevented by containing an electroless cap within a recess that is self-aligned to an interconnect line. Eliminating an increase in LER and preventing from reducing of the line-to-line spacing can decrease the risk of failure and increase the manufacturing yield of the electronic devices having reduced (e.g., nanometer scale) dimensions. The electronic devices can be, for example, computer system architecture devices, e.g., transistors, memories, logic devices, and any other integrated circuit and microelectronic devices.

Figure 2A shows a cross-sectional view 200 of a substrate to fabricate an interconnect structure according to one embodiment of the invention. In one embodiment, substrate 201 includes a monocrystalline silicon. In one embodiment, substrate 201 includes a silicon-on-insulator ("SOI"). For alternate embodiments, substrate may comprise compound semiconductors, e.g., indium phosphide, gallium arsenide, gallium nitride, silicon germanium, and silicon carbide. In another embodiment, substrate 201 may include e.g., glass, and quartz. Substrate 201 may include one or more metallization layers of integrated circuits having active and passive devices, e.g., transistors, switches, optoelectronic devices, capacitors, resistors, interconnects (not shown). The one or more metallization layers of integrated circuits of substrate 201 may be separated from adjacent metallization layers by a dielectric material (not shown), e.g., interlayer dielectric. The adjacent metallization layers may be electrically interconnected by vias (not shown).

Figure 2B is a view similar to Figure 2A, after a dielectric layer 203 is formed over the substrate 201 according to one embodiment of the invention. In one embodiment, dielectric layer 203 is an interlayer dielectric ("ILD"). In one embodiment, dielectric layer 203 is a low-k dielectric, e.g., silicon dioxide, silicon oxide, and carbon doped oxide ("CDO"), or any combination thereof. In one embodiment, Dielectric layer 203 includes a nitride, oxide, a polymer, phosphosilicate glass, fluorosilicate ("SiOF") glass, organosilicate glass ("SiOCH"), or

any combination thereof. In one embodiment, dielectric layer 203 includes a spin-on low-k dielectric material. In one embodiment, dielectric layer 203 is silicon dioxide. In another embodiment, dielectric layer 203 is silicon nitride. dielectric layer 203 may be deposited using any suitable deposition technique. In one embodiment, dielectric layer 203 may be deposited using blanket deposition technique, for example, chemical vapor deposition ("CVD"), sputtering, spin-on, or another thin film deposition technique. In one embodiment, dielectric layer 203 is deposited to the thickness in the approximate range of 50nm to 2μm.

Figure 2C is a view similar to Figure 2B, after a photoresist layer 204 is deposited over dielectric layer 203 to form one or more openings in dielectric layer 203 according to one embodiment of the invention. In one embodiment, photoresist layer 204 is deposited on a hard mask layer 202 formed on dielectric layer 203, as shown in Figure 2C. In another embodiment, photoresist layer 204 is deposited directly onto dielectric layer 203. As shown in Figure 2C, photoresist layer 204 and hard mask layer 202 are patterned and etched to form openings, such as an opening 220. Patterning and etching of the photoresist and hard mask is known to one of ordinary skill in the art of microelectronic device manufacturing. Patterning and etching of the photoresist may be performed using one of the techniques known to one of ordinary skill in the art of microelectronic device manufacturing. The technique may include masking the photoresist layer, exposing the masked layer to light, and then developing the unexposed portions to remove the portions of the photoresist layer that are exposed to light to form a window in the photoresist layer. In one embodiment, the process of exposing to light and removing the photoresist layer may be performed in a plasma reactor. The opening in hard mask 202 may be etched to expose a portion of dielectric layer 203 using a dry etching, e.g., reactive ion etching ("RIE"), wet etching, or any combination thereof techniques.

Figure 2D is a view similar to Figure 2C, after one or more openings, such as an opening 206, are formed in dielectric layer 203 according to one embodiment of the invention. In one embodiment, the openings are, such as opening 206, is etched through openings in hard mask 203, such as opening 220. In another embodiment, the openings are formed by etching the dielectric layer through the openings in patterned photoresist 204 deposited directly onto dielectric layer 203. In one embodiment, the openings in the dielectric layer 203, for example, trenches, are formed using an anisotropic dry etching, e.g., plasma etching. In another embodiment, the openings in the dielectric layer 203 are formed using dry etching, wet etching, or a combination thereof techniques known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the openings in dielectric layer 203 has the width in the approximate range of 0.005microns ("μm ") to 5 μm, and the depth in the approximate range

of 0.005 μm to 10 μm. In one embodiment, the size of openings is determined by the size of a conductive line formed within ILD 203 later on in the process.

After forming the openings, such as opening 206, the photoresist and hard mask are removed. Removing of the photoresist and the hard mask from dielectric layer 203 is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the photoresist and hard mask may be removed using a chemical technique, mechanical technique, or both.

Figure 2E is a view similar to Figure 2D, after a conductive layer 205 is deposited over dielectric layer 203 according to one embodiment of the invention. As shown in Figure 2E, forming of the conductive layer 205 involves filling the one or more openings in dielectric layer 203 with a conductive material to form one or more conductive lines. In one embodiment, a base layer (not shown) is first deposited on dielectric layer 203 covering the internal sidewalls and bottom of the openings, and then a conductive layer 205 is deposited on the base layer. In one embodiment, the base layer includes a conductive seed layer (not shown) deposited on a conductive barrier layer (not shown). The seed layer can include copper, and the conductive barrier layer can include aluminum, titanium, tantalum, tantalum nitride, and the like metals. The conductive barrier layer can be used to prevent diffusion of the conductive material from the seed layer, e.g., copper, into ILD 203. Additionally, the conductive barrier layer can be used to provide adhesion for the seed layer (e.g., copper). In one embodiment, to form the base layer, the conductive barrier layer is deposited onto the dielectric layer 203 covering the sidewalls and bottom of the opening, and then the seed layer is deposited on the conductive barrier layer. In another embodiment, the conductive base layer includes the seed layer that is directly deposited onto dielectric layer 203 covering the sidewalls and bottom of the openings. Each of the conductive barrier layer and seed layer may be deposited using any thin film deposition technique known to one of ordinary skill in the art of semiconductor manufacturing, e.g., by sputtering, blanket deposition, and the like. In one embodiment, each of the conductive barrier layer and the seed layer has the thickness in the approximate range of 1 to 100 nm. In one embodiment, the barrier layer may be a thin dielectric that has been etched to establish conductivity to the metal layer below. In one embodiment, the barrier layer may be omitted altogether and appropriate doping of the copper line may be used to make a "self-forming barrier".

Conductive layer 205 fills the openings, such as an opening 206, and covers portions of the base layer (not shown) outside of the openings that are on top of dielectric layer 203. In one embodiment, conductive layer 205 e.g., copper, is deposited onto the seed layer of base layer of copper, by an electroplating process. In one embodiment, conductive layer 205 is deposited into

the openings using a damascene process that is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, conductive layer 205 is deposited onto the seed layer using one of selective deposition techniques known to one of ordinary skill in the art of semiconductor manufacturing, e.g., electroplating, electroless plating, and the like. In one embodiment, the choice of a material for conductive layer 205 determines the choice of a material for the seed layer. For example, if the material for conductive layer 205 includes copper, the material for the seed layer also includes copper. In one embodiment, conductive layer 205 includes e.g., copper (Cu), ruthenium (Ru), nickel (Ni), cobalt (Co), chromium (Cr), iron (Fe), manganese (Mn), titanium (Ti), aluminum (Al), hafnium (Hf), tantalum (Ta), tungsten (W), Vanadium (V), Molybdenum (Mo), palladium (Pd), gold (Au), silver (Au), platinum Pt, or any combination thereof.

Figure 2F is a view similar to Figure 2E, after portions of conductive layer 205 and the base layer are removed from the top surface of dielectric layer 203 outside the openings to form patterned conductive lines, such as a conductive line 208 according to one embodiment of the invention. Portions of conductive layer 205 may be removed chemically, e.g., using etching, mechanically, e.g., using polishing, or by a combination of thereof techniques, e.g., using a chemical-mechanical polishing ("CMP") technique known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, one or more patterned conductive lines are formed within dielectric layer 203 using methods described above. In another embodiment, the conductive lines are formed by patterning and etching of the conductive layer deposited on the top surface of dielectric layer 203. Patterning and etching of the conductive layer deposited on the top surface of the dielectric layer 203 is known to one of ordinary skill in the art of microelectronic device manufacturing. In one embodiment, the thickness of the conductive line, for example, a thickness 211 is in the approximate range of 0.015μm to 1μm. In one embodiment, the width of the conductive line, for example, a width 209 is in the approximate range of 5nm to about 500nm. In one embodiment, the spacing between the conductive lines, for example, a spacing 207, is from about 5nm to about 500nm. In one embodiment, the spacing between the conductive lines is from about 2nm to about 100nm.

Figure 2G is a view similar to Figure 2F, after the conductive lines, for example, a conductive line 208, in a dielectric layer over a substrate are recessed according to one embodiment of the invention. As shown in Figure 2G, channels, such as a channel 212, are formed in dielectric layer 203. As shown in Figure 2G, channels, such as channel 212, have sidewalls made of dielectric layer 203, such as sidewalls 214 and 216, and a bottom made of a respective conductive line, such as a bottom 218 made of conductive line 208.

In one embodiment, the channel has depth, such as a depth 213 from about 5 nm to about 50nm. In one embodiment, the depth of the channel is from about 2 nm to about 20nm. In one embodiment, the channel has depth that is from about 10% to about 50% of the thickness of the conductive line, such as a thickness 211 shown in Figure 2F. In one embodiment, the conductive lines are recessed to the depth, which is determined based on the thickness of a capping layer, as described in further detail below.

Figure 3A is a three-dimensional view 300 of an interconnect structure after recessing the conductive lines, such as a conductive line 305 and a conductive line 304, in a dielectric layer 303 over a substrate 301 according to one embodiment of the invention. Substrate 301, dielectric layer 303, and the conductive lines 305 and 304, can be, for example, any of the respective substrates, dielectric layers, and conductive lines, as described above. As shown in Figure 3A, channels, such as a channel 302 and a channel 307, are formed in a dielectric layer 303 over substrate 301 by recessing the conductive lines. As shown in Figure 3A, the channels are self-aligned to the respective conductive lines. For example, channel 307 is self-aligned to conductive line 305 and channel 302 is self-aligned to conductive line 304. As shown in Figure 3A, the length of the channel, e.g., a length 315 is along the length of the conductive line, and the width of the channel, e.g., a width 307 is along the width of the conductive line. In one embodiment, the length of the channel is substantially longer that the width of the channel. In one embodiment, the width of the channel is less than 100nm, and the length of the channel is at least 500nm. In one embodiment, the width of the channel is from about 5 nm to about 500nm, and the length of the channel is from about a few hundred nanometers to about a few hundred microns. As shown in Figure 3A, the conductive lines, such as conductive lines 305 and 304 are separated by a distance, such as a spacing 309. In one embodiment, the spacing between the conductive lines, such as lines 305 and 304 is from about 5nm to about 500nm. In one embodiment, the spacing between the conductive lines, such as lines 305 and 304 is from about 2nm to about 100nm.

In one embodiment, recessing the conductive lines, such as line 208, lines 304 and 305, involves wet etching the conductive lines uniformly independent of a crystallographic orientation using a chemistry containing an etchant, an oxidizer, an inhibitor, and a solvent. That is, adding an inhibitor and a solvent to the etchant provides uniform etching of the conductive material independent of a crystallographic orientation, by forming, during etching, a passivation layer (not shown) on the conductive material. The wet etch chemistry containing an etchant, an oxidizer, an inhibitor, and solvent provides control over the depth of the etching of the conductive line, so that only a portion (e.g., 5% to 50%) of the conductive line can be recessed.

In one embodiment, the chemistry to wet etch the conductive lines to provide a channel that is free from a pattern dependence and a crystallographic preference comprises between about 1% to about 40% by mass of an etchant, between about 1% to about 10% by mass of an oxidizer, and between about 0.1% to about 1% by mass of an inhibitor, and between about 1 to about 60% by mass of an organic solvent. In one embodiment, the chemistry to wet etch the conductive lines comprises an etchant from about 0.1% to about 70% by mass (depending on the etch rate of the etchant), an oxidizer from about 0.1% to about 10% by mass (depending on the strength of the oxidizer), an inhibitor from about 50 parts per million (ppm) to about 1% by mass; and a solvent between about 1 to about 60% by mass.

In one embodiment, the chemistry to etch the conductive lines can include an etchant, for example, a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer, for example, a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, an inhibitor, for example, an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof, and a solvent. The solvent can be an aqueous system (preferred), e.g., water, or an organic solvent. The examples of an organic solvents are propylene carbonate, sulfolane, glycol ethers, methylene chloride, and the like.

For example, regarding the etchant in the chemistry to etch copper conductive lines, Cu metal is typically in a zero oxidation state. In order to etch copper, the copper needs to be oxidized into a 0+n oxidation state where 'n' can be any of 1, 2 , 3 or 4. Typically, 1st state and 2^{d} state are more common oxidation states of copper. For any molecule to act as an etchant, it needs to be able to bind copper in one of its oxidation states 1, 2, 3 or 4. This binding typically occurs through the use of group 15 (Nitrogen family), group 16 (Oxygen family) or group 17 (Halogen family) atoms in a molecule. In one embodiment, the etchant to etch copper conductive lines is an organic etchant, for example, any of glycine, ethylenediaminetetraacetic, alpha-amino acids, polycarboxylic acids (for example, citric acid that is a tricarboxylic acid), oxalic and malonic acids.

For example, an oxidizer in the chemistry to etch copper conductive lines is used to change the copper oxidation state from an insoluble copper metal to a soluble copper ion. The oxidizer can be chosen from any of the oxidizers, for example, any of peroxides (e.g., hydrogen peroxide), ozone, permanganates, chromates, perborates and hypohalites, and the like.

For example, to etch the copper constituting the current carrying line in a uniform and non-crystallographic orientation, it is important to add an inhibitor to the chemistry. The role of an inhibitor is to form a passivation layer (a polymeric compound formed from the molecules of the inhibitor binding copper in a specific and periodic manner). The formation of this passivation

layer during the controlled etch of copper is critical to ensure uniformity of etching and preventing etching attacks (e.g., forming voids) along crystallographic (e.g., grain) boundaries. For example, any inhibitor that is not decomposed in the chosen oxidizer and etchant combination may be used in the chemistry to etch copper conductive lines. The classes of inhibitors are known to one of ordinary skill in the art of electronic device manufacturing. For example, any of organic inhibitors including azoles, amines, amino acids, phosphates and phosphonates can be used in the chemistry to etch the copper conductive lines.

In another embodiment, the conductive copper lines are recessed by wet etching using a chemistry comprising a citric acid and peroxide. A chemistry comprising citric acid and peroxide, however, typically has high etching rate that can be difficult to control. Additionally, an etching rate of the chemistry comprising citric acid and peroxide depends on a crystallographic orientation that may produce rough etched surface. Addition of a corrosion inhibitor, for example, benzotriazole ("BTA") to the chemistry, and dilution of the citric acid and peroxide in organic solvent can slow down the etching rate dramatically and eliminate the crystallographic nature of the etch, such as etching the voids in Cu along the grain boundaries producing a smooth surface.

In one embodiment, the conductive lines are recessed by wet etching that involves any of spraying, and pouring the etching chemistry onto the conductive lines. In one embodiment, the conductive lines are recessed by wet etching that involves immersing the conductive lines into the etching chemistry solution. In one embodiment, the conductive lines are recessed by wet etching at a temperature from about 15°C to about 50°C for a predetermined time. In at least some embodiments, the conductive lines are recessed by dry etching, e.g., plasma etching.

Figure 2H is a view similar to Figure 2G, after the capping layers are selectively deposited onto the respective recessed conductive lines in the channels to prevent electromigration according to one embodiment of the invention. The conductive lines etched using the chemistry as described above, have a smooth uniform top surface to adhere the capping layer. As shown in Figure 2H, a capping layer 215 is deposited onto recessed conductive line 208 within channel 212. In one embodiment, the channel, such as channel 212, is configured to contain a capping layer within the width of the conductive line, e.g., width 209 shown in Figure 2F. That is, the recessed conductive line creates a channel which contains the growth of the capping layer within the channel that mitigates the reduction in line-to-line spacing and increase in LER. As shown in Figure 2H the capping layer 215 is located on the conductive line 208 within the sidewalls of the channel 212. In one embodiment, the capping layer is deposited on the recessed conductive line by an electroless deposition (e.g., plating), a chemical vapor deposition ("CVD"), a physical vapor deposition ("PVD"), or any other selective deposition

techniques known to one of ordinary skill in the art of electronic device manufacturing. In one embodiment, a conductive line, such as line 208, comprises a first metal, and the capping layer comprises a second metal other than the first metal to prevent electromigration of the first metal from the conductive line. In one embodiment, the metal for the capping layer is heavier than the metal for the conductive line to prevent electromigration.

For example, the conductive line can be made of any of the metals including copper, aluminum. In one embodiment, the capping layer, such as capping layer 215, is made of cobalt ("Co"), cobalt electroless alloys, e.g., CoBP, CoWBP, CoWP, CoWB, CoWP, or a combination thereof. In another embodiment, a capping layer, such as capping layer 215, is made of nickel ("Ni"), Ni electroless alloys, e.g., NiBP, NiWBP, NiWP, NiWB, NiWP, or a combination thereof. In another embodiment, a capping layer, such as capping layer 215, is made of platinum ("Pt") group metals, for example, Pt, Pd, Ru, Ir, Rh as pure elements or alloys. The typical alloy elements for Pt group metals are W, B, P. In yet another embodiment, a capping layer, such as capping layer 215, is made of refractory metals, for example, Ta, W, Mo, or a combination thereof.

In one embodiment, the Co capping layer is deposited within a channel onto the recessed Cu conductive layer. In one embodiment, Ni capping layer is deposited within a channel onto the recessed Cu conductive layer. In one embodiment, refractory metal capping layer is deposited within a channel onto the recessed Cu conductive layer.

In one embodiment, the capping layers comprising a Pt group metal, Co, Ni, or a combination thereof, are deposited onto the conductive layers, e.g., copper, aluminum, using any of an electroless deposition, and a vapor phase deposition, e.g., CVD. In one embodiment, the capping layers including refractory metals are deposited onto the conductive layers, e.g., copper, aluminum, using any of a CVD and PVD techniques known to one of ordinary skill in the art of electronic device manufacturing. In one embodiment, the thickness of the capping layer, e.g., a thickness 221, is from about 2 nm to about 50 nm. In one embodiment, the thickness of the capping metal layer is sufficient to prevent electromigration from the underlying conductive layer. In one embodiment, the capping layer has the thickness that is no greater than the depth of the channel within which the capping layer is deposited.

Figure 3B is a view 310 similar to Figure 3A, after capping layers are deposited into the respective channels formed by the recessed conductive lines according to one embodiment of the invention. As shown in Figure 3B, capping layers, such as a capping layer 311 and 319 are selectively deposited into respective channels, such as channel 302 and channel 307, as described above. As shown in Figure 3A, the capping layers are contained within their respective channels. As shown in Figure 3B, the capping layer 319 is separated from capping layer 311 by

spacing 309. In one embodiment, the spacing between conductive lines 305 and 304 and the spacing between the capping layers 319 and 311 is the same.

Figure 4 is a top view of an interconnect structure 400 having capping layers selectively deposited within channels formed by the recessed conductive lines in a dielectric layer 401 over a substrate according to one embodiment of the invention. As shown in Figure 4, the LER of the interconnect lines, such as an interconnect line 403 is substantially reduced, the edges of the interconnect lines are smooth, and a line-to-line spacing, such as a line-to-line spacing 405 is increased and maintained between the lines. In one embodiment, the line-to-line spacing is increased by 2x cap thickness. This can result in rather dramatic decreases in electric field and time to dielectric breakdown, especially, for a future technology node having 20nm lines and 20nm spaces. The minimum cap thickness known to work today is 5nm. This means that with a conventional approach the line-line space would be 10nm instead of the 20nm drawn on a mask. Furthermore, currently, the size of the protrusions in the overhang tends to be about 50% of the cap thickness. For a typical cap thickness of 5-10nm using methods described above LER can be decreased by 3-5nm independent of line width. For a future 20 nm technology node, decrease in LER by 3-5nm can result in 15-20% increase in line-to-line spacing of an interconnect structure.

Figure 5 shows a block diagram of an exemplary embodiment of a data processing system 500 having one or more electronic devices, e.g., transistors, memories, such as a memory 504, and a memory 518, processing logic devices, such a processing logic device 526, and any other integrated circuit and microelectronic devices that are built using methods described herein. As shown in Figure 5, data processing system 500 includes a processor 502 having processing logic 526. In at least some embodiments, processing logic 526 contains at least one conductive line in a dielectric layer over a substrate, a channel in the dielectric layer over the one conductive line; and a capping layer on the at least one conductive line in the channel to prevent electromigration, as described herein. In at least some embodiments, each of the memories 504 and 518 contains at least one conductive line in a dielectric layer over a substrate, a channel in the dielectric layer over the one conductive line; and a capping layer on the at least one conductive line in the channel to prevent electromigration, as described herein

In alternative embodiments, the data processing system may be connected (e.g., networked) to other machines in a Local Area Network (LAN), an intranet, an extranet, or the Internet. The data processing system may operate in the capacity of a server or a client machine in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The data processing system may be a personal computer (PC), a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web

appliance, a server, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that data processing system. Further, while only a single data processing system is illustrated, the term "data processing system" shall also be taken to include any collection of data processing systems that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies described herein.

The exemplary data processing system 500 includes a processor 502, a main memory 504 (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM) or Rambus DRAM (RDRAM), etc.), a static memory 506 (e.g., flash memory, static random access memory (SRAM), etc.), and a secondary memory 518 (e.g., a data storage device), which communicate with each other via a bus 530.

Processor 502 represents one or more general-purpose processing devices such as a microprocessor, central processing unit, or the like. More particularly, the processor 502 may be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, processor implementing other instruction sets, or processors implementing a combination of instruction sets. Processor 502 may also be one or more special-purpose processing devices such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. Processor 502 is configured to execute the processing logic 526 for performing the operations described herein.

The computer system 500 may further include a network interface device 508. The computer system 500 also may include a video display unit 510 (e.g., a liquid crystal display (LCD), a light emitting diode display (LED), or a cathode ray tube (CRT)), an alphanumeric input device 512 (e.g., a keyboard), a cursor control device 514 (e.g., a mouse), and a signal generation device 516 (e.g., a speaker).

The secondary memory 518 may include a machine-accessible storage medium (or more specifically a computer-readable storage medium) 531 on which is stored one or more sets of instructions (e.g., software 522) embodying any one or more of the methodologies or functions described herein. The software 522 may also reside, completely or at least partially, within the main memory 504 and/or within the processor 502 during execution thereof by the computer system 500, the main memory 504 and the processor 502 also constituting machine-readable storage media. The software 522 may further be transmitted or received over a network 520 via the network interface device 508.

While the machine-accessible storage medium 531 is shown in an exemplary embodiment to be a single medium, the term "machine-readable storage medium" should be

taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "machine-readable storage medium" shall also be taken to include any medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention. The term "machine-readable storage medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media.

In alternative embodiments, Figure 5 illustrates a computing device 500. The computing device 500 houses a board 530. The board may include a number of components, including but not limited to a processor 502 and at least one communication chip 508. The processor 502 is physically and electrically coupled to the board 530. In some implementations the at least one communication chip 508 is also physically and electrically coupled to the board 530. In further implementations, the communication chip 508 is integrated within the processor 502.

Depending on its applications, computing device 500 may include other components that may or may not be physically and electrically coupled to the board 530. These other components include, but are not limited to, volatile memory (e.g., DRAM), non-volatile memory (e.g., ROM), flash memory, a graphics processor, a digital signal processor, a crypto processor, a chipset, an antenna, a display, a touchscreen display, a touchscreen controller, a battery, an audio codec, a video codec, a power amplifier, a global positioning system (GPS) device, a compass, an accelerometer, a gyroscope, a speaker, a camera, and a mass storage device (such as hard disk drive, a solid state drive, a compact disk (CD) drive, a digital versatile disk (DVD) drive, and so forth).

The communication chip 508 enables wireless communications for the transfer of data to and from the computing device 500. The term "wireless" and its derivatives may be used to describe circuits, devices, systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a non-solid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. The communication chip 508 may implement any of a number of wireless standards or protocols, including but not limited to Wi-Fi (IEEE 802.11 family), WiMAX (IEEE 802.16 family), IEEE 802.20, long term evolution (LTE), Ev-DO, HSPA+, HSDPA+, HSUPA+, EDGE, GSM, GPRS, CDMA, TDMA, DECT, Bluetooth, derivatives thereof, as well as any other wireless protocols that are designated as 3G, 4G, 5G, andbeyond. The computing device 500 may include a plurality of communication chips 508. For instance, a first communication chip 508 may be dedicated to shorter range wireless

communications such as Wi-Fi andBluetooth and a second communication chip 1006 may be dedicated to longer range wireless communications such as GPS, EDGE, GPRS, CDMA, WiMAX, LTE, Ev-DO, and others.

The processor 502 of the computing device 500 includes an integrated circuit die packaged within the processor 502. In some implementations of the invention, the integrated circuit die of the processor includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein. The term "processor" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory.

The communication chip 508 also includes an integrated circuit die packaged within the communication chip 508. In accordance with another implementation of the invention, the integrated circuit die of the communication chip includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein.

In further implementations, another component housed within the computing device 600 may contain an integrated circuit die that includes one or more devices, such as transistors or metal interconnects, that are formed using methods and apparatuses to control a line edge roughness and line-to-line spacing in deposition of self-aligned metal caps as described herein.

In various implementations, the computing device 500 may be a laptop, a netbook, a notebook, an ultrabook, a smartphone, a tablet, a personal digital assistant (PDA), an ultra mobile PC, a mobile phone, a desktop computer, a server, a printer, a scanner, a monitor, a set-top box, an entertainment control unit, a digital camera, a portable music player, or a digital video recorder. In further implementations, the computing device 500 may be any other electronic device that processes data.

In the foregoing specification, embodiments of the invention have been described with reference to specific exemplary embodiments thereof. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of embodiments of the invention as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method to manufacture an electronic device, comprising:

recessing at least one conductive line in a dielectric layer over a substrate to form a channel; and

depositing a capping layer on the recessed conductive line in the channel to prevent electromigration.

2. The method of claim 1, wherein the recessing includes

etching the at least one conductive line uniformly independent of a crystallographic orientation.

3. The method of claim 1, wherein the channel is self-aligned to the conductive line.

4. The method of claim 1, wherein the at least one conductive line is recessed to a depth determined based on a thickness of the capping layer.

5. The method of claim 1, wherein the capping layer is deposited on the recessed conductive line by an electroless plating, a chemical vapor deposition, or a physical vapor deposition.

6. The method of claim 1, further comprising

forming a dielectric layer over the substrate;

forming at least one opening in the dielectric layer; and

filling the at least one opening with a conductive material to form the at least one conductive line.

7. The method of claim 1, wherein the at least one conductive line comprises a first metal, and the capping layer comprises a second metal other than the first metal.

8. A method to control line edge roughness, comprising:

etching at least one conductive line in a dielectric layer over a substrate with a first chemistry to a predetermined depth to form a channel self-aligned to the conductive line, wherein the channel is configured to contain a capping layer within a width of the at least one

conductive line, and wherein the first chemistry comprises an inhibitor configured to provide uniformity of etching independent of a crystallographic orientation.

9. The method of claim 8, wherein the first chemistry comprises between about 0.1% to about 70% by mass of an etchant, between about 0.1% to about 10% by mass of an oxidizer, and between about 50ppm to about 1% by mass of the inhibitor.

10. The method of claim 9, wherein the etchant includes a glycine, an ethylenediaminetetraacetic acid, an alpha-amino acid, a polycarboxylic acid, or a combination thereof; the oxidizer includes a peroxide, an ozone, a permanganate, a chromate, a perborate, a hypohalite, or a combination thereof, the inhibitor includes an azole, an amine, an amino acid, a phosphate, a phosphonate, or a combination thereof.

11. The method of claim 8, further comprising
depositing the capping layer onto the etched conductive line in the channel.

12. The method of claim 8, wherein the depth is determined based on a thickness of the capping layer.

13. An apparatus, comprising:
at least one first conductive line in a dielectric layer over a substrate,
and
a first capping layer selectively deposited on the at least one first conductive line within first sidewalls of the dielectric layer to prevent electromigration.

14. The apparatus of claim 13, wherein the first capping layer is self-aligned to the first conductive line.

15. The apparatus of claim 13, wherein the first conductive line comprises a first metal, and the first capping layer comprises a second metal other than the first metal.

16. The apparatus of claim 13, further comprising

a second capping layer selectively deposited on the second conductive line within second sidewalls of the dielectric layer, the second conductive line being at a first spacing from the

at least one first conductive line, and wherein the second capping layer is at the first spacing from the first capping layer.

17. The apparatus of claim 13, wherein the at least first conductive line is at a depth from 5 nanometers to 50 nanometers from a top surface of the dielectric layer.

18. The apparatus of claim 13, wherein the first conductive line is at a depth from a top surface of the dielectric layer that is from 10% to 50% of the thickness of the first conductive line.

19. The apparatus of claim 13, wherein the at least one first conductive line is an interconnect incorporated into a data processing system.

20. The apparatus of claim 13, wherein a spacing between the at least one first conductive line and a second conductive line in the dielectric layer is from 5 nm to 500 nm.

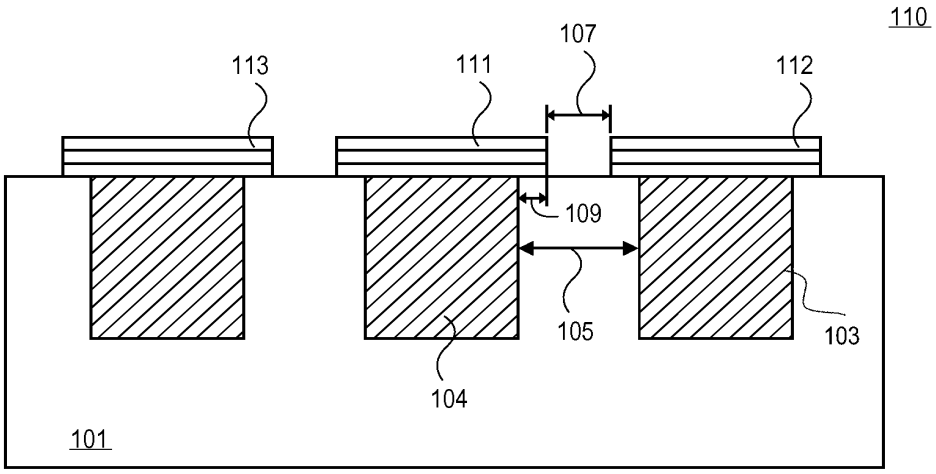


FIG. 1A
(PRIOR ART)

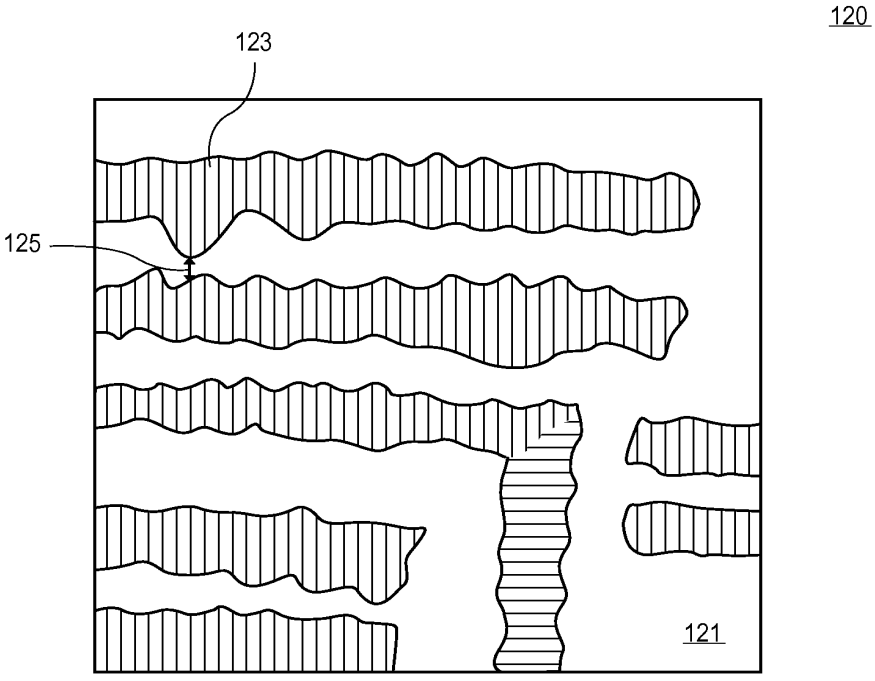


FIG. 1B
(PRIOR ART)

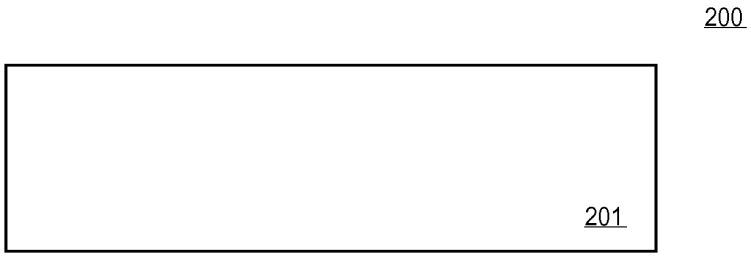


FIG. 2A

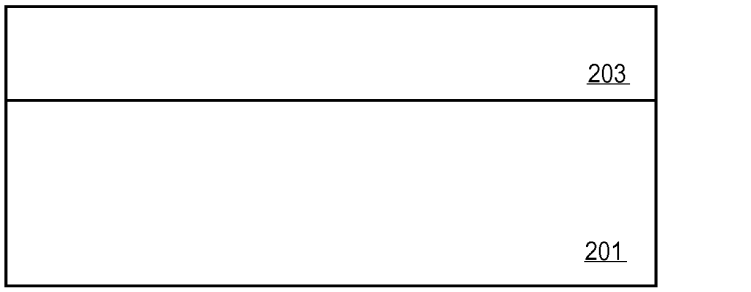


FIG. 2B

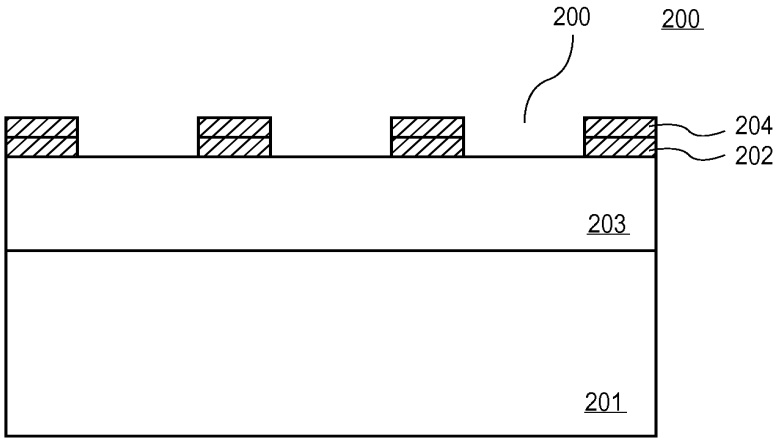


FIG. 2C

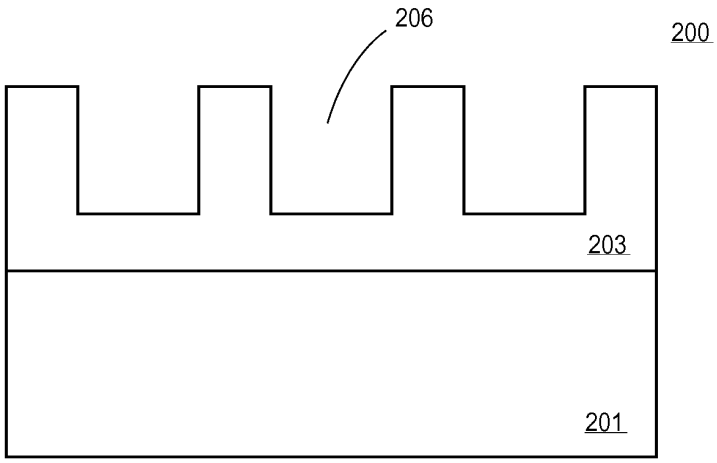


FIG. 2D

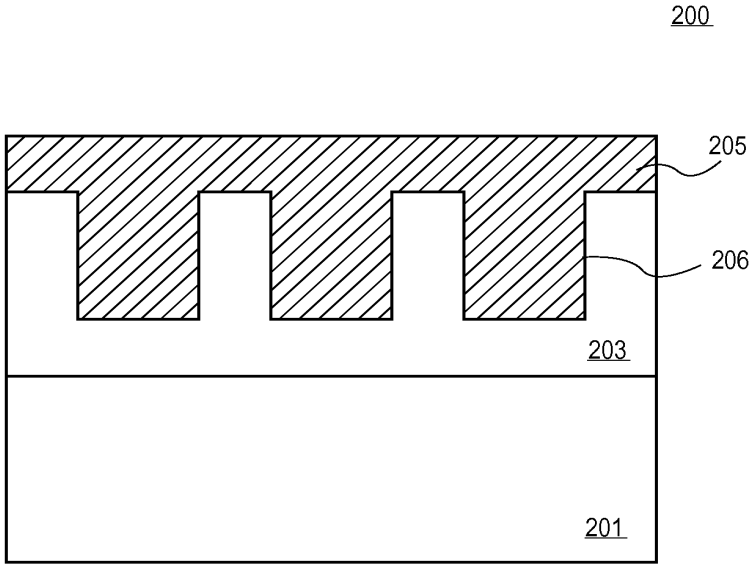


FIG. 2E

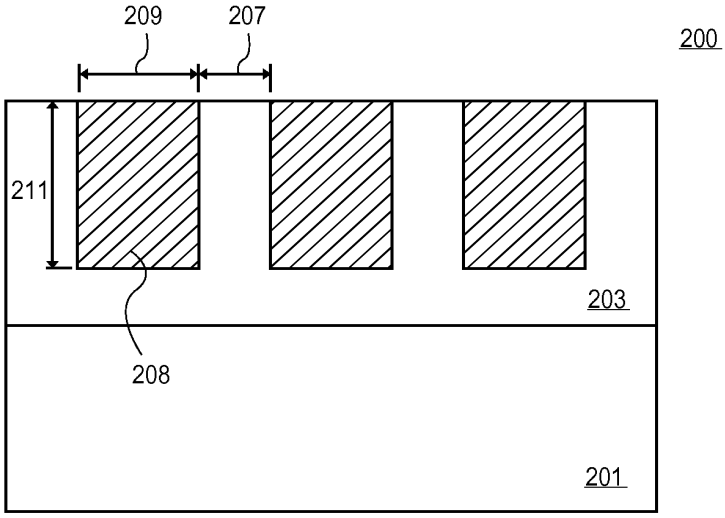


FIG. 2F

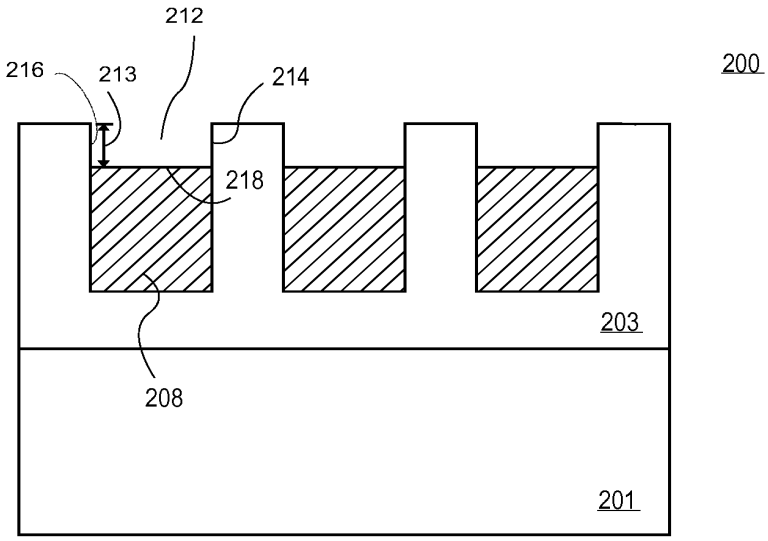


FIG. 2G

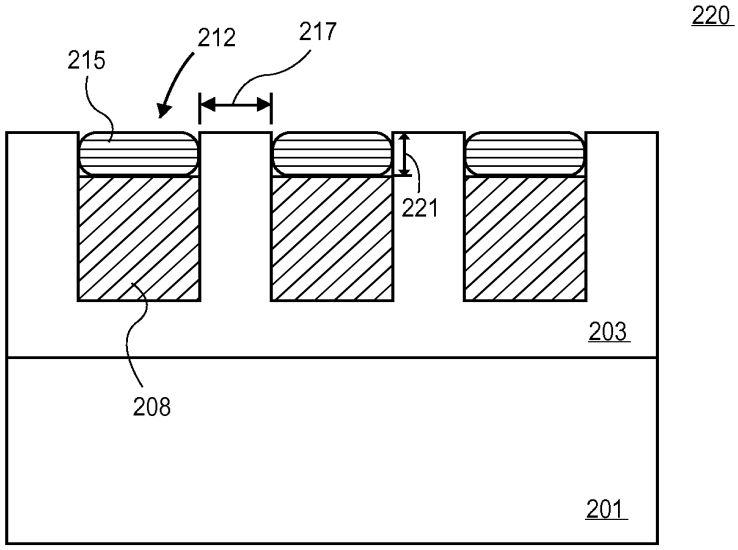


FIG. 2H

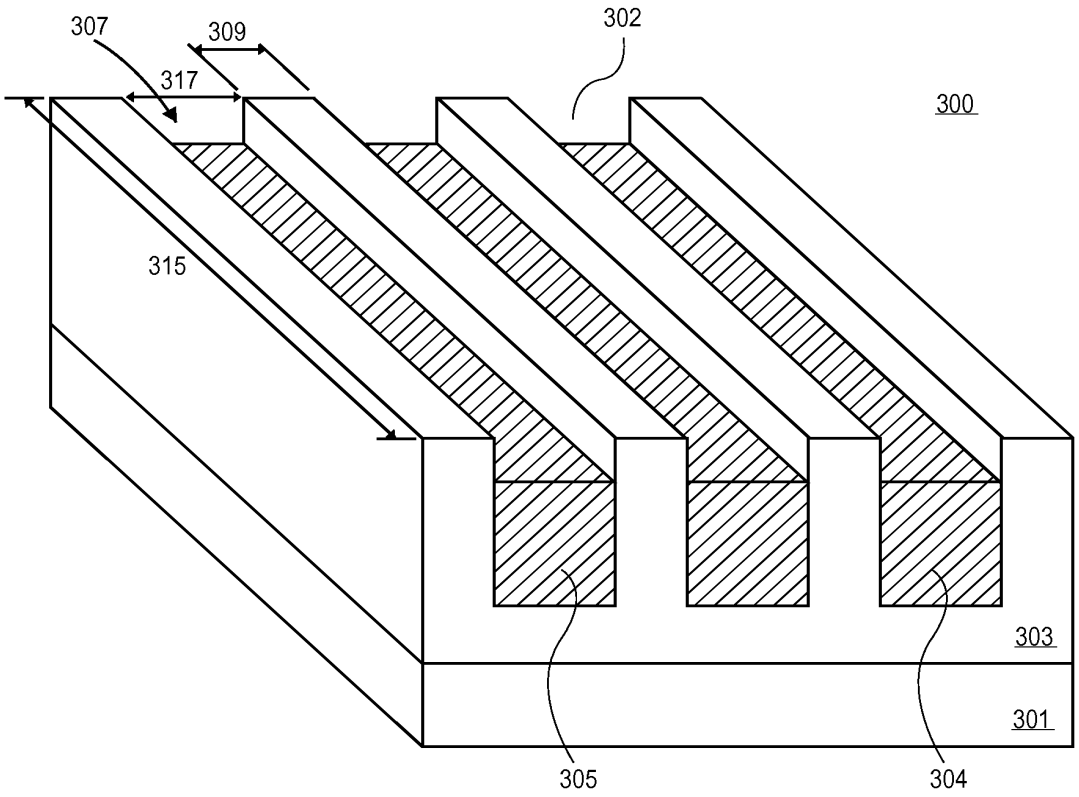


FIG. 3A

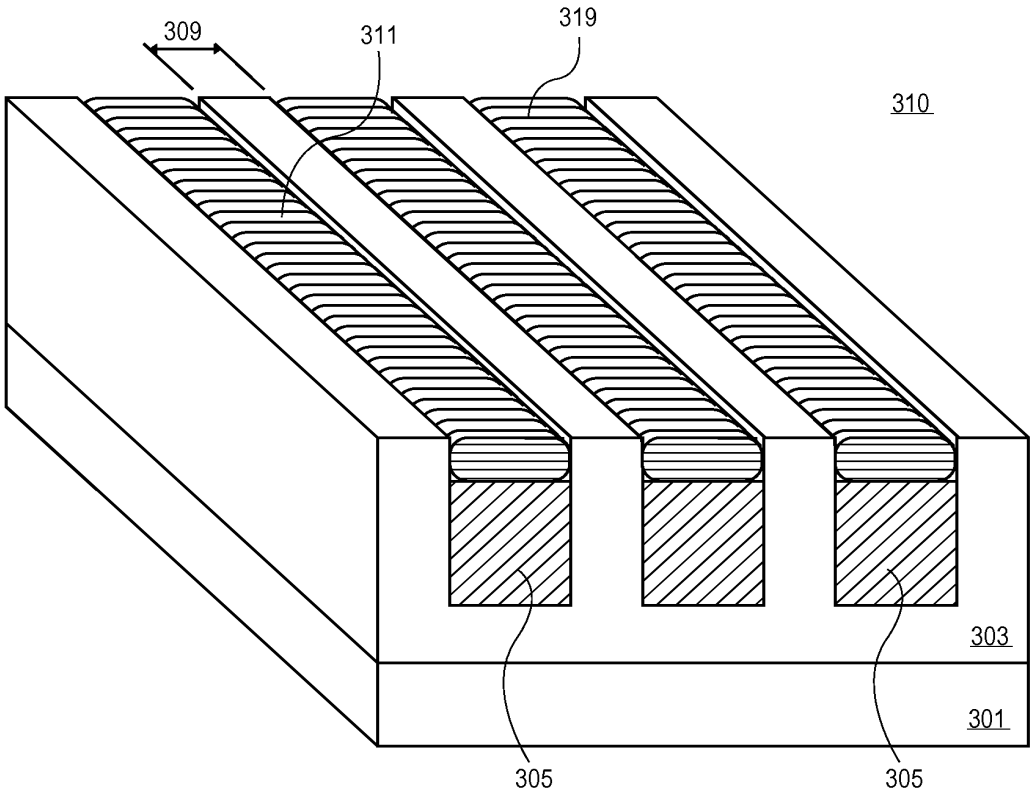


FIG. 3B

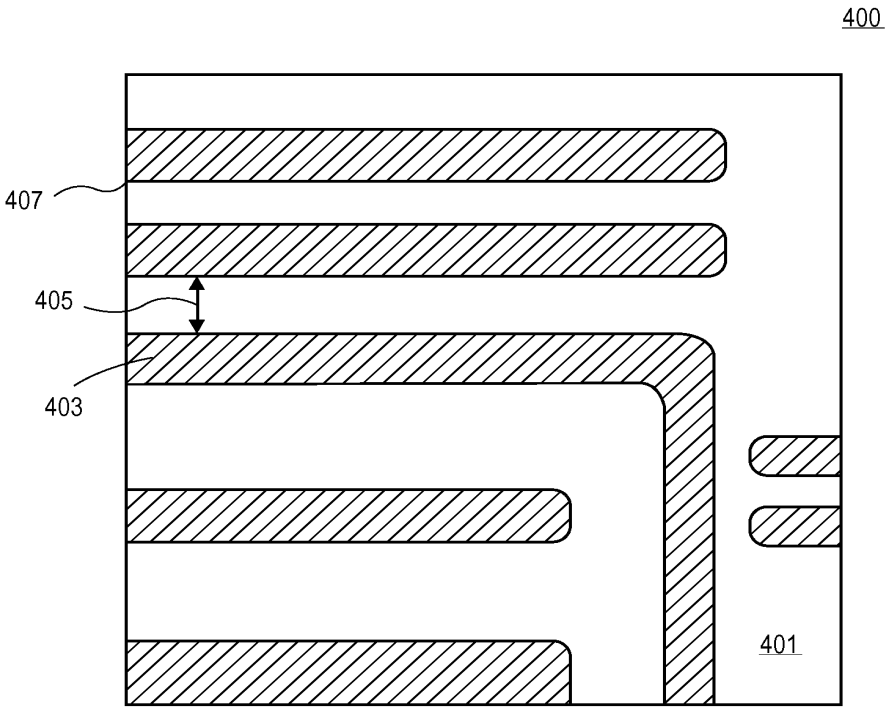


FIG. 4

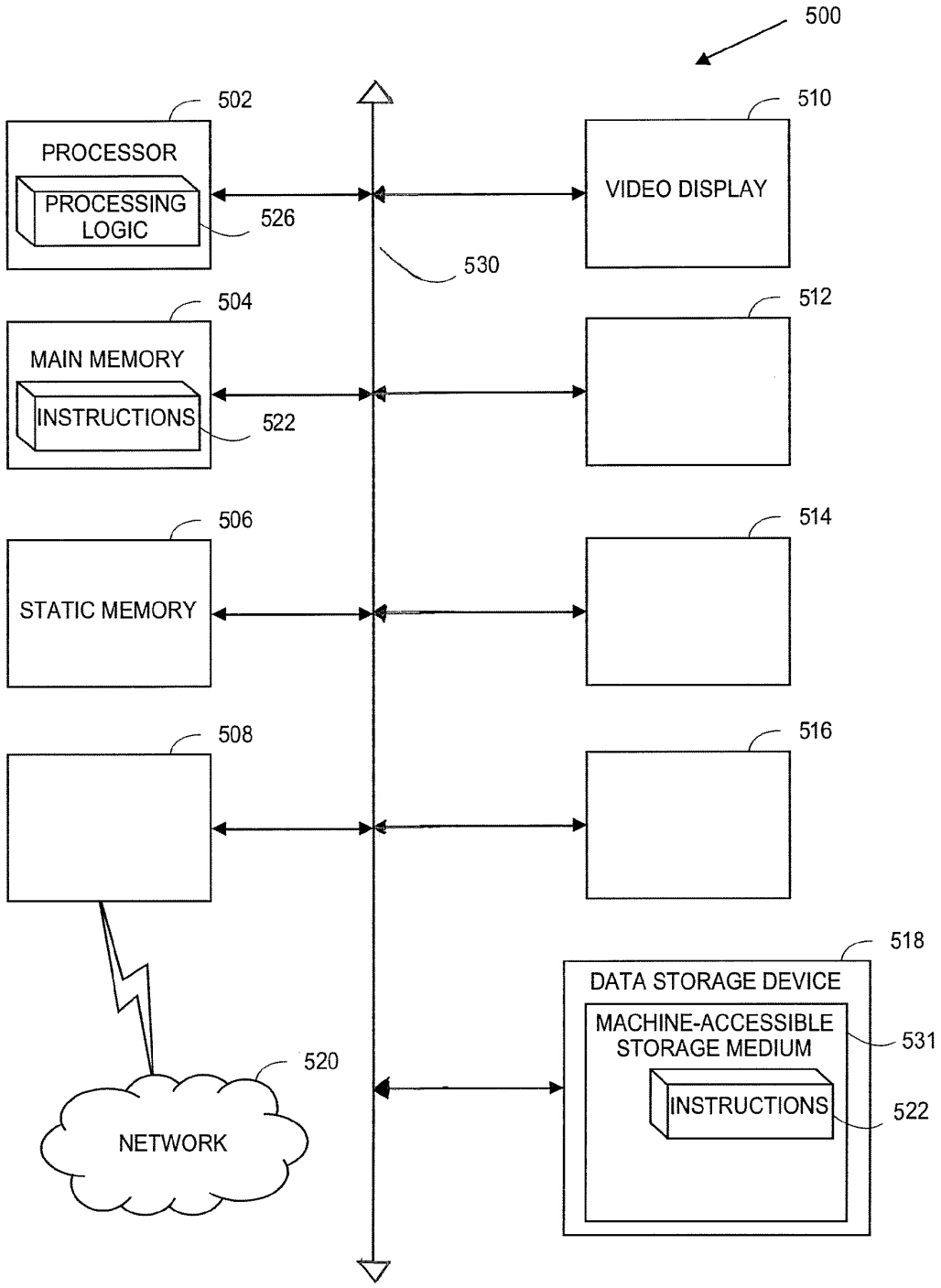

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FIG. 5