

# Lam Research Corporation v. Inpria Corporation

IPR 2024-00033

Patent No. 9,823,564



## Petitioner Lam's Demonstratives

Hearing Date: January 30, 2025





## I. Original Claims

|             |                                                                                |
|-------------|--------------------------------------------------------------------------------|
| Ground 1    | '888 Publication anticipates claims 1-12, as claims not entitled to priority   |
| Grounds 2-4 | Stowers 2008 (+Stowers 2009) anticipates or renders obvious claims 1-10 and 12 |
| Ground 5    | Trikeriotis anticipates or renders obvious claims 1, 3, 6-7, 9, and 11-12      |

## II. Proposed Amended Claims

Claims directed to a large genus lack written description and are not enabled

Numerous claim terms are indefinite

Stowers 2008 and Trikeriotis separately teach the proposed amended claims

Claims are anticipated or obvious over Keszler

# Original Claims

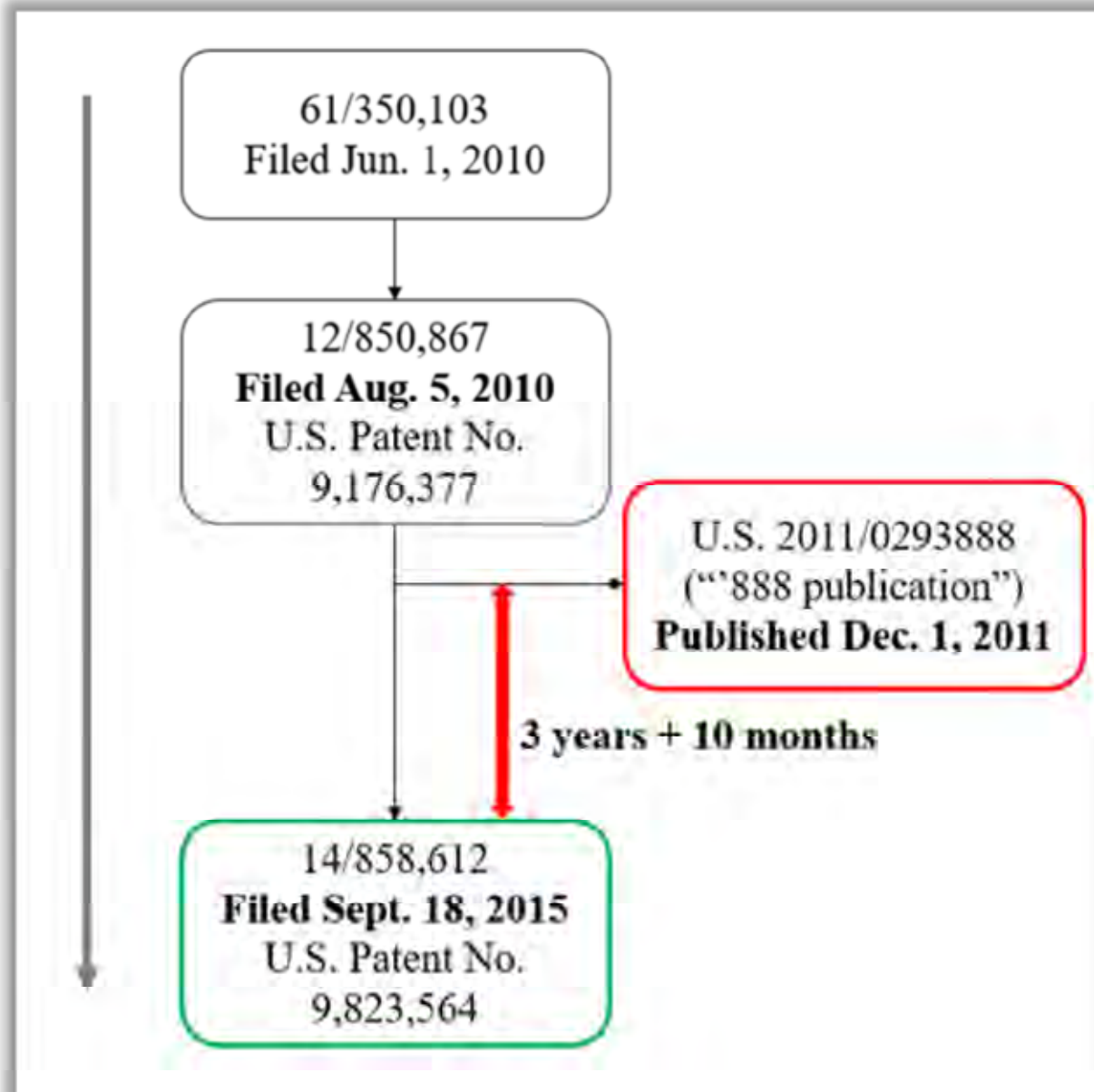
## Ground 1: The '888 Publication



- **Priority Date**

- '564 Patent claims priority to '867 Application, which was published as the '888 Publication.
- The claimed **thickness ranges of 5-30 nm and 5-25 nm are not disclosed** in the '867 Application.
  - Claimed ranges are not disclosed in '867 Application.
  - Claimed endpoints of 5 and 30 nm are not disclosed in '867 Application.
- Therefore, the '888 Publication is prior art, and anticipates all claims.

# Priority Chain for the '564 Patent



# The '564 Patent Claims Are Directed to Specific Thicknesses

**Claim 1:** A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average thickness from 5 nm to 30 nm, wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.

**Claim 6:** The structure of claim 1 wherein the average thickness is from 5 nm to 25 nm.

# The Specific Thickness Was Required for Allowance over Prior Art

## Patent Owner:

With regard to claim 1, the combination of Stowers and Meyers does not teach or suggest a thickness of between about 5 nm and about 30 nm. Rather, Stowers teaches a thickness of 35 nm or greater. Examiner has argued that 35 nm is within the range “about 30 nm”. While Applicant maintains the argument that “about 30 nm” is not obvious over Stowers, claim 1 has been amended to remove the term “about” in order to advance prosecution. Therefore, the ranges do not overlap and they are not close enough that one would expect them to have the same properties. As indicated by the Examiner, Meyers does not teach or suggest a thickness between 5 nm and 30 nm. Stowers in view of Meyers does not teach or suggest each and every element of claim 1. The combination of Stowers and Meyers therefore does not render claim 1 *prima facie* obvious. Thus, the combination does not render the presently claimed invention *prima facie* obvious.

# Patent Owner's Argument

## Patent Owner:

“The shared specification explicitly discloses several ranges of exemplary coating thicknesses:

- No more than about 1 micron (i.e., 1000 nm);
- No more than about 250 nm;
- From about 1 nanometers (nm) to about 50 nm;
- From about 1 nm to about 40 nm;
- From about 1 nm to about 25 nm;

\*\*\*

Each of these ranges either fully encompasses or overlaps nearly entirely with the claimed ranges of 5 nm to 30 nm (claim 1) or 5 nm to 25 nm (claim 6). Moreover, immediately after disclosing this slew of ranges, the specification states a “person of ordinary skill in the art will recognize that additional ranges of thicknesses within the explicit ranges above are contemplated and are within the present disclosure.”



*Gen. Hosp. Corp. v. Sienna Biopharm., Inc.*, 888 F.3d 1368, 1372 (Fed. Cir. 2018):



“The disclosure of a broad range of values does not by itself provide a written description support for a particular value within that range. . . . Instead, where a specification discloses a broad range of values and a value within that range is claimed, the disclosure must allow one skilled in the art to immediately discern the limitation at issue in the claims.”

## *Indivior UK Ltd. v. Dr. Reddy's Labs. S.A.*, 18 F.4th 1323, 1328–1329 (Fed. Cir. 2021):



A claim directed to a film comprising “about 40 wt % to about 60 wt % of a water-soluble polymetric matrix” **lacked written description** support in a specification that **did not recite either of the two end values** (40% and 60%) and did not disclose or claim the range (40–60%).



A narrower claim directed to a film comprising “about 48.2 wt % to about 58.6 wt % of the water-soluble polymetric matrix,” **lacked written description** support in the specification, even though the specification provided examples of films **having the two end point values** of the range (48.2% and 58.6%), because it would “amount[ ] to **cobbling together numbers after the fact.**”

# Broad Range Does Not Provide Written Description for Values Within the Range

## Petitioner:

“[C]laim 1 of the '564 patent lacks written description support in the '867 application because the specification does not disclose either of the two end values (5 nm and 30 nm) or the range (5 nm to 30 nm).”



*Pioneer Pet Prod., LLC v. Oil-Dri Corp. of Am.*, IPR2022-01138, Paper 21, 8 (Jul. 21, 2023) (“an example having a sodium bentonite content of 65% and an example having a sodium bentonite content of 70% [did not] support the amended range of 60% to 80%”)

## Petitioner:

“As to dependent claim 6, while the specification discloses a range of 1 nm to 25 nm, that disclosure does not provide written description support for the claimed range of 5 nm to 25 nm.”



*Grünethal GmbH v. Antecip Bioventures II LLC*, PGR2017- 00008, Paper 43, 17 (June 22, 2018) (“about 50 to about 500 mg” did not provide written description support for claim reciting “about 80 to about 500 mg.”).

# PO's Expert Could Not Identify Whether Other Ranges Were Disclosed



*Patent Owner's Expert  
Dr. Sanjay Banerjee*

Q. Would a POSA have known that the inventors had possession of any and all sub ranges within the explicit ranges mentioned in the '867 paragraph you quote in paragraph 27 of your declaration?

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A. I believe for my declaration I have opined specifically on the range 5 to 30 which was mentioned in claim 1 and 5 to 25 in the dependent claim. That's what I've specifically opined on, but as I just told you, '564 claims priority to '867 where other ranges are mentioned including sub ranges within the exemplary ranges.

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Q. So would a POSA have understood that the inventors had possession of a range from 21 to 38 nanometers?

\*\*\*

A. I've not contemplated that specific range in my report, but since '564 claims priority to '867 and the range that we just mentioned falls within some of the exemplary ranges in '867, in a broad sense I'd say yes, but you'd really have to give me more context to answer that more definitively.

## Patent Owner:

“Specifically, “the maturity of the science or technology, [and] the predictability of the aspect at issue” must be considered. *Id.* (quotation omitted); see also *In re Wertheim*, 541 F.2d 257, 264 (C.C.P.A. 1976) (“We see an important practical distinction between broad generic chemical compound inventions ... in which each compound within the genus is a separate embodiment of the invention, and inventions like that at bar, in which the range of solids content is but one of several process parameters.”). Here, a “lower level of detail” is required because the aspect at issue—the thickness limitation— can be predictably varied. See *RAI Strategic Holdings, Inc. v. Philip Morris Prod. S.A.*, 92 F.4th 1085, 1090 (Fed. Cir. 2024) (quotation omitted).”

*RAI Strategic Holdings, Inc. v. Philip Morris Prods. S.A.*, 92 F.4th 1085, 1088 (Fed. Cir. 2024):



When “a broad described range pertains to a different invention than the narrower (and subsumed) claimed range, then the broader range does not describe the narrower range.”

# PO Admitted That Different Thicknesses Were Different Inventions

## Patent Owner:

With regard to claim 1, the combination of Stowers and Meyers does not teach or suggest a thickness of between about 5 nm and about 30 nm. Rather, Stowers teaches a thickness of 35 nm or greater. Examiner has argued that 35 nm is within the range “about 30 nm”. While Applicant maintains the argument that “about 30 nm” is not obvious over Stowers, claim 1 has been amended to remove the term “about” in order to advance prosecution. Therefore, the ranges do not overlap and they are not close enough that one would expect them to have the same properties. As indicated by the Examiner, Meyers does not teach or suggest a thickness between 5 nm and 30 nm. Stowers in view of Meyers does not teach or suggest each and every element of claim 1. The combination of Stowers and Meyers therefore does not render claim 1 *prima facie* obvious. Thus, the combination does not render the presently claimed invention *prima facie* obvious.

# Patent Owner Has the Burden Regarding Priority Support

“[A]lthough Petitioner bears the ultimate burden of persuasion to prove unpatentability of the challenged claims, **Patent Owner bears the burden of production on the question of whether claims 1–12 are entitled to the filing date of the '867 application**, when relying on that date to overcome the patentability challenges. *See Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1379–80 (Fed. Cir. 2015) (discussing burdens applicable to priority date disputes).”

# Patent Owner's Argument

## Patent Owner:

“This is sufficient written description. *See RAI*, 92 F.4th at 1088-89 (discussing *Wertheim*, 541 F.2d at 263-65 (35%-60% range supported by 25%-60% disclosure); *In re Blaser*, 556 F.2d 534, 536-38 (C.C.P.A. 1977) (80°-200° C range supported by 60°-200° C disclosure); and *Kolmes v. World Fibers Corp.*, 107 F.3d 1534, 1537-39 (Fed. Cir. 1997) (8-12 turns per inch range supported by 4-12 turns per inch disclosure)).”

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## Case Law:

“In the context of this invention, in light of the description of the invention as employing solids contents within the **range of 25-60% along with specific embodiments of 36% and 50%**, we are of the opinion that, as a factual matter, persons skilled in the art would consider processes employing a **35-60% solids content range to be part of appellants' invention** and would be led by the Swiss disclosure so to conclude.”

# Patent Owner's Argument

## Patent Owner:

“This is sufficient written description. *See RAI*, 92 F.4th at 1088-89 (discussing *Wertheim*, 541 F.2d at 263-65 (35%-60% range supported by 25%-60% disclosure); *In re Blaser*, 556 F.2d 534, 536-38 (C.C.P.A. 1977) (80°-200° C range supported by 60°-200° C disclosure); and *Kolmes v. World Fibers Corp.*, 107 F.3d 1534, 1537-39 (Fed. Cir. 1997) (8-12 turns per inch range supported by 4-12 turns per inch disclosure)).”

## Case Law:

“We further note that in SN 159,159 appellants disclosed initially mixing the starting materials at a **temperature up to 80 degree C** prior to heating the reaction blend thus obtained to a **maximum temperature of 200 degree C**. We conclude that SN 159,159 adequately **supports the limitation "80 degree C to 200 degree C"** as recited in claims 7-12.”

# Patent Owner's Argument

## Patent Owner:

“This is sufficient written description. *See RAI*, 92 F.4th at 1088-89 (discussing *Wertheim*, 541 F.2d at 263-65 (35%-60% range supported by 25%-60% disclosure); *In re Blaser*, 556 F.2d 534, 536-38 (C.C.P.A. 1977) (80°-200° C range supported by 60°-200° C disclosure); and *Kolmes v. World Fibers Corp.*, 107 F.3d 1534, 1537-39 (Fed. Cir. 1997) (8-12 turns per inch range supported by 4-12 turns per inch disclosure)).”

## Case Law:

“At col. 5, lines 38-40, the specification states that the coverings or wrappings are formed "at the rate of 4-12 turns per inch, with 8 turns per inch being preferred." All the claimed limitations including the 8-12 turns per inch are thus well supported by the specification.”

# Conclusion: '888 Publication Anticipates all Claims

- Not Entitled to Priority Date
  - Claimed ranges are not disclosed.
  - Claimed endpoints (5 or 30 nm) are not disclosed.
  - 5-30 nm is a different invention to broader described ranges.
  - Therefore, '888 Publication is prior art.
- **Anticipation of Claim Limitations**
  - No dispute that claim limitations are disclosed.
  - Ranges of 5 to 30 nm and 5 to 25 nm are anticipated by at least the specific 20 nm example.

# No Dispute that the '888 Publication Discloses Each Limitation

Petitioner:

“Inpria does not dispute that the '888 publication discloses each limitation of claims 1-12. POR at 31. Inpria only argues that the '888 publication is not prior art.”

| '564 Patent Claims | “Support” in the Specification       | '888 Publication |
|--------------------|--------------------------------------|------------------|
| Claim 1            | Page 3, lines 9-23                   | ¶¶ 0009-0010     |
|                    | Page 5, lines 26-27                  | ¶ 0032           |
|                    | Page 8, lines 14-17                  | ¶ 0039           |
|                    | Page 21, lines 16-18                 | ¶ 0068           |
|                    | Page 23, line 16 to page 24, line 18 | ¶¶ 0073-0075     |
| Claims 2, 4 and 5  | Page 3, lines 13-15                  | ¶ 0009           |
| Claim 3            | Page 15, line 19 to page 16, line 16 | ¶ 0056           |
| Claim 6            | Page 21, lines 16-28                 | ¶ 0068           |
| Claim 7            | Page 9, lines 13-25                  | ¶ 0041           |
|                    | Page 13, lines 2-5                   | ¶ 0050           |
| Claim 8            | Page 2, line 30                      | ¶ 0007           |
| Claim 9            | Page 22, lines 15-18                 | ¶ 0070           |
| Claim 10           | Page 25, line 22-23                  | ¶ 0079           |
| Claim 11           | Page 20, lines 10-11                 | ¶ 0065           |
| Claim 12           | Page 23, lines 26-30                 | ¶ 0074           |

# No Dispute that the '888 Publication Discloses Each Limitation

|                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. A structure comprising a substrate and a coating material on a surface of the substrate, | "[T]he invention pertains to a patterned <b>structure comprising a substrate</b> and a patterned <b>inorganic material on a surface</b> of the substrate." ¶0010.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| coating material comprises metal ions with radiation sensitive ligands and                  | <p>"Generally, <b>the patterned coating material comprises metal suboxide cations, ligands comprising a peroxide group</b> and inorganic polyatomic anions." ¶0009.</p> <p>"<b>The coating materials can be designed to be sensitive to selected radiation</b>, such as ultraviolet light and/or electron beams." ¶0032.</p> <p>"Specifically, the precursor solution can comprise sufficient <b>radiation sensitive ligands</b> such that the solution has a molar concentration ratio of radiation sensitive ligands to metal suboxide cations of at least about 2 and in some embodiments at least about 5." ¶0039.</p> <p>"<b>Radiation sensitive ligands of particular interest have a peroxide group, —O—O—.</b>" ¶0059.</p>                                                     |
| coating material has an average thickness from 5 nm to 30 nm,                               | <p>In Example 4, which "describes a method that has been used to pattern an Hf suboxide based coating material ... <b>[t]he resist was applied with a thickness of 20 nm</b> by spin coating on a silicon wafer, followed by a post-apply bake of 50° C." ¶¶0102-0107.</p> <p>It is "an elementary principle of patent law that when, as by recitation of ranges or otherwise, a claim covers several compositions, the claim is 'anticipated' if one of them is in the prior art." <i>Titanium Metals Corp. of Am. v. Banner</i>, 778 F.2d 775, 782 (Fed. Cir. 1985). A thickness of <b>20 nm</b> falls squarely within the claimed range of "from 5 nm to 30 nm."</p> <p>The '888 publication also discloses thickness ranges that overlap with the claimed range. ¶¶0068, 0100.</p> |

# No Dispute that the '888 Publication Discloses Each Limitation

exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.

“The method can comprise irradiating a layer of coating material with **extreme ultraviolet** light at a dose of no more than about 100 mJ/cm<sup>2</sup>.” ¶0011.

“Specifically, the **un-irradiated coating material can be relatively more easily dissolved** by suitable developer compositions while the exposed coating material can remain appropriately resistant to the developer composition. Since the **un-irradiated coating material can be relatively more easily dissolvable with a developer in comparison with the irradiated coating material**, the contact time with the developer can be reduced while still maintaining desired removal of the coating composition.” ¶0043.

“While not wanting to be limited by theory, it is believed that **upon absorption of the radiation, the peroxide functional groups are fragmented, and the composition correspondingly condenses through the formation of bridging metal-oxygen bonds**. Through the condensation reaction, the radiation pattern is transferred to a pattern in the coating material. Specifically, there is a pattern of irradiated, and correspondingly condensed, coating material and of **un-irradiated coating material, which is substantially unchanged from its composition prior to patterned irradiation of the coating material**.” ¶0046.

“With **electron beam** lithography, the electron beam generally induces secondary electrons which **generally modify the irradiated material**.” ¶0075.

# No Dispute that the '888 Publication Discloses Each Limitation

|                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2...the metal ions comprise metal suboxide ions.           | “Generally, the patterned coating material comprises <b>metal suboxide cations</b> , ligands comprising a peroxide group and inorganic polyatomic anions.” ¶0009.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 3...metal of the metal ions comprises...Zr...Hf...         | <p>“<b>Metal suboxide cations</b> of particular interest include, for example, <math>\text{ZrO}^{+2}</math>, <math>\text{ZrOOH}^+</math>, <math>\text{Zr}(\text{OH})_2^{+2}</math>, <math>\text{Zr}(\text{OH})_3^+</math>, <math>\text{HfO}^{+2}</math>, <math>\text{HfOOH}^+</math>, <math>\text{Hf}(\text{OH})_2^{+2}</math>, <math>\text{Hf}(\text{OH})_3^+</math>, combinations thereof and/or combinations with other metal suboxide cations.” ¶0056.</p> <p>“10. The aqueous inorganic patterning composition of claim 1 comprising...<b>Zr...Hf...</b>”</p>                                                                                                                                                                                                     |
| 4...radiation sensitive ligands comprise peroxide ligands. | “Generally, the patterned coating material comprises metal suboxide cations, <b>ligands comprising a peroxide group</b> and inorganic polyatomic anions.” ¶0009.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 5...coating material further comprises polyatomic anions.  | “Generally, the patterned coating material comprises metal suboxide cations, ligands comprising a peroxide group and <b>inorganic polyatomic anions.</b> ” ¶0009.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 6...average thickness is from 5 nm to 25 nm.               | <p>In Example 4, which “describes a method that has been used to pattern an Hf suboxide based coating material ... [t]he resist was applied with a thickness of 20 nm by spin coating on a silicon wafer, followed by a post-apply bake of 50° C.” ¶¶0102-0107.</p> <p>It is “an elementary principle of patent law that when, as by recitation of ranges or otherwise, a claim covers several compositions, the claim is ‘anticipated’ if one of them is in the prior art.” <i>Titanium Metals Corp. of Am. v. Banner</i>, 778 F.2d 775, 782 (Fed. Cir. 1985). A thickness of <b>20 nm</b> falls within the claimed range of “from 5 nm to 25 nm.”</p> <p>The '888 publication also discloses thickness ranges that overlap with the claimed range. ¶¶0068, 0100.</p> |

# No Dispute that the '888 Publication Discloses Each Limitation

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|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>7...coating material has high absorption of EUV radiation relative to conventional radiation-based resists.</p> | <p><b>“Relative to organic resists, the inorganic coating material provides distinct advantages with respect to absorption of selected radiation</b> as well as high contrast between exposed and non-exposed regions such that high resolution can be achieved with moderate radiation doses.” ¶0050. Organic resists are “conventional” resists. ¶0049 (referring to organic resists as “conventional”); ¶0033 (same).</p> <p>“With appropriate selection of the composition, the <b>patterning composition can be sensitive to, for example, ultraviolet light</b>, x-rays or electron beams, as well as a particular wavelength or range of wavelengths within each radiation type.” ¶0037.</p> <p>“The <b>ultraviolet range</b> can be subdivided in several ways under accepted Standards, <b>such as extreme ultraviolet (EUV)</b> ...” ¶0073.</p> <p><b>“HfO<sup>+2</sup> provides good absorption of electron beam material and extreme UV radiation.”</b> ¶0057.</p>                            |
| <p>8...having a metal ion to radiosensitive ligand ratio of at least 2.</p>                                        | <p>The specification of the '564 patent does not disclose a “metal ion to radiosensitive ligand ratio of at least 2.” Rather, the specification states that “the composition has a molar concentration ratio of ligands to metal suboxide cations of at least about 2.” EX1001, 2:31-33. In other words, the specification describes a “ligand to metal” ratio of at least 2, not a “metal to ligand” ratio.</p> <p>To the extent claim 8 contains an obvious error that is correctable and should recite a “ligand to metal” as opposed to a “metal to ligand” ratio, then the '888 publication discloses this limitation. EX1003 ¶ 0007 (“the composition has a molar concentration ratio of <b>ligands to metal suboxide cations of at least about 2</b>”). Indeed, during prosecution, Inpria identified the specification at “page 2, line 30” reciting a “molar concentration ratio of ligands to metal suboxide cations of at least about 2” as providing support for this claim. EX1007, 141.</p> |
| <p>9...coating material has been heated to temperatures from 45° C to 150° C.</p>                                  | <p>“In embodiments in which heat is applied to remove solvent, the coating material can be heated to <b>temperatures from about 45° C to about 150° C.</b>” ¶0070.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

# No Dispute that the '888 Publication Discloses Each Limitation

|                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10...following exposure an exposed coating region is insoluble in an aqueous solvent.                                                    | <p>“In general, the developer can be <b>aqueous</b> acids or bases.” ¶0079.</p> <p>“In additional aspects, the invention pertains to a method for forming a patterned structure comprising ... contacting the irradiated layer with a developing composition to <b>dissolve un-irradiated material to form the patterned inorganic material.</b>” ¶0011.</p> <p>“In particular, the <b>irradiated coating</b> material can result in a <b>stable inorganic material with a high level of resistance to the developer</b>, e.g., a suitable liquid to dissolve un-irradiated coating material.” ¶0033.</p> <p>In other words, the developer does not dissolve the irradiated coating material, and only dissolves the un-irradiated coating material.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 11...following exposure an exposed coating region is soluble in an organic solvent.                                                      | <p>The '888 publication does not disclose this limitation. However, when Inpria presented this claim during prosecution (EX1007, 405), Inpria noted in the Remarks that support for this new claim could be found “at page 20, lines 10-11” of the original specification. <i>Id.</i>, 141. The cited passage recites: “Traditional organic resists are soluble in nonpolar solvents and are deposited onto hydrophobic surfaces.” <i>Id.</i>, 26. If the cited sentence provides written description support for this claim, as stated by Inpria, then the '888 publication, which also contains this sentence (EX1003 ¶0065), anticipates.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 12...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> . | <p>“The <b>EUV</b> images were obtained using projection lithography with a numerical aperture of 0.25 operating at 13 nm. The resist was applied with a thickness of 20 nm by spin coating on a silicon wafer, followed by a post-apply bake of 50° C. <b>After exposure at approximately 80 mJ/cm<sup>2</sup></b>, a post-exposure bake of 75° C. was used prior to development in 25% TMAH. The developed patterns are shown in FIGS. 18A-D. The <b>patterns shown</b> in FIG. 18 have pitches of A) 32-nm, B) 30-nm, C) 28-nm and D) 26-nm.” ¶0107.</p> <p>“35. A method for <b>forming a patterned</b> structure comprising ... irradiating a layer of coating material with <b>extreme ultraviolet light at a dose of no more than about 100 mJ/cm<sup>2</sup></b>.” Claim 35.</p> <p>“The method can comprise irradiating a layer of coating material with <b>extreme ultraviolet light at a dose of no more than about 100 mJ/cm<sup>2</sup></b> or an electron beam at a dose equivalent to no more than about 300 µC/cm<sup>2</sup> at 30 kV, and contacting the irradiated layer with a developing composition to dissolve un-irradiated material to form the patterned inorganic material.” ¶0011.</p> <p>“The amount of electromagnetic radiation can be characterized by a fluence... Suitable radiation fluences can be from about 1 mJ/cm<sup>2</sup> to about 150 mJ/cm<sup>2</sup>, in further embodiments from <b>about 2 mJ/cm<sup>2</sup> to about 100 mJ/cm<sup>2</sup></b> and in further embodiments from <b>about 3 mJ/cm<sup>2</sup> to about 50 mJ/cm<sup>2</sup></b>.” ¶0074.</p> |

# Conclusion: '888 Publication Anticipates all Claims

- **Not Entitled to Priority Date**
  - Claimed ranges are not disclosed.
  - Claimed endpoints (5 or 30 nm) are not disclosed.
  - 5-30 nm is a different invention to broader described ranges.
  - Therefore, '888 Publication is prior art.
- **Anticipation of Claim Limitations**
  - No dispute that claim limitations are disclosed.
  - Ranges of 5 to 30 nm and 5 to 25 nm are anticipated by at least the specific 20 nm example.

# Original Claims

Grounds 2-4: Stowers 2008  
(and Stowers 2009)



- **Stowers 2008 Is Prior Art**
  - Critical Date of '564 Patent is June 1, 2010 (if granted claimed priority)
  - **Objective Evidence Shows that OSU Publication of Stowers 2008 was Publicly Available by October 2008.**
  - **Subjective Evidence of a *Request* for an Embargo is not material.**
  - **Whether corroborating ProQuest Publication Was Embargoed Does Not Affect OSU Publication.**



***Petitioner's Expert***  
***Dr. Sylvia Hall-Ellis***

46. Attached hereto as Attachment 1A is a true and correct copy of the online catalog record for this dissertation from The Valley Library at Oregon State University (Corvallis, Oregon). The catalog record indicates that a copy of the dissertation is located in The Valley Library at Oregon State University, in the institution's digital repository, ScholarsArchive@OSU, and through the ProQuest Dissertations and Theses database. I personally identified and retrieved the library catalog record which is Attachment 1A.

# OSU Made Stowers 2008 Publicly Available By October 21, 2008



*Petitioner's Expert*  
*Dr. Sylvia Hall-Ellis*

Attached hereto as Attachment 1B is a true and correct copy of the **MARC record** for the doctoral dissertation titled *Direct Patterning of Solution Deposited Metal Oxides* obtained from the OCLC bibliographic database. . . . **As can be seen in the "Entered" field in the MARC record for this exhibit, a cataloger in The Valley Library at Oregon State University created OCLC record number 263038762 on October 21, 2008, as show in the "Entered" field ("20081021").**

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In view of above, this doctoral dissertation **was publicly available on October 21, 2008**, because by that date it had been **received, cataloged, and indexed in The Valley Library at Oregon State University**, placed in the custody of UMI, and made part of the OCLC bibliographic database.

**OCLC** 263038762 No holdings in XXX - 2 other holdings

|      |     |          |   |               |   |      |   |       |      |      |     |
|------|-----|----------|---|---------------|---|------|---|-------|------|------|-----|
| Re   |     | En 200   |   | Re 2023021    |   |      |   |       |      |      |     |
| c    |     | tere 810 |   | place 9000156 |   |      |   |       |      |      |     |
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# OSU Made Stowers 2008 Publicly Available By October 21, 2008



**From:** Engelbert, Brad <Brad.Engelbert@oregonstate.edu>  
**Sent:** Tuesday, August 13, 2024 11:23 AM  
**To:** Murphy, Risa L.  
**Subject:** RE: Dissertation Declaration question

[EXTERNAL EMAIL]  
Hello, Risa.

I'm not aware of any declaration or certification that we provide for our resources, but the date that the dissertation was published through our archive is coded into the record. OSU Libraries made this dissertation publicly available on 10-21-2008. We would have received it before that date because there is a certain amount of processing and description that is done before it is published in the archive, but there isn't a record of that date. I don't know if that helps. Let me know if you have any other questions.

Best,

Brad Engelbert

Cataloging and Government Documents Manager  
Oregon State University  
121 The Valley Library  
Corvallis, OR 97331-4501



*Dr. Jason Stowers*

7. When I submitted my thesis in October 2008, **I requested that it be embargoed** for a period of one year before it would be released to the public. I understood this to mean that my thesis would be unavailable to the public until sometime in October 2009, one year after I submitted it.

# Petitioner Has Met the Preponderance of the Evidence Standard



“Whether a reference qualifies as a ‘printed publication’ is a legal conclusion based on underlying factual findings. . . . The underlying factual findings include whether a reference was publicly accessible. . . . In an IPR, the petitioner bears the burden of establishing by a preponderance of the evidence that a particular document is a printed publication. . . . ‘A reference will be considered publicly accessible if it was disseminated or otherwise made available to the extent that persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence can locate it.’” *Nobel Biocare Servs. AG v. Instradent USA, Inc.*, 903 F.3d 1365, 1375 (Fed. Cir. 2018)

- **Petitioner’s Evidence**

- MARC Record
- Ellis-Hall Declaration
- OSU Website
- OSU Email

- **Patent Owner’s Evidence**

- Dr. Stowers’ request for embargo

- Stowers 2008 Is Prior Art
  - Objective Evidence Shows that OSU Publication of Stowers 2008 was Publicly Available by October 2008.
  - Subjective Evidence of a *Request* for an Embargo is not material.
  - Whether the ProQuest Publication Was Embargoed Does Not Affect OSU Publication.
- Disclosures of Stowers 2008
  - Stowers 2008 Inherently Discloses the Required Properties.
    - No dispute that Stowers 2008 has same precursor materials as the '564 Patent
    - Petitioner's Expert: Evaluated the minimal differences and concluded there was no material affect on properties.
    - PO's Expert: Provided generic testimony only, and did not evaluate minimal differences between Stowers 2008 and '564 Patent.

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                                                                                                                                                                                                         | Expressly Disclosed | Inherently Disclosed | Obvious            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------------------|--------------------|
| 1. A structure comprising a substrate and a coating material on a surface of the substrate,                                                                                                                                                                                | Yes                 |                      |                    |
| coating material comprises metal ions with radiation sensitive ligands and                                                                                                                                                                                                 | Yes                 | Yes                  |                    |
| coating material has an average thickness from 5 nm to 30 nm,                                                                                                                                                                                                              | Yes                 |                      | Yes                |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | Yes                 | Yes                  |                    |
| 2...the metal ions comprise metal suboxide ions.                                                                                                                                                                                                                           | Yes                 |                      |                    |
| 3...metal of the metal ions comprises...Zr...Hf...                                                                                                                                                                                                                         | Yes                 |                      |                    |
| 4...radiation sensitive ligands comprise peroxide ligands.                                                                                                                                                                                                                 | Yes                 |                      |                    |
| 5...coating material further comprises polyatomic anions.                                                                                                                                                                                                                  | Yes                 |                      |                    |
| 6...average thickness is from 5 nm to 25 nm.                                                                                                                                                                                                                               |                     |                      | Yes                |
| 7...coating material has high absorption of EUV radiation relative to conventional radiation-based resists.                                                                                                                                                                |                     | Yes                  | Yes                |
| 8...having a metal ion to radiosensitive ligand ratio of at least 2.                                                                                                                                                                                                       |                     | Yes                  | Yes (Stowers 2009) |
| 9...coating material has been heated to temperatures from 45° C to 150° C.                                                                                                                                                                                                 | Yes                 |                      |                    |
| 10...following exposure an exposed coating region is insoluble in an aqueous solvent.                                                                                                                                                                                      | Yes                 |                      |                    |
| 12...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> .                                                                                                                                   |                     | Yes                  | Yes                |

## Patent Owner:

A principal basis for Lam's argument that Stowers 2008 anticipates or renders the claims obvious is that the films are identical to the '564 patent films. According to Lam, because the films are identical, it is appropriate for Lam to point to the teachings in the '564 patent itself to show inherent properties of the Stowers 2008 films. *See, e.g.*, Pet., 38, 44, 48 (pointing to inherency cases regarding the “work of the inventor” and disclosure of the “patent itself”). **Lam's assumption that the films are the same, however, is unsupported and Lam fails to meet the strict requirements of inherency.** EX2009, ¶¶30-39.

# The Stowers 2008 Films Are Identical In All Material Aspects

- No dispute about the identity of the precursor materials—dispute is about small variations in concentrations and processing conditions:

Lam's theory depends exclusively on the fact the identity of the precursor chemicals is the same. Pet., 2 (“same components”), 21 (listing components), 36 (“same components”), 37 (“exact same components”), 44 (“same components”), 47 (“same components”). . . . Here, there are significant differences in concentrations and processing conditions, nearly all of which Lam and its expert completely ignore.

Patent Owner:

|                         | Stowers 2008                           | '564 Patent                                              |
|-------------------------|----------------------------------------|----------------------------------------------------------|
| Metal Concentration     | 0.5 M                                  | 0.16 M (Zr)<br>0.15 M (Hf)                               |
| Rests                   | 15 minute rests after each addition    | 5 minute rests after each addition.                      |
| Pre-exposure bake       | None disclosed                         | 40-200° C for 0.1-5 minutes<br>50° C                     |
| Post-exposure bake      | 300° C for 5 minutes                   | 40-200° C for 1-5 minutes<br>75° C                       |
| Spin coating conditions | 3000 rpm for 30 seconds                | 100 RPM for 5 seconds and then 3000 RPM for 30-60 second |
| Substrate               | silicon wafer chips or silicon coupons | Five inch silicon wafers                                 |
| Metal to peroxide ratio | 1 to 0.75                              | 1 to 0.66-0.88 (Zr)<br>1 to 6.62-8.81 (Hf)               |

# Dr. Banerjee Testified About Processing Conditions Generally – Not About the Differences Between Stowers and the '564 Patent Films



*Patent Owner's Expert  
Dr. Sanjay Banerjee*

I have been asked to consider, in the context of films such as those discussed in the '564 patent, **whether differences in the ratios/concentrations of materials and differences in the manner in which those materials are combined can have an impact** on the resulting film produced. As I explain below, a person of ordinary skill in the art would have understood that differences in the ratios and concentrations of materials used to form coating layers, as well as differences in the manner in which those materials are combined, can result in coating films with different characteristics. . . . [A] a person of ordinary skill in the art would have understood that **the characteristics of the coating formed can be impacted** by a number of factors, including concentrations of materials in the precursor solutions, the time allowed for combination of the precursor solutions, and the level of dilution of the solution used to deposit the coating layer by spin coating.

# Dr. Banerjee Example: Rest Times



*Patent Owner's Expert  
Dr. Sanjay Banerjee*

A person of ordinary skill in the art would have understood that, similarly, **allowing the mixtures to rest for too long of a time period could allow for unwanted reactions** between the precursor materials (e.g., those that produce “large sol particles”) and thereby make the resulting solution less useful for forming the desired coating material. Therefore, a person of ordinary skill in the art would have understood that coating films with different characteristics can also result when there are differences in the way in which the precursor materials are combined, where **one such difference may be the resting time after one mixing operation** before another mixing operation is commenced.

# Dr. Holland Testified That the Specific Differences Were Immaterial



*Petitioner’s Expert  
Dr. Karey Holland*

| Property                                 | Specific Effect on Stowers 2008 and '564 Patent Films                                                                                                                                                                                                                  |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Metal Concentration                      | “[T]he difference in metal concentration between precursor solutions Stowers 2008 and the '564 patent do not change the resulting film.”                                                                                                                               |
| Rests                                    | “Accordingly, the 15 minutes rest period in Stowers 2008 merely allows more time for ligand exchange, and does not “result in different coating films” as Dr. Banerjee suggests.”                                                                                      |
| Pre-exposure bake and Post-exposure bake | “[I]t is clear that the pre- and post-exposure bakes of Stowers 2008 are within the ranges used in the '564 patent. Accordingly, any differences in the baking conditions in Stowers 2008 and the '564 patent will not change the composition of the resulting films.” |

# Dr. Holland Testified That the Specific Differences Were Immaterial



*Petitioner's Expert  
Dr. Karey Holland*

| Property                | Specific Effect on Stowers 2008 and '564 Patent Films                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Spin coating conditions | “[T]he only difference between the spin coating conditions in Stowers 2008 and the '564 patent, is that the '564 patent includes an initial 100 RPM spin for five seconds. Compare EX1008, 68 with EX1001, 22:7. As the '564 patent explains, this ‘spreads the resist across the wafer.’ EX1001, 22:17-20. Accordingly, this will not change the composition of the resulting films.”                                                                       |
| Metal to peroxide ratio | “Notably, the metal to peroxide ratio used in Stowers 2008 is within the range of those used for Zr-based resists in the '564 patent, and thus would impart the same properties. . . . HafSOx films of Stowers 2008 (formed from precursor solutions having a ligand : metal ratio of 1:0.75) and the HafSOx films of the '564 patent examples (made from precursor solutions having a ligand : metal ratio of 1:6.62-8.81) would have the same properties.” |

# Inherent Properties Do Not Need to Be Recognized by the Prior Art

| Inherently Disclosed Property                                                                                                                                                                                                                                              | Support for Inherency                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| radiation sensitive ligands                                                                                                                                                                                                                                                | Same as '564 patent films.                                                                                             |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | Same as '564 patent films.                                                                                             |
| coating material has high absorption of EUV radiation relative to conventional radiation-based resists.                                                                                                                                                                    | Same as '564 patent films.<br>Alternative Inherency Argument: As density increases, EUV absorbance increases. (EX1025) |
| having a metal ion to radiosensitive ligand ratio of at least 2.                                                                                                                                                                                                           | Same as '564 patent films.                                                                                             |
| coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> .                                                                                                                                        | Same as '564 patent films.<br>Alternative Inherency Argument: Correlation between e-beam and EUV. (EX1022)             |



*Alcon Research, Ltd. v. Apotex Inc.*, 687 F.3d 1362, 1369 (Fed. Cir. 2012) (analyzing inherency based on the disclosure of the “patent itself”); *Telemac Cellular Corp. v. Topp Telecom, Inc.*, 247 F.3d 1316, 1327-28 (Fed. Cir. 2001) (finding that features were inherent “as evidenced by [the patentee]’s own documents”); *Mylan Pharms. Inc. v. Merck Sharp & Dohme Corp.*, IPR2020-00040, Paper 21, 53 (May 12, 2020) (“The inventors’ documents, including the patent itself, may provide evidence of an inherent disclosure.”).



*EMI Grp. N. Am., Inc. v. Cypress Semiconductor Corp.*, 268 F.3d 1342, 1349–51 (Fed. Cir. 2001) (“Theoretical mechanisms or rules of natural law that are recited in a claim, that themselves are not patentable, however, do not need to be recognized by one of ordinary skill in the art for a finding of inherency. . . . Inherency is not necessarily coterminous with the knowledge of those of ordinary skill in the art. Artisans of ordinary skill may not recognize the inherent characteristics or functioning of the prior art.”).

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                          | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. A structure comprising a substrate and a coating material on a surface of the substrate, | Stowers 2008 discloses “[a] new system for directly patterning functional metal oxides by UV and EUV.” EX1008, 65. Precursor “solutions were spin coated at 3000 rpm for 30 seconds resulting in films...” Id., 68. “Substrates were either silicon wafer chips (n+ heavily doped) or silicon coupons with 200 nm of thermal oxide.” Id. A POSA would understand that the precursor solutions are spin coated onto wafers, i.e., a substrate. EX1002 ¶96. Stowers 2008 therefore discloses a “structure comprising a substrate and a coating material on a surface of the substrate.”                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| coating material comprises metal ions with radiation sensitive ligands and                  | <p><b>Express Disclosure:</b> A POSA would understand that the “working solutions” of Stowers 2008 contain “metal ions,” since, in solution, <math>ZrOCl_2</math> and <math>HfOCl_2</math> exist as <math>ZrO_2^+</math> and <math>HfO_2^+</math>, i.e., metal cations. EX1002 ¶99; EX1021 ¶0009 (“hafnium suboxide (<math>HfO_2^+</math>), may be provided by providing an aqueous solution of hafnium oxy chloride (<math>HfOCl_2(aq)</math>).”). Since those precursor solutions in Stowers are spin-coated to make films, it follows that the resulting films also contain metal ions. EX1002 ¶99. A POSA would also understand that the peroxide groups in Stowers 2008’s precursor solution is a radiation sensitive ligand. EX1002 ¶100. Stowers 2008 states that “both <math>ZrSO_x</math> and <math>HfSO_x</math> are UV sensitive” and that “[t]he extinction coefficients of these materials have previously been determined.” EX1008, 69. Stowers 2008 then notes that “[i]t is expected that these extinction coefficients will be different with the presence of peroxide in the as-deposited material...” Id.</p> <p><b>Inherent Disclosure:</b> Moreover, as shown below, Stowers 2008’s precursor solutions contain the same components—<math>HfOCl_2</math> or <math>ZrOCl_2</math>, <math>H_2O_2</math>, and <math>H_2SO_4</math>—as the precursor solutions used to make the coating materials in the Examples of the ’564 patent. Specifically, Example 1 of the ’564 patent discloses that “[s]eparate aqueous solutions were prepared for the components of the precursor solution” and “the respective solutions can be referred to as Part A for the metal suboxide cations, Part B for the peroxide-based ligand solution and Part C for the solution comprising polyatomic anions.” Id., 21:18-23. Solution “Part A1” contains “<math>ZrOCl_2 \cdot 8H_2O</math>,” solution “Part A2” contains “<math>HfOCl_2 \cdot 8H_2O</math>,” solution “Part B” contains “<math>H_2O_2(aq)</math>” and solution “Part C” contains “<math>H_2SO_4(aq)</math>.” Id., 21:22-55.</p> |

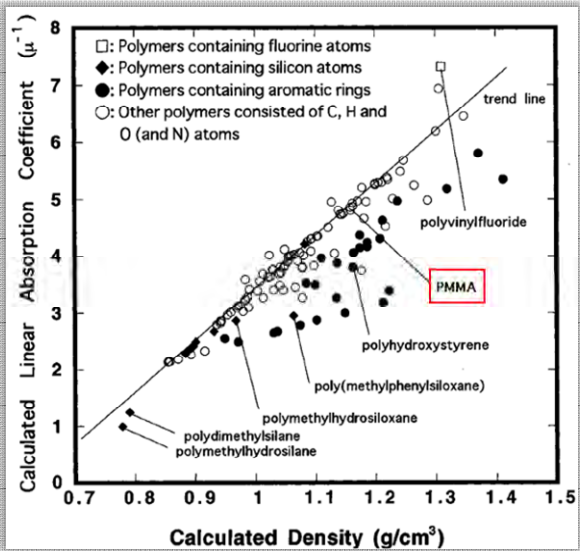
# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                                                                                                                                                                                                         | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| coating material has an average thickness from 5 nm to 30 nm,                                                                                                                                                                                                              | <p>Stowers 2008 states that “[w]orking [precursor] solutions were spin coated at 3000 rpm for 30 seconds resulting in films 30 to 35-nm thick.” EX1008, 68. Stowers 2008 also expressly refers to “films on the order of 30-nm thick.” <i>Id.</i>, 71; EX1009, 265 (Inpria admitting that “Stowers described coatings with thicknesses from 30 to 35 nm in Chapter 3.”). Therefore, Stowers 2008 discloses this limitation because it discloses 30 nm thick HafSOx and ZircSOx films, which is within the claimed range of “from 5 nm to 30 nm.” EX1002 ¶105.</p> <p>Moreover, it is well-settled that “[a] prior art reference that discloses an overlapping but different range than the claimed range can be anticipatory, even where the prior art range only partially or slightly overlaps with the claimed range.” <i>Genentech, Inc. v. Hospira, Inc.</i>, 946 F.3d 1333, 1338 (Fed. Cir. 2020).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | <p><b>Express Disclosure:</b> Stowers 2008 discloses patterning of ZircSOx films by exposure to UV radiation. EX1008, 68 (“Patterning by UV light was achieved...”). Stowers 2008 “found that ZircSOx could be patterned by UV light in either positive or negative tone.” <i>Id.</i>, 70. In other words, Stowers 2008 discloses that exposure of a ZircSOx film to UV radiation altered the chemical properties of the film such that the exposed regions have a different dissolution rate than the un-exposed regions of the film. EX1002 ¶108.</p> <p>Stowers 2008 also evaluated whether HafSOx films could be patterned by EUV, but these “experiments were hampered by an error in processing.” EX1008, 73. “Even with these errors, a contrast of 0.3 and a sensitivity of 194 mJ/cm<sup>2</sup> [d0.8] were demonstrated.” <i>Id.</i>; Fig. 3-6 (“Characteristic contrast curve for EUV exposed HafSOx”) ; Fig. 3-7 (showing “SEM image of 30 nm lines and spaces patterned by EUV interference lithography.”). That HafSOx films could be patterned by EUV indicates that exposure to EUV altered the chemical properties of the film such that the exposed regions have a different dissolution rate than the un-exposed regions of the film. EX1002 ¶¶109-110.</p> <p><b>Inherent Disclosure:</b> This limitation is an inherent property of the claimed coating material, as Inpria itself stated during prosecution of a later patent. EX1009, 263 (“Whether or not claim 10 is amended to remove the reference to e-beam in claim 10 [which recited “wherein interaction of the coating material with EUV and/or e beam radiation alters the chemical properties of the coating material creating a structure with differential dissolution rates”] is still a description of a property of the coating material.”). Therefore, since Stowers 2008 discloses the same films as the ’564 patent, they necessarily satisfy this limitation.</p> |

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                         | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2...the metal ions comprise metal suboxide ions.           | Stowers 2008's films include $ZrO_2+$ or $HfO_2+$ cations, which are metal suboxide ions. EX1001, 10:45-59 ("Metal suboxide cations of particular interest include, for example, $ZrO_2+$ ..., [or] $HfO_2+$ ..."); EX1021 ¶0009 ("hafnium suboxide ( $HfO_2+$ ), may be provided by providing an aqueous solution of hafnium oxy chloride ( $HfOCl_2(aq)$ )."); EX1002 ¶111.                                                                                                                                                                                                                                                         |
| 3...metal of the metal ions comprises...Zr...Hf...         | Claim 3 depends on claim 1 and recites that "the metal of the metal ions comprises...Zr...[or] Hf..." Stowers 2008's films include $ZrO_2+$ or $HfO_2+$ cations. EX1002 ¶112.                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 4...radiation sensitive ligands comprise peroxide ligands. | Claim 4 depends on claim 1 and recites that "the radiation sensitive ligands comprise peroxide ligands." Stowers 2008's films contain peroxide as the radiation sensitive ligand. EX1002 ¶113.                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 5...coating material further comprises polyatomic anions.  | Claim 5 depends on claim 1 and recites that "the coating material further comprises polyatomic anions." Stowers 2008 discloses adding $H_2SO_4$ to the working precursor solutions. EX1008, 52 (" $H_2SO_4$ (aq) was added to give a metal to sulfate ratio of 1 to 0.5-0.7" and "the solution was allowed to rest."). $H_2SO_4$ exists in solution as $SO_4^{2-}$ . EX1021 ¶0009 ("polyatomic anion in solution, such as sulfate ( $SO_4^{2-}$ ), may be provided by providing an aqueous solution of sulfuric acid ( $H_2SO_4(aq)$ )"); EX1002 ¶114.                                                                                |
| 6...average thickness is from 5 nm to 25 nm.               | <b>Obviousness:</b> Stowers 2008 discloses that " $HfSO_x$ , and...ZircSOx, can be deposited in films ranging in thickness from 2 to 500 nm." EX1008, 2; 66 (" $HfSO_x$ [and] ZircSOx...materials has (sic) been deposited in thickness ranges of 3 to 500 nm."). Thus, Stowers 2008 discloses $HfSO_x$ and ZircSOx films having thicknesses in a range that encompasses the claimed range of "from 5 nm to 25 nm," thereby establishing a presumption of obviousness. Moreover, it would have been well within the skillset of a POSA to experiment with the spin rates and times to obtain the claimed thickness. EX1002 ¶¶132-133. |

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                                          | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7...coating material has high absorption of EUV radiation relative to conventional radiation-based resists. | <p><b>Inherent Disclosure:</b> As explained by Dr. Holland, the HafSOx films of Stowers 2008 are the same as the HafSOx films of the '564 patent, i.e., they have the same components (HfOCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub>, and H<sub>2</sub>SO<sub>4</sub>) and same metal to Hf to peroxide ratio. EX1002 ¶¶115-117. Thus, they are the same films in all material respects. Accordingly, the HafSOx films of Stowers 2008 must necessarily have “high absorption of EUV radiation relative to conventional radiation-based resists,” as asserted by the '564 patent. EX1001, 8:67-9:2 (“Relative to organic resists, the inorganic coating material provides distinct advantages with respect to absorption of selected radiation...”); 11:26-27 (“HfO<sub>2</sub>+ provides good absorption of...extreme UV radiation.”).</p> <p><b>Obviousness:</b> Stowers 2008 discloses that “ZircSOx and particularly HafSOx have a higher density than other resists like...PMMA (1.19 g/cm<sup>3</sup>)” and recites their “assumed” densities of “4 g/cm<sup>2</sup> for ZircSOx and 5 g/cm<sup>3</sup> for HafSOx.” EX1008, 90; 83 (“PMMA [is] a traditional polymer electron beam resist.”). A POSA would have known that as density increases, EUV absorbance increases. Indeed, the trend is generally linear as shown below. A POSA would have known that HafSOx and ZircSOx are more absorptive of EUV radiation than conventional resists materials, like PMMA, because the POSA would have known the “assumed” densities of HafSOx and ZircSOx from Stowers 2008, and would have known that as the density increases, so does absorption of EUV. EX1002 ¶139.</p>  |

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>8...having a metal ion to radiosensitive ligand ratio of at least 2.</p>       | <p><b>Inherent Disclosure:</b> Stowers 2008 discloses precursor solutions having a Zr or Hf to peroxide ratio of 1:0.75, which is equal to 0.75 peroxide per one Zr or Hf. This peroxide content is greater than the no more than 0.5 ligand per metal recited in the claims. But, as publications from named inventor Keszler show, “[e]ven with excess peroxide in the precursor solution, the Hf:O22-ratio saturates near 2:1 in the solution, and it persists in the film.” EX1016, 5. Stated differently, even with more than 0.5 peroxide per metal in the precursor solution, the ratio saturates near 0.5 peroxide per metal, and that ratio persists in the films. EX1002 ¶119.</p> <p>Accordingly, although the precursor solutions of Stowers 2008 describe more than 0.5 peroxide per Hf or Zr, per the inventor’s own admission, it is inherent that the resulting films contain a metal to peroxide ratio of approximately 1:0.5, or “at least 2” metal ions per peroxide ligand, as claimed. EX1002 ¶120.</p> <p><b>Obviousness (Stower’s 2009):</b> Stowers 2009 discloses that “[s]olutions for spin coating were prepared by combining the ZrOCl<sub>2</sub> (aq) or HfOCl<sub>2</sub> (aq) with the remaining reagents [H<sub>2</sub>O<sub>2</sub> and H<sub>2</sub>SO<sub>4</sub>] to produce metal-to-peroxide ratios of 1:0.5.” EX1010, 19. This is a “metal ion to radiosensitive ligand ratio of at least 2.” EX1002 ¶148.</p> <p>A POSA would have been motivated to combine Stowers 2008 and Stowers 2009 because the references are by the named inventors (Jason Stowers and Douglas Keszler) and relate to the same subject matter as the ’564 patent, i.e., metal oxide sulfate films for EUV, UV and e-beam lithography. A POSA would have been motivated to incorporate the metal to peroxide ratio of Stowers 2009 into the films of Stowers 2008 with a reasonable expectation of success because Stowers 2009 reports that “[w]ith a 30-keV electron-beam, resist sensitivities as low as 8 µC/cm<sup>2</sup> have been realized.” EX1010, Abstract, Figure 1; EX1002 ¶¶148-149. In essence, using the ratio disclosed in Stowers 2009 in the precursor solutions of Stowers 2008 would have been nothing more than substituting one known ratio for another.</p> |
| <p>9...coating material has been heated to temperatures from 45° C to 150° C.</p> | <p>Claim 9 depends on claim 1 and recites that “the coating material has been heated to temperatures from 45° C to 150° C.” Stowers 2008 discloses that “[p]ositive tone patterning could be achieved by subjecting the resist to a prebake of 100° C for two min.” EX1008, 70; EX1002 ¶121.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

# Stowers 2008 Anticipates or Renders Obvious Claims 1-10 and 12

| '564 Patent Claims                                                                                                                       | Disclosures in Stowers 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10...following exposure an exposed coating region is insoluble in an aqueous solvent.                                                    | Stowers 2008 discloses developing the films “by immersion in .05-1 M HCl” (EX1008, 68), which is undisputedly an aqueous solution (id., 88 (referring to “6-12 M HCl (aq)”), and states that with HCl, “ZircSOx could be patterned by UV light in either positive or negative tone” (id., 70). EX1002 ¶122.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 12...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> . | <p><b>Inherent Disclosure:</b> As explained by Dr. Holland, the ZircSOx and HafSOx films of Stowers 2008 are the same as the ZircSOx and HafSOx films of the '564 patent, i.e., they have the same components (HfOCl<sub>2</sub> or ZrOCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub>, and H<sub>2</sub>SO<sub>4</sub>) and same metal to peroxide ratio. EX1002 ¶123. Thus, they are the same films in all material respects. Accordingly, the ZircSOx and HafSOx films of Stowers 2008 must necessarily be capable of being “effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm<sup>2</sup>,” as asserted by the '564 patent. EX1001, 23:33-41 (HafSOx patterned with with EUV dose of 80 mJ/cm<sup>2</sup>); 22:50-54 (ZircSOx patterned with 193 nm UV at a dose of 20 mJ/cm<sup>2</sup>); EX1002 ¶124.</p> <p><b>Obviousness:</b> Stowers 2008 reports that patterning of the ZircSOx “materials with electron beam lithography produced excellent results.” EX1008, 127. “ZircSOx films were exposed to determine the highest resolution obtainable with our 30 keV electron beam lithography system” and “observed that 16 nm wide isolated features can be patterned at a dose of 112 μC/cm<sup>2</sup>.” Id., 89.</p> <p>As Stowers himself confirmed in 2011, an “e-beam [or electron beam] dose of 249 μC/cm<sup>2</sup> (30 keV)...has been well characterized to correspond to an EUV dose of 25 mJ/cm<sup>2</sup>.” EX1022, 7. Thus, if an e-beam dose of 249 μC/cm<sup>2</sup> “corresponds” to an EUV dose of 25 mJ/cm<sup>2</sup>, a POSA would in turn understand that an e-beam dose of 112 μC/cm<sup>2</sup> “corresponds” to an EUV dose that is less than 25 mJ/cm<sup>2</sup>, i.e., “no more than 100 mJ/cm<sup>2</sup>.” EX1002 ¶145.</p> <p>Given that Stowers 2008 discloses effective patterning of ZircSOx with an e-beam dose corresponding to an EUV equivalent dose of less than 25 mJ/cm<sup>2</sup>, a POSA would reasonably expect that those same ZircSOx films “can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm<sup>2</sup>.” EX1002 ¶146.</p> |

- **Stowers 2008 Is Prior Art**

- Objective Evidence Shows that OSU Publication of Stowers 2008 was Publicly Available by October 2008.
- Subjective Evidence of a *Request* for an Embargo is not material.
- Whether the ProQuest Publication Was Embargoed Does Not Affect OSU Publication.

- **Disclosures of Stowers 2008**

- Stowers 2008 Inherently Discloses the Required Properties.
  - No dispute that Stowers 2008 has same precursor materials as the '564 Patent
  - Petitioner's Expert: Evaluated the minimal differences and concluded there was no material affect on properties.
  - PO's Expert: Provided generic testimony only, and did not evaluate minimal differences between Stowers 2008 and '564 Patent.

# Original Claims

## Ground 5: Trikeriotis



- **Trikeriotis Is Prior Art**

- Regardless of the publication of the paper version, the identical electronic version of Trikeriotis was publicly available on March 25, 2010, and is prior art.



*Petitioner's Expert  
Dr. Sylvia Hall-Ellis*

The **Trikeriotis paper is available** and can be downloaded from the International Society for Optical Engineering (SPIE) website and the digital repositories *ResearchGate22* and *Semantic Scholar*. The SPIE website indicates **a March 25, 2010, publication date**.



*Patrick Franzen*

9. Exhibit A to this declaration is a true and correct copy, from the SPIE Digital Library and SPIE's business records, of a paper authored by M. Trikeriotis, et al., "Development of an inorganic photoresist for DUV, EUV, and electron beam imaging," first published on the SPIE Digital Library in SPIE Proceedings Vol. 7639 titled "Advances in Resist Materials and Processing Technology XXVII," on 25 March 2010. The paper was later published in the print version of Vol. 7639 which published on 3 May 2010.

- **Trikeriotis Is Prior Art**

- Regardless of the publication of the paper version, the identical electronic version of Trikeriotis was publicly available on March 25, 2010, and is prior art.

- **Disclosures of Trikeriotis**

- Trikeriotis discloses radiation sensitive ligands, as confirmed by Ober.
- The extremely high densities of Hafnium and Zirconium demonstrate that Trikeriotis' resists have high absorption – regardless of any outliers in conventional resist absorptions.
- Trikeriotis discloses that more than 80% of the exposed film was soluble at less than 25 mJ/cm<sup>2</sup>, meeting the “effectively patterned” limitation.

- **Claim 1 – Metal Ions with Radiation Sensitive Ligands**
- **Claim 7 – High Absorption of EUV Radiation Relative to Conventional Radiation Based Resists**
- **Claim 12 – Effectively Patterned ... at a Dose of No More Than 100 mJ/cm<sup>2</sup>**

# Trikeriotis Discloses Metal Ions with Radiation Sensitive Ligands



*Petitioner's Expert  
Dr. Karey Holland*

Trikeriotis discloses that the “absorption coefficient of the films depends on the ligands.” EX1024, 18. As I described above, the absorption coefficient (also called the extinction coefficient) is an indication of the radiation sensitivity of the material. Supra, ¶ 53; EX1035, 679. Accordingly, because the absorption coefficients is dependent upon the ligand, a POSA would understand that the ligand is radiation sensitive.

Trikeriotis disclosed that “different ligands on the surface of the nanoparticles give them unique properties, allowing these films to act as positive or negative tone photoresists.” EX1024, 15. This indicates that the ligands are radiation sensitive because if the mechanism of photoactivity (i.e., sensitivity to radiation) were not dependent on the selection of the ligand, any ligand could be selected. Trikeriotis, however, explains that you can change the photoactivity by changing the ligands, which indicates that the ligands are sensitive to radiation.

## Patent Owner:

“As shown in Figure 1 below, Ober displays the “organic ligand shell” as being a coating attached to the zirconium or hafnium oxide core. EX2009, ¶58. Beneath the blown-up illustration of the nanoparticle in Figure 1 is the film, which shows a “photoactive compound” in blue that is separate and distinct from the organic ligands.”

- Ober is not part of Ground 5, but was instead relied on to show that a single limitation “the coating material can be effectively patterned” is an inherent property of the films of Trikeriotis (which were tested by Ober):

## Petitioner:

Moreover, as confirmed by Ober and Giannelis, “[w] have found that a hafnium oxide ( $\text{HfO}_2$ ) core with a diameter of 2nm, surrounded by organic ligands (binding molecules), **can be patterned at EUV wavelengths with extremely high sensitivity ( $<5\text{mJ}/\text{cm}^2$ )**.” EX1027, 1-2 (referring to the films of Trikeriotis).

# Patent Owner Points to the Later Ober Publication which Is Not Part of Ground 5

## Patent Owner:

“As shown in Figure 1 below, Ober displays the “organic ligand shell” as being a coating attached to the zirconium or hafnium oxide core. EX2009, ¶58. Beneath the blown-up illustration of the nanoparticle in Figure 1 is the film, which shows a “photoactive compound” in blue that is separate and distinct from the organic ligands.”

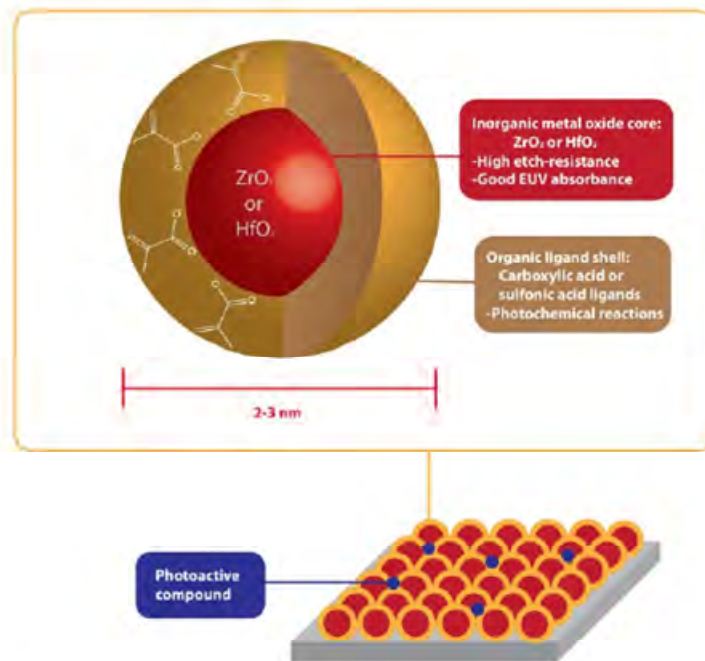


**Figure 1.** Schematic of the extreme-UV (EUV) nanoparticle photoresist with its core metal oxide and the organic ligand surrounding the core.  $\text{ZrO}_2$ : Zirconium dioxide,  $\text{HfO}_2$ : Hafnium oxide.

## Patent Owner:

“Ober further discloses that it is the “photoactive compound” that is the radiation sensitive part of the film, not the “organic ligands” that Lam pointed to in its Petition. *Id.* This is demonstrated in Figure 2 of Ober.”

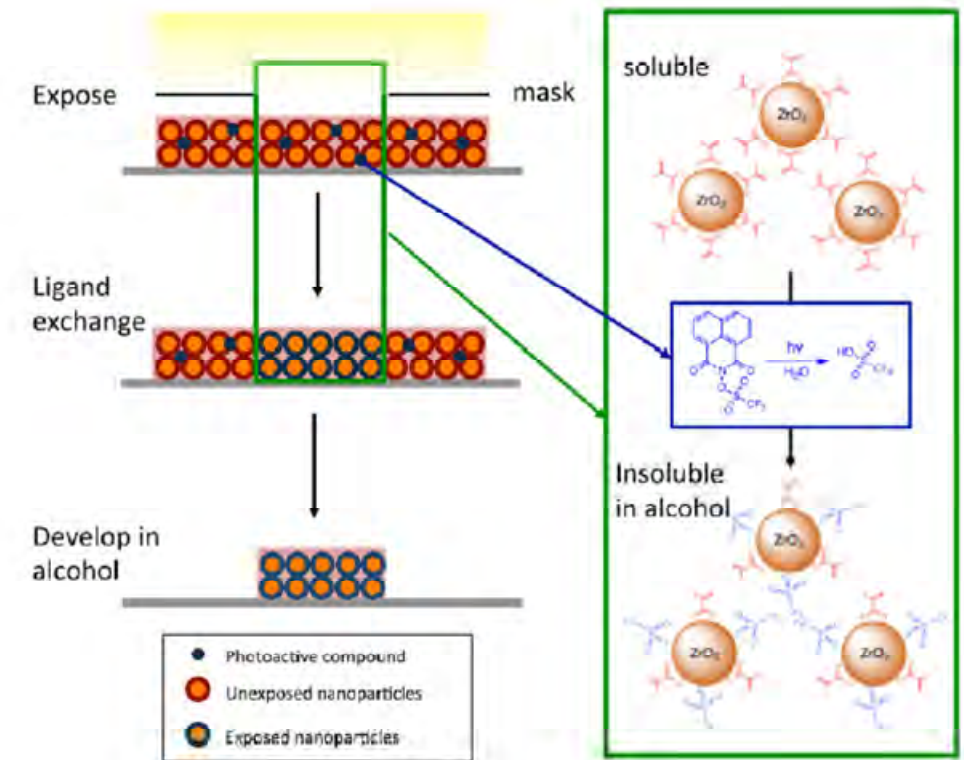


**Figure 2.** Schematic of the ligand-displacement patterning mechanism for negative-tone pattern formation.  $h\nu$ : Energy.  $\text{H}_2\text{O}$ : Water.

# Ober Supports That Trikeriotis Has Radiation Sensitive Ligands



*Petitioner's Expert  
Dr. Karey Holland*

“As shown in Figure 2, photoactive compounds (shown in blue) are cleaved after exposure to radiation.

*Id.* A ligand exchange occurs where the red ligands are displaced by the blue ligands. *Id.* Ober describes the red ligand as the “starting ligand” and the blue ligand as the “displacing ligand.”

*Id.*, 2. Accordingly, . . . both the red compound and blue photoactive compound are “ligands.””

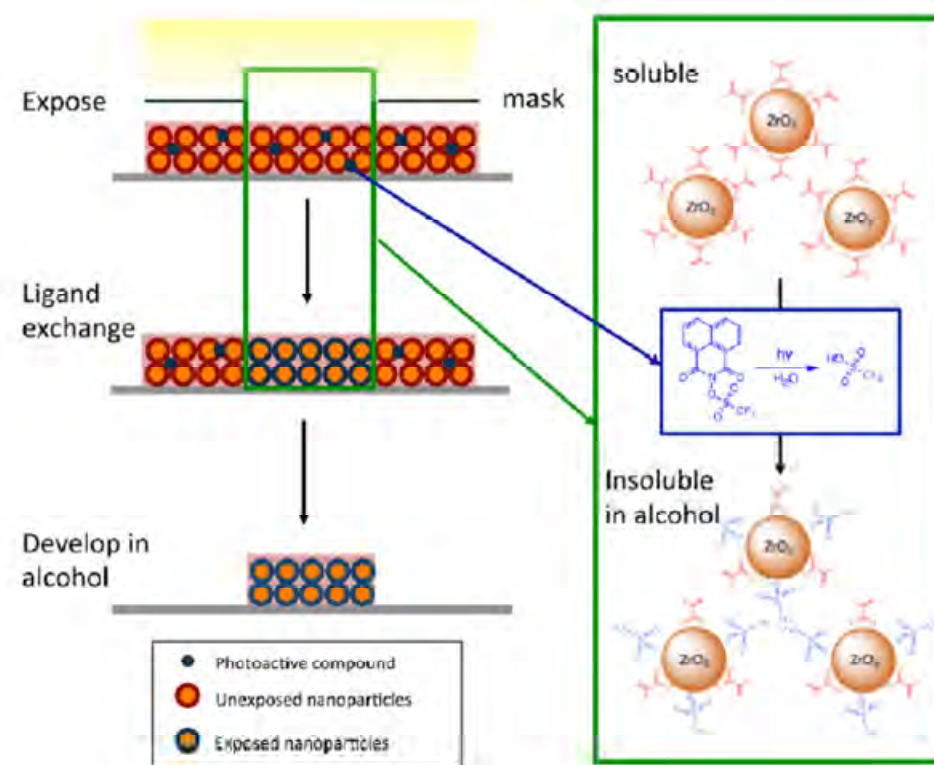


*Figure 2. Schematic of the ligand-displacement patterning mechanism for negative-tone pattern formation.  $h\nu$ : Energy.  $H_2O$ : Water.*



**Patent Owner's Expert**  
**Dr. Sanjay Banerjee**

Q. So if we look at figure 2, the caption says "Schematic of the ligand displacement patterning mechanism for negative tone patterning formation"; correct?

A. Yes.

\*\*\*

Q. So the blue ligands replace the pink ligands; is that right?

A. The blue photoactive compound byproducts displace the pink ligand.

\*\*\*

Q. And so the starting ligand is the one in pink?

A. Yes.

Q. And the displacing ligand is the one in blue; is that right?

A. That's correct.

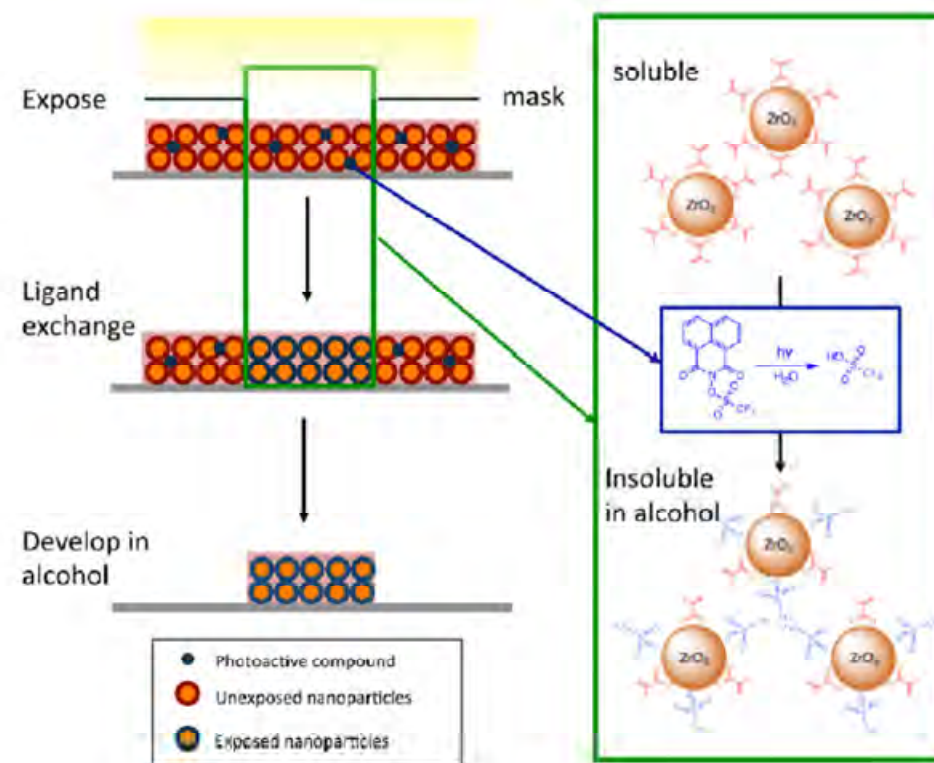


*Figure 2. Schematic of the ligand-displacement patterning mechanism for negative-tone pattern formation.  $h\nu$ : Energy.  $H_2O$ : Water.*

# Trikeriotis' Hafnium Resists Have High Absorption of EUV Radiation Relative to Conventional Resists



*Petitioner's Expert  
Dr. Karey Holland*

“A POSA would have known that as the density increases, the EUV absorbance increases. Indeed, the trend is generally linear, with the EUV absorption coefficient becoming larger as the density increases. . . . Dr. Banerjee takes issue with the outliers shown on the graph of EX1025. . . . Dr. Banerjee cherry picks these alleged outliers, without considering the context of the metal oxide resists. . . . [T]he metal oxide materials of Stowers 2008 and Trikeriotis would have a significantly higher calculated linear absorption.

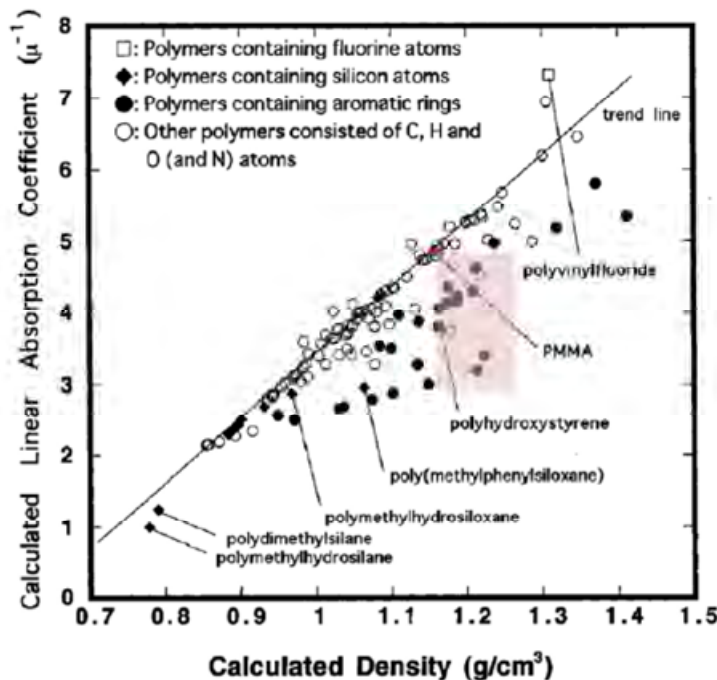
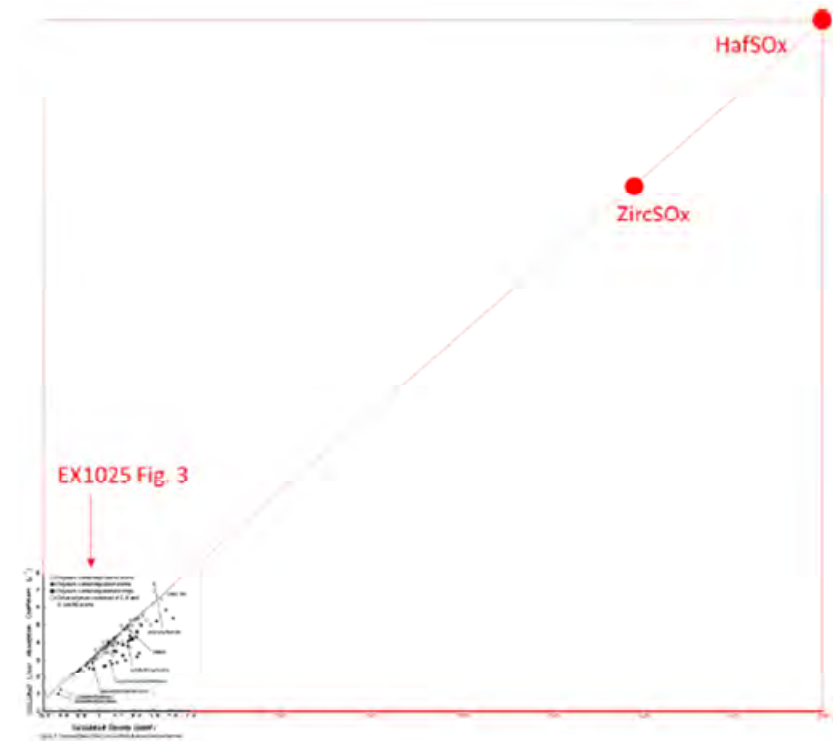


Figure 3. Calculated linear absorption coefficient versus calculated density.

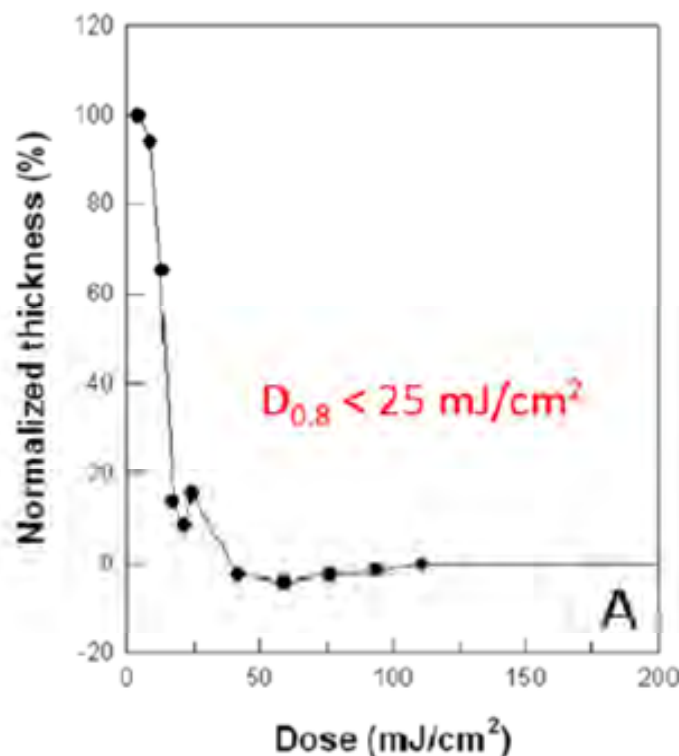


# Trikeriotis' Resists Can Be Effectively Patterned



*Petitioner's Expert  
Dr. Karey Holland*

“Figures 5 and 6 of Trikeriotis 2010, the Hf nanoparticle films can clearly be patterned in positive tone with DUV radiation dose of less than  $100 \text{ mJ/cm}^2$ . Figure 5A shows a sensitivity of less than  $25 \text{ mJ/cm}^2$ . . . . In Trikeriotis Figure 5A, at a dose of less than  $25 \text{ mJ/cm}^2$ , the normalized thickness is less than 20% (i.e., more than 80% of the exposed film was soluble), and therefore the  $D_{0.8}$  of the Trikeriotis film is  $25 \text{ mJ/cm}^2$ .”



# Disclosures of the Claims in Trikeriotis

| '564 Patent Claims                                                                                                                                                                                                                                                         | Expressly Disclosed | Inherently Disclosed | Obvious |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------------------|---------|
| 1. A structure comprising a substrate and a coating material on a surface of the substrate,                                                                                                                                                                                | Yes                 |                      |         |
| coating material comprises metal ions with radiation sensitive ligands and                                                                                                                                                                                                 | Yes                 |                      |         |
| coating material has an average thickness from 5 nm to 30 nm,                                                                                                                                                                                                              | Yes                 |                      |         |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | Yes                 |                      |         |
| 3...metal of the metal ions comprises...Zr...Hf...                                                                                                                                                                                                                         | Yes                 |                      |         |
| 6...average thickness is from 5 nm to 25 nm.                                                                                                                                                                                                                               |                     |                      | Yes     |
| 7...coating material has high absorption of EUV radiation relative to conventional radiation-based resists.                                                                                                                                                                |                     | Yes                  | Yes     |
| 9...coating material has been heated to temperatures from 45° C to 150° C.                                                                                                                                                                                                 | Yes                 |                      |         |
| 11...following exposure an exposed coating region is soluble in an organic solvent.                                                                                                                                                                                        | Yes                 |                      |         |
| 12...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> .                                                                                                                                   | Yes                 | Yes                  |         |

# Disclosures of the Claims in Trikeriotis

| '564 Patent Claims                                                                                                                                                                                                                                                         | Trikeriotis Disclosure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. A structure comprising a substrate and a coating material on a surface of the substrate,                                                                                                                                                                                | Trikeriotis discloses “[u]niform thin films can be spin-coated on Si wafers using either aqueous or PGMEA dispersions of the nanoparticles.” EX1024, 18. Trikeriotis therefore discloses a “structure comprising a substrate and a coating material on a surface of the substrate.” EX1002 ¶151.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| coating material comprises metal ions with radiation sensitive ligands and                                                                                                                                                                                                 | Trikeriotis discloses “an inorganic resist made of hafnium oxide nanoparticles that can be used both for optical (DUV or EUV) and electron beam lithography.” EX1024, 16. Trikeriotis states that “[h]afnium oxide nanoparticles are used as a core to build the inorganic nanocomposite into an imageable photoresist” and that “a variety of organic ligands can be used to control the surface chemistry of the final product.” EX1024, 15. “The absorption coefficient of the films depends on the ligand...” Id., 18 (i.e., the ligands are radiation sensitive). Therefore, Trikeriotis discloses a “coating material compris[ing] metal ions with radiation sensitive ligands.” EX1002 ¶152.                                       |
| coating material has an average thickness from 5 nm to 30 nm,                                                                                                                                                                                                              | Trikeriotis discloses that “[b]y varying the nanoparticle loading in the dispersion and the spin speed, the film thickness can be controlled...In general, film thicknesses ranging from 30 nm to 200 nm can be easily achieved.” EX1024, 18. In Figure 8, Trikeriotis “shows the SEM image of the 60 nm lines and spaces that were printed on the film. The film that was used was only 30 nm thick.” Id., 21. Trikeriotis therefore discloses that the “coating material has an average thickness from 5 nm to 30 nm.” EX1002 ¶153.                                                                                                                                                                                                     |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | Trikeriotis discloses electron beam and UV lithography of the coating material. Figure 5 of Trikeriotis shows “[c]ontrast curves of the nanoparticle films under 254 nm light exposure: positive tone (left) and negative tone (right).” EX1024, Figure 5. As to electron beam lithography, Trikeriotis discloses that “both positive tone and negative tone images could be obtained.” EX1024, 22. Trikeriotis, therefore, discloses that “exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.” EX1002 ¶¶154-155. |
| 3...metal of the metal ions comprises...Zr...Hf...                                                                                                                                                                                                                         | Claim 3 depends on claim 1 and recites that “the metal of the metal ions comprises...Hf...” Trikeriotis’ films are based on hafnium oxide. EX1002 ¶156.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

# Disclosures of the Claims in Trikeriotis

| '564 Patent Claims                                                                                          | Trikeriotis Disclosure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6...average thickness is from 5 nm to 25 nm.                                                                | <b>Obviousness:</b> Claim 6 depends on claim 1 and requires that “the average thickness is from 5 nm to 25 nm.” As noted above, in Figure 8, “the film that was used was only 30 nm thick.” EX1024, 21. It would have been within the routine skillset of a POSA to experiment with the spin rate and time to obtain the desired thickness. EX1002 ¶157.                                                                                                                                                                                                                                                                                                                                                                                                    |
| 7...coating material has high absorption of EUV radiation relative to conventional radiation-based resists. | <b>Inherent Anticipation/Obviousness:</b> Claim 7 depends on claim 1 and recites that “the coating material has high absorption of EUV radiation relative to conventional radiation-based resists.” Trikeriotis’s films are based on hafnium oxide. A POSA would know hafnium oxide has a mass density of ~9.68 g/cm <sup>3</sup> . See, e.g., EX1026, 4. As explained above in Ground 3, POSA would have also known that PMMA, a conventional organic resist, has a mass density of ~ 1.19 g/cm <sup>3</sup> . EX1008, 90. Since a POSA would have known that as the mass density increases, the EUV absorption increases (EX1025, Figure 3), a POSA would have known that hafnium oxide has a higher absorption of EUV than organic resists. EX1002 ¶158. |
| 9...coating material has been heated to temperatures from 45° C to 150° C.                                  | Claim 9 depends on claim 1 and recites that “the coating material has been heated to temperatures from 45° C to 150° C.” Trikeriotis discloses that “[f]ilms with the desired thickness are prepared and then baked at 130°C for 60 sec on a hot plate.” EX1024, 20; EX1002 ¶159.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 11...following exposure an exposed coating region is soluble in an organic solvent.                         | Claim 11 depends on claim 1 and recites that “following exposure an exposed coating region is soluble in an organic solvent.” This claim recites positive tone image developed in organic solvent. EX1002 ¶160. Trikeriotis discloses that “[f]or the positive tone imaging, the film is baked after exposure (PEB) at 130°C for 3 min and then aqueous tetrametylammonium hydroxide (TMAH) is used for the development.” EX1024, 20. TMAH is an organic compound, i.e., it contains carbon. EX1002 ¶160. Aqueous tetrametylammonium hydroxide is therefore an “organic” solvent. Id.                                                                                                                                                                       |

# Disclosures of the Claims in Trikeriotis

| '564 Patent Claims                                                                                                                       | Trikeriotis Disclosure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> . | <p><b>Express Anticipation:</b> Claim 12 depends on claim 12 and recites that “the coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm<sup>2</sup>.” Figure 5A of Trikeriotis shows that the discloses films could be patterned in positive tone with a 254 nm UV radiation dose of less than 100 mJ/cm<sup>2</sup> as it shows a sensitivity D0.8 of less than 25 mJ/cm<sup>2</sup>. EX1002 ¶161.</p> <p><b>Inherent Anticipation:</b> Moreover, as confirmed by <b>Ober</b> and Giannelis, “[w] have found that a hafnium oxide (HfO<sub>2</sub>) core with a diameter of 2nm, surrounded by organic ligands (binding molecules), can be patterned at EUV wavelengths with extremely high sensitivity (&lt;5mJ/cm<sup>2</sup>).” EX1027, 1-2 (referring to the films of Trikeriotis).</p> |

- **Trikeriotis Is Prior Art**

- Regardless of the publication of the paper version, the identical electronic version of Trikeriotis was publicly available on March 25, 2010, and is prior art.

- **Disclosures of Trikeriotis**

- Trikeriotis discloses radiation sensitive ligands, as confirmed by Ober.
- The extremely high densities of Hafnium and Zirconium demonstrate that Trikeriotis' resists have high absorption – regardless of any outliers in conventional resist absorptions.
- Trikeriotis discloses that more than 80% of the exposed film was soluble at less than 25 mJ/cm<sup>2</sup>, meeting the “effectively patterned” limitation.

# Proposed Amended Claims

## Overview



# Proposed Amended Claims

| Original '564 Patent Claim | Contingent Substitute Claim | Substitute Claim Language                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                          | 13                          | A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average thickness <u>of about 25 nm</u> <del>from 5 nm to 30 nm</del> , wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. |
| 2                          | 14                          | The structure of claim <del>13</del> wherein the metal ions comprise metal suboxide ions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 3                          | 15                          | The structure of claim <del>13</del> wherein the metal of the metal ions comprises Cu, Al, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, Y, Zr, Nb, Mo, In, Sn, Sb, Hf, Ta, W, Ir, Pt, La, Ce, Pr, Nb, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu or a combination thereof.                                                                                                                                                                                                                                                                                                               |
| 4                          | 16                          | The structure of claim <del>13</del> wherein the radiation sensitive ligands comprise peroxide ligands.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 5                          | 17                          | The structure of claim <del>13</del> wherein the coating material further comprises polyatomic anions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 6                          | N/A                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 7                          | 18                          | The structure of claim <del>13</del> wherein the coating material has high absorption of EUV radiation relative to conventional radiation-based resists.                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 8                          | 19                          | The structure of claim <del>13</del> having a <u>molar concentration ratio of radiation sensitive ligands to</u> metal ion <del>to radio-sensitive ligand ratio</del> of at least <u>about</u> 2.                                                                                                                                                                                                                                                                                                                                                                              |
| 9                          | 20                          | The structure of claim <del>13</del> wherein the coating material has been heated to temperatures from 45° C. to 150° C.                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 10                         | 21                          | The structure of claim <del>13</del> wherein following exposure an exposed coating region is insoluble in an aqueous solvent.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 11                         | 22                          | The structure of claim <del>13</del> wherein following exposure an exposed coating region is soluble in an organic solvent.                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 12                         | 23                          | The structure of claim <del>13</del> wherein the coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> .                                                                                                                                                                                                                                                                                                                                                                                           |

# Changes to the Claim Language in Claims 13 and 19

| Original '564 Patent Claim | Contingent Substitute Claim | Substitute Claim Language                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                          | 13                          | A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average thickness <u>of about 25 nm</u> <del>from 5 nm to 30 nm</del> , wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. |
| 8                          | 19                          | The structure of claim <del>13</del> having a <u>molar concentration ratio of radiation sensitive ligands to</u> metal ion <del>to radio-sensitive ligand ratio</del> of at least <u>about</u> 2.                                                                                                                                                                                                                                                                                                                                                                              |

# Proposed Amended Claims

## Lack of Written Description and Enablement



- No Written Description

- Claim 13 uses functional claiming to claim a very broad genus, *i.e.*, “ligands” that have the function of being “radiation sensitive”.
- The chemical arts are very unpredictable.
- The specification only discloses one species of ligands (peroxides), and two examples of metal/ligand coatings: HafSO<sub>x</sub> and ZircSO<sub>x</sub>.
- This minimal disclosure is insufficient to provide written description for all metal coatings with all radiation sensitive ligands.

# Written Description: Claim 13 Includes Functional Language to Claim a Genus

Claim 13: A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average thickness of about 25 nm, wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.



“When a patent claims a genus using functional language to define a desired result, ‘the specification must demonstrate that the applicant has made a generic invention that achieves the claimed result.’” *AbbVie Deutschland GmbH & Co., KG v. Janseen Biotech, Inc.*, 759 F.3d 1285, 1299 (Fed. Cir. 2014)

# Written Description of A Genus Requires Disclosure of Sufficient Species or a Structure/Function Correlation



“[W]ritten description of a broad genus requires description not only of the outer limits of the genus but also of either a representative number of members of the genus or structural features common to the members of the genus, . . . with enough precision that a relevant artisan can visualize or recognize the members of the genus. . . . We have also held that functional claim language can meet the written description requirement when the art has established a correlation between structure and function.” *Regents of Univ. of Minnesota v. Gilead Scis., Inc.*, 61 F.4th 1350, 1356 (Fed. Cir. 2023)



Where “the art is unpredictable...disclosure of more species is necessary to adequately show possession of the entire genus.” *Synthes USA, LLC v. Spinal Kinectics, Inc.*, 734 F.3d 1332, 1344 (Fed. Cir. 2013).



It is “difficult to establish” the “structure-function correlation” when art is “highly unpredictable.” *AbbVie Deutschland GmbH & Co., KG v. Janseen Biotech, Inc.*, 759 F.3d 1285, 1299 (Fed. Cir. 2014)

# The Relevant Art is Unpredictable



**Petitioner's Expert**  
Dr. Karey Holland

“A POSA would understand that the technology that is the subject of claim 13 and the remaining proposed substitute claims is highly unpredictable. . . . Chemical reactions and properties can be highly variable and difficult to predict. For example, combining certain elements or functional groups into a molecule can affect the properties of the molecule in unpredictable ways. . . . One chemical property that can be difficult to predict is whether a specific ligand will be “radiation sensitive.”



Case law confirms that chemical arts are highly unpredictable. *In re Marzocchi*, 439 F.2d 220, 223-24 (CCPA 1971); *In re Fisher*, 427 F.2d 833, 839 (CCPA 1970) (contrasting predictable mechanical and electrical elements with unpredictable chemical reactions).

# The Claimed Genus Is Extremely Large – Which Supports No Written Description

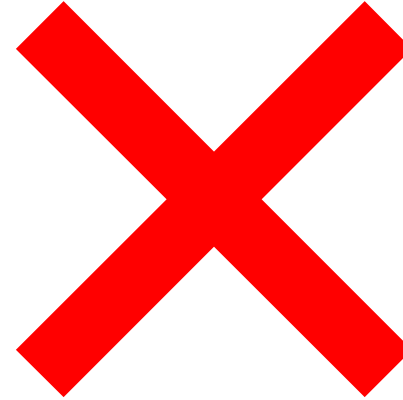


**Petitioner's Expert**  
**Dr. Karey Holland**

“A POSA would understand that, as used in the '564 patent, a “ligand” is an atom or molecule with a functional group that binds to a central atom—typically a metal—in a coordination complex. Given this understanding, a POSA would know that there are nearly an infinite number of atoms or molecules that could qualify as a ligand.”



**Patent Owner's Expert**  
**Dr. Sanjay Banerjee**



Where “the structural limitations still encompass [at least] some number of thousands of compounds” in the patentee’s “best case,” the claim’s genus is considered broad. *Idenix Pharms. LLC v. Gilead Scis. Inc.*, 941 F.3d 1149, 1157-58 (Fed. Cir. 2019)

# The Specification Discloses Only a Single Species of “Radiation Sensitive Ligands” – Peroxide Ligands



**Petitioner's Expert**  
**Dr. Karey Holland**

The specification of the '564 patent identifies only one example of “radiation sensitive ligands”: ligands with peroxide groups. EX1001, 5:45-47, 6:9-14. But a POSA would understand that a large number of other ligands could potentially be “radiation sensitive.”

## Patent Owner:

And here, the specification discloses several groups and specific species of peroxide ligands—not a single species. EX1001, 12:4-33 (describing “inorganic peroxide based ligands,” such as “peroxysulfate,” “peroxydisulfate,” “peroxychlorates,” “or the like or combinations thereof” as well as “organic compositions” or the “chemically simplest ligand...hydrogen peroxide”), 15:33-50.

Third, Lam ignores the specification's description of the peroxide group's structure and description of condensation reactions initiated by “break[ing] the oxygen-oxygen bond.” *Id.*, Fig. 1; 3:6-9; 7:57-8:5; 12:13-19 (describing “peroxide group, —O—O—.”).

# The Specification Discloses Only Two Species of “Metal Ions with Radiation Sensitive Ligands” – Hafnium and Zirconium with Hydrogen Peroxide



*Petitioner's Expert  
Dr. Karey Holland*

The specification of the '564 patent identifies **only two examples** of “metal ions with radiation sensitive ligands.” EX1001, 21:12-23:41. These two examples are (1) **hafnium ions with ligands made from hydrogen peroxide**, and (2) **zirconium ions with ligands made from hydrogen peroxide**. EX1001, 21:12-23:41.

# One or Two Examples Is Not Sufficient to Meet the Written Description Requirement

## Petitioner:

Where the art is unpredictable, as here, disclosing a single species is insufficient to support generic claims. *Juno Therapeutics, Inc. v. Kite Pharma, Inc.*, 10 F.4th 1330, 1340-42 (Fed. Cir. 2021) (no written description where patent “discloses only one CD19-specific scFv” but claimed “genus of functional CD19-specific scFvs”); *AbbVie*, 759 F.3d at 1300; see *Enzo Biochem, Inc. v. Gen-Probe Inc.*, 323 F.3d 956, 967 (Fed. Cir. 2002) (specification’s lack of “a sufficient number of species” failed to show “the inventors...had possession of the breadth of the genus, as opposed to merely one or two such species”).

# One or Two Examples Is Not Sufficient to Meet the Written Description Requirement

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Where the art is unpredictable, as here, disclosing a single species is insufficient to support generic claims. *Juno Therapeutics, Inc. v. Kite Pharma, Inc.*, 10 F.4th 1330, 1340-42 (Fed. Cir. 2021) (no written description where patent “discloses only one CD19-specific scFv” but claimed “genus of functional CD19-specific scFvs”); *AbbVie*, 759 F.3d at 1300; see *Enzo Biochem, Inc. v. Gen-Probe Inc.*, 323 F.3d 956, 967 (Fed. Cir. 2002) (specification’s lack of “a sufficient number of species” failed to show “the inventors...had possession of the breadth of the genus, as opposed to merely one or two such species”).

PO cites to *Hynix Semiconductor Inc. v. Rambus Inc.*, 645 F.3d 1336, 1352 (Fed. Cir. 2011), for the proposition that a single species can describe a genus. Reply at 1-2. *Hynix* is entirely inapposite. In *Hynix*, the art was predictable—relating to a physical electronic “bus” structure—and “the supposed genus consists of only two species, a multiplexed and a non-multiplexed bus.” 645 F.3d at 1352. This stands in stark contrast to the genus here, which encompasses a notably larger number of potential species within an unpredictable field of art. EX1040 ¶¶ 145-146. These facts confirm the lack of written description here. See *Idenix Pharms. LLC v. Gilead Scis. Inc.*, 941 F.3d 1149, 1157-58 (Fed. Cir. 2019); *AbbVie Deutschland GmbH & Co., KG v. Janseen Biotech, Inc.*, 759 F.3d 1285, 1299 (Fed. Cir. 2014).

# Specification Must Provide Description of Effective vs. Ineffective Ligands

## Petitioner:

[T]he Federal Circuit’s holding *Idenix* is dispositive. In *Idenix*, the Court explained that “written description of an invention involving **a chemical genus...requires a precise definition**, such as by structure, formula, [or] **chemical name** of the claimed subject matter sufficient to distinguish it” and held that the asserted claims were invalid because “**the specification...provides no method of distinguishing effective from ineffective compounds** for the compounds reaching beyond the formulas disclosed in the [asserted patent].” *Idenix*, 941 F. 3d at 1164 (internal quotations omitted).

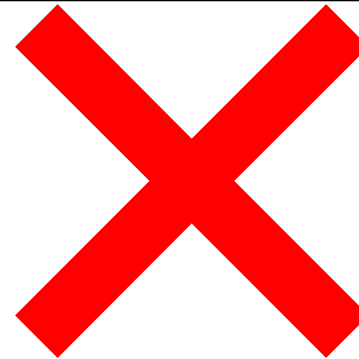


**Petitioner’s Expert**  
Dr. Karey Holland

“For example, combining certain elements or functional groups into a molecule can affect the properties of the molecule in unpredictable ways. . . . One chemical property that can be difficult to predict is whether a specific ligand will be “radiation sensitive.”



**Patent Owner’s Expert**  
Dr. Sanjay Banerjee



# No Structure/Function Correlation

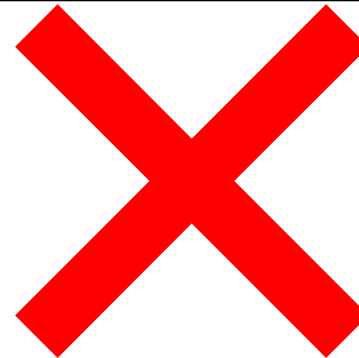


**Petitioner's Expert**  
*Dr. Karey Holland*

"[T]he specification of the '564 patent does not provide any common structural features of ligands that result in "radiation sensitive" functionality. See EX1001. Aside from identifying the example of peroxide ligands, nothing in the specification discusses any structures of ligands that provide ligands with radiation sensitivity. *Id.*"

\*\*\*

"The specification of the '564 patent also does not identify any common structures of coating materials that provide functionality wherein "exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material." See EX1001. Due to the lack of disclosure of any common structural features, the '564 patent does not adequately describe the full scope of claimed coating materials."



**Patent Owner's Expert**  
*Dr. Sanjay Banerjee*

- No Written Description

- Claim 13 uses functional claiming to claim a very broad genus, *i.e.*, “ligands” that have the function of being “radiation sensitive”.
- The chemical arts are very unpredictable.
- The specification only discloses one species of ligands (peroxides), and two examples of metal/ligand coatings: HafSO<sub>x</sub> and ZircSO<sub>x</sub>.
- This minimal disclosure is insufficient to provide written description for all metal coatings with all radiation sensitive ligands.

- No Enablement

- Given the lack of working examples, a POSA would have to make and test combinations of metal/ligand coatings to practice the full scope of the claims.
- The required, iterative testing is extensive and arduous and constitutes undue experimentation.

# The Broad Functional Genus Lacks Enablement



“In unpredictable art areas, [the Federal Circuit] has refused to find broad generic claims enabled by specifications that demonstrate the enablement of only one or a few embodiments and do not demonstrate with reasonable specificity how to make and use other potential embodiments across the full scope of the claim.”

*PPG Indus., Inc. v. Guardian Indus. Corp.*, 75 F.3d 1558, 1564 (Fed. Cir. 1996).



“A claim is not enabled when, ‘at the effective filing date of the patent, one of ordinary skill in the art could not practice their full scope without undue experimentation.’”

*Idenix Pharms. LLC v. Gilead Scis. Inc.*, 941 F.3d 1149, 1154 (Fed. Cir. 2019)

## Petitioner:

Enablement requires more than simply providing POSAs a “research assignment[]” to “create a wide range of candidate[s]” and “then screen each to see which happen to” have the claimed functionality. *Amgen Inc. v. Sanofi*, 598 U.S. 594, 614 (2023). A mere “starting point” from which POSAs must “engage in an iterative, trial-and-error process to practice the claimed invention,” as presented by the substitute claims, is not enabling. *Wyeth*, 720 F.3d at 1386.

# The '564 Patent Requires Undue Experimentation to Practice the Full Scope



***Petitioner's Expert***  
***Dr. Karey Holland***

The specification of the '564 patent identifies **only two examples** of “metal ions with radiation sensitive ligands.” EX1001, 21:12-23:41. These two examples are (1) hafnium ions with ligands made from hydrogen peroxide, and (2) zirconium ions with ligands made from hydrogen peroxide. EX1001, 21:12-23:41.

\*\*\*

However, a POSA **would not know which other combinations of metal ions and ligands** resulted in “metal ions with radiation sensitive ligands.” In order to make and use the full scope of the invention, **a POSA would have to repeatedly make photoresists using a combination of metal ions and ligands, and then test each and every combination** in order to determine if the ligands were radiation sensitive. Given, (1) the **sophisticated materials and equipment involved** in the manufacture of photoresists, and (2) the **near-infinite number of potential combinations** of metal ions and ligands, the required testing would be a lengthy and arduous process, and would **qualify as undue experimentation**.

# The '564 Patent Requires Undue Experimentation to Practice the Full Scope



**Patent Owner's Expert**  
*Dr. Sanjay Banerjee*

**Q** Is there something in the '564 patent specification that would help you determine whether a particular ligand is a radiation sensitive ligand suitable for use in the structure of claim 1 of the '564 patent?

**A** Yeah. If the POSA was a synthetic chemist, he or she could, you know, mix up this precursor solution and then expose that resist and then measure the etch rate and the developer and compare them between the exposed and the nonexposed parts. That would be one experimental technique that you could use.

**Q** So a POSA would need to test by creating the precursor solution and exposing that resist and then measuring the etch rate and the development and compare to understand whether a ligand is radiation sensitive such that it is suitable for use in claim 1 of the '564 patent?

\*\*\*

**A** I've not discussed any of that or analyzed any of that in my report, but in general the answer is yes. R&D takes time.

- **Enablement**

- Given the lack of working examples, a POSA would have to make and test combinations of metal/ligand coatings to practice the full scope of the claims.
- This testing is extensive and arduous, requiring undue experimentation.

# Proposed Amended Claims

## Indefiniteness



- **Claims 13-23: “About 25 nm”**
  - The specification does not provide guidance as to the variation permitted by “about 25 nm,” and PO’s Expert provided no testimony on the subject.

# Claims 13-23: “About 25 nm” is Indefinite

## Petitioner:

The term “about” is indefinite where the specification fails to give sufficient guidance to construe the magnitude of variation permitted. *See Amgen, Inc. v. Chugai Pharm. Co., Ltd.*, 927 F.2d 1200, 1217–18 (Fed. Cir. 1991); *Synthes (USA) v. Smith & Nephew, Inc.*, 547 F. Supp. 2d 436 (E.D. Pa. 2008).

## Examiner's Rejection:

4. Claims 1-7 and 21-25 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention. Instant claims 1-7 and 21-26 recite the term, “about” The term “about” in claims 1, 6, 21, 22 and 25 is a relative term which renders the claim indefinite. The term “about” is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention. Appropriate correction is required.

# Claims 13-23: “About 25 nm” is Indefinite



***Petitioner's Expert***  
***Dr. Karey Holland***

[N]othing in the specification informs a POSA as to the amount of deviation or variation that is permitted or contemplated by the use of the modifier “about.” See EX1001. It is unclear whether “about” 25 nm would allow 1% deviation from 25 nm, 5% deviation, 10% deviation, 25% deviation, or some other range. Simply put, the range of thicknesses permitted by the “about 25 nm” limitation would not be clear to a POSA.



***Patent Owner's Expert***  
***Dr. Sanjay Banerjee***

Q Would about, an average thickness of about 1 micron include 1.1 microns thickness?

\*\*\*

A I don't believe I have opined on, on the range of thicknesses we should qualify as about. That would depend on the context.

\*\*\*

Q In the context of the '867 application would about, an average thickness of about 1 micron include an average thickness of 1.1 microns?

\*\*\*

A I've not opined on, you know, the degree of fuzziness about that 1 micron number which would count as about. Once again, that depends on the context I think.

# Claims 13-23: “About 25 nm” is Indefinite

## Preliminary Guidance:

We are not persuaded that Dr. Banerjee’s refusal or inability to answer questions during cross-examination about whether particular values fall within or outside the scope of “about 25 nm” is determinative on the question of indefiniteness. Ex. 1033, 92:8–13, 115:2–116:3, 121:7–11, 123:19–126:16. For example, Petitioner does not show that this line of questioning falls within the scope of his direct examination, as presented in his supporting declaration (Ex. 2009), and, therefore, it is unsurprising that Dr. Banerjee was unprepared or unwilling to answer these questions.

At this juncture, therefore, we preliminarily find that Petitioner has not established a reasonable likelihood that one of ordinary skill in the art would not have been able to discern the scope of “about 25 nm,” as recited in proposed substitute claim 13, with reasonable certainty. However, we encourage the parties to address this issue should Patent Owner further pursue proposed substitute claims 13–23.

# Summary of Petitioner's Indefiniteness Positions

- Claims 13-23: “About 25 nm”
  - The specification does not provide guidance as to the variation permitted by “about 25 nm,” and PO’s Expert provided no testimony on the subject.
- **Claims 13-14 and 16-23: “Metal Ions”**
  - The specification includes certain metalloids and non-metals as examples of “metals,” but provides no guidance on how to determine which extra elements are included.

# Claims 13-14 and 16-23: Term “Metal Ions” Is Indefinite

## '564 Patent

Further tuning of the composition for radiation absorption can be adjusted based on the addition of **other metal ions**. For example, one or more ions (cations or anions) comprising titanium, zinc, calcium, indium, tin, **antimony**, bismuth or combinations thereof can be added to the precursor solution to form a coating material with an absorption edge moved to longer wavelengths, to provide, for example, sensitivity to 248 nm wavelength ultraviolet light. **Also**, one or more ions (cations or anions) comprising magnesium, **boron**, calcium, aluminum, **silicon**, *phosphorous* or combinations thereof can be used to increase the absorption cross section at shorter wavelengths.

**PERIODIC TABLE**

Legend:

- Metals
- Nonmetals
- Metalloids

'564 Patent

# Claims 13-14 and 16-23: Term “Metal Ions” Is Indefinite



**Petitioner's Expert**  
**Dr. Karey Holland**

The **standard periodic table** that is well known to those in field, and even to students just beginning to learn about chemistry, **identifies each element as a metal, metalloid, or nonmetal**. . . . Typically, a POSA would understand the term “metal” to refer to elements identified as “metals” on the periodic table. However, **the specification of the '564 patent provides some examples of elements that it refers to as “metals” that a POSA would understand to be either metalloids or nonmetals**. . . . Accordingly, a POSA would be **unable to determine which additional elements should fall within the scope of “metals.”**

|                      |                       |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          |                         |                        |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
|----------------------|-----------------------|-----------------------|----------------------------|----------------------|-------------------------|------------------------|-----------------------|-------------------------|---------------------------|--------------------------|--------------------------|-----------------------|------------------------|------------------------|--------------------------|-------------------------|------------------------|-----------------------|--------------------------|-----------------------|------------------------|-----------------------|-----------------------|------------------------|-----------------------|-------------------------|-------------------------|----------------------|--------------------------|-----------------------|-------------------------|
| 1<br>H<br>Hydrogen   |                       |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          |                         | 2<br>He<br>Helium      |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 3<br>Li<br>Lithium   | 4<br>Be<br>Beryllium  |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          | 5<br>B<br>Boron         | 6<br>C<br>Carbon       | 7<br>N<br>Nitrogen    | 8<br>O<br>Oxygen         | 9<br>F<br>Fluorine    | 10<br>Ne<br>Neon       |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 11<br>Na<br>Sodium   | 12<br>Mg<br>Magnesium |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          | 13<br>Al<br>Aluminum    | 14<br>Si<br>Silicon    | 15<br>P<br>Phosphorus | 16<br>S<br>Sulfur        | 17<br>Cl<br>Chlorine  | 18<br>Ar<br>Argon      |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 19<br>K<br>Potassium | 20<br>Ca<br>Calcium   | 21<br>Sc<br>Scandium  | 22<br>Ti<br>Titanium       | 23<br>V<br>Vanadium  | 24<br>Cr<br>Chromium    | 25<br>Mn<br>Manganese  | 26<br>Fe<br>Iron      | 27<br>Co<br>Cobalt      | 28<br>Ni<br>Nickel        | 29<br>Cu<br>Copper       | 30<br>Zn<br>Zinc         | 31<br>Ga<br>Gallium   | 32<br>Ge<br>Germanium  | 33<br>As<br>Arsenic    | 34<br>Se<br>Selenium     | 35<br>Br<br>Bromine     | 36<br>Kr<br>Krypton    |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 37<br>Rb<br>Rubidium | 38<br>Sr<br>Strontium | 39<br>Y<br>Yttrium    | 40<br>Zr<br>Zirconium      | 41<br>Nb<br>Niobium  | 42<br>Mo<br>Molybdenum  | 43<br>Tc<br>Technetium | 44<br>Ru<br>Ruthenium | 45<br>Rh<br>Rhodium     | 46<br>Pd<br>Palladium     | 47<br>Ag<br>Silver       | 48<br>Cd<br>Cadmium      | 49<br>In<br>Indium    | 50<br>Sn<br>Tin        | 51<br>Sb<br>Antimony   | 52<br>Te<br>Tellurium    | 53<br>I<br>Iodine       | 54<br>Xe<br>Xenon      |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 55<br>Cs<br>Cesium   | 56<br>Ba<br>Barium    | 57<br>La<br>Lanthanum | 72<br>Hf<br>Hafnium        | 73<br>Ta<br>Tantalum | 74<br>W<br>Tungsten     | 75<br>Re<br>Rhenium    | 76<br>Os<br>Osmium    | 77<br>Ir<br>Iridium     | 78<br>Pt<br>Platinum      | 79<br>Au<br>Gold         | 80<br>Hg<br>Mercury      | 81<br>Tl<br>Thallium  | 82<br>Pb<br>Lead       | 83<br>Bi<br>Bismuth    | 84<br>Po<br>Polonium     | 85<br>At<br>Astatine    | 86<br>Rn<br>Radon      |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
| 87<br>Fr<br>Francium | 88<br>Ra<br>Radium    | 89<br>Ac<br>Actinium  | 104<br>Rf<br>Rutherfordium | 105<br>Db<br>Dubnium | 106<br>Sg<br>Seaborgium | 107<br>Bh<br>Bohrium   | 108<br>Hs<br>Hassium  | 109<br>Mt<br>Meitnerium | 110<br>Ds<br>Darmstadtium | 111<br>Rg<br>Roentgenium | 112<br>Cn<br>Copernicium | 113<br>Nh<br>Nihonium | 114<br>Fl<br>Flerovium | 115<br>Mc<br>Moscovium | 116<br>Lv<br>Livermorium | 117<br>Ts<br>Tennessine | 118<br>Og<br>Oganesson |                       |                          |                       |                        |                       |                       |                        |                       |                         |                         |                      |                          |                       |                         |
|                      |                       |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          |                         |                        | 58<br>Ce<br>Cerium    | 59<br>Pr<br>Praseodymium | 60<br>Nd<br>Neodymium | 61<br>Pm<br>Promethium | 62<br>Sm<br>Samarium  | 63<br>Eu<br>Europium  | 64<br>Gd<br>Gadolinium | 65<br>Tb<br>Terbium   | 66<br>Dy<br>Dysprosium  | 67<br>Ho<br>Holmium     | 68<br>Er<br>Erbium   | 69<br>Tm<br>Thulium      | 70<br>Yb<br>Ytterbium | 71<br>Lu<br>Lutetium    |
|                      |                       |                       |                            |                      |                         |                        |                       |                         |                           |                          |                          |                       |                        |                        |                          |                         |                        | 90<br>Th<br>Thorium   | 91<br>Pa<br>Protactinium | 92<br>U<br>Uranium    | 93<br>Np<br>Neptunium  | 94<br>Pu<br>Plutonium | 95<br>Am<br>Americium | 96<br>Cm<br>Curium     | 97<br>Bk<br>Berkelium | 98<br>Cf<br>Californium | 99<br>Es<br>Einsteinium | 100<br>Fm<br>Fermium | 101<br>Md<br>Mendelevium | 102<br>No<br>Nobelium | 103<br>Lr<br>Lawrencium |

Metals

Nonmetals

Metalloids

- Metals
- Nonmetals
- Metalloids

# Summary of Petitioner's Indefiniteness Positions

- **Claims 13-23: “About 25 nm”**
  - The specification does not provide guidance as to the variation permitted by “about 25 nm,” and PO’s Expert provided no testimony on the subject.
- **Claims 13-14 and 16-23: “Metal Ions”**
  - The specification includes certain metalloids and non-metals as examples of “metals,” but provides no guidance on how to determine which extra elements are included.
- **Claims 18 and 23: Terms of Degree**
  - “High absorption” and “effectively patterned” are subjective comparisons and the specification provides no guidance on how to determine if these comparisons are met.

# Claims 18 and 23: Terms of Degree Are Indefinite

Claim 18: The structure of claim 13 wherein the coating material has **high absorption** of EUV radiation **relative to conventional radiation-based resists**.

Claim 23: The structure of claim 13 wherein the coating material can be **effectively patterned** with UV radiation or EUV radiation at a dose of no more than  $100 \text{ mJ/cm}^2$ .

## Petitioner:

For a term of degree to be definite, “the patent **must provide ‘some standard for measuring that degree’** such that the claim language ‘provide[s] enough certainty to one of skill in the art when read in the context of the invention.’” *GE Lighting Sols., LLC v. Lights of Am. Inc.*, 663 F. App’x 938, 940 (Fed. Cir. 2016). Otherwise, the claim scope “depends on the unpredictable vagaries of any one person’s opinion” and is indefinite. *Biosig Instruments, Inc. v. Nautilus, Inc.*, 783 F.3d 1374, 1381 (Fed. Cir. 2015).

## Claims 18 and 23: Terms of Degree Are Indefinite



**Petitioner's Expert**  
*Dr. Karey Holland*

[T]he specification provides no guidance as to what level of increased absorption qualifies as “high absorption” as required by claim 18. EX1001. The term “high absorption” is not found anywhere in the specification. And while a POSA would understand that the absorption of the claimed resist must be higher than the absorption of a conventional resist, a POSA would have no way to determine how much higher is needed to qualify as “high absorption”—e.g., whether a 10%, 20%, 50%, etc. increase in absorption was needed.

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While a POSA would understand whether or not a coating material could be “patterned” at all—a POSA would have no way to determine whether a coating material could be “effectively patterned.” The specification of the '564 patent does not provide any guidance as to how to determine “effective patterning.” EX1001. There is no test for effective patterning described in the specification, nor is there any description of characteristics that can be used to determine whether such patterning is “effective.” *Id.* Instead, whether a coating material could be “effectively patterned” could only be a subjective determination which could differ according to the evaluator.

# Summary of Petitioner's Indefiniteness Positions

- **Claims 13-23: “About 25 nm”**
  - The specification does not provide guidance as to the variation permitted by “about 25 nm,” and PO’s Expert provided no testimony on the subject.
- **Claims 13-14 and 16-23: “Metal Ions”**
  - The specification includes certain metalloids and non-metals as examples of “metals,” but provides no guidance on how to determine which extra elements are included.
- **Claims 18 and 23: Terms of Degree**
  - “High absorption” and “effectively patterned” are subjective comparisons and the specification provides no guidance on how to determine if these comparisons are met.
- **Claims 13-23: *IPXL* Mixed-Claim Types**
  - The claimed structures include steps requiring “exposure” and that the structure “has been heated,” and mixed apparatus/method claims are indefinite.

# Claims 13-23: Mixed-Claim Types Are Indefinite

Claim 13: A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average thickness of about 25, wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.

Claim 20: The structure of claim 13 wherein the coating material has been heated to temperatures from 45° C. to 150° C..

## Petitioner:

When a single claim is directed to an apparatus or article, but requires a method step, the claim is indefinite. *IPXL Holdings, LLC v. Amazon.com, Inc.*, 430 F.3d 1377 (Fed. Cir. 2005). Such a claim is indefinite because “it is unclear whether infringement [] occurs when one creates a system...or whether infringement occurs when the user actually” uses the system to perform the method step. *Id.* at 1384.

## Claims 13-23: Mixed-Claim Types Are Indefinite



**Petitioner's Expert**  
*Dr. Karey Holland*

A POSA would understand that this “wherein” clause requires a method step—e.g., “exposure of the coating material to UV, EUV and/or electron-beam radiation.” However, in my opinion, a POSA would not recognize any of the structures recited in claim 13 as performing the claimed exposure step. Specifically, the “exposure” step would necessarily be performed by a system that creates radiation—for example, the devices described at EX1001, 15:65-16:12—and then directs the radiation onto the coating material.

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A POSA would understand that this “wherein” clause requires a method step—e.g., “heat[ing]” the coating material “to temperatures from 45° C. to 150° C.” Again, in my opinion, a POSA would not recognize any of the claimed structures as performing the claimed heating step. Specifically, the “heat[ing]” step would necessarily be performed by an unclaimed heating element which would include a controllable heat source.

# Conclusion: The Proposed Substitute Claims Are Indefinite

- **Claims 13-23: “About 25 nm”**
  - The specification does not provide guidance as to the variation permitted by “about 25 nm,” and PO’s Expert provided no testimony on the subject.
- **Claims 13-14 and 16-23: “Metal Ions”**
  - The specification includes certain metalloids and non-metals as examples of “metals,” but provides no guidance on how to determine which extra elements are included.
- **Claims 18 and 23: Terms of Degree**
  - “High absorption” and “effectively patterned” are subjective comparisons and the specification provides no guidance on how to determine if these comparisons are met.
- **Claims 13-23: *IPXL* Mixed-Claim Types**
  - The claimed structures include steps requiring “exposure” and that the structure “has been heated,” and mixed apparatus/method claims are indefinite.

# Proposed Amended Claims

## Stowers 2008 and Trikeriotis





- **New Range Limitation: “About 25 nm”**
  - Stowers 2008 anticipates the “about 25 nm” limitation.
  - Stowers 2008 renders the “about 25 nm” limitation obvious.
  - Trikeriotis renders the “about 25 nm” limitation obvious.

# Stowers 2008 Discloses HafSOx and ZircSOx Films of 2-500 nm and 30-35 nm

Claim 13: A structure comprising a substrate and a coating material on a surface of the substrate, wherein the coating material comprises metal ions with radiation sensitive ligands and wherein the coating material has an average **thickness of about 25 nm**, wherein exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material.

## Stowers 2008:

Work in direct patterning was initiated after the development of the thin-film chemistry of the material HafSOx [1]. HafSOx is an aqueous solution-deposited material based on various compositions of hafnium oxide sulfate that was initially designed as a high-k dielectric. HafSOx, and its zirconium analog ZircSOX, can be deposited in films ranging in thickness from 2 to 500 nm. The films are characterized

## Stowers 2008:

combined to produce a working solution which were directly spin coated. Working solutions were prepared by combining the  $\text{ZrOCl}_2$  (aq) or  $\text{HfOCl}_2$  (aq) with  $\text{H}_2\text{O}_2$  (aq) to give a metal to peroxide ratio of 1 to 0.75. The solution was allowed to rest for 15 min. to enable ligand exchange to approach equilibrium. Following this,  $\text{H}_2\text{SO}_4$  (aq) was added to give a metal to sulfate ratio of 1 to 0.5-0.7. Again the solution was allowed to rest for 15 min to enable ligand exchange to reach equilibrium. Solutions were diluted with 18 M $\Omega$  purified water to give a final metal concentration of 0.5 M.

Substrates were either silicon wafer chips ( $n^+$  heavily doped) or silicon coupons with 200 nm of thermal oxide. The substrates for UV exposure were prepared for spincoating by sonication in Decon Labs, Contrad 70 at 45°C for 60 min. Substrates for EUV exposure were prepared by immersion in a fresh piranha etch solution (3 parts  $\text{H}_2\text{SO}_4$  to 2 parts  $\text{H}_2\text{O}_2$ ) for 1 min. Working solutions were spin coated at 3000 rpm for 30 seconds resulting in films 30 to 35-nm thick.

# Stowers 2008 Anticipates “about 25 nm”

“[T]he evidence showed that the claimed amount of 100 mg was not critical compared to the prior art's disclosure of between 20 and 175 mg EDTA. The clear and convincing evidence at trial ‘reveal[ed] a minimal difference between the [prior art] range . . . and the [claimed value].’ . . . ‘[O]ne of ordinary skill would interpret [prior art range] as clearly disclosing [the claimed value] as an acceptable choice within that range.’” *Warner Chilcott Co., LLC v. Teva Pharmaceuticals USA, Inc.*, 89 F.Supp.3d 641 (2015) (finding a claim directed to 100 mg anticipated by a range of 20 to 175 mg).

## Stowers 2008:

### Stowers 2008:

Work in direct patterning was initiated after the development of the thin-film chemistry of the material HafSOx [1]. HafSOx is an aqueous solution-deposited material based on various compositions of hafnium oxide sulfate that was initially designed as a high-k dielectric. HafSOx, and its zirconium analog ZircSOX, can be deposited in films ranging in thickness from 2 to 500 nm. The films are characterized

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# Stowers 2008 Renders “about 25 nm” Obvious



*In re Peterson*, 315 F.3d 1325, 1330 (Fed. Cir. 2003) (“encompassing ranges shifts the burden to the applicant”).



**Petitioner’s Expert**  
**Dr. Karey Holland**

[A] POSA would have recognized that film thickness is a variable that a POSA would have been motivated to optimize. For example, A POSA would have known that pattern collapse, which refers to the deformation of photoresist lines that occurs during the development process, was an issue that needed to be mitigated. See, e.g., EX1012 at Abstract (“However for sub 100 nm line width patterns, the pattern collapse, generated during the drying step of the developing process, becomes a serious limiting phenomenon.”). A POSA would have recognized that film thickness was one parameter that could be optimized to help avoid pattern collapse. *Id.*, 1 (“Two solutions allow avoiding pattern collapse: decreasing the resist thickness or change the dry process step.”); *id.*, 8 (“we have shown that the mode of pattern collapse depends on the pattern height”).

Given the ease with which film thickness can be varied, e.g., by adjusting spin rates and times (EX1008, 6; EX1001, 14:30-32), finding an optimum thickness range to mitigate pattern collapse would have required nothing more than routine experimentation. Indeed, Stowers 2008 already teaches that depositing films “at 3000 rpm for 30 seconds result[ed] in films 30 to 35-nm thick.” EX1008, 70; see also *id.*, 86 (“HafSO<sub>x</sub> has been deposited as thin as 2-3 nm in a film.”). Thus, a POSA could have easily deposited the claimed coatings at a thickness of about 25 nm based on the teachings of Stowers 2008 with routine experimentation.

# Trikeriotis Renders “about 25 nm” Obvious



**Petitioner's Expert**  
**Dr. Karey Holland**

Trikeriotis discloses that “film thicknesses ranging from 30 nm to 200 nm can be easily achieved.” EX1024, 18. Although Trikeriotis was testing a variety of film thicknesses, including those thicker than 30 nm, Trikeriotis explained that “[t]he trend of ever decreasing feature sizes in subsequent lithography generations is paralleled by the need to reduce resist thickness to prevent pattern collapse.” EX1024, 15. This is consistent with a POSA’s understand that film thickness should be reduced to avoid pattern collapse. *E.g.*, EX1012, 8 (“pattern collapse depends on the pattern height”). Accordingly, as discussed above a POSA would have recognized that film thickness is a variable that a POSA would have been motivated to optimize.

Given the ease with which film thickness can be varied, *e.g.*, by adjusting spin rates and times (EX1008, 6; EX1001, 14:30-32), finding an optimum thickness range to mitigate pattern collapse would have required nothing more than routine experimentation. Indeed, Dr. Banerjee stated during his deposition that optimizing the thickness “is not rocket science[,] [i]t’s not extensive experimentation by any means.” EX1033, 75:5-11. Thus, a POSA could have easily deposited the claimed coatings at a thickness of about 25 nm based on the teachings of [Trikeriotis] with routine experimentation.

# Petitioner Does Not Rely on Inherency for the Thickness Limitation

## Preliminary Guidance:

The record here, however, is not so clear. To arrive at the claimed value of “about 25 nm,” Petitioner relies on an inherency theory that Stowers 2008 would have prompted an ordinarily skilled artisan “to reduce Stowers 2008’s 30 nm thickness to avoid pattern collapse.” Opp. 15. We are not persuaded at this juncture that the evidence cited by Petitioner adequately supports that inherency theory. *Id.* (citing Ex. 1009, 265; Ex. 1040 ¶¶ 130–132).

## Preliminary Guidance:

Petitioner asserts that Trikeriotis teaches a film thickness of 30–200 nm and that “[t]he trend of ever decreasing feature sizes in subsequent lithography generations is paralleled by the need to reduce resist thickness to prevent pattern collapse.” Opp. 16 (citing Ex. 1024, 15, 18) (emphasis omitted, alteration in original). In view of this, Petitioner argues it would have been obvious to use a reduced film thickness to avoid pattern collapse. *Id.* at 16–17 (citing Ex. 1012, 8; Ex. 1040 ¶¶ 133–134). At this preliminary stage, here again, we find Petitioner appears to rely on an inherency theory not established adequately on this record.

## Petitioner:

Both PO and the Board (in the PG) appear to misinterpret Petitioner’s arguments with respect to Stowers 2008. With respect to the “about 25 nm” thickness limitation, Stowers 2008 expressly (not inherently) anticipates and/or renders obvious the limitation. Opp. at 14–16. . . . Further, given that PO has identified no unexpected results for “about 25 nm” as opposed to a different thickness, Stowers 2008 renders the limitation obvious. . . . In addition, given Stowers 2008’s disclosure of 30 nm (EX1040, ¶¶ 130–132; EX1012, 8), it would have been obvious to reduce the thickness disclosed in Stowers 2008 to 25 nm to reduce pattern collapse. EX1040, ¶¶ 130–132. . . . PO and the Board also appear to misinterpret Petitioner’s arguments related to Trikeriotis. Trikeriotis renders the “about 25 nm” limitation obvious—it does not anticipate it (either expressly or inherently). Trikeriotis discloses that “film thicknesses ranging from 30 nm to 200 nm can be easily achieved.” EX1024, 18. It then provides an express motivation to attempt even thinner films: “[t]he trend of ever decreasing feature sizes...is paralleled by the need to reduce resist thickness to prevent pattern collapse.” EX1024, 15.

- **New Range Limitation: “About 25 nm”**
  - Stowers 2008 anticipates the “about 25 nm” limitation.
  - Stowers 2008 renders the “about 25 nm” limitation obvious.
  - Trikeriotis renders the “about 25 nm” limitation obvious.
- **New Ratio Limitation: “radiation sensitive ligands to metal ion of at least about 2”**
  - The ratio is a results-effective variable, which would be optimized by a POSA.
  - Stowers 2008 renders the ratio limitation obvious.

# Stowers 2008 Renders the Claimed Ligand Ratio Obvious



**Petitioner's Expert**  
**Dr. Karey Holland**

Stowers 2008 discloses a metal oxide precursor solution that is deposited onto substrates that made by mixing  $\text{ZrOCl}_2$  or  $\text{HfOCl}_2$  with  $\text{H}_2\text{O}_2$  (peroxide) and then adding  $\text{H}_2\text{SO}_4$  (sulfuric acid). EX1008, 68. The peroxide to Hf (*i.e.*, radiation sensitive ligand to metal) ratio of in the Stowers 2008 precursor solution is 0.75 to 1. Stowers discloses that the addition of peroxide allows the films to act as a photoresist (*i.e.*, they become photo-patternable). *Id.* 143 (the dielectric materials were adapted to be photoresists by “changing the chemistries to a peroxide based system.”). Accordingly, would have been routine and obvious to the optimize concentration of peroxide in the solution and/or film (and therefore the ratio of ligand to metal). A POSA would understand such optimization to be routine to identify the optimum conditions.



- **New Range Limitation: “About 25 nm”**
  - Stowers 2008 anticipates the “about 25 nm” limitation.
  - Stowers 2008 renders the “about 25 nm” limitation obvious.
  - Trikeriotis renders the “about 25 nm” limitation obvious.
- **New Ratio Limitation: “radiation sensitive ligands to metal ion of at least about 2”**
  - The ratio is a results-effective variable, which would be optimized by a POSA.
  - Stowers 2008 renders the ratio limitation obvious.

# Proposed Amended Claims

Keszler



- **Keszler Anticipates or Renders Obvious Claims 13-23**
  - Keszler describes generic metal oxide coatings, supported by specific examples.
  - Keszler expressly or inherently anticipates claims 13-18 and 20-23.
  - Keszler renders claim 19 obvious.

## Patent Owner:

Lam argues that the proposed amended claims 13-18 and 20-23 are anticipated by Keszler and the peroxide ratio in dependent claim 19 is obvious over Keszler. Opp., 17-25. The Board should reject Lam's arguments in their entirety because Lam applies a mix-and-match analysis that is inappropriate for anticipation. "[A]nticipation is not proven by multiple, distinct teachings that the artisan might somehow combine to achieve the claimed invention." *Biscotti*, 878 F.3d at 1069.

Keszler is a lengthy disclosure describing several independent embodiments for "solution processed thin films and laminates." EX1038, 3. Where embodiments are related, Keszler includes an explicit reference. *E.g., id.*, 38 (Example 2 listing "solutions made according to Example 1"), 39 (same for Example 3), 42 (Example 5 referring to "the approach described above").

Lam's analysis attempts to cobble together Example 4, regarding "nanolaminate films" with no reference to radiation exposure or photolithography, with Example 7, a photolithography embodiment that uses thicknesses outside of the claimed "about 25 nm." Opp., 17-25. Anticipation does not allow combination of separate embodiments. *Biscotti*, 878 F.3d at 1069.

# Petitioner Does Not “Cobble Together” Separate Embodiments

## (54) Title: SOLUTION PROCESSED THIN FILMS AND LAMINATES, DEVICES COMPRISING SUCH THIN FILMS AND LAMINATES, AND METHOD FOR THEIR USE AND MANUFACTURE

U.S. Patent Publication No. 2005/0242330 A1 discloses compounds and solution deposition of inorganic compounds in a manner that addresses deficiencies of prior technologies. For example, solution deposition according to the present invention avoids using organic materials required for metal-organic deposition techniques, and hence also avoids organic burnout and the cracking problems associated with burnout.

One embodiment of the present invention concerns devices, such as electronic devices, having a thin film or laminate structure comprising at least one hafnium and/or zirconium oxy hydroxy sulfate ( $\text{MO}_{2-x-z/2}(\text{OH})_z(\text{SO}_4)_x$ ) compound, hafnium and/or zirconium oxy hydroxy tungstate ( $\text{MO}_{2-x-z/2}(\text{OH})_z(\text{WO}_4)_x$ ) compound, hafnium and/or zirconium oxy hydroxy borate ( $\text{MO}_{2-3x/2-z/2}(\text{OH})_z(\text{BO}_3)_x$ ) compound, hafnium and/or zirconium oxy hydroxy phosphate ( $\text{HfO}_{2-3x/2-z/2}(\text{OH})_z(\text{PO}_4)_x$ ) compound, and/or hafnium and/or zirconium oxy hydroxy silicate ( $\text{MO}_{2-2x-z/2}(\text{OH})_z(\text{SiO}_4)_x$ ) compound, where M is hafnium or zirconium, x and z may be fixed or variable. X may have any value in a range of from about 0.1 to about 3.5/(polyatomic ion charge). For example, x may be any value within the

In another embodiment, masks or templates can be fabricated using the films of the present invention in a single layer process. A thin film of an inorganic precursor, such as a solid acid or base, is deposited onto a substrate in combination with a peroxide or similar anion. The film is heated to produce a structurally rigid film. It is then exposed through a photomask or via a laser or electron beam to induce condensation/crosslinking in exposed areas. The solubility of the exposed areas decreases relative to the unexposed areas. The unexposed areas can then be selectively etched, producing a negative-tone image in the film. Positive-tone images also can be formed by preheating the film to higher temperatures before exposure. In some embodiments, an  $\text{M}(\text{OH})_x/\text{H}_2\text{O}_2$  film is formed by treating a film such as  $\text{HfSO}_x$  with a mixture of sodium hydroxide and hydrogen peroxide. The resulting film is then patterned by exposure to light or an electron beam.

# Petitioner Does Not “Cobble Together” Separate Embodiments

## Example 4 How to Make the Films:

### Example 4

This example describes a general method for producing smooth, dense, and pinhole-free ultra-thin nanolaminate films as thin as about 2 nm. Precursor solutions containing  $\text{HfOCl}_2 \cdot 8\text{H}_2\text{O}$  or  $\text{ZrOCl}_2 \cdot 8\text{H}_2\text{O}$ ,  $\text{H}_2\text{O}_2$  (30%) and  $\text{H}_2\text{SO}_4(\text{aq})$  were prepared as described in U.S. Patent Publication No. 2005/0242330 A1. The precursor solutions contained a metal ion concentration of about 0.05 M to 0.4 M with 70%  $\text{H}_2\text{O}_2$  and 50% sulfate relative to metal. The difference in metal ion concentrations allowed for thickness per coat variation from 3 nm to 25 nm. Thin films were deposited on silica substrates with thermally grown  $\text{SiO}_2$ . Substrates were cleaned by using an ultrasonic bath with Contrad-70 solution at 45 °C for 60 minutes followed by a rinse with deionized water. Films were deposited by using a spin coater with a spin rate of 3000 rpm for 30 seconds followed by hotplate polymerization at 125 °C for 1-2 minutes. Spin-coating and polymerization steps were repeated until the desired thickness was reached. After the desired thickness

## Example 7 How to Pattern the Films:

### Example 7

This example describes general methods for patterning a single-layer inorganic film. A single inorganic film containing peroxide or related coordinating species is spin-cast, liquid misted, or ink-jet printed onto an appropriate substrate. The film is heated at modest temperatures of less than 100°C to provide structural integrity to the film. The film is then exposed through a photomask to high-energy light, a maskless pattern via spatial light modulation, a defined laser beam, or electron beam to define a pattern or other preferred film features. Two examples of photogryaphically patterned films are shown in FIGS. 33 and 34. FIG. 33 is a patterned  $\text{ZrO}_{2-x}(\text{SO}_4)_x$  film. FIG. 34 is a patterned  $\text{TiO}_2$  film. The  $\text{TiO}_2$  film was about 15-50 nm thick. It was patterned using an unfiltered deuterium lamp, followed by etching with 0.1-0.2 M HCl for less than 60 seconds. FIGS. 35-37 are  $\text{HfO}_{2-x}(\text{SO}_4)_x$  films patterned by an electron beam. The films were about 30-60 nm thick. They were patterned using an electron beam at a dose level of 200  $\mu\text{C}/\text{cm}^2$ , followed by etching with 5-12 M HCl for about 1-4 minutes.

# Unrebutted Testimony that Keszler Films Match the '564 Patent Films

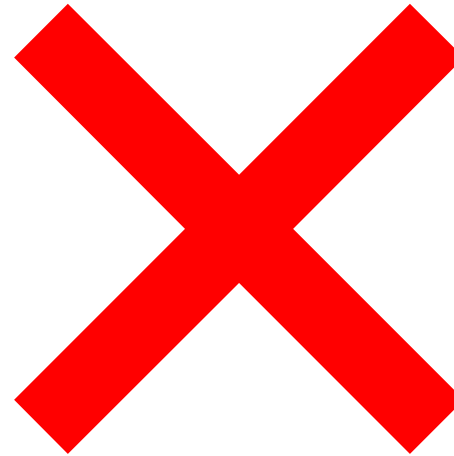


**Petitioner's Expert**  
*Dr. Karey Holland*

Moreover, the precursor solutions of Keszler Example 4 contains the same components as the precursor solutions used to make the coating materials in the Examples of the '564 patent and therefore necessarily have the same properties. . . . Any differences in the final concentrations and ratios between the precursor solutions in Keszler in and the '564 patent are immaterial. . . . Because the films of the '564 patent are the same in all material aspects as the films of Keszler, they necessarily have the same properties.



**Patent Owner's Expert**  
*Dr. Sanjay Banerjee*



# Keszler Anticipates or Renders Obvious Claims 1-12

| '564 Patent Claims                                                                           | Disclosures in Keszler                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13. A structure comprising a substrate and a coating material on a surface of the substrate, | Keszler discloses “patterning a device using a photoresist” by “providing a structure” which comprises a “resist layer.” EX1038, 4:16-25. Example 4 of Keszler discloses that “thin films were deposited on silica substrates” by spin coating precursor solutions onto the substrate. <i>Id.</i> , 40:8-20. Similarly, Example 7 disclose “inorganic film containing peroxide or related coordinating species is spin-cast, liquid misted, or ink-jet printed onto an appropriate substrate.” <i>Id.</i> , 42:8-10. A POSA would have understood that the films are “coatings” on the surface of a “substrate.” EX1040, ¶¶90-91.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| coating material comprises metal ions with radiation sensitive ligands and                   | <p>Keszler discloses that the “resist layer typically includes disclosed hafnium and/or zirconium oxy hydroxy compounds.” EX1038, 4:16-25. In Example 4, Keszler discloses precursor solutions comprising hafnium (“Hf”) or zirconium (“Zr”) ions and peroxide (“H2O2”) ligands. <i>Id.</i>, 38:6-63. Consistent with Keszler’s description of HfOCl2 and ZrOCl2 as “metal ion[s],” a POSA would understand that because HfOCl2 and ZrOCl2 are in aqueous solutions, they exist as HfO+2 and ZrO+2 cations. EX1040, ¶¶93-94. Indeed, Keszler explains that “the metal-containing cation may be provided using an aqueous solution of a hafnium oxy halide, such as hafnium oxy chloride (HfOCl2 (aq)).” EX1038, 12:34-13:1.</p> <p>Keszler discloses that the peroxide in the precursor solution of Keszler Example 4 is a radiation sensitive ligand. EX1038, 28:9-12. A POSA would understand that the hydrogen peroxide (H2O2) of the precursor solutions of Keszler Example 4 are “peroxide” (O22-) and that because inclusion of the peroxide into the precursor solutions provides a “new lithographic patterning method,” the peroxides are “radiation sensitive ligands.” EX1040, ¶96. Because the precursor solutions in Keszler are spin-coated to make films, it follows that the resulting films also contain metal ions and the radiation-sensitive peroxide ligands. EX1040, ¶95.</p> <p><b>Inherent Anticipation:</b> Moreover, the Keszler Example 4 precursor solutions contain the same components as the precursor solutions used to make the coating materials in the Examples of the '564 patent (i.e., HfOCl2 or ZrOCl2, H2O2 and H2SO4) and other publications discussing the photosensitivity of the peroxide ligands in HafSOx and ZircSOx. EX1040, ¶¶97-100. Any differences in the precursor solutions or processing conditions are immaterial. <i>Id.</i> Accordingly, because the '564 patent and other post-priority publications describe that the peroxide in the precursor solution is a radiation sensitive ligand (i.e., an inherent property of the material), EX1001, 6:9-10, the peroxide in the precursor solution of Keszler is also a radiation sensitive ligand.</p> |

# Keszler Anticipates or Renders Obvious Claims 1-12

| '564 Patent Claims                                                                                                                                                                                                                                                         | Disclosures in Keszler                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| coating material has an average thickness of about 25 nm,                                                                                                                                                                                                                  | Keszler discloses depositing the precursor solutions as “a thin film (from about 1 nm to about 100 nm).” EX1038, 32:3-15. For example, Example 4’s precursor solutions can produce “films as thin as about 2 nm.” <i>Id.</i> 40:1-2. Indeed, by varying the concentration of the metal ion in the precursor solution, Keszler formed films having thicknesses “from 3 to 25 nm.” <i>Id.</i> 40:13-14.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| exposure of the coating material to UV, EUV and/or electron-beam radiation alters the chemical properties of the coating material creating an exposed coating material with differential dissolution rates between exposed and un-exposed regions of the coating material. | Keszler discloses that that patterns are formed by changing the chemical structure of the resist layer via radiation, which creates a coating material with differential dissolution rates between exposed and un-exposed regions. <i>Id.</i> 28:15-21; see also <i>id.</i> at 8:1-12.<br><b>Inherent Anticipation:</b> As described above, the Keszler Example 4 precursor solutions are the same in all material aspects to those in the Examples of the '564 patent and other publications discussing the mechanism of $\text{HfSO}_x$ and $\text{ZircSO}_x$ photosensitivity. EX1040, ¶¶97-100. Thus, because the '564 patent and other post-priority publications show radiation breaks the peroxide bond of the $\text{HfSO}_x$ and $\text{ZircSO}_x$ resists, which induces condensation causing a difference in solubility between the exposed and unexposed regions, radiation exposure must also cause a chemical change resulting in differential dissolution in the Keszler $\text{HfSO}_x$ and $\text{ZircSO}_x$ resists. EX1040, ¶105-108. |
| 14...the metal ions comprise metal suboxide ions.                                                                                                                                                                                                                          | Keszler further discloses that “the metal containing ion may comprise a metal suboxide.” EX1038, 13:20-21. As Keszler notes, the $\text{HfOCl}_2 \cdot 8\text{H}_2\text{O}$ or $\text{ZrOCl}_2 \cdot 8\text{H}_2\text{O}$ in the precursor solutions are “metal ion[s]” <i>Id.</i> 38:6-63. Consistent with Keszler’s description, a POSA would understand that $\text{HfOCl}_2$ and $\text{ZrOCl}_2$ exist in solution as $\text{HfO}^{+2}$ and $\text{ZrO}^{+2}$ , respectively. EX1040, ¶109.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 15...metal of the metal ions comprises...Zr...Hf...                                                                                                                                                                                                                        | Keszler’s films include $\text{HfO}^{+2}$ and $\text{ZrO}^{+2}$ cations and therefore comprises Zr or Hf. Section IV.B; EX1040, ¶111.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 16...radiation sensitive ligands comprise peroxide ligands.                                                                                                                                                                                                                | Keszler’s films include peroxide as the radiation sensitive ligand.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

# Keszler Anticipates or Renders Obvious Claims 1-12

| '564 Patent Claims                                                                                           | Disclosures in Keszler                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 17...coating material further comprises polyatomic anions.                                                   | The Keszler precursor solution of Example 4 comprises H <sub>2</sub> SO <sub>4</sub> . EX1038, 38:6-63. Keszler further explains that the films may comprise “a polyatomic anion, such as sulfate (SO <sub>4</sub> <sup>2-</sup> ), [which] may be provided using an aqueous solution of sulfuric acid (H <sub>2</sub> SO <sub>4</sub> (aq)). Id. 13:1-2. Consistent with Keszler’s description, a POSA would understand that H <sub>2</sub> SO <sub>4</sub> exists in solution as SO <sub>4</sub> <sup>2-</sup> , which is a polyatomic anion. EX1040, ¶113. Accordingly, the Keszler films “further comprises polyatomic anions.”                                                                                                                                                                                                                       |
| 18...coating material has high absorption of EUV radiation relative to conventional radiation-based resists. | <b>Inherent Anticipation:</b> The HafSO <sub>x</sub> and ZircSO <sub>x</sub> films are materially the same as those in the '564 patent. EX1040, ¶¶97-100, 116. Thus, Keszler’s HafSO <sub>x</sub> films must necessarily have “high absorption of EUV radiation relative to conventional radiation-based resists,” per the '564 patent. EX1001, 8:67-9:2, 11:26-27.<br>Moreover, a publication by Jason Stowers and Douglas Keszler (inventors of both Keszler and the '564 patent) reports that metal oxide sulfate (MSO <sub>x</sub> ), such as HafSO <sub>x</sub> and ZircSO <sub>x</sub> , have 4-x more EUV absorption compared to “conventional polyhydroxystyrene” resists. EX1022, 3; EX1040, ¶114. This is consistent with reports that EUV absorption increases with density of materials. EX1025, 4; EX1002, ¶136; see also EX1040, ¶¶115-116. |
| 19...molar concentration ratio of radiation sensitive ligands to metal ion of at least 2.                    | <b>Obviousness:</b> Keszler discloses a precursor solution comprising HfOCl <sub>2</sub> or ZrOCl <sub>2</sub> , with H <sub>2</sub> O <sub>2</sub> and H <sub>2</sub> SO <sub>4</sub> to form photoresists. EX1038, 32:14-15. Keszler Example 4’s precursor solution comprises a molar concentration ratio of ligand to metal of 0.7:1. EX1040, ¶125. Keszler discloses that the peroxide allows the films to act as photoresists. EX1038, 28:9-12 (inclusion of peroxide provides a “new lithographic patterning method.”); EX1040, ¶126. The peroxide content of the films is therefore a result-effective variable that a POSA would modify to optimize the sensitivity of the film. EX1040, ¶¶135-138. The optimization of the result-effective peroxide content is “within the grasp” of a POSA.                                                    |
| 20...coating material has been heated to temperatures from 45° C to 150° C.                                  | The Keszler films in Example 4 were heated “at 125 °C for 1-2 minutes.” EX1038, 40:17-19. Similarly, the Keszler films in Example 7 were “heated at modest temperatures of less than 100 °C” before exposure. Id. at 44:11-12. EX1040, ¶117.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

# Keszler Anticipates or Renders Obvious Claims 1-12

| '564 Patent Claims                                                                                                                       | Disclosures in Keszler                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21...following exposure an exposed coating region is insoluble in an aqueous solvent.                                                    | A POSA would understand claim 21 to recite a negative tone resist. EX1040, ¶118. Keszler discloses that the “resist may be a positive resist or a negative resist.” EX1038, 6:26. Keszler explains that the exposed portions of the negative tone resists are “insoluble in acid,” which is an aqueous solvent. Id. 29:2-5, 32:25-27; EX1040, ¶119.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 22...following exposure an exposed coating region is soluble in an organic solvent.                                                      | <b>Inherent Anticipation:</b> A POSA would understand claim 22 to recite a positive tone resist. EX1040, ¶120. Keszler discloses that the “resist may be a positive resist or a negative resist.” EX1038, 6:26. And, as described above, the Keszler Example 4 precursor solutions are the same in all material aspects to those in the '564 patent's Examples. EX1040, ¶¶97-100, 121. Thus, because the '564 patent describes that HafSOx and ZircSOx may be a positive tone resist when an organic solvent is used as the developer, the exposed region of the Keszler films must be soluble in an organic solvent. EX1040, ¶121.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 23...coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> . | Keszler discloses that the HafSOx materials were patterned with an “electron beam at dose levels ranging from greater than 0 μC/cm <sup>2</sup> to at least 400 μC/cm <sup>2</sup> ” and could be patterned as “at dose levels as low as 2 μC/cm <sup>2</sup> .” EX1038, 33:13-18. A dose of 2 μC/cm <sup>2</sup> corresponds to a UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> as confirmed by the '564 patent (EX1001, (“The method can comprise irradiating a layer of coating material with extreme ultraviolet light at a dose of no more than about 100 mJ/cm <sup>2</sup> or an electron beam at a dose equivalent to no more than about 300 μC/cm <sup>2</sup> at 30 kV”)) and articles from Jason Stowers and Douglas Keszler (inventors of both Keszler and the '564 patent) (EX1022, (explaining an EUV dose of 249 μC/cm <sup>2</sup> corresponds to an UV dose of 25 mJ/cm <sup>2</sup> )). EX1040, ¶¶122-124. Accordingly, the HafSOx and ZircSOx films of Keszler are “can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm <sup>2</sup> .” Id. |

- **Keszler Anticipates or Renders Obvious Claims 13-23**
  - Petitioner has not “cobbled together” distinct embodiments of Keszler, but has evaluated the express teachings of Keszler and its examples.
  - Keszler expressly or inherently anticipates claims 13-18 and 20-23.
  - Keszler renders claim 19 obvious.

# Thank You

