

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LAM RESEARCH CORP.,

Petitioner,

v.

INPRIA CORP.,

Patent Owner.

Case No. IPR2024-00033

Patent No. 9,823,564

PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE

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LIST OF EXHIBITS

Exhibit	Description	Previously Submitted
1001	U.S. Patent No. 9,823,564 (“’564 patent”)	X
1002	Expert Declaration of Karey Holland, Ph.D. (“Holland Declaration”)	X
1003	U.S. Patent Publication No. 2011/0293888 (“’888 publication”)	X
1004	U.S. Application No. 12/850,867 Prosecution History (“’867 application PH”)	X
1005	U.S. Application No. 61/350,103 (“’103 provisional”)	X
1006	Declaration Sylvia Hall-Ellis, Ph.D. Regarding Authenticity and Public Availability (“Hall-Ellis Declaration”)	X
1007	’564 Patent Prosecution History (“’564 patent PH”)	X
1008	Stowers, Jason K. <i>Direct patterning of solution deposited metal oxides</i> . Oregon State University, 2008 (“Stowers 2008”)	X
1009	U.S. Patent No. 10,782,610 Prosecution History (“’610 patent PH”)	X
1010	Stowers, Jason, and Douglas A. Keszler. <i>High resolution, high sensitivity inorganic resists</i> . Microelectronic Engineering 86.4-6 (2009): 730-733 (“Stowers 2009”)	X
1011	Complaint for <i>Inpria Corp. v. Lam Research Corp.</i> , 1-22-cv-01359	X
1012	Jouve, A., et al. <i>Overcoming pattern collapse of ultra high resolution dense lines obtained with EUV resists</i> . Advances in Resist Technology and Processing XXII. Vol. 5753. SPIE, 2005 (“Jouve”)	X
1013	Stowers, Jason, Alan Telecky, and Andrew Grenville. <i>Imageable oxides: new solutions for resist</i> . EUVL Symposium. 2010, available at https://euvlsymposium.lbl.gov/pdf/2010/pres/RE-08.pdf	X
1014	Telecky, Alan, et al. <i>Photopatternable inorganic hardmask</i> . Journal of Vacuum Science & Technology B 28.6 (2010): C6S19-C6S22 (“Telecky 2010”)	X
1015	Summons for <i>Inpria Corp. v. Lam Research Corp.</i> , 1-22-cv-01359	X
1016	Amador et al. <i>Patterning chemistry of HafSOx resist</i> . Advances in Patterning Materials and Processes XXXI. Vol. 9051. SPIE, 2014	X
1017	Reserved	X
1018	Decker, Shawn R. <i>On the Properties and Characteristics of Solution Processed Hafnium Based Thin-Films from Aqueous Precursors</i> . Oregon State University, 2017	X

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1019	Oleksak et al. <i>Evaluation of Thermal and Radiation Induced Chemistries of Metal Oxo-Hydroxo Clusters for Next-Generation Nanoscale Inorganic Resists</i> . ACS Applied Nano Materials 1.9 (2018): 4548-4556	X
1020	Reserved	X
1021	U.S. Patent No. 7,773,365	X
1022	Stowers et al. <i>Directly patterned inorganic hardmask for EUV lithography</i> . Extreme Ultraviolet (EUV) Lithography II. Vol. 7969. SPIE, 2011 ("Stowers 2011")	X
1023	Reserved	X
1024	Trikeriotis et al. <i>Development of an inorganic photoresist for DUV, EUV, and electron beam imaging</i> . Advances in Resist Materials and Processing Technology XXVII. Vol. 7639. SPIE, 2010 ("Trikeriotis") (Library Version)	X
1025	Matsuzawa et al. <i>Theoretical estimation of absorption coefficients of various polymers at 13nm</i> . Journal of Photopolymer Science and Technology 12.4 (1999): 571-576.	X
1026	Puurunen et al. <i>Hafnium oxide films by atomic layer deposition for high-κ gate dielectric applications: Analysis of the density of nanometer-thin films</i> . Applied Physics Letters 86.7 (2005).	X
1027	Ober and Giannelis. <i>New oxide nanoparticle extreme-UV photoresists achieve high sensitivity</i> . SPIE Newsroom (2014): 2-4.	X
1028	<i>Curriculum Vitae</i> of Sylvia D. Hall-Ellis, Ph.D.	X
1029	<i>Curriculum Vitae</i> of Karey L. Holland, Ph.D.	X
1030	Anderson, Jeremy T., et al. <i>Solution-processed HfSOx and ZrSOx inorganic thin-film dielectrics and nanolaminates</i> . Advanced Functional Materials 17.13 (2007): 2117-2124 ("Anderson")	X
1031	Trikeriotis et al. <i>Development of an inorganic photoresist for DUV, EUV, and electron beam imaging</i> . Advances in Resist Materials and Processing Technology XXVII. Vol. 7639. SPIE, 2010 ("Trikeriotis") (Electronic Version)	X
1032	Deposition Transcript of Jason Stowers, Ph.D. (October 11, 2024)	X
1033	Deposition Transcript of Sanjay K. Banerjee, Ph.D. (September 27, 2024)	
1034	Oleksak RP & Herman GS, <i>Characterization of High-Resolution HfSOx Inorganic Resists</i> . Proc. SPIE 9048, Extreme Ultraviolet (EUV) Lithography V, 90483H (2014).	
1035	Trakhtenberg S et al., <i>Non-Catalytic Photo-Induced Immobilization Process In Polymer Films</i> , in Physico-	

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1036	Krysak, Marie E., et al., <i>Investigation of Novel Inorganic Resist Material for EUV Lithography</i> . Proc. SPIE 9048, Extreme Ultraviolet (EUV) Lithography V, 904805 (2014) ("Krysak")	
1037	Brainard, Robert L, <i>Photoresists for EUV Lithography</i> , in EUV Litogarphy (Bakshi, V. Ed. 2018)	
1038	International Application Publication No. WO2008/082448 ("Keszler")	
1039	R. Chang & K Goldsby, <i>Chemistry</i> (11th ed. 2013) (excerpts).	
1040	Expert Declaration of Karey Holland, Ph.D.	
1041	Declaration of Heather Stewart	
1042	Email from Brad Engelbert, Cataloging & Government Documents Manager of Oregon State University, to Risa L. Murphy, Morgan, Lewis & Bockius (August 13, 2024)	
1043	Declaration of Patrick Franzen	
1044	Fallica et al., <i>Absorption Coefficient of Metal-Containing Photoresists in the Extreme Ultraviolet</i> , J Micro/Nanolith. MEMS MOEMS 17(2), 023505 (2018)	
1045	Reserved	
1046	Kirchauer, Heinrich, <i>Photolithography Simulation</i> , Vienna University of Technology, 1998 (available at https://www.iue.tuwien.ac.at/phd/kirchauer/diss.html) (excerpt)	
1047	Schnabel, Wolfram, <i>Polymers & Electromagnetic Radiation: Fundamentals & Practical Applications</i> (2014).	

I. INTRODUCTION

The '564 Patent is not entitled to its claimed priority date because the '867 Application does not sufficiently support the specified thickness ranges. Moreover, Inpria's own admissions confirm that Stowers 2008's "magic sauce recipe" is within the patent's scope. Furthermore, Trikeriotis clearly discloses all necessary structural and functional elements, rendering the claims obvious. These points overwhelmingly support finding all claims unpatentable.

II. THE '564 PATENT IS NOT ENTITLED TO ITS CLAIMED PRIORITY DATE

Inpria does not dispute it secured the '564 Patent's allowance by distinguishing it by a mere 5 nm difference in coating thickness from the prior art. Yet, Inpria argues that the '867 Application supports undescribed claimed ranges by describing broader ranges encompassing the claimed ranges. This contradicts Inpria's prosecution statements that the narrower claimed range represents a different invention.

A. Inpria Incorrectly Applies the Written Description Standard

The specification "must clearly allow persons of ordinary skill in the art to recognize that the inventor **invented** what is claimed." *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010).¹ When "a broad described range

¹ Emphasis added throughout unless otherwise noted.

pertains to a **different invention** than the narrower (and subsumed) claimed range, then the broader range does not describe the narrower range.” *RAI Strategic Holdings, Inc. v. Philip Morris Prods. S.A.*, 92 F.4th 1085, 1088 (Fed. Cir. 2024).

Here, patentees obtained the '564 Patent by distinguishing the prior art based on the claimed thickness. EX1007, 508. Patentees told the Examiner that the claimed thickness of 30 nm (upper end of claim 1's range) and a thickness of 35 nm (taught by the prior art) “are **not close enough that one would expect them to have the same properties.**” EX1007, 508. Thus, according to patentees, a “30 nm” thickness is a **different invention** than other thicknesses in the specification. *RAI*, 92 F.4th at 1088.

Although Inpria admits that the specification does not recite the claimed thicknesses of “5 nm to 30 nm” (claim 1) or “5 nm to 25 nm” (claim 6), it argues that the specification discloses that “additional ranges of thicknesses within the explicit ranges above are contemplated and are within the present disclosure.” POR, 8. But Inpria fails to explain how a POSA would know the inventors possessed the **specific** ranges of 5 nm to 30 nm and 5 nm to 25 nm, when the specification mentions neither. The ranges disclosed in the priority application closest to the claimed ranges are “about 1 nm to about 40 nm” and “about 1 nm to about 25 nm.” Yet, because Inpria explained that a thickness of 30 nm is a different invention than the prior art's thickness of 35 nm, the disclosed ranges **cannot describe the claimed invention.**

Notably, Inpria's expert, Dr. Banerjee, was unable to answer questions regarding which other ranges a POSA understood the inventors possessed. EX1033, 41:18-44:18. If Inpria's own expert cannot tell if the inventors possessed any other specific ranges within the specification's disclosed ranges, neither could a POSA.

Dr. Banerjee relies on the specification's disclosure of different coating techniques and how to vary the spin coating method to achieve different thicknesses. EX2009, ¶¶24-26; *see* EX1033, 49:21-50:3 (“a POSA would know *how to achieve* specific ranges within those exemplary ranges”). But whether a POSA would know *how to achieve* a specific thickness goes to *enablement*—a separate requirement from the written description requirement. *Nuvo Pharms. (Ir.) Designated Activity Co. v. Dr. Reddy's Lab 'ys, Inc.*, 923 F.3d 1368, 1382 (Fed. Cir. 2019).

Inpria incorrectly attempts to analogize to *BioDelivery Science International v. Alvogen PB Research & Development LLC*. POR at 11-12. In *BioDelivery*, the specification disclosed the claimed range's endpoints. 576 F. Supp. 3d 184, 211 (D. Del. 2021). Specifically, the specification's disclosure of “**4.0...6.0...or 7.5** and any incremental value thereof” disclosed the endpoints of “about 4 to about 6” and “about 4 to about 7.5.” *Id.*

Other decisions are consistent: a claimed range may have adequate written description where the specification discloses the range's endpoints and the claimed range is directed to the same invention as what the specification disclosed. *E.g.*,

Kolmes v. World Fibers Corp., 107 F.3d 1534, 1539 (Fed. Cir. 1997); *In re Eickmeyer*, 602 F.2d 974, 981 (C.C.P.A. 1979); *In re Wertheim*, 541 F.2d 257, 256 (C.C.P.A. 1976); *In re Baird*, 348 F.2d 974, 982 (C.C.P.A. 1965) (“32° F and 176° F” did not support claimed range of “40° F to 80° F”).

Here, however, the **'867 Application does not disclose the claimed endpoints** of 5 nm or 30 nm. And Inpria explained during prosecution that the claimed range **constitutes a different invention** than other broader ranges, such as the specification's disclosed ranges. *Indivior UK Ltd. v. Dr. Reddy's Laboratories*, 18 F.4th 1323 (Fed. Cir. 2021), confirms the point. There, the broad range of “at least 25 %” and “at least 50%” did not support the claimed range of “about 40 wt % to about 60 wt %.” *Id.* at 1329. Further, the application disclosed other, different percentages, “rendering it even less clear that an invention of ‘about 40 wt % to about 60 wt %’ was contemplated,” such that a POSA “would not have immediately discerned” that the claimed range was inventive. *Id.*

Although Inpria argues that, unlike *Indivior*, the '867 Application discloses “several bounded ranges, including narrow ranges, that encompass the claimed range and the examples,” the '867 Application never once mentioned the claimed endpoints, despite disclosing other ranges and “additional ranges within the explicit ranges.” POR at 16. Thus, like *Indivior*, a POSA would not have immediately discerned that the '867 Application discloses the claimed thickness ranges.

Inpria's attempt to distinguish Lam's other precedent is futile. For example, in *Pioneer Pet Products LLC v. Oil-Dri Corp. of Am.*, IPR2022-01138, Paper 21, 8 (Jul. 21, 2023) and *Grünethal GmbH v. Antecip Bioventures II LLC*, PGR2017-00008, Paper 43, 17 (June 22, 2018), the Board found that the specifications, which did not disclose the claimed endpoints, did not demonstrate to a POSA that the claimed range was part of the invention. Similarly, the '867 Application does not disclose the claimed range's endpoints. And there is **no guidance** on how to select a specific range of thicknesses or whether any thickness provides any advantages or unexpected results. EX1040, ¶¶34-38. Indeed, since the specification implies *any* range that is less than 1000 nm would suffice, a POSA would be unable to determine **what narrower ranges** were possessed. EX1004, 23:14-26. Inpria's own expert could not identify what other ranges a POSA would have understood the inventors to have possessed based on the specification. EX1033, 41:18-44:18 (testifying "more context" was required to make the determination).

Although the Federal Circuit overturned the Board's determination in *RAI*, it did so "based on the unique facts" of the case, which are not present here. 92 F.4th at 1085. There, the specification disclosed "both endpoints" and there was no "indicat[ion] that changing the length of the heating member changes the invention." *Id.* at 1090. Here, in contrast, the patentees explained during prosecution that a 30 nm thickness and a 35 nm thickness "are not close enough that one would expect

them to have the same properties.” EX1007, 508. Unlike *RAI*, the '867 Application **did not disclose each of the claimed ranges' endpoints**, and the evidence shows **that changing the thickness changes the invention**. Accordingly, the '564 patent's claims cannot claim priority to the '867 Application.

B. Inpria Must Be Held to the Statements Patentee Made During Prosecution

Unbelievably, Inpria argues that statements made during prosecution are “legally irrelevant.” The Federal Circuit has not “limit[ed] the written description inquiry to only the four corners of the specification.” *Allergan USA, Inc. v. MSN Lab'ys Priv. Ltd.*, 111 F.4th 1358, 1376 (Fed. Cir. 2024). Rather, such statements may be highly relevant to whether the written description requirement has been satisfied. *OrthoAccel Techs., Inc. v. Propel Orthodontics, LLC*, 785 F. App'x 871, 875 (Fed. Cir. 2019) (affirming district court's “reli[ance] on evidence from the prosecution history of the [asserted] patent” to determine written description); *ICN Photonics, Ltd., v. Cynosure, Inc.*, 73 F. App'x 425, 429 (Fed. Cir. 2003); *Bradford Co. v. Conteyor N. Am., Inc.*, 603 F.3d 1262, 1269-70 (Fed. Cir. 2010).

Inpria also confuses issue preclusion, prosecution history estoppel, and the general legal principle of estoppel. POR at 19-22. Lam neither argues “prosecution history estoppel.” nor “issue preclusion.” POR at 21.

Instead, “[t]he public notice function of a patent and its prosecution history requires that a patentee be held to what he declares during the prosecution of his

patent.” *Teva Pharms. USA, Inc. v. Sandoz, Inc.*, 789 F.3d 1335, 1344 (Fed. Cir. 2015). And it is irrelevant that patentee’s statements were made in the context of an obviousness rejection. *Biogen Int’l GmbH v. Mylan Pharms.*, No. 1:17-CV-116, 2020 WL 3317105, at *15 (N.D.W.V. June 18, 2020) (Biogen’s statements to overcome obviousness rejection “underscore[d] the **failure of the specification** to teach a POSA” that the inventors had “actually invented” the claimed method as of the priority date).

Here, Patentees defined **the invention** during prosecution of the ’564 Patent as having an average thickness from 5 nm to 30 nm, and stated that such a range **is a different invention** than the prior art’s thickness of 35 nm. EX1007, 508. The ’867 Application simply failed to disclose the **invention** having thicknesses of 5 nm to 30 nm or 5 nm to 25 nm. Accordingly, the ’564 patent’s claims cannot claim priority to the ’867 Application.

III. THE ’888 PUBLICATION ANTICIPATES CLAIMS 1-12 (GROUND 1)

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. *Id.* However, because the ’564 patent cannot claim priority to the ’867 application, *see supra* § II, the ’888 publication is prior art and anticipates claims 1-12.

**IV. STOWERS 2008 ANTICIPATES CLAIMS 1-5, 7-10, 12 (GROUND 2)
AND RENDERS CLAIMS 1-10 AND 12 OBVIOUS (GROUND 3)**

The first named inventor of the '564 patent, Dr. Stowers, stated in an email to the then-CEO of Inpria, Dr. Grenville, that Dr. Stowers' dissertation (Stowers 2008) at page 68 disclosed the "magic sauce recipe." EX2008, 6. Dr. Grenville responded: "At least that part is covered by the patent application." *Id.* During his deposition Dr. Stowers admitted that (i) the "magic sauce recipe" means the invention or the special thing in his dissertation (or "a joke"), (ii) the only "recipe" this email could have referred to is the HafSOx and ZircSOx recipes disclosed in Chapter 3 of his dissertation (Stowers 2008), and (iii) that, while there were two patent application on which he was listed as an inventor, only the yet-to-be-filed application that led to the '564 patent discussed the recipe on page 68 of his dissertation, so the "patent application" that Dr. Grenville referenced could only refer to that application. EX1032, 60:16-61:9; 63:24-65:22; 69:15-71:7. Stated differently, the first named inventor admitted that the "magic sauce recipe" of Stowers 2008 was the HafSOx or ZircSOx resist recipes that Inpria's CEO said were covered by the '564 Patent.

Therefore, Inpria's arguments that the HafSOx and ZircSOx photoresists disclosed in Stowers 2008 are somehow different than those disclosed in the '564 patent are not credible and must be rejected.

A. Stowers 2008 is Prior Art

Inpria's argument that Stowers 2008 is not prior art is based on Dr. Stowers' incorrect belief that he embargoed his dissertation from October 2008 to October 2009. But we know that Stowers 2008 was **not** embargoed, as a third-party publisher published it on January 15, 2009. EX1041 ¶8. Accordingly, Stowers 2008 qualifies as prior art because it was published more than one year before the '564 Patent's alleged June 1, 2010 priority date. 35 U.S.C. §102(b) (pre-AIA).

As support for their argument that Stowers 2008 did not publish until October 2009 at the earliest, Inpria cites a declaration by Dr. Stowers stating that when he "submitted [his] thesis in October 2008, [he] requested that it be embargoed for a period of one year before it would be released to the public." POR, 25-28; EX2008 ¶7. Dr. Stowers' only evidence is (i) the email with Dr. Grenville (discussed above) after the purported embargo had expired, and (ii) a screenshot of the *current* process at OSU for requesting an embargo despite admitting that the alleged embargo request was made in "paper form" in 2008. *Id.* ¶ 9. Tellingly, Dr. Stowers has "no receipt" and did not "get a copy of that form" for the allegedly requested embargo. EX1032, 49:14-18. And the OSU library does not have any information regarding embargos for dissertations submitted before 2017. EX2012, 1. Yet, the OSU Library "made this dissertation publicly available on **10-21-2008.**" EX1042.

ProQuest's publication of Stowers 2008 on **January 15, 2009** further undermines Inpria's "embargo" theory. EX1041 ¶8. ProQuest explained that Stowers 2008's full text was loaded into the "ProQuest® Digital Dissertations and Theses database, which is accessible via the world wide web to authenticated subscribers" on **January 15, 2009**. *Id.* ¶¶ 4-8. That is more than one year before June 10, 2010. Accordingly, Stowers 2008 is pre-AIA §102(b) prior art.

B. Inpria Concedes that Stowers 2008 Discloses all of the Structural Limitations of the Claims

Inpria alleges that Lam's inherency arguments are deficient because Lam "has not proven Stowers 2008's films are identical to the '564 Patent Films." POR at 31-37. Yet Inpria does not dispute that Stowers 2008 discloses the following claimed structural features:

Claim	Structural Feature
1	• "A structure comprising a substrate and a coating material on a surface of the substrate" • "the coating material comprises metal ions" • "the coating material has an average thickness from 5 nm to 30 nm"
2	• "the metal ions comprise metal suboxide ion"
3	• "the metal of the metal ions comprises Zr [or] Hf"
4	• "the . . . ligands comprise peroxide ligands"
5	• "the coating material further comprises polyatomic anions"
8	• "a metal ion to [] ligand ratio of at least 2"
9	• "the coating material has been heated to temperatures from 45° C to 150° C"

10	• “following exposure an exposed coating region is insoluble in an aqueous solvent.”
11	• “following exposure an exposed coating region is soluble in an organic solvent”

Instead, Inpria only challenges whether the coatings of Stowers 2008's coatings have the claimed *functional* properties.

C. Stowers 2008 Coatings Have the Claimed Functional Properties

Inpria incorrectly argues that Lam fails to show Stowers 2008 discloses a coating with the following functional properties: (1) the coating material comprises ligands that are “radiation sensitive,” (2) “radiation alters the chemical properties of the coating material ... creating different dissolution rates,” (3) the “coating material has high absorption of EUV radiation relative to conventional radiation-based resists,” and (4) the “coating material can be effectively patterned with UV radiation or EUV radiation at a dose of no more than 100 mJ/cm².”

Inpria's arguments ignore that the Stowers 2008 materials are the same “HafSOx” (for hafnium-based coatings) and “ZircSOx” (for zirconium-based coatings) materials disclosed in the '564 patent. This is no surprise because Inpria's then-CEO admitted the “magic sauce recipe” in Stowers 2008 was covered by the patent application leading to the '564 patent. EX1040, ¶40.

Inpria's other arguments are misplaced. It argues that these coatings in the '564 patent have different functional properties than the Stowers 2008 coatings

because they (1) contain different concentrations of metals, (2) use different rest times, (3) have different spin coating speeds, (4) have different metal to peroxide ratios, and (5) have different baking conditions. But none of these alleged differences change the resulting film's chemistry. EX1040, ¶¶41-51. Coatings made from precursor solutions having concentrations of either 0.5 M hafnium or 0.15 M hafnium both form HafSO_x materials. EX1040, ¶42; EX1034, 2. The different rest times are inconsequential; they merely allow more "ligand exchange" time. EX1040, ¶¶46-48. As to coating speeds, the '564 patent discloses an additional 5-second, 100 RPM spin, which merely provides more time to "spread the resist across the wafer." EX1001, 22:17-20; EX1040, ¶49. And Inpria cherry-picks parts of Stowers 2008 while ignoring others to assert that there are differences in the baking conditions. EX1040, ¶50. Stowers 2008 discloses a prebake of 100 °C and a post-exposure bake of 50 °C², within the '564 patent's pre- and post-bake protocol (40 - 200 °C). EX1008, 70; EX 1001, 22:20-43. Accordingly, the HafSO_x and ZircSO_x coating materials of Stowers 2008 and '564 patent are the same in all material respects and necessarily have the same properties. EX1002 ¶¶101-104, EX1040, ¶51.

² Inpria wrongly asserts that Stowers includes a post-exposure bake of 300 °C, but this heating step occurred *after development*. EX1008, 68-69.

Any differences between Stowers 2008 and the '564 patent merely go to optimizing the resist material. EX1040, ¶51. Dr. Stowers' later publications confirm it; Dr. Stowers explained that a "HafSO_x solution is formed by the sequential addition of aqueous HfOCl₂, H₂O₂, and H₂SO₄." EX1019, 2. Thus, the concentrations and ratios can be optimized, so long as the order of addition of HfOCl₂, H₂O₂, and H₂SO₄ (which are identical in the '564 patent and Stowers 2008) is kept constant. EX1040, ¶48.

1. Radiation Sensitive Ligands

Inpria's own expert admits that the peroxide group in Stowers 2008's working solutions is a radiation sensitive ligand. EX1033, 165:21-166:11 ("We now know that [peroxide] is radiation sensitive."). Although Dr. Banerjee implies that Dr. Stowers was unaware that peroxide was radiation sensitive, recognition of an inherent property is not required. *EMI Grp. N. Am., Inc. v. Cypress Semiconductor Corp.*, 268 F.3d 1342, 1349–51 (Fed. Cir. 2001). Even so, Stowers 2008 describes peroxide as radiation sensitive. EX1008, 46; EX1040, ¶54. And it explains that the photosensitive HafSO_x and ZircSO_x materials were adapted by "changing the chemistries to a peroxide based system." EX1008, 143. Thus, a POSA would understand that the peroxide in Stowers 2008's working solutions is a radiation sensitive ligand. EX1040, ¶54.

Inpria alleges that Lam advances a “flawed ‘extinction coefficient’ theory.” POR at 37. Not so. As Dr. Holland explained, and Dr. Banerjee agreed with, the “extinction coefficient is a property that determines how strongly a material absorbs radiation at a particular wavelength.” EX1002, ¶100; EX1033, 161:3-7. This measurement indicates the material’s sensitivity to radiation. EX1040, ¶53. Accordingly, because the extinction coefficient changes when peroxide is added, a POSA would understand the peroxide to be “radiation sensitive.” *Id.*

Moreover, Dr. Stowers’ later publications confirm the Stowers 2008 coatings’ peroxide are radiation sensitive. EX1040, ¶56. In 2009, Dr. Stowers explained that, for HafSO_x and ZircSO_x, “the mechanism that leads to negative tone patterning is dependent on the presence of peroxide” because “beam-induced decomposition and elimination of peroxide promotes condensation reactions, cross-linking of metal-oxo bridges, and the production of three-dimensional framework structures.” EX1010, 21. And in 2018 Dr. Stowers explained HafSO_x includes a “radiation sensitive peroxide ligand.” EX1019, 2. Accordingly, based on Dr. Stowers’ own characterizations, the peroxide ligand in the coatings of 2008 was “radiation sensitive.”

2. Radiation Alters the Chemical Properties of the Coating Material. . .Creating Different Dissolution Rates

By obscuring how photoresists work, Inpria disputes that Stowers 2008's "radiation alters the chemical properties of the coating material...creating different dissolution rates." EX1040, ¶¶63-68. As Stowers 2008 explains, "[d]uring exposure, a spatially varying light intensity incident on the film **chemically induces** a corresponding **spatially varying solubility difference** in the film." EX1008, 23 (emphasis added). Although Inpria cites reported "processing errors" as proof that the radiation did not necessarily alter the chemical properties of the film, POR at 39-40, Stowers explained that samples degraded when shipped to Switzerland, and, even under these conditions, HafSO_x was EUV sensitive. EX1008, ¶72.

Inpria cites Dr. Banerjee's explanation that radiation could change a photoresist's *physical* or chemical properties or that other aspects of the lithography process may cause the chemical change. POR at 39. Yet, Dr. Banerjee admits that he did not identify a single physical property that radiation exposure could change. EX1033, 144:22-145:2. The only authority Dr. Banerjee cites is a boilerplate sentence in an unrelated patent's background section. EX2006, 1:18-20. And even that authority discloses only **chemical** changes occurring by radiation exposure. EX1040, ¶65. Any physical change that occurred would be caused by a chemical change. *Id.* And Dr. Banerjee admitted that the other aspects of the lithography process would cause **additional** changes. EX1033, 140:14-141:1.

Inpria ignores the voluminous evidence showing the mechanism of HafSOx and ZircSOx photosensitivity. For example, Dr. Stowers explained that, for HafSOx and ZircSOx, radiation “induced decomposition and elimination of peroxide promotes condensation reactions.” EX1010, 21. The peroxide bond’s decomposition is irrefutably a chemical change. EX1040, ¶¶70-71. Dr. Stowers further explained that “[t]hese frameworks produce the **differential solubility between unexposed and exposed regions.**” EX1010, 21. And Dr. Keszler—a named inventor and Dr. Stowers’ thesis advisor—also explained that peroxide inhibits the “condensation process” by “the binding of peroxide to Hf.” EX1016, 2. The radiation-induced decomposition of peroxide “initiate[s] the condensation” of HafSOx, which “induce[s] solubility changes and contrast in the films.” *Id.* Accordingly, radiation alters the chemical properties of the Stowers 2008 coatings (i.e., breaks the peroxide bonds), creating different dissolution rates—an inherent property of the Stowers 2008 coatings. EX1040, ¶¶68-71.

3. Coating Material Has High Absorption of EUV Radiation Relative to Conventional Radiation-Based Resists

Inpria argues that the Board must reject Lam’s arguments because the EUV correlation between density and EUV absorption is a “trend.” Yet, when asked where HafSOx and ZircSOx would fall on the graph, Dr. Banerjee pointed to a location well off the chart (Pet. at 53; EX1025, Fig. 3), admitting that the Stowers 2008 materials have high absorption relative to conventional radiation-based resists.

EX1033, 179:8-180:6. Although there may be some variation in the “trend” where densities are similar, Stowers 2008 reports that the density of HafSOx and ZircSOx is between 4 g/cm³ and 5 g/cm³—about 3 to 4 times higher than PMMA, a “conventional radiation-based resist.” EX1008, 90; EX1025, 4. Accordingly, even if the HafSOx or ZircSOx deviated from the trend line, the EUV absorption would be high relative to conventional radiation-based resists. EX1040, ¶¶77.

Inpria incorrectly argues that Dr. Stowers’ post-priority publications are “irrelevant” because they do not inform “what a POSA would have known or been motivated to do.” POR at 44. “Extrinsic evidence can be used to demonstrate what is ‘necessarily present’ in a prior art embodiment even if the extrinsic evidence is not itself prior art.” *Hospira, Inc. v. Fresenius Kabi USA, LLC*, 946 F.3d 1322, 1329 (Fed. Cir. 2020). Such extrinsic evidence can include “the work of the inventor or the patentee.” *Id.* at 1329-30.

Here, Dr. Stowers’ publication confirms the “trend” in EX1025. EX1040, ¶78. Dr. Stowers reported that the Inpria HafSOx resists have 4-times increased density and a corresponding 4-times increased EUV absorption compared to “conventional polyhydroxystyrene” resists. EX1022, 3. Thus, Dr. Stowers’ publications confirm that the Stowers 2008 materials have high absorption—again an inherent property of the Stowers 2008 coatings. *Id.*, ¶¶78-80.

4. The Coating Material Can Be Effectively Patterned With UV Radiation or EUV Radiation at a Dose of no More Than 100 mJ/cm²

Inpria argues that Lam “curiously” looks to Stowers 2008 Chapter 4, which relates to electron-beam testing of HafSOx and ZircSOx, to show that the Stowers 2008 coating materials can be patterned with UV or EUV at a dose of no more than 100 mJ/cm². POR at 44-45. As explained above, there were “processing errors” (*e.g.*, degradation during shipping) in the samples for EUV exposure. EX1008, 72. Even under these conditions, HafSOx “exhibited...a sensitivity of 194 mJ/cm².” *Id.* Stowers 2008 explains that the “results would be vastly improved” without these errors. *Id.* These processing errors did not occur in the samples exposed to e-beam. EX1032, 15:21-25.

Stowers 2008 reports that ZircSOx can be patterned with an e-beam dose of 112 $\mu\text{C}/\text{cm}^2$. EX1008, 89. Similarly, HafSOx was patterned with e-beam doses of 60 $\mu\text{C}/\text{cm}^2$ and 300 $\mu\text{C}/\text{cm}^2$. *Id.* at 99-100. Dr. Stowers’ 2011 article relates to both HafSOx and ZircSOx, using the generic term “MSOx.” EX1022, 3. Thus, the correlation between an e-beam dose of 249 $\mu\text{C}/\text{cm}^2$ and EUV dose of 25 mJ/cm² applies to *both* HafSOx and ZircSOx. EX1040, ¶83.

However, even if the e-beam to EUV dose applies only to HafSOx, Dr. Stowers also explained that the dose **improves** with zirconium-based formulations. EX1014, 3 (“For HafSOx, $E_{1:1}=90 \text{ mJ}/\text{cm}^2$;...and for ZircSOx, $E_{1:1}=25 \text{ mJ}/\text{cm}^2$.”).

Thus, even applying Inpria's arguments, the effective dose for ZircSOx would be **less** than 25 mJ/cm². EX1040, ¶83. Additionally, Stowers 2008 discloses that HafSOx can be patterned with e-beam doses of 60 µC/cm² and 300 µC/cm², which correspond to an EUV dose of **less than 100 mJ/cm²**. *Id.*, ¶84.

V. TRIKERIOTIS ANTICIPATES AND/OR RENDERS OBVIOUS CLAIMS 1, 3, 6-7, 9, 11-12 (GROUND 5)

A. Trikeriotis is Prior Art

Inpria wrongly argues that Trikeriotis is not prior art. Trikeriotis on its face confirms that it was published *before* the June 10, 2010 Priority Date:



EX1024, 1 (dated 22-24 February, 2010). Further, a declaration from SPIE's Director of Publications and Platforms confirms that Trikeriotis was presented as part of a conference on 22-24 February 2010, and was later published online on 25 March 2010 and published in print on 3 May 2010. EX1043, ¶¶1, 8-9. Accordingly, Trikeriotis is prior art published by another before June 10, 2010, and qualifies as prior art. 35 U.S.C. §102(a) (pre-AIA).

B. Trikeriotis's Coatings meet the claims' structural limitations

Inpria attempts to evade a finding of anticipation and/or obviousness by alleging that Lam's analysis is "conclusory." POR at 48-49. Not so. Lam explained how Trikeriotis meets each limitation. Petition at 58-62. Inpria argues that, for example, Lam did not explain how Trikeriotis' disclosure that "uniform thin films can be spin-coated on Si wafers" meets the limitation of a "structure comprising a substrate and a coating material." Tellingly, Inpria does not argue that a "thin film" is not a "coating" or that a "Si-wafer" is not a "substrate." Lam has identified "where each element of the claim[s are] found" in Trikeriotis, thus satisfying its burden of identifying "with particularity...the evidence that supports the grounds." 37 C.F.R. § 42.104(b)(4); 35 U.S.C. § 312(a)(3).

1. Metal Ions

The only structural characteristic in the independent claim that Inpria identifies as allegedly missing from Trikeriotis is that the nanoparticle resist materials "contain metal ions." POR at 48. Yet Trikeriotis discloses "an inorganic resist made of hafnium oxide nanoparticles." EX1024, 16. The nanoparticles were made from a solution comprising HfOCl_2 , which would be understood by a POSA to exist in Trikeriotis' solution as HfO^{2+} , and is therefore a **metal ion**. *Id.*; Pet. 34-35; EX1002 ¶99; EX1002 ¶99. Thus, Trikeriotis discloses all structural limitations in claim 1.

2. Average Thickness of 5 nm to 25 nm (claim 6)

Inpria cherry picks statements from Trikeriotis that a POSA would have been motivated to create “thicker films,” not thinner films. POR at 56. Although Trikeriotis was testing a variety of 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. Accordingly, film thickness is a result-effective variable that a POSA would have found obvious to optimize. *In re Applied Materials, Inc.*, 692 F.3d 1289, 1297 (Fed. Cir. 2012) (“A recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective.”). Specifically, a POSA would have been motivated to prevent pattern collapse by optimizing the photoresist to reduce its thickness.³ EX1002, ¶157. Therefore, it would have been obvious to reduce the thickness to 5 nm to 25 nm.

C. The Trikeriotis Coatings Have the Claimed Functional Properties

Inpria's arguments that the Trikeriotis coatings do not have the claimed functional properties ignore the disclosure of Trikeriotis and Dr. Holland's explanation of how the Trikeriotis coatings inherently possess these properties.

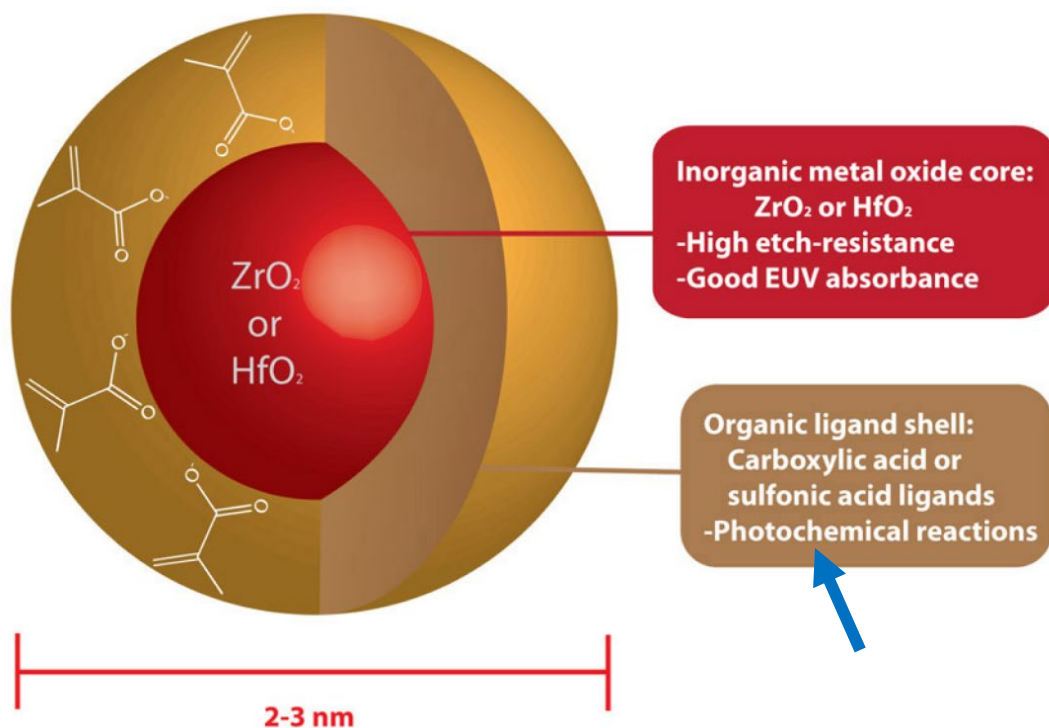
³ The Petition further describes the motivation to reduce film thickness in detail.

Petition at 49-51.

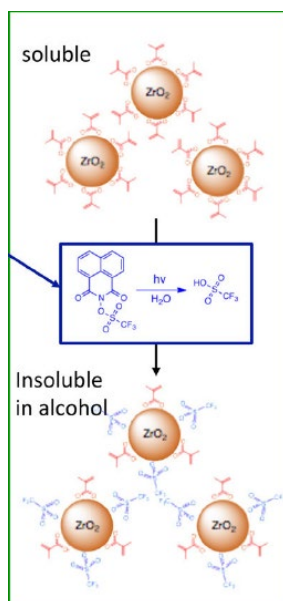
1. Radiation Sensitive Ligands

Trikeriotis discloses inorganic resists made of hafnium oxide nanoparticles with “a variety of organic ligands [that] can be used to control the surface chemistry of the final product.” EX1024, 15. Trikeriotis explains that the “absorption coefficient of the films depends on the ligands,” which is an indication of the material’s radiation sensitivity. *Id.*, 18. EX1040, ¶59. Because the extinction coefficient changes with the use of different organic ligands, a POSA would understand the organic ligands to be “radiation sensitive.” EX1040, ¶60. And Trikeriotis explains that the “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. Accordingly, Trikeriotis makes clear that the **ligands** are radiation sensitive. *Id.*

Inpria also suggests that Lam’s arguments are “contradicted by other evidence introduced by Lam,” namely Ober. POR at 51-53 (citing EX1027). Ober shows that the “photochemical reactions” take place within the organic ligand shell (blue arrow) :

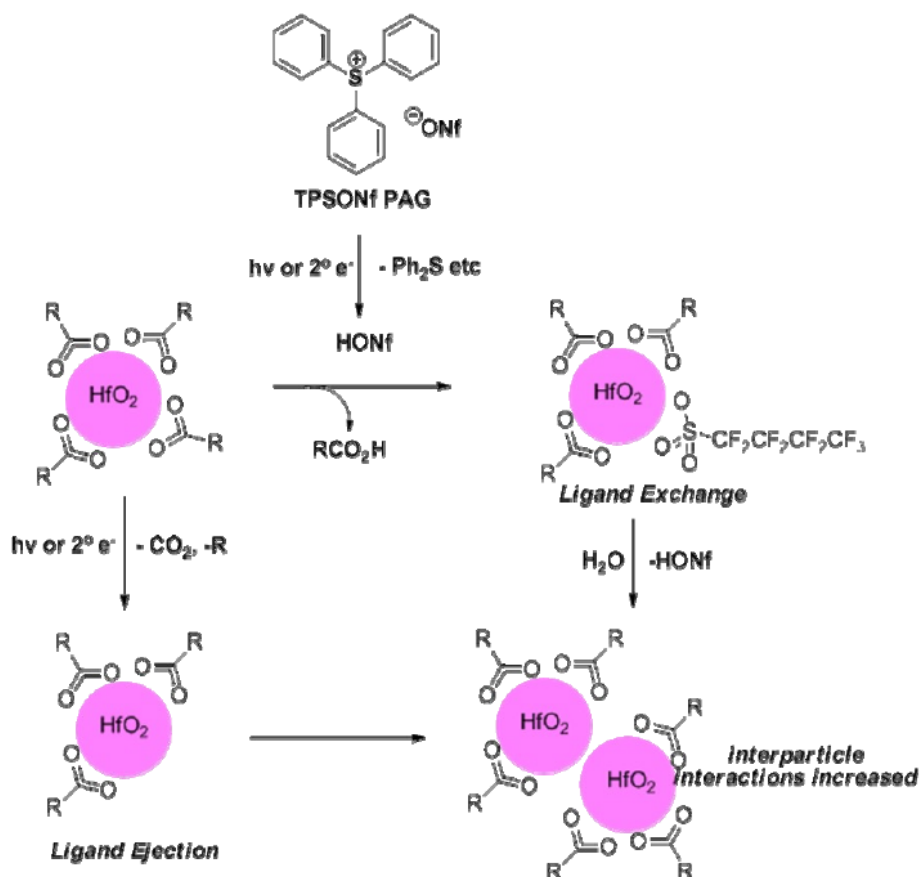


EX1027, 1. Inpria ignores this disclosure and points to the “photoactive compounds” that Ober also discloses. POR 53-54. Ober explains that when photoactive compounds are used, “displacement of the starting ligands by **new ligands**, which are produced by the photoactive compounds.” EX1027, 2. Ober Figure 2 shows this “ligand-displacement” method:



However, both the red “starting ligands” and blue “new ligands” **are ligands**, where the radiation cleaves part of the blue ligand. *Id.*; EX1040, ¶61. Dr. Banerjee admits that the “new ligands” are ligands which are modified by radiation. EX1033, 181:19-182:7, 183:15-20. Accordingly, even under Inpria’s theory, Trikeriotis’s ligands are “radiation sensitive.”

Inpria’s theory aside, later studies confirm that the red “starting ligands” are radiation sensitive. EX1040, ¶62. In Krysak, the authors found that the “inorganic/organic hybrid nanoparticle resist system” reported by Ober works through *either* a photoactive generator-free mechanism which “involves a ligand ejection by photo decarboxylation” *or* the “ligand exchange mechanism” described in Figure 2 of Ober. EX1036, 1, 5-6; EX1040, ¶62.



As shown above, radiation causes decarboxylation of the ligands. EX1036, 6; EX1040, ¶62. Accordingly, the organic ligands of the Trikeriotis nanoparticle are necessarily “radiation sensitive.” *Id.*

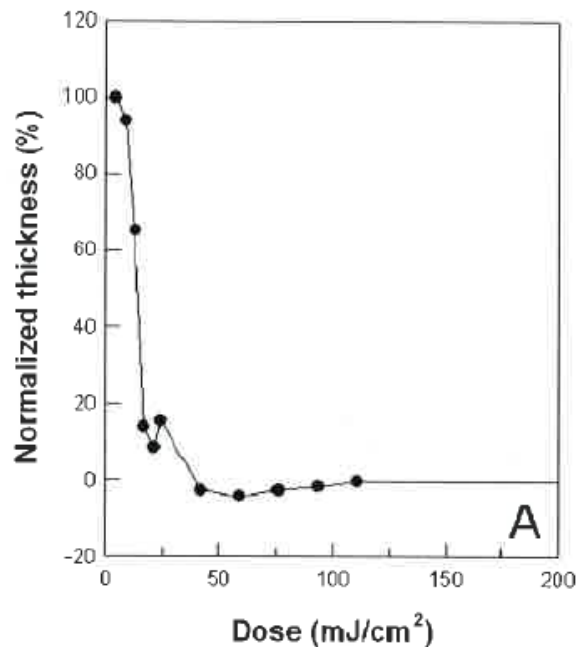
2. High Absorption of EUV Radiation

Inpria recycles the same arguments used in opposition to Stowers 2008—i.e., density does not correlate to EUV absorption. Inpria is mistaken. *See supra* at § IV.C.3. Additionally, because “[a]bsorption of EUV light in matter depends entirely on the atomic composition and the absorption cross section of elements,” the Trikeriotis nanoparticles—which contain hafnium and have a significantly higher

EUV absorbance than carbon—necessarily have higher EUV absorption than traditional organic resists. EX1044, 2; EX1040, ¶79.

3. Effectively Patterned with No More than 100 mJ/cm²

Inpria attempts to obfuscate the Trikeriotis data by arguing that there is “no evidentiary basis” for Lam’s “theory” that the Trikeriotis coatings can be effectively patterned with a dose of no more than 100 mJ/cm². Dr. Holland pointed to the contrast curves of Trikeriotis, which shows that the films were patterned with a dose of less than 100 mJ/cm²:



EX1002, ¶161 (showing Figure 5 of EX1024). The contrast curve shows a positive tone resist where the exposed portion is removed (i.e., the normalized thickness is reduced to 0 from a dosage well below 100 mJ/cm², and in fact at a dose as low as about 25 mJ/cm² about 80% of the resist is removed). EX1040, ¶85-86. Thus, at a

dose of **less than 100 mJ/cm²** (shown on the x-axis), the exposed portion is completely removed and the coating material was “effectively patterned.” *Id.*

Inpria attempts to obscure the issue by pointing to confusion over the term $D_{0.8}$. Dr. Holland stated that the $D_{0.8}$ of the Trikeriotis coating material was less than 25 mJ/cm². EX1002, ¶161. This is a term Dr. Holland adopted from the '564 patent inventors.⁴ *See, e.g.*, EX1008 (publication by '564 patent inventor Stowers referring to a $D_{0.8}$ of 194 mJ/cm²); EX1010, 20 (publication by '564 patent inventors Stowers and Keszler referring to a $D_{0.8}$ of 290 $\mu\text{C}/\text{cm}^2$). $D_{0.8}$ refers to the dose required for 80% exposed film to be soluble (for a positive tone resist) or insoluble (negative tone resist). EX1040, ¶86; EX1037, 43; EX1046, 1; EX1047, 186. Accordingly, Dr. Holland's annotation “ $D_{0.8} < 25 \text{ mJ}/\text{cm}^2$ ” shows that the Trikeriotis coatings can be effectively patterned with a dose of no more than 100 mJ/cm². EX1040 ¶¶86-87.

VI. CONCLUSION

The '564 patent is not entitled to its claimed priority date because the '867 Application does not provide adequate written description. Thus, the '888 Publication is prior art that anticipates claims 1-12. Additionally, Inpria's

⁴ Dr. Banerjee explained that $D_{0.8}$ was not a standard term in the field. EX1033, 184:14-20. It is therefore unsurprising that Dr. Holland could not recall the specific meaning of $D_{0.8}$ during her deposition.

acknowledgment of the “magic sauce recipe” in Stowers 2008 and Trikeriotis’s clear disclosures demonstrate obviousness. These points support granting the Petition.

Dated: October 23, 2024

Respectfully Submitted,

/ Dion M. Bregman /
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CERTIFICATION OF COMPLIANCE WITH TYPE-VOLUME LIMITS

This Petitioner's Reply includes 5,470 words, as counted by Microsoft Word, and is therefore in compliance with the 5,600-word limit established by 37 C.F.R. 42.24(c)(1). Accordingly, pursuant to 37 C.F.R. 42.24(d), lead counsel for Petitioner hereby certifies that this Petitioner's Reply complies with the applicable type-volume limits.

Dated: October 23, 2024

Respectfully submitted,

/ Dion M. Bregman /

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6(e)(4), it is hereby certified that on October 23, 2024 an electronic copy of this PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE and supporting exhibits, were served via email to Patent Owner's counsel of record in this proceeding:

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