

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LAM RESEARCH CORP.,
Petitioner

v.

INPRIA CORP.,
Patent Owner

Case IPR2024-00033
Patent No. 9,823,564

**DECLARATION OF JOHN S. MCCLOY, PH.D.
IN SUPPORT OF PATENT OWNER'S PRELIMINARY RESPONSE**

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I, John S. McCloy, Ph.D., declare as follows:

I. INTRODUCTION

1. I have been retained by Inpria Corporation (“Patent Owner”) as an independent expert consultant in this proceeding before the United States Patent and Trademark Office (“PTO”) against Lam Research Corporation (“Petitioner”) regarding U.S. Patent No. 9,823,564 (“the ’564 patent”) (EX1001).¹ I have been asked to consider whether a person of ordinary skill in the art would have understood the inventors of the ’564 patent to be in possession of certain features recited in the claims of the ’564 patent. I have also been asked to provide opinions relating the formation of resist films and relating to the possible changes to materials based on exposure to ultraviolet (UV) or extreme ultraviolet (EUV) radiation. My opinions are set forth below.

2. I am being compensated at a rate of \$400/hour for my work in this proceeding. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

¹ Where appropriate, I refer to exhibits that I understand are to be attached to the petition for *Inter Partes* Review of the ’964 patent.

II. BACKGROUND AND QUALIFICATIONS

3. I am an independent consultant. All of the opinions stated in this declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and experience in researching and teaching aspects of semiconductor technology, as referenced in this declaration.

4. I am over the age of 18 years and, if I called upon, I am competent to testify regarding the matters herein. I understand that a copy of my current curriculum vitae, with details of my education, professional, and academic experience, is attached as Exhibit 2002. The following text is a summary of some of my experiences relevant to the matters set forth in this declaration.

5. I am a tenured full Professor and the current Director (Department Head) in the School of Mechanical and Materials Engineering at Washington State University (WSU), located in Pullman, Washington. I also hold official affiliate positions in the WSU Department of Physics and Astronomy and the Department of Chemistry.

6. I previously held the position of director of the Institute of Materials Research at WSU (materialsresearch.wsu.edu), which consisted of an interdisciplinary group of researchers including my research group Crystals and Semiconductors, as well as a number of facilities including furnaces for growth of semiconductor crystals, a microelectronics cleanroom, and a number of state-of-the-

art instruments for measuring optical and electrical properties of semiconductor materials. I was also the director of the Materials Science and Engineering Program (MSEP) at WSU, which managed the curriculum and recruiting of the highly interdisciplinary PhD program.

7. I have been teaching at WSU since 2013 and have advised and graduated 17 PhD students and 3 MS students. I currently have a research group of about 20 students, post-docs, and scientists. In addition to other courses focusing on functional properties of materials (electrical and optical properties) and materials characterization, I have taught Electronic Materials (which includes semiconductor physics and processing).

8. I received my B.S. degree in Materials Science and Engineering from the Massachusetts Institute of Technology in 1996. I received my M.S. degree and Ph.D. in Materials Science and Engineering from the University of Arizona in 2007 and 2008, respectively. I also received my M.A. degree in Cultural Anthropology from the University of Arizona in 2004.

9. Since 2013, I have held various research and teaching positions in the School of Mechanical and Materials Engineering at WSU. I have published more than 260 technical papers in journals, technical conferences, books, and public reports. I am an inventor of three issued patents covering various technologies, including semiconductor optical materials and electrical devices. I am a Fellow of

the American Ceramic Society (ACerS) and a senior member of SPIE, the Optical Engineering Society. I have served in elected office positions for technical committees in ACerS and SPIE, as well as for other societies such as the American Chemical Society and the International Congress on Glass.

10. I also have industry experience outside of academia. From 2000-2008, I held various engineering roles at Raytheon Missile Systems in Tucson, AZ. While at Raytheon, I was a manufacturing project engineer in the Electro-Optic Sensors and Precision Assembly factory, where we made cryogenically cooled infrared seeker systems, including integration of focal plane arrays. I also worked in the integration and test organization at Raytheon and participated in hardware-software integration and flight testing of an infrared kinetic warhead. My experience at Raytheon also included working on coatings as a part of the Optical Design Team and designing and developing materials, including chemical vapor deposition (CVD) of wide bandgap semiconductors for optical elements, as a part of the Opto-Mechanical Design team. I have also worked for Intel in Arizona, focusing on statistical analysis of chip die attach processes. I also spent about 1.5 years at Crane Interpoint, a hybrid microelectronics manufacturing facility in Washington, where I was a process engineer in manufacturing support and new product development, responsible for thick film screen printing technology of metals and dielectrics, including lithography.

11. Between 2008 and 2013, I worked in the Department of Energy (DOE) national laboratory system. At the DOE's Pacific Northwest National Laboratory in Richland, WA, I worked with state-of-the-art synthesis and characterization equipment, including molecular beam epitaxy used to make thin film semiconductor materials. My work in this area focused on characterization of these materials using electrical, magnetic, and optical techniques. I also performed and published work on arsenic sulfide and related glass systems and their optical property changes due to radiation; these chemistries are photosensitive, and have been previously considered as inorganic photoresists. I am still affiliated with this laboratory, and, in conjunction with my students and research at WSU, have made use of equipment at multiple DOE research facilities, including X-ray synchrotrons, neutron scattering facilities, and electron microscopy centers.

12. I have received accolades for my achievements in academia as well as in the industry. I currently hold the Lindholm Endowed Chair in Materials Engineering at WSU. I was a Fulbright Scholar at the University of Sheffield in the United Kingdom, performing research on synthesis and characterization of ceramics and glasses. I have been awarded the Fulrath-Okasaki Award from the American Ceramic Society and the Anjan Bose Outstanding Researcher Award by WSU. At Raytheon I was twice named an Engineer "with Honors."

13. I am not an attorney and offer no legal opinions, but in the course of my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art.

III. MATERIALS REVIEWED

14. The opinions contained in this Declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge regarding semiconductor processing, including lithography and photoresist materials used to pattern semiconductor devices.

15. In forming my opinions expressed in this Declaration, I reviewed the following materials and information: U.S. Patent 9,823,564 (EX1001), Holland Declaration (EX1002), the file history for U.S. Patent Application 12/850,867 (EX1004), U.S. Patent No. 5,874,128 (EX2003), U.S. Patent No. 5,658,615 (EX2004), U.S. Patent No. 6,987,572 (EX2005), U.S. Patent No. 7,220,531 (EX2006), and Seong-Yun Moon, Jong-Man Kim, *Chemistry of photolithographic imaging materials based on the chemical amplification concept*, Journal of Photochemistry and Photobiology C: Photochemistry Reviews 8 (2007) 157-173 (“Moon”) (EX2007). I also reviewed any other materials I refer to in this Declaration in support of my opinions.

16. My opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also

been guided by my appreciation of how a person of ordinary skill in the art would have understood the state of the art, the prior art, and the claims and the specification of the '564 patent at the time of the invention.

17. I understand that the '564 patent issued from U.S. Patent Application No. 14/858,612 ("the '612 application") filed on September 18, 2015, and claims priority to U.S. Patent Application No. 12/850,867 ("the '867 application") filed on August 5, 2010, and Provisional Patent Application No. 61/350,103 ("the '103 provisional") filed on June 1, 2010. (EX1001, Cover.) For purposes of rendering my opinions, I have been asked to initially consider that the time of the invention of the '564 patent is around June 1, 2010 to August 5, 2010. My opinions reflect how one of ordinary skill in the art (which I described below) would have understood the '564 patent and the state of the art at the time of the invention as I was asked to consider noted above.

IV. PERSON OF ORDINARY SKILL IN THE ART

18. For purposes of this declaration, I have been asked to assume what I understand to be Petitioner's definition of a person of ordinary skill in the art. I have been informed that Petitioner has defined a person of ordinary skill in the art as an individual with at least a graduate degree, such as a masters or Ph.D., in a relevant discipline such as in chemistry, materials science, chemical engineering, physics, or an equivalent field. I further understand that Petitioner's definition includes such a

person of ordinary skill in the art having 1-3 years of experience in the research, design, development and/or testing of resist materials.

19. Based on my knowledge and experience, I understand what such a person of ordinary skill in the art would have known at the time of the alleged invention. All of my opinions in this declaration are from the perspective of one of ordinary skill in the art, during the relevant timeframe (e.g., the time of the invention), which I discussed above as being around June 1, 2010 to August 5, 2010.

V. CLAIM CONSTRUCTION

20. I understand that claim terms are typically given their ordinary and customary meanings, as would have been understood by a person of ordinary skill in the art at the time of the alleged invention. I have been asked to apply the plain and ordinary meaning of the terms in those claims. I understand that in considering the meaning of the claims, one must consider the language of the claims, the specification, and the prosecution history of record. I have done so to support my opinions in this petition where appropriate.

VI. DISCLOSURE OF THE '867 APPLICATION

21. I have been asked to review and consider whether a person of ordinary skill in the art would have understood, based on the disclosure of the '867 application, that the inventors of the '564 patent were in possession of a certain element of claim 1, namely the recited average thickness range of 5 nm to 30 nm for

the coating material. As detailed below, in my opinion, based on the disclosure of the '867 application, such a person of ordinary skill in the art would have understood the inventors had possession of the invention recited in claim 1, including the 5 nm to 30 nm average thickness range.

22. The '867 application discloses depositing a coating material on the surface of a substrate and further details the process by which such depositing can be accomplished. (EX1004, 22:21-24:21.)² The '867 application notes that “[i]f patterning is performed using radiation, spin coating can be a desirable approach to cover the substrate relatively uniformly, although there can be edge effects.” (*Id.*, 23:1-2.) In addition to spin coating, the '867 application also discloses other techniques for depositing the coating material. (*Id.*, 22:21-27.)

23. In the context of spin coating, the '867 application explains that “[t]he thickness of the coating generally can be a function of the precursor solution concentration, viscosity and the spin speed.” (*Id.*, 23:14-15.) With respect to spin

² These citations to EX1004 are to the '867 application that spans pages 3-51 of EX1004. As a result, the page numbers for the exhibit are offset from the pages of the patent application by two. For example, page 22 of EX1004 corresponds to page 20 of the '867 application.

speed of the wafer during spin coating, the '867 application provides certain example spin speeds:

In some embodiments, a wafer can be spun at rates from about 500 rpm to about 10,000 rpm, in further embodiments from about 1000 rpm to about 7500 rpm and in additional embodiments from about 200 rpm to about 600 rpm. **The spinning speed can be adjusted to obtain a desired thickness.**

(*Id.*, 23:3-6 (emphasis added).)

24. Aside from spin coating, the '867 application discloses that “[f]or other coating processes, the thickness can generally also be adjusted through the selection of the coating parameters.” (*Id.*, 23:15-16.) The '867 application also describes controlling the thickness of the coating by applying the coating material in multiple coating steps. (*Id.*, 22:27-30 (“The coating material can be applied in multiple coating steps to provide greater control over the coating process. For example, **multiple spin coatings can be performed to yield an ultimate coating thickness desired.**”) (emphasis added).) The importance and desirability of certain thicknesses or thickness ranges is further supported by the '867 application's explanation as to how such thicknesses can be measured. (*Id.*, 23:24-26 (“The thickness can be evaluated using non-contact methods of x-ray reflectivity and/or ellipsometry based on the optical properties of the film.”).)

25. The '867 application explains that “it can be desirable to use a thin coating to facilitate formation of small and highly resolved features” (*id.*, 23:16-18), where specific example thickness ranges are provided:

In some embodiments, the coating materials can have an average thickness of no more than about 1 micron, in further embodiments no more than about 250 nanometers (nm), in additional embodiments from about 1 nanometers (nm) to about 50 nm, in other embodiments from about 1 nm to about 40 nm and in some embodiments from about 1 nm to about 25 nm.

(*Id.*, 23:18-22.) While providing these example thickness ranges, the '867 application states that “[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.” (*Id.*, 23:22-24.) The '867 application also discloses an example in which the “coating material was deposited at a thickness [from] 10-50 nm,” (*id.*, 35:14-15) and an example where the “resist was applied with a thickness of 20nm” (*id.*, 36:29-30).

26. Notably, many of the example ranges (“no more than about 1 micron,” “no more than about 250 nanometers (nm),” “about 1 nanometers (nm) to about 50 nm,” and “about 1 nm to about 40 nm”) include the claimed range. In addition, both

of the “1 nm to 25 nm” and “10-50 nm” ranges overlap the claimed range, and the example thickness of 20 nm falls within the claimed range.

27. In my opinion, based on the description of the '867 application, a person of ordinary skill in the art would have immediately discerned that the inventors possessed the claimed range of 5 nm to 30 nm. As I discuss above, the inventors provided example ranges that include the claimed range and explained how various thicknesses can be achieved. Moreover, the inventors explicitly stated that “[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.” (*Id.*, 23:22-24.) I agree with this statement in the specification, as the details and examples provided convey to a person of ordinary skill in the art that additional ranges within those example ranges are within the disclosure of the '867 application. Therefore, such a person of ordinary skill in the art would have further understood that the inventors were in possession of those additional ranges, including the range of 5 nm to 30 nm.

VII. SPIN COATING OF FILMS

28. I have also been asked to consider whether spin coating resist films to form a coating on a substrate necessarily results in the layer of material having a uniform thickness. In my opinion, a person of ordinary skill in the art would have understood that spin coating a resist film may result in varying thicknesses for the

film at different points on the substrate. Because spin coating relies on the substrate spinning while the material is deposited, the rotation of the substrate can result in uneven forces at different points on the wafer, which in turn can cause varying thickness for the deposited material.

29. This is confirmed, for example, by Kim (EX2003), which explains how spin-coating resist films involves centrifugal forces that can result in differences in the thickness of the photoresist layer:

The spin-coating process using the spinner 5, however, suffers a drawback. Specifically, *it is difficult to obtain a uniform thickness layer of photoresist on the wafers 10*. The centrifugal force, which is generated by the rotation of the spinner 5, causes the photoresist to move away from the axis of rotation. Because the magnitude of the centrifugal force depends on the distance from the axis of rotation, the movement of photoresist material varies with position on the wafer. *The results in uneven photoresist coating layer on the wafers 10*.

(EX2003, 2:21-30 (emphasis added).)

However, the apparatus and methods described above fail to consider that *a cause of the uneven photoresist thickness is the radially varying centrifugal force, which yields a radially varying thickness of*

photoresist material. In other words, the dispensed photoresist is influenced by the varying centrifugal force as the spinner rotates and the material spreads over the whole surface of the wafer. The magnitude of the centrifugal force influencing the photoresist material is proportional to the square of the radius at which the material is located on the rotated wafer. Therefore the level of centrifugal force varies with the position on the wafer. For example, the force is almost zero at the center of the wafers and is at a maximum at the circumference of the wafers. *Such differences in the centrifugal force result in differences in the thickness of the photoresist layer; inevitably the thickness of the photoresist layer at the center of the wafer will be different from that at the other areas of the wafer. Moreover, a wafer having a larger radius (e.g., 12 inch wafers which are still under development) will have a greater difference in the center-to-edge thickness of a photoresist layer than the 8 inch wafers that are currently used. The difference in thickness can be controlled to some extent by adjusting the spinning velocity of the spinner and modifying the process variables in association with the viscosity of the photoresist. However, the difference between the thicknesses at the center of the wafer where the centrifugal force is zero compared to the thickness at the*

other areas of the same wafer cannot be fundamentally eliminated.

(*Id.*, 2:55-3:15 (emphasis added).)

30. Similarly, Hasebe (EX2004) explains that a uniform coating thickness can not be obtained when spin coating resist because there can be changes in the viscosity of the material as it moves from the center of the wafer towards the outside edges of the wafer, and because the velocity at the peripheral portion of the wafer is higher than that it is at the middle of the wafer:

For example, spin coating is known as a method of forming a resist film. According to this method, a table is rotated with a semiconductor wafer being placed and fixed thereon. For example a resist solution consisting of a solvent and a photo-sensitive resin is dropped on the central portion of the upper surface of the wafer. The resist solution is spirally diffused from the central position of the wafer to its peripheral portion in accordance with the rotational and centrifugal forces of the wafer, thereby coating the resist solution on the semiconductor wafer.

According to this method, in the process of diffusing the resist solution from the central position of the wafer to its peripheral portion, the solvent in the resist solution evaporates. *For this reason, the viscosity of the resist solution varies in a diffusion direction, and the*

thickness of the resist film at the central portion is different from that at the peripheral portion. In addition, the peripheral velocity at the peripheral portion is higher than that at the central position, and a scattering amount of the resist solution at the peripheral portion is much larger than that at the central position. *Thus, a uniform coating can not be obtained.*

(EX2004, 1:17-38 (emphasis added).)

31. While Kim and Hasebe both predate the '564 patent, a person of ordinary skill in the art would have understood that the same challenges in trying to provide a uniform layer of material would exist for other spin-coated resist materials, including those that existed around the time of the invention of the '564 patent.

VIII. IMPACT OF DIFFERENCES IN RATIOS AND CONCENTRATIONS OF MATERIALS AND PROCESSING CONDITIONS ON RESULTING FILMS

32. 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.

33. As one example, the '564 patent teaches that higher ratios of peroxide to metal in the precursor solutions used to produce the coating films can provide advantages, including improved stability of the precursor material:

The precursor solutions have been formulated with improved stability and control of the precipitation so that radiation can be used to induce a change in the material. *In particular, peroxide-based ligands stabilize the precursor solutions while also providing control over the processing of the materials.*

Specifically, the precursor solution can comprise sufficient radiation sensitive ligands 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. *In particular, the higher peroxide-based ligand concentrations provide for a surprisingly large improvement in the precursor stability. While not wanting to be limited by theory, the increase in the radiation sensitive ligand concentration evidently reduces agglomeration of the metal cations to stabilize the solution. Thus the precursor solution can be stable relative to settling of solids without further stirring for at least two hours and possibly for significant*

longer periods of time, such as greater than a month. Due to the long stability times, the improved precursors have increased versatility with respect to potential commercial uses. Hydrogen peroxide provides a desirable radiation sensitive ligand, although other inorganic peroxides can be suitable.

(EX1001, 5:55-6:11 (emphasis added); *see also id.*, 13:11-14 (“As noted above, a relatively large ratio of peroxide-based ligand relative to the metal cations can be used to greatly stabilize the precursor solutions.”).)

34. In addition to the ratio of peroxide ligands to metal of at least about 2 and 5 above, the '564 patent further discloses other ratios where the peroxide is much higher in concentration than the metal:

The precursor composition generally comprises a ligand concentration of at least a factor of about 2 times the metal cation concentration, in further embodiments, at least a factor of about 3, in other embodiments at least a factor of about 4 and in additional embodiments a factor from about 5 to about 25 times the metal cation concentration.

(*Id.*, 12:33-39.)

35. The '564 patent further discloses that the greater stability of the precursor solutions results in a higher-quality resulting coating material, where the

contrast between irradiated and non-irradiated regions of the coating material is improved:

The precursor solutions have been formulated to achieve very high levels of stability such that the precursor solutions have appropriate shelf lives for commercial products. Also, it has been discovered that the formulation of the precursor solutions can be designed to achieve desired levels of radiation absorption for a selected radiation based on the selection of the metal cations. ... The control of the precursor solution is based on high concentrations of radiation sensitive ligands to the metal cations, specifically peroxide-based ligands. In particular, if the mole ratio of peroxide groups to the metal cations is at least 2, more stable solutions can be formed. The more stable precursor solutions provide an added advantage of greater contrast between the ultimate irradiated coating material and un-irradiated coating material.

(*Id.*, 9:55-10:7.)

36. Therefore, as the '564 patent confirms, a person of ordinary skill in the art would have understood that changing the precursor materials to have a higher percentage of peroxide ligands results in changes to the coating material that is eventually formed. As one example, the '564 patent notes that the coating material demonstrates improved contrast in some situations:

As described herein, significant improvements in the precursor solutions have been accomplished through the use of significantly higher radiation sensitive ligand concentrations. Even more surprisingly, significantly increasing the radiation sensitive ligand concentration in the precursor solutions results in a coating material that has greater contrast following radiation exposure so that there are surprising added benefits where precursor solution stabilization further accomplishes improved patterning and shorter development times.

(*Id.*, 6:26-35.)

37. In addition to differences resulting from different concentrations of precursor materials, a person of ordinary skill in the art would have understood that different coating films can also result because of differences in the way in which the precursor materials are combined. For example, the '564 patent discloses a particular mixing sequence where ZrOCl_2 or HfOCl_2 is combined with H_2O_2 , then there is a five-minute rest, then H_2SO_4 is added, and then the solution is again allowed to rest for five minutes. (EX1001, 21:23-55.) The '564 patent discloses that “[t]his particular mixing sequence has been found to limit particle growth.” (*Id.*, 21:55-56.)

38. A person of ordinary skill in the art would have understood that the '564 patent, which teaches that the solution resulting from the above mixing

sequence is then diluted with “ultrapure water,”³ discloses that performing the mixing of the three materials in that particular order and limiting the resting time after the mixing steps in turn limits the formation of larger, undesirable particles in the solution. The ’564 patent explains that stability of a precursor material is lost “if a phase separation occurs with the production of large sol particles.”⁴ (*Id.*, 13:16-17.) In other words, the constituent parts of the precursor material combine and

³ The ’564 patent further discloses that this mixing sequence is used to form a solution that is then diluted with “ultrapure water” to achieve formations of a solution that have a desired concentration of metal. (EX1001, 21:57-66.) A person of ordinary skill in the art would have understood that the final dilution step using purified water both provides a solution with a desired metal concentration as well as slows down any further reaction between the constituent materials combined in the two mixing steps.

⁴ The nanometer-sized original sol/particle size, described in the scientific literature as “radius of gyration,” is a size-related value collected by techniques such as small-angle X-ray scattering, which contains information about size, shape, symmetry, and homogeneity. Smaller values indicate smaller unit particles which would result in the possibility for thinner and more uniform films.

produce large particles that make the precursor less useful in the desired combination for which the precursor is designed.

39. 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.

40. A person of ordinary skill in the art would have known and appreciated that other aspects of the coating film formation process can also influence the characteristics of the resulting coating film. For example, as discussed immediately above, the '564 patent discloses diluting the solution resulting from mixing the precursor materials to achieve a desired concentration of metal ions. (EX1001, 21:62-64 (“Using the method described above, a 30 mL formulation of an Hf based precursor solution with a final hafnium concentration of 0.15 M was obtained.”).) In this context, the '564 patent explains that having a lower concentration of metal ions in the solution results in lower viscosity, which in turn allows for the formation

of a thinner coating. (EX1001, 5:11-17 (“In some embodiments, the inorganic precursor solution can have a relatively low concentration of metal ions such that the rheology of the coating composition, e.g., the viscosity, allows the formation of a thin coating on the substrate. The use of a thinner coating is consistent with the formation of higher resolution structures upon exposure to radiation and development of the pattern.”), 6:50-54 (“The metal ion concentration can be selected to provide desired properties for the precursor solution, with more dilute solutions generally consistent with the formation of thinner coating materials.”), 13:4-9 (“The concentrations of the species in the precursor solutions can be selected to achieve desired properties of the solution. In particular, lower concentrations overall can result in a desirable properties of the solution for certain coating approaches, such as spin coating, can achieve thinner coatings using reasonable coating parameters.”).) A person of ordinary skill in the art would have understood that a final hafnium concentration in the Hf-based precursor solution greater than the 0.15 M disclosed in the ’564 patent could impact the ability to deposit the resulting coating to the desired thickness as thinner coatings are more difficult to achieve with higher metal concentrations due to increased viscosity.

41. As demonstrated by the examples that I present above, 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.

IX. CHANGES TO MATERIALS BASED ON EXPOSURE TO UV OR EUV RADIATION

42. I have been asked to consider, in the context of films that are exposed to UV or EUV as a part of a patterning process, whether such exposure necessarily results in the altering of chemical properties of the films that results in differential dissolution rates. As I explain below, patterning of such films in processes that include exposure to UV or EUV radiation does not require the exposure to change chemical properties in a manner that results in differential dissolution rates.

43. For example, a person of ordinary skill in the art would have known that such exposure to UV or EUV radiation could alter a physical property of the material as opposed to a chemical property. (EX1006, 1:18-20 (“The chemical *or physical* properties of the photoresist can be changed by being exposed to light.”) (emphasis added).)

44. Similarly, a person of ordinary skill in the art also would have known that chemical changes that result in different dissolution rates can be driven by aspects of the lithography process besides the actual exposure to light/radiation. For example, post-exposure bake operations, where the substrate is heated after

exposure, was known to result in chemical reactions that made portions of the resist susceptible to removal while leaving other portions behind:

As shown in step 30, the wafer may be subjected to a post exposure bake process step. The post exposure bake process may be used to drive a chemical reaction in the exposed portions of the resist such that portions of the resist may be removed in subsequent processing. As such, the performance of the post exposure bake process may be critical to the performance of the lithography process.

(EX2005, 8:20-26.)

45. Therefore, a person of ordinary skill in the art would have understood that exposure to UV or EUV radiation can result in either physical or chemical changes to the resist material. While such changes can result in differential dissolution rates between exposed and unexposed regions, the differential dissolution rates used for patterning the exposed resist can also be the result of steps in the lithography process other than the actual exposure to the radiation, such as the post-exposure bake referenced above. (EX2007, 7 (“Upon irradiation, acids photogenerated from a PAG catalytically *cleaves t-BOC groups during postexposure bake (PEB)* at high temperature as shown in FIG. 9”) (emphasis added).) Indeed, a person of ordinary skill in the art would have understood that exposure may result in chemical changes to the exposed portions that, by themselves,

do not produce differential dissolution rates. In such a scenario subsequent processing steps are required in order to induce further chemical changes that produce those differential dissolution rates used for patterning the resist.

X. CONCLUSION

46. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: January 26, 2024

By: John S. McCloy
John S. McCloy, Ph.D.