UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Renesas Electronics Corporation and Renesas Electronics America, Inc.,

Petitioners

v.

Lone Star Silicon Innovations, LLC,

Patent Owner

U.S. Patent No. 6,326,231

Inter Partes Review Case No.: IPR2017-01868

PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 6,326,231

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Exhibit	Description
1001	Subramaniam, et al., U.S. Patent No. 6,326,231 B2
1002	Complaint in Lone Star Silicon Innovations LLC, v. Micron Tech., Inc., 2:16-cv-1116 (E.D. Tex.) (exhibits omitted)
1003	Complaint in Lone Star Silicon Innovations, LLC v. Nanya Tech. Corp., 2:16-cv-01117 (E.D. Tex.) (exhibits omitted)
1004	Complaint in Lone Star Silicon Innovations LLC v. Renesas Elecs. Corp., CA No. 2:16-cv-01438 (E.D. Tex.) (exhibits omitted)
1005	Prosecution History of Application s.n. 09/207,562, granted as U.S. Patent No. 6,326,231
1006	Foote, et al., U.S. Patent No. 5,710,067
1007	Declaration of Dr. Dean Neikirk
1008	Curriculum Vitae of Dr. Dean Neikirk
1009	Patent Term Calculation for U.S. Patent No. 6,326,231
1010	Shibata, Japanese Unexamined Patent Application Publication No. Hei 08-191068
1011	Certified Translation of Shibata, Japanese Unexamined Patent Application Publication No. Hei 08-191068
1012	Cheung, U.S. Patent No. 6,562,544
1013	Foote, et al, U.S. Patent No. 6,903,007
1014	Text comparison of U.S. Patent No. 6,903,007 to U.S. Patent No. 5,710,067
1015	Konjuh, et al., U.S. Patent No. 6,051,282, filed as U.S. Patent application s.n. 09/090,848 on June 4, 1998

Exhibit	Description
1016	Ogawa, et al., "Practical Resolution Enhancement Effect by New Complete Anti-Reflective Layer in KrF Excimer Laser Lithography," SPIE Optical/Laser Microlithography, v. 1927, pp 263-274 (1993)
1017	Joesten, et al., "Footing Reduction of Positive Deep-UV Photoresists on Plasma Enhanced ARL (PEARL) SiON Substrates," SPIE Advances in Resist Technology and Processing XV, pp. 960-971 (June 29, 1998)
1018	Lee, et al., "ARC for Sub-0.18µm Logic and Gigabit DRAM Frontend and Backend Processes," Symp. VLSI Technology, pp. 86-87 (June 1998)

I. INTRODUCTION

Petitioners request *inter partes* review of U.S. Patent No. 6,326,231 (the "231 Patent"). Claims 1-5 and 7 (the "Challenged Claims") are invalid over several prior art references.

The '231 Patent describes solutions to problems in semiconductor manufacture that arise through use of antireflection coatings, specifically those made of silicon oxynitride. An oxide barrier layer is placed between the antireflection layer and a photoresist layer. The oxide layer prevents nitrogen from the silicon oxynitride from chemically interacting with the photoresist layer. Without the presence of a barrier layer, this chemical interaction would impair patterning performance.

As explained herein, use of silicon oxynitride antireflection layers and oxide barrier layers were well known, predictable techniques before the '231 Patent was filed. Thus, the Challenged Claims are invalid over prior art.

II. MANDATORY NOTICES PURSUANT TO 37 C.F.R. § 42.8

A. <u>Real Parties-in-Interest (37 C.F.R. § 42.8(b)(1))</u>

The real parties-in-interest for this Petition are Renesas Electronics Corporation and Renesas Electronics America, Inc.

B. <u>Related Matters (37 C.F.R. § 42.8(b)(2))</u>

Lone Star Silicon Innovations LLC presently asserts the '231 Patent in the following cases: *Lone Star Silicon Innovations LLC, v. Micron Tech., Inc.,* 2:16-cv-1116 (E.D. Tex.); *Lone Star Silicon Innovations, LLC v. Nanya Tech. Corp.,* 17-cv-04032 (N.D. Cal.); and *Lone Star Silicon Innovations LLC v. Renesas Elecs. Corp.,* CA No. 5:17-cv-03981 (N.D. Cal.).¹ Ex. 1002-1004. Those proceedings would be affected by a decision in this *inter partes* review ("IPR").

The '231 Patent is the subject of IPR2017-01565, filed by Micron Technologies on June 9, 2017. Petitioners had no role in preparation of IPR2017-01565. This Petition presents grounds of invalidity that are different than those presented in IPR2017-01565, including invalidity challenges based on prior art (discussed below) that cannot be antedated.

C. <u>Lead and Backup Counsel and Service Information (37 C.F.R.</u> <u>§§ 42.8(b)(3)-(4))</u>

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District of Texas in July 2017.

¹ The Nanya and Renesas cases were transferred to California from the Eastern

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Service Information: Please address all correspondence to lead counsel. Petitioners also consent to e-mail service at <u>BH-LoneStar-IPR@bakerlaw.com</u>.

III. <u>37 C.F.R. §§ 42.103, 42.104 REQUIREMENTS</u>

A. <u>Payment of Fees</u>

The PTO is authorized to charge Deposit Account No. 23-3050 for all fees associated with this Petition, including all fees set forth in 37 CFR § 42.15(a).

B. Grounds for Standing (37 C.F.R. § 42.104(a))

Petitioners certify that the '231 Patent is eligible for *inter partes* review and that Petitioners are not barred or estopped from requesting *inter partes* review of the Challenged Claims of the '231 Patent on the grounds identified herein. Petitioners were served with a complaint asserting infringement of the '231 Patent on December 21, 2016, less than one year before the filing date of this Petition. *See* Ex. 1004. Petitioners have not initiated a civil action challenging the validity of any claim of the '231 Patent.

IV. <u>THE '231 PATENT</u>

A. <u>Summary of the '231 Patent's Disclosure</u>

The '231 Patent is directed to semiconductor manufacturing techniques and, in particular, to techniques for forming silicon oxynitride antireflection coatings over highly reflective materials in a semiconductor substrate.

The '231 Patent explains that antireflection coatings were well known solutions to microlithography problems involving patterning errors in photoresists. Although it is desired to pattern a photoresist only in places of intentional radiation exposure, reflective surfaces underneath a photoresist can cause radiation exposure at other locations of the photoresist. The unintended exposure occurs when radiation that passes through the photoresist is reflected back into the photoresist by reflective surfaces underlying the photoresist. Ex. 1001, Col. 1:18-49. An antireflection coating helps solve these issues by absorbing radiation that passes through the photoresist. *Id.* at 1:58-2:7.

The '231 Patent identifies titanium nitride as a conventional antireflection coating. The '231 Patent identifies problems with titanium nitride coatings, including inability to reduce reflectivity when used with certain metals and "poisoning" of deep ultraviolet photoresists. Poisoning occurs when nitrogen

migrates from the titanium nitride antireflection coating into the photoresist, which desensitizes the photoresist to deep ultraviolet light. *Id.* at 2:27-43.

The '231 Patent proposes an antireflective coating 14 that contains two layers: a silicon oxynitride layer (**gram**) and a thin oxide layer (**gram**).² *Id.* at 2:44-49; 6:13-34. The silicon oxynitride layer is formed on an underlying substrate 12 (**blue**) that includes reflective metal surfaces. *Id.*, at 6:13-34. The oxide layer is formed over the silicon oxynitride layer. *Id.*, at 3:43-4:60, 6:13-34. Thereafter, a photoresist 16 (**gray**) is formed over the oxide layer of the antireflective coating 14. *Id.*, at 5:65-6:9, 6:35-48. The oxide layer prevents nitrogen from migrating from the silicon oxynitride layer to the photoresist 16. *Id.*, at 7:60-65.



Ex. 1001, FIG. 1 (annotated)

² The '231 Patent does not have a figure that illustrates the silicon oxynitride layer and the oxide layer separately from each other.

The Challenged Claims recite that the silicon oxynitride layer (green) has a thickness of 100Å-1,500Å. *Id.*, at. 8:31-33. The patent's specification discloses several ranges of thickness for the silicon oxynitride layer, including 100Å-1,500Å, 125Å-1,400Å, 150Å-1,300Å, and 125Å-600Å. *Id.* at 4:33-39, 4:66-5:8. No range is identified as critical. Although the patent states that the range 125Å-600Å is preferred, it does not identify any advantages that are obtained either by the preferred range or by any of the other disclosed ranges.

The Challenged Claims recite that the oxide layer (**yellow**) has a thickness between 5Å-50Å. The patent's specification discloses several ranges of oxide layer thickness, including 5Å-50Å, 10-40Å, and 15-35Å. *Id.* at 4:66-5:8. Again, no range is identified as critical. The '231 Patent does not identify any range as providing any unique advantage. *Id.*

Instead, the '231 Patent states that reflectivity of the resultant antireflective layer 14 will depend on a variety of factors, including the relative amounts of oxygen and nitrogen of the silicon oxynitride layer, initial thickness of the silicon oxynitride layer, thickness of the oxide layer, and thickness of the resultant antireflection coating. *Id.* at 5:9-15. Thus, the claims' thickness ranges appear to be among a variety of different parameters that are adjusted to manage performance of the antireflection coating.

The '231 Patent states that the silicon oxynitride layer (grean) can be fabricated by any suitable technique, including chemical vapor deposition ("CVD"), low pressure chemical vapor deposition or plasma enhanced chemical vapor deposition ("PECVD"). *Id.*, at 4:10-25. The patent states that the oxide layer (*yellow*) may be formed by contacting the silicon oxynitride layer with either an oxygen plasma or a nitrogen plasma or by depositing the oxide layer by CVD techniques. *Id.*, at 4:50-60. *See also*, Ex. 1007, § IV.A.

B. <u>Prosecution History of the '231 Patent</u>

The '231 Patent was granted from U.S. application s.n. 09/207,562, which was filed on December 8, 1998. It makes no priority claim to any other filing.

Claims from the '562 application were rejected four times over prior art. In a first rejection, issued in July 2000, the pending claims were rejected as obvious over Roman, U.S.P. 5,639,687, Ionov, U.S.P. 6,013,582 and, for some claims, Fuse, U.S.P. 4,527,007. Ex. 1005, pp. 49-54. Roman disclosed an antireflective coating made of a silicon nitride layer and an oxide layer. *Id*. The Office Action concluded it would have been obvious to use silicon oxynitride as a substitute for Roman's silicon nitride layer. *Id*. Fuse was cited for disclosure of an oxide layer formed from N₂O or O₂ plasmas. *Id*.

The applicants argued against the rejection in an October 2000 response. *Id.*, pp. 56-61. The applicants argued the prior art did not teach use of an integral antireflective coating layer formed from silicon oxynitride and an oxide layer. *Id.* With respect to Roman, the applicants argued that the oxide layer was not an integral part of an antireflective coating because Roman discloses an intervening layer provided between the oxide layer and the silicon nitride layer. *Id.* The applicants also characterized Ionov's silicon oxynitride layer as relating to etching, not to antireflective coatings. *Id.*

The Office issued a final rejection in January 2001. *Id.*, pp. 64-70. The Office concluded that Roman discloses an oxide film that was deposited over an antireflective coating, which is exactly what the then-pending claims recited. *Id.* The Office also concluded that Ionov discloses silicon oxynitride for use as an antireflective coating. *Id.*

Applicants conducted an interview with the Office in January 2001. *Id.*, pp. 71-72. An interview summary indicates that the applicants and the Examiner identified use of an oxide layer as a nitrogen barrier as a feature that might overcome the prior art. *Id.* Applicants filed a Response After Final Action, later in January, that amended the claims to recite that an "oxide layer forms a barrier to migration of nitrogen atoms from the silicon oxynitride layer." *Id.*, pp. 73-83. The Office issued an Advisory Action in February 2001, and the applicants filed a

Continuing Prosecution Application in March 2001 to have the new amendment entered for examination. *Id.*, pp. 85-91.

The Office issued another Office Action in April 2001, rejecting all claims over prior art – Adkisson, U.S.P. 6,030,541, Roman (above), and Puchner, U.S.P. 6,156,620. *Id.*, pp. 92-98. Here, the Office Action identified Adkisson as a primary reference that disclosed a silicon oxynitride layer and an oxide layer, both having requisite thicknesses. *Id.* The Office Action acknowledged that Adkisson does not disclose forming an antireflective coating over a metal layer. *Id.* Instead, Adkisson stated that the antireflective coating may be formed over "any substrate." *Id.*

The applicant amended the claims in May 2001 to recite that a silicon oxynitride layer is deposited "*on*" the metal layer. *Id.*, pp. 99-106. Earlier, the claims recited that the silicon oxynitride layer was "over" the metal layer. *Id.* The applicants argued that the prior art would not suggest placing an antireflective coating on a metal layer. *Id.* Applicants did not reconcile this statement, however, with its admission that titanium nitride antireflective coatings were used with metals having high reflectivity. Ex. 1001, Col. 2:27-35.

The Office issued a Final Rejection, rejecting the claims again based on Adkisson, Roman and Puchner. Ex. 1005, pp. 110-117. The Office rejected applicants' prior argument, identifying teachings from both Roman and Adkisson

that support a conclusion that it would have been obvious to form an antireflective coating on a metal layer. *Id.* Following an interview and a Response After Final Rejection, however, the Office reversed itself and allowed the application. *Id.*, pp. 118-131. A Notice of Allowance included a statement of reasons for allowance, which indicated "the prior art does not teach a process wherein an antireflective coating (ARC) layer is formed directly on a metal layer." *Id.*, pp. 129-130. The Office granted the '231 Patent in December 2001.

The prosecution history includes an information disclosure statement that identifies Foote, U.S.P 5,710,067 ("Foote '067" (Ex. 1006)). Ex. 1005, p. 47. The Office did not rely on Foote '067 in any prior art analysis.

V. PERSON OF ORDINARY SKILL IN THE ART

A person having ordinary skill in the art at the time of the alleged invention ("POSITA") would have had a graduate's degree in physics, material science, electrical engineering, or a related degree, with some emphasis in semiconductor device fabrication, or an undergraduate degree in one of these fields and two to three years' experience in semiconductor device design and fabrication. Such a person would have also had at least a basic understanding, through education or experience, of antireflection coatings used in semiconductor manufacture and the materials that constitute them. *See* Ex. 1007, § V.

Dr. Neikirk, whose curriculum vitae is attached (Ex. 1008), has a B.S. in Physics and Mathematics, a M.S. and Ph.D. in Applied Physics, and over thirty years of experience with semiconductor fabrication, including practical experience related specifically to semiconductor modeling and fabrication, and teaching experience teaching fabrication techniques to undergraduate and graduate students. Ex. 1007, § V. Thus, he is qualified as a POSITA.

VI. <u>CLAIM CONSTRUCTIONS</u>

The '231 Patent likely will expire before this IPR, if instituted, reaches final written decision. The '231 Patent is scheduled to expire on December 8, 2018 (Ex. 1009), which is less than eighteen months from the filing date of this Petition. Therefore, the Board applies the same claim construction standards as in district court. 37 CFR § 42.100(b).

The following construction applies:

The clause "depositing a silicon oxynitride layer *on* the metal layer" requires direct contact between the silicon oxynitride layer and the metal layer.

This construction flows from the May 2001 amendment that substituted "on" for [[over]] and the accompanying remarks that explain the amendment requires this direct contact. *See*, § IV.B (above).

All other terms are given their plain and ordinary meanings.

VII. LEGAL FRAMEWORK FOR ANALYSIS

A claim is anticipated when a single prior art reference discloses all elements of that claim. 35 U.S.C. § 102. A challenged claim is obvious when "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. 35 U.S.C. § 103; *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). Obviousness questions are resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when available, secondary considerations, such as commercial success, long felt but unsolved needs, and failure of others. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966).

Claim 1 describes ranges of thickness both for a silicon oxynitride layer and an oxide layer, and claim 7 refers to a range of reflectivities. When a claimed range overlaps a range disclosed in the prior art, there is a presumption of obviousness. *Fike Corp. v. Donadon Safety Discs & Dev.*, IPR 2015-00341, Final Written Dec., paper 17, p. 13 (Feb. 2016), citing *Ormco Corp. v. Align Tech., Inc.*, 463 F.3d 1299 (Fed. Cir. 2006). Even a slight overlap can establish obviousness. *Id.*, citing *In re Woodruff*, 919 F.2d 1575 (CCPA 1990) (prior art range abuts claimed range). And obviousness may exist when the claimed range and the prior art's range do not overlap but are close enough that a skilled worker recognizes them as having the same properties. *Id*.

VIII. <u>NO SECONDARY CONSIDERATIONS SUPPORT NON-</u> <u>OBVIOUSNESS</u>

Petitioners are unaware of any secondary considerations to suggest that the claimed methods are non-obvious. Petitioners, for example, are unaware of any long-felt need in the art that the claimed methods solve, failure by others, or skepticism by others that the claimed methods would work for their intended purpose.

Instead, the secondary considerations evidence actually indicates that the claimed methods were obvious and well known. For example, rather than there being a long-felt need or failure by others to fabricate semiconductor devices using antireflection coatings from silicon oxynitride layers and oxide layers, the prior art indicates that, in the 1990s, multiple parties developed nearly-identical solutions using these techniques. *See*, § X (below). Thus, the art demonstrates simultaneous invention, which favors an obviousness holding. *Geo M. Martin Co. v. Alliance Mach. Sys. Int'l LLC*, 618 F.3d 1294, 1305-06 (Fed. Cir. 2010).

IX. THE CHALLENGED CLAIMS ARE UNPATENTABLE

There is "a reasonable likelihood that the petitioner[s] [will] prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). Claims 1-5 and 7 are anticipated and rendered obvious by prior art, as explained below.

The Challenged Claims are unpatentable over the following references:

	Reference	Citation				
1.	Shibata (Ex. 1011):	Japanese Unexamined Patent Application Publication No. Hei 08-191068, published July 23, 1996 (Ex. 1010); certified translation provided as Ex. 1011.				
2.	Cheung (Ex. 1012):	U.S. Patent No. 6,562,544, filed as U.S. Patent application s.n. 08/743,628 on November 4, 1996.				
3.	Foote '007 (Ex. 1013):	U.S. Patent No. 6,903,007, filed as U.S. patent application 08/857,055 on May 15, 1997.				
4.	Konjuh (Ex. 1015):	U.S. Patent No. 6,051,282, filed as U.S. Patent application s.n. 09/090,848 on June 4, 1998.				
5.	Ogawa (Ex. 1016):	Ogawa, et al., "Practical Resolution Enhancement Effect by New Complete Anti-Reflective Layer in KrF Excimer Laser Lithography," SPIE Optical/Laser Microlithography, v. 1927, pp 263-274 (1993).				
6.	Joesten (Ex. 1017):	Joesten, et al., "Footing Reduction of Positive Deep-UV Photoresists on Plasma Enhanced ARL (PEARL) SiON Substrates," SPIE Advances in Resist Technology and Processing XV, pp. 960-971 (June 29, 1998).				
7.	Lee (Ex. 1018):	Lee, et al., "ARC for Sub-0.18µm Logic and Gigabit DRAM Frontend and Backend Processes," Symp. VLSI Technology, pp. 86-87 (June 1998).				

Ogawa and Shibata are prior art to the '231 Patent under 35 U.S.C. § 102(b). Cheung, Foote '007, and Konjuh are prior art under 35 U.S.C. § 102(e). Joesten and Lee are prior art under 35 U.S.C. § 102(a).

Petitioners request review and cancellation of the Challenged Claims of the '231 Patent based on the grounds detailed below:

Ground 1: Claims 1-5 are anticipated by Shibata.

Ground 2: Claim 7 is obvious over Shibata, Lee, Cheung and Joesten.

Ground 3: Claims 1-3 and 5 are anticipated by Foote '007.

Ground 4: Claims 1-5 are obvious over Konjuh and Ogawa.

Ground 5: Claim 7 is obvious over Konjuh, Ogawa, Lee, Joesten and Cheung.

X. OVERVIEW OF THE PRIOR ART

The prior art references presented herein all are directed to semiconductor fabrication techniques that use silicon oxynitride antireflection coatings. Ogawa proposed silicon oxynitride antireflection films as an antireflection layer in 1993, fully five years before the '231 Patent was filed. Ogawa discloses such films being provided over metal reflective layers at thicknesses that correspond to those recited in the Challenged Claims. Lee describes such films in 1998.

The remaining references – Shibata, Cheung, Foote '007, Konjuh, and Joesten – are directed to solving "footing" problems that arise when silicon oxynitride layers are used with photoresists. Footing occurs when nitrogen in the silicon oxynitride interacts with photoresists that are placed over the silicon oxynitride. *See*, Ex. 1007, § VIII.A. As a consequence, the photoresists become less responsive to exposure and less amenable to patterning. Shibata, Cheung, Foote '007, Konjuh, and Joesten each propose placing oxide layers between the silicon oxynitride layer and the photoresist as a barrier to prevent this chemical interaction.

A. <u>Ogawa (Ex. 1016)</u>

Ogawa (Ex. 1016) describes semiconductor processing techniques using silicon oxynitride antireflective layers, which he calls "ARLs." Ogawa describes several different structures using ARLs, including three-layer and four-layer structures, shown in FIG. 1(a) and (b), respectively:



Ogawa (Ex. 1016), FIGS. 1(a), 1(b) (annotated)

See also, Ex. 1007, § VIII.B. In both cases, the antireflective layer ARL (green) is silicon oxynitride. The ARL is formed on a substrate (blue) that is made either of tungsten-silicide (W-Si) or aluminum silicon (Al-Si). Ogawa states that, for a W-Si substrate, the ARL film may have a thickness of 30 nm (300Å) and, for an Al-Si substrate, the ARL may have a thickness of 25nm (250Å). *Id.*, Abstract.

FIG. 1(a) shows a three-layer structure where a photoresist (*gray*) is placed on the ARL. The ARL cancels reflective light from the interface between the photoresist and the ARL. *Id.*, § 2.2.

FIG. 1(b) shows a four-layer structure where an inorganic film, such as silicon dioxide (**yellow**), is formed on the ARL and the photoresist (**gray**) is formed on the inorganic film. Ogawa characterizes the inorganic film as "clear." *Id.* Here, the ARL cancels reflective light from the interface between the photoresist and the inorganic film. *Id.*

Ogawa teaches that the three-layer and four-layer structures find application with a variety of wavelengths. Ogawa refers to 248 nm radiation as an example. *Id. See also*, Ex. 1007, § VIII.B.

B. <u>Lee (Ex. 1018)</u>

Lee also describes silicon oxynitride antireflection layers. Lee describes silicon oxynitride antireflection layers (green) provided over metal substrates

(*blue*) such as interconnects. Ex. 1018, p. 1. Lee also describes application to transistor gate fabrication and DRAM circuitry. *Id.* The antireflection coatings are proposed for "deep-UV lithography," which indicates use of radiation at 248 nm or less. *Id.*, Abstract; Ex. 1007, § VIII.C.



Lee explains that the antireflection layer ARC (gran) finds application with aluminum (Al) substrates. Ex. 1018, p. 86 (ARC Design and Lithography). Lee illustrates reflectivity of the silicon oxynitride antireflection layers over a variety of layer thicknesses. *Id.*, FIG. 2b. Lee's FIG. 2b illustrates in an inset (*red*) that the reflectivity R is less than 10% over a film thickness between 10-40 nm (100-400Å). *Id.* For ARC thicknesses between 120Å-360Å reflectivity of the ARC changes less than 2%.

C. <u>Shibata (Ex. 1011)</u>

Shibata describes silicon oxynitride antireflection layers, and oxide layers as barriers to prevent footing in photoresists.

Shibata teaches that antireflection films conventionally are made of silicon nitride or silicon oxynitride (called "P-SiN" and "P-SiON" films, respectively), and were used with highly-reflective surfaces such as aluminum or tungsten. *Id.*, ¶¶ 0002-04. Shibata indicates these antireflection films 2 caused patterning problems because nitrogen atoms from the P-SiN and P-SiON films react with hydrogen atoms in the resist films 3, which lowers patterning accuracy. *Id.*, ¶ 0005.

Shibata illustrates a conventional manufacturing process in FIG. 5(b). There, a highly-reflective film 1 (**bbos**) is provided on a semiconductor substrate (not shown). The antireflection film 2 (**gravn**) is formed on the first film 1, having a thickness of 100-1,000Å. Resist 3 (**grav**) is provided on the anti-reflective film 2. *Id.*, ¶¶ 0002-5. The footing effect is shown in FIG. 5(b) where the patterned resist 3 has a wider base than desired.



See also, Ex. 1007, § VIII.D.

Shibata proposes to apply a plasma treatment to the antireflection film 2 (grean) to form an oxide film 4 (grean) thereon. *Id.*, \P 0007. The oxide film 4 generally has a thickness of 40Å-100Å; in FIG. 3 (below), Shibata provides several examples of oxide thickness, including variants with 35Å and 40Å thicknesses. Shibata teaches that, when the oxide's thickness is less than 100Å, there is no effect on reflectivity. *Id.*, \P 0018. Formation of the oxide film causes nitrogen to be removed, which prevents reaction between the nitrogen and the resist. *Id.*, \P 0010, 0012, 0018-0019.

Plasma	Processing	Distance	Chamber	N ₂ O	Thickness
output	time (sec)	between	pressure	flow	of oxide
(W)		electrodes	(Torr)	rate	film
		(mm)		(1/min)	(angstroms)
300	30	12.5	4.25	1	40
600	30	12.5	4.25	1	54
600	60	12.5	4.25	1	59
900	30	12.5	4.25	1	63
900	60	12.5	4.25	1	68
300	180	12.5	4.25	1	70
300	30	12.5	1.6	1	70
300	30	12.5	6.0	1	70
300	30	12.5	4.25	3	40
300	30	12.5	4.25	5	40
300	30	5	4.25	1	60
300	30	15	4.25	1	35

Shibata (Ex. 1011), FIG. 3 (annotated)

Shibata's manufacturing process, therefore, includes an anti-reflective film 2 (gram) provided on a highly-reflective film 1 (blue) of aluminum or tungsten. *Id.*, $\P 0002$. The anti-reflective film 2 may be plasma nitride or plasma oxynitride and have a thickness of 100-1,000Å. *Id.*, $\P 0002$, 0009-0010, 0022, 0027, 0029. The oxide layer 4 is formed on the anti-reflective film 2 by exposing a top surface of the anti-reflective film to either a nitrous oxide plasma or an oxygen plasma. *Id.*, $\P 0007$, 0015 (N₂O), 0017, 0021 (oxygen).

Shibata explains that the characteristics of the antireflection film may be adjusted along with other processing conditions to achieve a predetermined reflectance with respect to a wavelength of light used for exposure. *Id.*, ¶ 0026. *See also*, Ex. 1007, § VIII.D.

D. <u>Cheung (Ex. 1012)</u>

Cheung describes silicon oxynitride antireflection layers, and oxide layers as barriers to prevent footing in photoresists.

Cheung discloses an antireflection coating having a silicon oxynitride layer 210 (grean) and a silicon oxide layer 240 (grean), called a "capping layer." Ex. 1012, at 12:10-28, 12:64-13:39, 17:40-56.



Cheung (Ex. 1012), FIG. 3A (annotated)

Cheung simulates reflectivity of the structure using a silicon oxynitride thickness of 300Å and a range of capping layer thicknesses between 50Å-1,000Å. *Id.*, 17:29-51. Cheung presents simulated reflectivity values when the substrate **(blue)** is tungsten silicide substrate (FIG. 6) and when the substrate is polysilicon (FIG. 7). Both simulations use radiation at 248 nm. *Id.*



Cheung (Ex. 1012), FIGS. 6, 7 (annotated)

See also, Ex. 1007, § VIII.F.

Cheung states that capping layers of 100Å provide substantial reduction in footing without noticeably affecting photolithographic performance. *Id.*, 13:10-13. These simulations show that reflectivity is below 10% for all ranges, even where the oxide layer thickness is 50Å (5 nm in the graphs).

Cheung also simulates performance of the antireflection coating when placed over aluminum (*Id.*, FIG. 9). Even for aluminum, Cheung's simulations show reflectivity will be less than 10% for antireflection coating with extremely thin oxides (e.g., 50Å). *Id.*, Col. 18:35-37.

E. <u>Foote '007 (Ex. 1013)</u>

Foote '007 describes silicon oxynitride antireflection layers, and oxide layers as barriers to prevent footing in photoresists.

Foote '007 describes an antireflective coating for use in semiconductor Ex. 1013, Abstract. The antireflective coating includes an antifabrication. reflective layer of silicon oxime, silicon oxynitride, or silicon nitride, and a barrier layer of silicon dioxide. Id. The barrier layer prevents interaction between the anti-reflective layer and a photoresist layer that overlies the antireflective coating, which contributes to footing. Id.

Foote '007 confirms that footing is caused by chemical interaction between an anti-reflective layer 22 (green) and a photoresist 14 (gray). Id. at 2:55-67. Specifically, amines (hydrogen-nitrogen bonds) in a silicon oxime anti-reflective layer 22 interact with the photoresist material. The footing appears as enlarged portions 22' of the photoresist layer 14 in FIG. 4. Id.

Foote '007 explains it was already known that footing can be inhibited by forming a silicon dioxide barrier layer (not shown in FIG. 4) on the surface of the anti-reflective layer 22 before the photoresist 14 is formed. Id., at 3:1-6. This barrier layer prevents the amines from interacting with the photoresist 14.





See also, Ex. 1007, § VIII.E.

Foote '007 describes a semiconductor structure having a substrate 40, a gate oxide layer 42, a polysilicon layer 44 (all **blug**). *Id.* at 6:25-31. The polysilicon layer 44 is described as "any suitable semiconductor, metal, or other material layer;" it ultimately forms a gate of a transistor. *Id.*, 1:22-27, 6:31-35, 12:30-46. An anti-reflective layer 46 (green) is formed on the metal layer 44, and is made of silicon oxime, silicon oxynitride or silicon nitride. *Id.*, 6:25-45. It has a thickness of 200Å-400Å. *Id.*, at 6:37-48. A silicon dioxide barrier layer 48 (green) is formed on the anti-reflective layer 46 using a nitrous oxide (N₂O) plasma, which converts a surface portion of the anti-reflective layer 46 to silicon dioxide. *Id.*, 6:25-30, 6:55-7:7. The barrier layer 48 has a thickness of 10-40Å. *Id.*, 5:12-21; 6:55-7:7.

As indicated, Foote '007 is a continuation in part of Foote '067, which was considered by the Office during prosecution of the '231 Patent. Foote '007 contains disclosure that is not found in Foote '067, including, for example, discussion of FIGS. 1-7, and Cols. 1:14-3:41, 4:48-5:22, and 6:20-9:30. *See*, Ex.

1014.³ Thus, Foote '007 presents new questions of patentability that the Office has not yet considered.

F. Konjuh (Ex. 1015)

Konjuh also describes silicon oxynitride antireflection layers, and oxide layers as barriers to prevent footing in photoresists.

Konjuh cites Ogawa as describing an example of deep ultraviolet antireflective layers. Ex. 1015, Col. 1:26-40. As part of this discussion, Konjuh describes inorganic ARLs as being thinner than organic ARLs (300Å vs. 1,500Å) and being formed by chemical vapor deposition. *Id.* Konjuh cites silicon oxynitride as an example of an inorganic ARL. Konjuh, however, explains that silicon oxynitride ARLs have problems, namely that amines (NH₂ groups), which form on the surface of the ARL layer, inhibit development of the photoresist, which leads to footing. *Id.*, Col. 1:4-63.

Konjuh proposes forming a surface layer on an ARL to counteract the effect of amines. *Id.*, Col. 2:36-67. The ARL is exposed to a nitrous oxide gas (N₂O) in the presence of radio frequency power – an N₂O plasma. *Id.* Ex. 1007, § VIII.G.

³ Ex. 1014 provides a computer-generated comparison of text from Foote '007 and Foote '067, as downloaded from the PTO website. Text marked in <u>underlined</u>, blue font represents disclosure from Foote '007 that does not appear in Foote '067.

Konjuh teaches that the surface treatment creates a silicon dioxide layer at the surface of the silicon oxynitride antireflective layer. *Id.*, Col. 2:36-67. The surface layer provides a barrier that prevents the amines from migrating into the photoresist layer.

Konjuh does not expressly identify the thickness of her oxide layer. Instead, Konjuh explains that the oxide layer corresponds to the peak of the oxygen concentration illustrated in FIG. 3. Id., Col. 2:58-67. In FIG. 3, the peak (*red*) has a width of approximately 50Å.



Konjuh does not provide a drawing that illustrates her structure after surface treatment. Konjuh, FIG. 3 (annotated) Below, Konjuh's FIG. 1 has been annotated to illustrate the surface layer added to a structure that Konjuh identifies as prior art. Konjuh explains that the prior art structure includes a substrate 12 (blue), an ARL 18 (green) and a photoresist 10 (gray). Id., at 1:50-63. The surface layer is represented in grellow. Also, footing effects from the original FIG. 1 are omitted because Konjuh explains that the surface layer prevents amines from migrating into the photoresist. Id., at 2:45-47.



Konjuh (Ex. 1015), FIG. 1 (annotated)

Konjuh does not identify the material composition of the substrate 12 (blue). Again, Konjuh cites to Ogawa (*Id.*, Col. 1:28-32), which describes applications to tungsten-silicide (W-Si) and aluminum-silicon (Al-Si) substrates. *See*, § X.A (p. 16 above); Ex. 1007, § VIII.B.

G. <u>Joesten (Ex. 1017)</u>

Joesten describes various techniques for reducing footing in deep ultraviolet photoresists from silicon oxynitride antireflection layers. Joesten, like Konjuh, explains that footing arises due to formation of amines at the surface of the silicon oxynitride layer, which contaminate photoresists. Ex. 1017, § 1. Joesten performs several experiments with the antireflection layer, including applying surface treatments of the silicon oxynitride layer and varying reflectivity. *Id.*, Abstract. The surface treatments include forming an oxide cap on the silicon oxynitride layer, post-ash treatment and several nitrous oxide plasma treatments. *Id*.

The nitrous oxide plasma experiments are described in Joesten, § 3.3.2. Joesten performed a plasma treatment on a silicon oxynitride layer having a

thickness of 300Å. Joesten concludes that the plasma treatment forms a thin oxide layer at the surface of the silicon oxynitride layer (although Joesten had difficulty confirming the exact composition of the film). The plasma treatment improves footing by 2X as compared to a baseline film. *Id.*, § 3.3.2.



See also, Ex. 1007, § VIII.H.

Joesten experiments with reflectivity of many of her antireflection coatings to determine if reflectivity is related to footing. Ex. 1017, Abstract. In FIG. 10, for example, Joesten describes reflectivity of silicon oxynitride films based on the films' thicknesses. Reflectivity is shown to be less than 10% (*red*) for all silicon oxynitride thicknesses greater than 200Å. Elsewhere, Joesten alters reflectivity of specific experimental samples to test for footing:

An additional experiment is performed to determine if the degree of footing is dependent upon the total reflectivity, the standing wave phase at the substrate interface or a combined effect of the two. The experiment consists of five runs *varying reflectivity from 1.0% to 22.0%*. The

resulting substrates have similar n and k values, except for *the 267Å film of 1% reflectivity*, and have a phase relationship relative to the reflectivity minimum at 300Å varying from -0.67 to 2.68 radians. The reflectivity curves are shown in Figure 12.

Id., § 3.3.3 (emphases added). See also, Ex. 1007, § VIII.H.

H. Motivation to Combine Teachings

The prior art's teachings would motivate a skilled worker to consider the teachings of Ogawa, Lee, Shibata, Cheung, Konjuh and Joesten together.⁴ All references are directed to use of antireflection coatings of a specific material composition – silicon oxynitride. Shibata, Cheung, Konjuh and Joesten are directed at techniques for solving footing problems that silicon oxynitride antireflection layers cause. Moreover, they describe a common solution – forming an oxide barrier layer on the top surface of the silicon oxynitride, before a photoresist is placed on it. Thus, a worker of skill would have ample motivation to consider the teachings of these references together. Ex. 1007, § VIII.I.

⁴ Foote '007 is § 102(e) art and seems to have been commonly-owned with the '231 Patent at the time the '231 Patent was filed. It may be disqualified from use under §103 (c)(1) and, therefore, is not discussed in obviousness analysis in this Petition.

Moreover, the prior art references contain teachings that motivate a skilled worker to vary thickness (claim 1) and reflectivity (claim 7) parameters of the antireflection coating to meet the claimed ranges. Ogawa and Shibata both teach that optimal thickness of the silicon oxynitride layer can be determined to suit individual circumstances, such as exposure wavelength. Ex. 1016, § 2.1, Ex. 1011, ¶ 0026. Lee demonstrates that silicon oxynitride antireflection layers can reduce reflectivity to less than 10% for metal substrates. Cheung also simulates thickness of such antireflection layers with oxide capping layers across a range of thicknesses and estimates reflectivities to be obtained therefrom. Ex. 1012, FIGS. 6-7 and 9. Joesten, again, analyzes performance of dual silicon oxynitride / oxide coatings across a range of surface treatments and reflectivity values, and assesses their effect on footing performance. Ex. 1017, §§ 3.3.2-3.3.4. This body of work demonstrates that performance of dual silicon oxynitride / oxide antireflection coatings was a well understood, predictable field of endeavor by the time the '231 Patent was filed and that it was well within the skill of an ordinarily skilled worker to tailor thickness and/or reflectivity characteristics to meet individual applications. Ex. 1007, § VIII.I. See, KSR, 550 U.S. at 418 (often necessary to consider interrelated teachings of multiple prior art references).

XI. ANALYSIS OF CHALLENGED CLAIMS

Each ground is described in turn below.

Ground 1: Claims 1-5 are Anticipated by Shibata.

Shibata discloses all elements of claims 1-5, as shown below and confirmed

by Dr. Neikirk:

Claim 1	Shibata				
[1.0] A method of forming a silicon oxy- nitride antireflection coating over a metal layer, comprising:	Shibata discloses a method of forming a silicon oxynitride antireflection coating over a metal layer. Ex. 1007, § IX.A.1.				
	Shibata (Ex. 1011), FIG. 1(a) (annotated)				
	Shibata states:				
	The conventional semiconductor device is configured as described above, and is provided with P-SiN film 2 or <i>a P-SiON film as an antireflection film</i> for improving the accuracy of patterning a chemically amplified resist on first film 1. However, since nitrogen atoms and nitrogen molecules adhere to the upper surface of P-SiN film 2 or the P-SiON film and nitrogen atoms in P-SiN film 2 react with hydrogen atoms in the chemically amplified resist film, there is a problem that the accuracy of patterning of the chemically amplified resist is lowered.				
	Ex. 1011, Col. 2 (Problem to be Solved by the Invention).				
	In the figure, 1 is a first film made of a material having high reflectance such as aluminum, tungsten or the like formed on a semiconductor substrate (not				

Claim 1	Shibata
	 shown,) 2 is a plasma nitride film formed on first film 1 for example, as an antireflection film formed with a thickness of 100–1000 angstroms (hereinafter referred to as a P-SiN film,) and 3 is a positive chemically amplified resist film formed on P-SiN film 2. Ex. 1011, Col. 1 (Prior Art)
[1.1] providing a semiconductor substrate comprising the metal layer over at least part of the semiconductor	Shibata discloses providing a semiconductor substrate (not shown in Shibata's drawings) comprising a metal layer 1 (blue) over at least part of the semiconductor substrate. Ex. 1007, § IX.A.2. Shibata states:
substrate;	In the figure, 1 is a first film made of a material having high reflectance such as aluminum, tungsten or the like formed on a semiconductor substrate (not shown,) 2 is a plasma nitride film formed on first film 1 for example, as an antireflection film formed with a thickness of 100–1000 angstroms (hereinafter referred to as a P-SiN film,) and 3 is a positive chemically amplified resist film formed on P-SiN film 2. Ex. 1011, Col. 1 (Prior Art); See also, ¶ 0013 (components in FIG. 1 with same reference numerals as in the prior art design are the same).
[1.2] depositing a silicon oxynitride layer on the metal layer having a thickness from about 100Å to about 1500Å; and	Shibata discloses depositing a silicon oxynitride layer 2 (green) on the metal layer 1 (blue) having a thickness from about 100Å to about 1,500Å. Ex. 1007, § IX.A.3. Shibata states: In the figure, 1 is a first film made of a material having high reflectance such as aluminum, tungsten or the like formed on a semiconductor substrate (not shown), 2 is a plasma nitride film formed on first film 1 for example, as an antireflection film formed with <i>a thickness of</i> 100–1000 angstroms (hereinafter referred to as a P-SiN film,) and 3 is a positive chemically amplified resist

Claim 1	Shibata				
	film formed on P-SiN film 2.				
	Ex. 1011, Col. 1 (Prior Art), FIG. 5; See also, \P 0013 (components in FIG. 1 with same reference numerals as in the prior art design are the same).				
	In addition, although the example of the P-SiN film was shown as the antireflection film in the above conventional example, <i>the same phenomenon also</i> occurs in plasma oxynitride film (hereinafter referred to as P-SiON film.)				
	Ex. 1011, ¶ 0004. <i>See also</i> , ¶¶ 0017, 0020, 0022 (discussing silicon oxynitride (P-SiON) films).				
	First, P-SiN <i>film 2 is laminated on first film 1</i> on the semiconductor substrate. At this time, impurities such as nitrogen atoms and nitrogen molecules adhere to the upper surface of P-SiN film 2 (Figure 1 (a.)) At this time, P-SiN film 2 is formed by a parallel plate type plasma chemical vapor deposition apparatus as shown in Figure 2, using a gas system such as silane, nitrous oxide and nitrogen.				
	LA. 1011, 0014.				
[1.3] forming an oxide layer having a thickness from about 5Å to about 50Å over the silicon oxynitride layer to provide the silicon oxynitride antireflection coating,	Shibata discloses forming an oxide layer 4 (yellow) having a thickness from about 5Å to about 50Å over the silicon oxynitride layer 2 (green) to provide the silicon oxynitride antireflection coating.				
	Ex. 1007, § IX.A.4.				
	Shibata discloses oxide films having thicknesses of 35Å				

Claim 1		Shibata						
	and 40Å, among others:							
	Î	Plasma output (W)	Processing time (sec)	Distance between electrodes	Chamber pressure (Torr)	N ₂ O flow rate	Thickness of oxide film (angstroms)	Ţ
		300	30	12.5	4.25	1	40	Ī
	-	600	30	12.5	4.25	1	54	-
	-	600	60	12.5	4.25	1	59	-
		900	60	12.5	4.25	1	68	-
	ł	300	180	12.5	4.25	1	70	-
	t	300	30	12.5	1.6	1	70	t
		300	30	12.5	6.0	1	70	I
		300	30	12.5	4.25	3	40	-
	-	300	30	12.5	4.25	5	40 60	-
	-	300	30	5	4.25	1	60	-
	Į	300	30	1011)	4.23]
[1 4] wherein the oxide	See	<i>also</i> , E	Ex. 1011	¶ 0013, (0017-18	(40Å-1	.00Å)	
layer forms a barrier to migration of nitrogen atoms from the silicon	 Shibata discloses that the oxide layer 4 (yellow) forms a barrier to migration of nitrogen atoms from the silicon oxynitride layer 2 (grean). Ex. 1007, § IX.A.5. Shibata states: Since the method for manufacturing a semiconductor device according to Claim 1 of the present invention is such that a plasma nitride film or plasma oxynitride film is laminated on a first film, plasma treatment using a gas having oxidizing power is applied to the upper surface of the plasma nitride film or plasma oxynitride film to form an oxide film and a chemically amplified resist is coated on the oxide film and patterned, nitrogen is removed from the plasma nitride film or the plasma oxynitride film so as to prevent reaction between the nitrogen. 					con		
oxynitride layer.						ctor n is ride sing pper ride fied ned, <i>or</i>		
	Ex.	1011,9	¶ 0010 (e	ttect).			an 1:4:	
	satisfied, oxide film 4 can be formed to a thickness o 40 angstroms or more on the upper surface of P-SiN film 2, the nitrogen atoms at the upper part (depth of 4				are s of SiN f 40			

Claim 1	Shibata
	angstroms) of P-SiN film 2 are removed, and <i>it is</i> <i>possible to reliably prevent the reaction with the</i> <i>chemically amplified resist film 5</i> . In addition, since the thickness of oxide film 4 can be suppressed to 100 angstroms or less, there is no influence on the reflectance of the lower P-SiN film 4 as an anti- reflection film. Ex. 1011, ¶ 0018. See also, ¶¶ 0012, 0019, 0024.

Claim 2	Shihata
	Silibata

The method of claim 1,	Shibata discloses that the metal layer comprises at least
wherein the metal layer	one of aluminum, copper, gold, nickel, palladium,
comprises at least one	platinum, silver, tantalum, titanium, tungsten, zinc,
of aluminum, copper,	aluminum-copper alloys, aluminum alloys, copper alloys,
gold, nickel, palladium,	titanium alloys, tungsten alloys, titanium-tungsten alloys,
platinum, silver,	gold alloys, nickel alloys, palladium alloys, platinum
tantalum, titanium,	alloys, silver alloys, tantalum alloys, zinc alloys, and
tungsten, zinc,	metal silicides. Ex. 1007, § IX.B.
aluminum-copper	Shibata states:
alloys, aluminum	
alloys, copper alloys,	In the figure, 1 is a first film made of a material having
titanium alloys,	high reflectance such as aluminum, tungsten or the
tungsten alloys,	like formed on a semiconductor substrate (not shown),
titanium-tungsten	2 is a plasma nitride film formed on first film 1 for
alloys, gold alloys,	example, as an antireflection film formed with a
nickel alloys,	thickness of 100–1000 angstroms (hereinafter referred
palladium alloys,	to as a P-SiN film,) and 3 is a positive chemically
platinum alloys, silver	amplified resist film formed on P-SiN film 2.
alloys, tantalum alloys,	Ex. 1011, Col. 1 (Prior Art), FIG. 5.
zinc alloys, and metal	
silicides.	

Claim 3	Shibata
The method of claim 1,	Shibata discloses that the metal layer comprises at least

Claim 3	Shibata
wherein the metal layer comprises at least one of aluminum, copper, aluminum-copper alloys, aluminum alloys and copper alloys.	 one of aluminum, copper, aluminum-copper alloys, aluminum alloys and copper alloys. Ex. 1007, § IX.C. Shibata states: In the figure, 1 is a first film made of a material having high reflectance such as <i>aluminum</i>, tungsten or the like formed on a semiconductor substrate (not shown), 2 is a plasma nitride film formed on first film 1 for example, as an antireflection film formed with a thickness of 100–1000 angstroms (hereinafter referred to as a P-SiN film,) and 3 is a positive chemically amplified resist film formed on P-SiN film 2. Ex. 1011, Col. 1 (Prior Art), FIG. 5.

Claim 4	Shibata
The method of claim 1, wherein the oxide layer is formed by contacting the silicon oxynitride	Shibata discloses that the oxide layer 4 (yellow) is formed by contacting the silicon oxynitride layer with oxygen plasma. Ex. 1007, § IX.D. Shibata states:
plasma.	Next, the upper surface of P-SiN film 2 is formed by using the same apparatus subsequently to the formation of P-SiN film 2, and oxide film 4 is formed by <i>plasma</i> <i>treatment</i> with a gas having oxidizing power such as nitrous oxide (Figure 1 (b.)) At this time, nitrogen atoms and nitrogen molecules on the upper surface of P-SiN film 2 and nitrogen atoms in P-SiN film 2 are removed by oxygen atoms in the nitrous oxide, oxygen atoms are introduced instead and oxide film 4 is formed. Next, a chemically amplified resist is coated on oxide film 4 and patterned to form positive chemically amplified resist film 5 (Figure 1 (c.))
	Although nitrous oxide was used as a gas having oxidizing power for plasma processing in each of the

Claim 4	Shibata
	above-described embodiments, it goes without saying that any gas may be used as long as it has oxidizing power, and it goes without saying that <i>the same effect</i> <i>is exhibited even if, for example, oxygen, is used</i> . Ex. 1011, ¶ 0021.

Claim 5	Shibata
The method of claim 1, wherein the oxide layer is formed by contacting the silicon oxynitride layer with N ₂ O plasma.	Shibata discloses that the oxide layer 4 (yellow) is formed by contacting the silicon oxynitride layer with N ₂ O plasma. Ex. 1007, § IX.E. Shibata states: Next, the upper surface of P-SiN film 2 is formed by using the same apparatus subsequently to the formation of P-SiN film 2, and oxide film 4 is formed by <i>plasma</i> <i>treatment with a gas having oxidizing power such as</i> <i>nitrous oxide (Figure 1 (b.))</i> At this time, nitrogen atoms and nitrogen molecules on the upper surface of P-SiN film 2 and nitrogen atoms in P-SiN film 2 are removed by oxygen atoms in the nitrous oxide, oxygen atoms are introduced instead and oxide film 4 is formed. Next, a chemically amplified resist is coated on oxide film 4 and patterned to form positive chemically amplified resist film 5 (Figure 1 (c.))
	Ex. 1011, ¶ 0015.
	The following experiment was attempted using the apparatus of Figure 2. <i>Plasma treatment using nitrous oxide as a gas</i> having oxidizing power after forming a P-SiN film to a thickness of 450 angstroms on a silicon substrate was performed under varying the processing conditions of the apparatus of Figure 2, the formation of an oxide film having a thickness of a few angstroms was examined by XPS (abbreviation of X-ray Photoelectron Spectroscopy,) and the results are shown in Figure 3 In addition, it can be inferred that the

Claim 5	Shibata
	same result can be obtained regardless of whether P- SiON film is used instead of P-SiN film or a gas having oxidizing power is used instead of nitrous oxide.
	Ex. 1011, ¶ 0017.

Accordingly, claims 1-5 are invalid over Shibata.

Ground 2: Claim 7 is Obvious over Shibata, Lee, Cheung and Joesten.

A. Motivation to Combine Teachings of References

A worker of skill would have ample reason to consider the teachings of Shibata with those of Lee, Joesten and Cheung. First, Shibata, Lee, Joesten, and Cheung each are directed to the same field of endeavor – antireflection coatings made of silicon oxynitride. Shibata, Joesten, and Cheung are directed to solutions to footing problems that arise from such antireflection coatings, and they describe the same solution – N₂O plasma treatment to the surface of the silicon oxynitride layer. A worker of skill would be motivated to investigate reflectivity of such surface treatments to confirm they do not impair performance of the silicon oxynitride antireflection coating because the purpose of the antireflection coating is to cancel reflections from the substrate back to the photoresist.

Based on review of Shibata, Lee, Joesten, and Cheung, a person of skill would recognize that Shibata's structure can be tuned to achieve reflectivity less than 10%. Lee demonstrates that silicon oxynitride antireflection layers with no

coating can achieve reflectivity less than 10% at wavelengths less than 248 nm, even when used with metal substrates. Ex. 1018, FIG. 2b. Shibata suggests adjusting antireflection coating characteristics to achieve desired reflectivity parameters and, further, explains that oxide films having a thickness of less than 100Å have no effect on reflectivity of the antireflection coating. Ex. 1011, ¶ 0018. Cheung also teaches that oxide films that have thicknesses below 100Å do not noticeably affect reflectivity of antireflection films. Ex. 1013, Col. 13:10-14. Cheung and Joesten both illustrate antireflection films having silicon oxynitride layer thicknesses that correspond to those of Shibata (and the claims) having reflectivities less than 10% at wavelengths less than 248 nm. Ex. 1012, FIGS. 6, 7; Ex. 1017, FIGS. 10, 12. Thus, these teachings demonstrate to a worker of skill not only that the reflectivity properties of antireflections coating are predictable and well understood, but also that antireflection coatings can achieve reflectivity of less than 10% at wavelengths less than 248 nm. See also, Ex. 1007, §§ VIII.A, X.A.

B. <u>Analysis of Challenged Claim</u>

Shibata, Lee, Cheung and Joesten teach all elements of claim 7, as shown below and confirmed by Dr. Neikirk:

Claim 7	Shibata with Lee, Cheung, and Joesten
The method of claim 1, wherein the silicon oxynitride	Shibata discloses all elements of claim 1. Shibata does not describe reflectivity characteristics of

Claim 7

Shibata with Lee, Cheung, and Joesten

antireflection coating has a reflectivity of about 10% or less at a wavelength below about 248 nm. his antireflection coating.

Lee discloses that silicon oxynitride antireflection films achieve reflectivity less than 10% at wavelengths below 248 nm across a wide range of film thicknesses:



Lee (Ex. 1018), FIG. 2b (annotated)

Shibata teaches that when the thickness of an oxide film is less than 100Å, it does not influence the reflectivity of the base film:

In addition, since the thickness of oxide film 4 can be suppressed to 100 angstroms or less, there is no influence on the reflectance of the lower P-SiN film 4 as an anti-reflection film.

Shibata, ¶ 0017.

Other references disclose that reflectance of a dual-layer silicon oxynitride / oxide antireflection coatings achieve reflectivity of 10% or less at wavelengths below about 248 nm.

Cheung describes that an anti-reflection coating that includes a silicon oxynitride layer with a thickness of 300Å has reflectivity less than 10% at a wavelength below about 248 nm.

Cheung states:

A silicon oxynitride (SiO_XN_Y) ARC (or DARC) was used in these simulations because the use of such an ARC is preferred in the present invention. The

Claim 7 Shibata with Lee, Cheung, and Joesten simulated DARC was tuned for deep UV, and exhibited a refractive index of 2.15 and absorptive index of 0.53, again at a wavelength of 248 nm. The DARC's thickness was selected by simulating various DARC thicknesses between 50 Å and 1000 Å. This was done for a DARC layer applied over both tungsten silicide and polysilicon. As expected, the minimum reflectivity at the photoresist/DARC interface occurred at a DARC thickness of about 300 Å. Ex. 1012, Col. 17:29-51. Substrate Reflectivity Substrate Reflectivity 1.00 FIG. 6 FIG. 7 Cheung (Ex. 1012), FIGS. 6, 7 (annotated) Joesten also describes a variety of silicon oxynitride antireflection coatings with reflectivity below 10%: The use of a nitrous oxide plasma treatment reduces the foot by more than a factor of three. The combination of a surface treatment with the reflection maximum of 550Å completely eliminates all traces of footing for APEX-E 2408 and UV6. Ex. 1017, p. 960. At the 1,500Å film thickness, a local minimum of 16% reflectivity, a 2X improvement in footing results over the 300Å film, which has a reflectivity minimum of 3.0%. Ex. 1017, p. 966. The footing results for UV6, as seen in Figure 13, show a non-linear behavior with the phase on the reflectivity



Ground 3: Claims 1-3 and 5 are Anticipated by Foote '007.

Foote '007 discloses all elements of claims 1-3 and 5 from the '231 Patent,

as shown below and confirmed by Dr. Neikirk:



Claim 1	Foote '007
	Ex. 1007, § XI.A.1.
	Foote '007 states:
	An anti-reflective coating is formed between a material layer which is to be patterned on a semiconductor structure using photolithography, and an overlying photoresist layer. The <i>anti-reflective coating</i> suppresses reflections from the material layer surface into the photoresist layer that could degrade the patterning. The anti-reflective coating includes an anti- reflective layer of silicon oxime, <i>silicon oxynitride</i> , or silicon nitride, and a barrier layer which is grown on the anti-reflective layer using a nitrous oxide plasma discharge to convert a surface portion of the anti- reflective layer into silicon dioxide. Ex. 1013, Abstract.
[1.1] providing a semiconductor substrate comprising the metal layer over at least part of the semiconductor substrate;	Foote '007 discloses providing a semiconductor substrate 40 comprising a metal layer 44 (both blue) over at least part of the semiconductor substrate.
	$\begin{array}{c} 46 \\ 44 \\ 42 \\ 40 \end{array}$
	Foote '007 (Ex. 1013), FIG. 5a (annotated)
	Ex. 1007, § XI.A.2.
	Foote '007 states:
	FIG. 5 a illustrates a <i>semiconductor structure</i> at an intermediate step in the overall fabrication process, including a silicon substrate 40, a gate oxide layer 42 formed on the substrate 40, <i>a polysilicon material layer</i> 44 formed on the gate oxide layer 42, and an anti-reflective layer 46 formed on the polysilicon layer 44. In the illustrated example, the polysilicon layer 44 is to be patterned to form a conductive gate for a field-effect

Claim 1	Foote '007
	transistor using photolithography. However, the present invention is not so limited, and can be applied to patterning any suitable semiconductor, <i>metal</i> , or other material layer.
	Ex. 1013, Col. 6:25-36.
	A silicon oxime ARC in accordance with the present invention can be deposited on conductive and nonconductive layers comprising materials conventionally employed in the semiconductor industry. Such materials may comprise polysilicon, aluminum and alloys thereof such as aluminum- silicon alloys, refractory metals, such as tungsten, refractory metal alloys, such as titanium-tungsten, refractory metal compounds, and dielectric materials. The conductive layer may also comprise a plurality of conductive layers as conventionally employed in the manufacture of semiconductor devices. For example, the conductive layer may comprise a barrier layer for enhanced adhesion to the substrate. Such barrier layers may comprise titanium, titanium nitride or titanium- titanium nitride. A layer of conductive materials, e.g., aluminum or tungsten, is formed on the barrier layer.
	LA. 1013, COI. 12.30-40.
[1.2] depositing a silicon oxynitride layer on the metal layer having a thickness from about 100Å to about 1500Å; and	Foote '007 discloses depositing a silicon oxynitride layer 46 (gran) on the metal layer 44 (blue) having a thickness from about 100Å to about 1,500Å. The silicon oxynitride layer directly contacts the metal layer 44. Ex. 1007, § XI.A.3. Foote '007 states:
	The anti-reflective coating suppresses reflections from the material layer surface into the photoresist layer that could degrade the patterning. The anti-reflective coating includes an anti-reflective layer of silicon oxime, <i>silicon oxynitride</i> , or silicon nitride, and a

Claim 1	Foote '007
	barrier layer which is grown on the anti-reflective layer using a nitrous oxide plasma discharge to convert a surface portion of the anti-reflective layer into silicon dioxide.
	Ex. 1013, Abstract.
	The present invention overcomes the drawbacks of the prior art by providing a process by which a thin silicon dioxide barrier layer can be formed on a silicon oxime, <i>silicon oxynitride</i> , or silicon nitride anti-reflective layer.
	Ex. 1013, Col. 4:48-52.
	FIG. 5 a illustrates a semiconductor structure at an intermediate step in the overall fabrication process, including a silicon substrate 40, a gate oxide layer 42 formed on the substrate 40, a polysilicon material layer 44 formed on the gate oxide layer 42, and <i>an anti-reflective layer 46 formed on the polysilicon layer 44</i> .
	Ex. 1013, Col. 6:25-30.
	The anti-reflective layer 46 is preferably formed of silicon oxime (SiNO:H), silicon oxynitride (SiON:H), or silicon nitride (Si ₃ N ₄ :H) In a preferred embodiment of the present invention, the anti-reflective layer 46 is formed of silicon oxime in a Plasma Enhanced Chemical Vapor Deposition (PECVD) reactor to a thickness t of <i>approximately 200 to 400, preferably 300 angstroms.</i>
	EX. 1013, Col. 0:57-48.
[1.3] forming an oxide layer having a thickness from about 5Å to about 50Å over the silicon oxynitride layer to provide the silicon oxynitride anti-	Foote '007 discloses forming an oxide layer 48 (yallow) having a thickness from about 5Å to about 50Å over the silicon oxynitride layer to provide the silicon oxynitride antireflection coating. Ex. 1007, § XI.A.4.



Claim 1	Foote '007
	footing, can be inhibited by forming a silicon dioxide barrier layer on the surface of the silicon oxime layer before forming the photoresist thereon. The barrier layer acts as a seal or cap which separates the amines in the silicon oxime layer from the photoresist layer 14.
	Ex. 1013, Col. 3:1-6.
	The anti-reflective coating includes an anti-reflective layer of silicon oxime (SiNO:H), silicon oxynitride (SiON:H), or silicon nitride. (Si ₃ N ₄ :H), and a barrier layer which is grown on the anti-reflective layer using a nitrous oxide plasma discharge to convert a surface portion of the anti-reflective layer into silicon dioxide.
	The barrier layer prevents interaction between the
	anti-reflective layer and the photoresist layer that could create footing. The anti-reflective layer is deposited on the material layer using Plasma Enhanced Chemical Vapor Deposition (PECVD) in a reactor. The barrier layer is grown on the anti-reflective layer in-situ in the same reactor, thereby maximizing throughput.
	Ex. 1013, Col. 4:66-5:11.

Claim 2	Foote '007
The method of claim 1, wherein the metal layer comprises at least one of aluminum, copper, gold, nickel, palladium, platinum, silver, tantalum, titanium, tungsten, zinc, aluminum-copper alloys, aluminum alloys, copper alloys, titanium alloys,	 Foote '007 discloses that the metal layer comprises at least one of aluminum, titanium, tungsten, aluminum alloys, and titanium-tungsten alloys. Ex. 1007, § XI.B. Foote '007 states: Photolithography is a semiconductor fabrication process that is widely used for patterning material layers on a semiconductor wafer or structure. The material layers can be non-metal (e.g. silicon, polysilicon), <i>metal (e.g. aluminum)</i>, etc. Ex. 1013, Col. 1:22-27.

Claim 2	Foote '007
tungsten alloys, titanium-tungsten alloys, gold alloys, nickel alloys, palladium alloys, platinum alloys, silver alloys, tantalum alloys, zinc alloys, and metal silicides.	A silicon oxime ARC in accordance with the present invention can be deposited on conductive and nonconductive layers comprising materials conventionally employed in the semiconductor industry. Such materials may comprise polysilicon, aluminum and alloys thereof such as aluminum- silicon alloys, refractory metals, such as tungsten, refractory metal alloys, such as titanium-tungsten, refractory metal compounds, and dielectric materials. The conductive layer may also comprise a plurality of conductive layers as conventionally employed in the manufacture of semiconductor devices. For example, the conductive layer may comprise a barrier layer for enhanced adhesion to the substrate. Such barrier layers may comprise titanium, titanium nitride or titanium- titanium nitride. A layer of conductive material, such as one of the aforementioned conductive material, e.g., aluminum or tungsten, is formed on the barrier layer. Ex. 1013, Col. 12:30-46.

Claim 3	Foote '007
The method of claim 1, wherein the metal layer comprises at least one	Foote '007 discloses that the metal layer comprises at least one of aluminum, and aluminum alloys. Ex. 1007, § XI.C.
of aluminum, copper,	Foote '007 states:
alloys, aluminum alloys and copper alloys.	Photolithography is a semiconductor fabrication process that is widely used for patterning material layers on a semiconductor wafer or structure. The material layers can be non-metal (e.g. silicon, polysilicon), <i>metal (e.g. aluminum)</i> , etc.
	Ex. 1013, Col. 1:22-27.
	A silicon oxime ARC in accordance with the present invention can be deposited on conductive and nonconductive layers comprising materials

conventionally employed in the semiconductor industry. Such materials may comprise polysilicon, aluminum and alloys thereof such as aluminum- silicon alloys, refractory metals, such as tungsten, refractory metal alloys, such as titanium-tungsten, refractory metal compounds, and dielectric materials. The conductive layer may also comprise a plurality of conductive layers as conventionally employed in the manufacture of semiconductor devices. For example, the conductive layer may comprise a barrier layer for enhanced adhesion to the substrate. Such barrier layers may comprise titanium, titanium nitride or titanium- titanium nitride. A layer of conductive material, such as one of the aforementioned conductive materials, e.g., aluminum or tungsten, is formed on the barrier layer.
Ex. 1013, Col. 12:30-46.

Claim 5	Foote '007
The method of claim 1, wherein the oxide layer is formed by contacting the silicon oxynitride layer with N ₂ O plasma.	Foote '007 discloses that the oxide layer is formed by contacting the silicon oxynitride layer with N_2O plasma. Ex. 1007, § XI.D. Foote '007 states:
	The anti-reflective coating includes an anti-reflective layer of silicon oxime, silicon oxynitride, or silicon nitride, and a barrier layer which is grown on the anti- reflective layer <i>using a nitrous oxide plasma</i> discharge to convert a surface portion of the anti-reflective layer into silicon dioxide.
	Ex. 1013, Abstract. <i>See also</i> , Col. 4:66-5:4, 5:12-21, 6:55-7:7, 8:37-9:31 (nitrous oxide plasma).

Ground 4: Claims 1-5 are Obvious over Konjuh and Ogawa.

A. <u>Motivation to Combine</u>

A person of skill would have reason to combine the teachings of Konjuh and Ogawa. Konjuh cites Ogawa expressly as providing a discussing of deep UV antireflection layers. *Id.*, at 1:28-40. Moreover, Konjuh identifies a problem with such antireflection layers – footing – and provides a solution to such a problem. In following Konjuh's teachings, a person of skill would recognize that Konjuh's ARL finds application with substrates that contain metal, such as the tungsten silicide and aluminum silicon substrates described by Ogawa.



Konjuh (Ex. 1015), FIG. 1 (annotated)

Ex. 1007, § XII.A.

Thus, a worker of skill would recognize that the structure shown above includes: a substrate 12 (blue), formed either of tungsten silicide or aluminum silicon; an ARL 18 (green) formed on the substrate 12 (blue), made of silicon oxynitride and having an initial thickness of 300Å; an oxide layer (green), formed

on the ARL 18 and having a thickness of approximately 50Å; and a photoresist 10 (*gray*) formed on the oxide layer.

B. <u>Analysis of Challenged Claims</u>

Konjuh and Ogawa teach all elements of claims 1-5 from the '231 Patent, as

shown below and confirmed by Dr. Neikirk:

Claim 1	Konjuh and Ogawa
[1.0] A method of forming a silicon oxy- nitride antireflection coating over a metal layer, comprising:	The prior art discloses a method of forming a silicon oxynitride antireflection coating over a metal layer. Ex. 1007, § XII.B.1. The prior art teaches an integrated circuit structure that includes a silicon oxynitride antireflection coating 18 (green) formed on a substrate 12 (blue). The substrate 12 is made either of tungsten silicide (W-Si) or aluminum silicon (Al-Si). 18 10 12 Konjuh (Ex. 1015), FIG. 1 (annotated)
[1.1] providing a semiconductor substrate comprising the metal layer over at least part of the semiconductor substrate;	The prior art discloses providing a semiconductor substrate comprising the metal layer over at least part of the semiconductor substrate. Ex. 1007, § XII.B.2. The prior art teaches an integrated circuit structure that includes a substrate 12 (blue) formed of either tungsten silicide (W-Si) or aluminum silicon (Al-Si). Tungsten silicide and aluminum silicon both are metals. Ogawa states:

Claim 1	Konjuh and Ogawa
	 This new ARL, whose material is a type of hydro silicon oxynitride film (SiO_xN_y:H), can be applied to tungsten silicide (W-Si) and even to aluminum silicon (Al-Si) substrates by controlling deposition conditions in plasma enhanced chemical vapor deposition systems. Using this SiO_xN_y:H film with 30nm and 25nm thicknesses on W-Si and Al-Si substrates respectively, critical dimension (CD) variations for both substrates are drastically reduced to within 0.02µm for 0.30µm imaging. Ex. 1016, p. 263 (Abstract).
[1.2] depositing a silicon oxynitride layer on the metal layer	The prior art discloses depositing a silicon oxynitride layer on the metal layer having a thickness from about 100Å to about 1,500Å. Ex. 1007, § XII.B.3.
having a thickness from about 100Å to about 1500Å; and	The prior art teaches an integrated circuit structure that includes a silicon oxynitride antireflection layer 18 (green) formed on a metal substrate 12 (blue). The silicon oxynitride antireflection layer 18 possesses an initial thickness of 300Å.
	Konjuh, for example, states:
	 [I]norganic ARLs are generally thinner (e.g., 300Å) and are formed by chemical vapor deposition. An advantage of the inorganic ARLs is that they generally do not need to be removed after the photolithographic process has been completed. Also, the inorganic layers tend to be less expensive than the organic layers. One problem with inorganic ARLs such as silicon oxynitride is that amines (NH₂ groups) form on the surface of the layer.
	Ex. 1015, Col. 1:34-43.
	Ogawa states:
	Using this SiO _x N _y :H film with 30nm and 25nm thicknesses on W-Si and Al-Si substrates respectively, critical dimension (CD) variations for both substrates

Claim 1	Konjuh and Ogawa
	are drastically reduced to within 0.02µm for 0.30µm imaging.
	Ex. 1016, p. 263 (Abstract). These thicknesses correspond to 300Å for W-Si and 250Å for Al-Si, respectively.
[1.3] forming an oxide layer having a thickness from about 5Å to about 50Å over	The prior art discloses forming an oxide layer having a thickness from about 5Å to about 50Å over the silicon oxynitride layer to provide the silicon oxynitride antireflection coating. Ex. 1007, § XII.B.4.
the silicon oxynitride layer to provide the	The prior art teaches forming an oxide layer (yellow) on
silicon oxynitride	the silicon oxynitride layer 18 (green). The oxide layer
antireflection coating,	(yallow) has a thickness of approximately 50A.
	Konjuh states:
	In one embodiment, the surface layer is formed on an ARL of silicon oxynitride (SiON) by introducing N_2O into the chamber of chemical vapor deposition unit in the presence of radio frequency power
	The inventors believe the foregoing process forms a
	<i>layer of</i> SiO_2 <i>at the surface of the antireflective layer.</i> [I]n FIG. 3 the ARL had been treated with the process of this invention. The primary difference is the peak in the oxygen concentration which appears at the surface in FIG. 3. This peak is believed to represent a SiO ₂ layer.
	Ex. 1015, Col. 2:48-67.



Claim 2	Konjuh and Ogawa
The method of claim 1, wherein the metal layer comprises at least one of aluminum, copper, gold, nickel, palladium, platinum, silver, tantalum, titanium, tungsten, zinc, aluminum-copper alloys, aluminum alloys, copper alloys, titanium alloys, titanium-tungsten alloys, gold alloys, nickel alloys, palladium alloys, platinum alloys, silver alloys, tantalum alloys, zinc alloys, and metal silicides.	The prior art discloses that the metal layer comprises at least one of aluminum, copper, gold, nickel, palladium, platinum, silver, tantalum, titanium, tungsten, zinc, aluminum-copper alloys, aluminum alloys, copper alloys, titanium alloys, tungsten alloys, titanium-tungsten alloys, gold alloys, nickel alloys, palladium alloys, platinum alloys, silver alloys, tantalum alloys, zinc alloys, and metal silicides. Ex. 1007, § XII.C. The prior art teaches that the substrate 12 (bhue) may be either tungsten silicide (W-Si) or aluminum silicon (Al- Si). Tungsten silicide is a metal silicide under the claims. Aluminum silicon is an aluminum alloy under the claims. Ogawa states: This new ARL, whose material is a type of hydro silicon oxynitride film (SiO _x N _y :H), can be applied to <i>tungsten silicide (W-Si)</i> and even to <i>aluminum silicon</i> (<i>Al-Si) substrates</i> by controlling deposition conditions in plasma enhanced chemical vapor deposition systems. Using this SiO _x N _y :H film with 30nm and 25nm thicknesses on W-Si and Al-Si substrates respectively, critical dimension (CD) variations for both substrates are drastically reduced to within 0.02µm for 0.30µm imaging.
	Ex. 1016, p. 263 (Abstract).

Claim 3	Konjuh and Ogawa
The method of claim 1, wherein the metal layer comprises at least one of aluminum, copper, aluminum-copper alloys, aluminum alloys and copper	The prior art discloses that the metal layer comprises at least one of aluminum, copper, aluminum-copper alloys, aluminum alloys and copper alloys. Ex. 1007, § XII.D. The prior art teaches that the substrate 12 (blue) may be aluminum silicon (Al-Si). Aluminum silicon is an aluminum alloy under the claims.

Claim 3	Konjuh and Ogawa
alloys.	Ogawa states:
	This new ARL, whose material is a type of hydro silicon oxynitride film $(SiO_xN_y:H)$, can be applied to tungsten silicide (W-Si) and even to <i>aluminum silicon</i> (<i>Al-Si</i>) <i>substrates</i> by controlling deposition conditions in plasma enhanced chemical vapor deposition systems. Using this $SiO_xN_y:H$ film with 30nm and 25nm thicknesses on W-Si and Al-Si substrates respectively, critical dimension (CD) variations for both substrates are drastically reduced to within 0.02µm for 0.30µm imaging.
	Ex. 1016, p. 263 (Abstract).
Claim 4	Konjuh and Ogawa

The method of claim 1,	The prior art discloses that the oxide layer is formed by
wherein the oxide layer	contacting the silicon oxynitride layer with oxygen
is formed by contacting	plasma. Ex. 1007, § XII.E.
laver with oxygen	Konjuh states:
plasma.	For example, in some embodiments other oxygen- containing gases such as <i>pure oxygen</i> can be substituted for the N_2O .
	Ex. 1015, Col. 4:8-10.

┢

Claim 5	Konjuh and Ogawa
The method of claim 1, wherein the oxide layer is formed by contacting the silicon oxynitride layer with N ₂ O plasma.	The prior art discloses that the oxide layer is formed by contacting the silicon oxynitride layer with N ₂ O plasma. Ex. 1007, § XII.F.
	Konjuh states: In one embodiment, the surface layer is formed on an ARL of silicon oxynitride (SiON) by introducing N_2O into the chamber of chemical vapor deposition unit in the presence of radio frequency power. The N ₂ O is

Claim 5	Konjuh and Ogawa
	introduced at a rate of from 0.2 sccm to 8 sccm per square centimeter of wafer surface, preferably about 4 sccm/cm ² . The radio frequency power is applied at a rate of from 0.6 W to 6 W per square centimeter of wafer surface, preferably about 3 W/cm ² . The radio frequency power is typically applied for from 1 to 20 seconds.
	Ex. 1015, Col. 2:48-57.
	For example, in some embodiments other oxygen- containing gases such as pure oxygen can be substituted for the N_2O .
	Ex. 1015, Col. 4:8-10.

Ground 5: Claim 7 is Obvious over Konjuh, Ogawa, Lee, Joesten, and Cheung.

A. Motivation to Combine Teachings of References

A worker of skill would have ample reason to consider the teachings of Konjuh and Ogawa with those of Lee, Joesten, and Cheung. First, Konjuh, Ogawa, Lee, Joesten, and Cheung each are directed to the same field of endeavor – antireflection coatings made of silicon oxynitride. Konjuh, Joesten, and Cheung are directed to solutions to footing problems that arise from such antireflection coatings, and they describe the same solution – N_2O plasma treatment to the surface of the silicon oxynitride layer. A worker of skill would be motivated to investigate reflectivity of such surface treatments to confirm they do not impair performance of the silicon oxynitride antireflection coating because the purpose of

the antireflection coating is to cancel reflections from the substrate back to the photoresist.

Based on review of Konjuh, Ogawa, Lee, Joesten, and Cheung, a person of skill would recognize that Konjuh's structure can be tuned to achieve reflectivity less than 10%. Lee demonstrates that silicon oxynitride antireflection layers with no coating can achieve reflectivity less than 10% at wavelengths less than 248 nm, even when used with metal substrates. Ex. 1018, FIG. 2b. Cheung teaches that oxide films that have thicknesses below 100Å have no influence on reflectivity of antireflection films. Ex. 1012, ¶ 0017. Cheung and Joesten both illustrate antireflection films having silicon oxynitride layer thicknesses that correspond to those of Konjuh (and the claims) having reflectivities less than 10% at wavelengths less than 248 nm. Ex. 1012, FIGS. 6, 7; Ex. 1017, FIGS. 10, 12. And both Ogawa and Joesten provide teachings to tune layer parameters to cancel reflection components. Ex. 1016, § 2.1; Ex. 1017, § 3.3. A worker of skill would be motivated to tune parameters of the Konjuh structure to minimize reflectivity. See also, Ex. 1007, § XIII.A.

B. <u>Analysis of Challenged Claims</u>

Konjuh, Ogawa, Lee, Joesten and Cheung teach all elements of claim 7, as shown below and confirmed by Dr. Neikirk:

Claim 7 Konjuh and Ogawa with Lee, Joesten and Cheung

The method of claim 1, wherein the silicon oxynitride antireflection coating has a reflectivity of about 10% or less at a wavelength below about 248 nm.

Konjuh and Ogawa teach the subject matter of claim 1.

Neither Konjuh nor Ogawa teaches that reflectivity of the antireflection coating is about 10% or less at a wavelength below about 248 nm.

Ogawa, however, teaches that parameters of the antireflection coating may be optimized for individual use:

This method gives one direction for optimizing an ARL for some target substrate. Using this method, for any given substrates and ARL thicknesses, the optimal optical conditions as an ARL for a target substrate can be determined. Moreover, even if exposure wavelengths are changed, the optimization method does not change. For this case, the values of refractive indices of the substrates, photoresist, and various films need only be determined and the calculations once again performed with these new parameters.

Ex. 1016, p. 264.

Lee discloses that silicon oxynitride antireflection films achieve reflectivity less than 10% at wavelengths below 248 nm across a wide range of film thicknesses:



Lee (Ex. 1018), FIG. 2b (annotated)

Lee's graph shows reflectivity at less than 10% for a silicon oxynitride layer at thickness of 300Å, Konjuh's initial thickness.

Claim 7	Konjuh and Ogawa with Lee, Joesten and Cheung
	Other references disclose that reflectance of a dual-layer silicon oxynitride / oxide antireflection coatings achieve reflectivity of 10% or less at wavelengths below about 248 nm.
	Cheung describes that an anti-reflection coating that includes a silicon oxynitride layer with a thickness of 300Å has reflectivity less than 10% at a wavelength below about 248 nm.
	Cheung states:
	A silicon oxynitride (SiO _x N _Y) ARC (or DARC) was used in these simulations because the use of such an ARC is preferred in the present invention. The simulated DARC was tuned for deep UV, and exhibited a refractive index of 2.15 and absorptive index of 0.53, again at a wavelength of 248 nm. The DARC's thickness was selected by simulating various DARC thicknesses between 50 Å and 1000 Å. This was done for a DARC layer applied over both tungsten silicide and polysilicon. As expected, the minimum reflectivity at the photoresist/DARC interface occurred at a DARC thickness of about 300 Å.
	Ex. 1012, Col. 17:29-51.
	Substrate Reflectivity 100 00 00 00 00 00 00 00 00 0
	Laesten also describes a variety of silicon overitrida
	antireflection coatings with reflectivity below 10%:
	The use of a nitrous oxide plasma treatment reduces the

Claim 7	Konjuh and Ogawa with Lee, Joesten and Cheung
	foot by more than a factor of three. The combination of a surface treatment with the reflection maximum of 550Å completely eliminates all traces of footing for APEX-E 2408 and UV6.
	Ex. 1017, p. 960.
	At the 1,500Å film thickness, a local minimum of 16% reflectivity, a 2X improvement in footing results over the 300Å film, <i>which has a reflectivity minimum of</i> 3.0%.
	Ex. 1017, p. 966.
	The footing results for UV6, as seen in Figure 13, show a non-linear behavior with the phase on the reflectivity curve. As <i>reflectivity increases from l .0% to 5.0%</i> the footing appears to worsen, moving from a descending midpoint (267Å) to a minimum (300Å) on the reflectivity curve.
	Ex. 1017, p. 967.
	SiON Reflectivity Curve
	0.5 0.4 0.3 0.2 0.1 0.0 0.500 1000 1500 2000 Film Thickness (Å)
	Joesten (Ex. 1017), FIG. 10 (annotated)
	See also, Ex. 1007, § XIII.B.

XII. CONCLUSION

For the foregoing reasons, Petitioners request *inter partes* review and cancellation of claims 1-5 and 7 from the '231 Patent.

Respectfully submitted,

Date: <u>September 22, 2017</u>

By: / *Robert L. Hails* / Robert L. Hails Reg. No. 39,702

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CERTIFICATION

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the foregoing Petition for Inter Partes Review of U.S. Patent No. 6,326,231 contains, as measured by the word-processing system used to prepare this paper, 12,649 words. This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the world limit.

Date: September 22, 2017

By: /Robert L. Hails/

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.105(b), the undersigned hereby

certifies that on September 22, 2017, a copy of Petition for Inter Partes Review

of U.S. Patent No. 6,326,231 and all supporting exhibits has been served in its

entirety on the following counsel of record for Patent Owner in the manner

indicated:

Via Federal Express Overnight:

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