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Paper 41
Entered: April 11, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SAMSUNG ELECTRONICS CO., LTD.,
Petitioner,

v.

PROMOS TECHNOLOGIES, INC.,
Patent Owner.

———————

Case IPR2017-00037
Patent 6,699,789 B2

———————

Before KEVIN F. TURNER, JO-ANNE M. KOKOSKI, and
JEFFREY W. ABRAHAM, *Administrative Patent Judges.*

KOKOSKI, *Administrative Patent Judge.*

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R.§ 42.73

I. INTRODUCTION

We have jurisdiction to hear this *inter partes* review under 35 U.S.C. § 6, and this Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons that follow, we determine that Petitioner has shown by a preponderance of the evidence that claims 1–6, 8–15, and 17–20 ("the challenged claims") of U.S. Patent No. 6,699,789 B2 ("the '789 patent," Ex. 1001) are unpatentable. Additionally, we deny Patent Owner's Motion to Amend.

A. Procedural History

Samsung Electronics Co., Ltd. ("Petitioner") filed a Petition requesting an *inter partes* review of the challenged claims of the '789 patent. Paper 2 ("Pet."). ProMOS Technologies, Inc. ("Patent Owner") timely filed a Preliminary Response. Paper 6. Pursuant to 35 U.S.C. § 314(a), we instituted an *inter partes* review on the following grounds:

Reference(s)	Basis	Challenged Claims
Yamada[1]	§ 102(b)	1, 2, 4, 5, 8, 9, 18–20
Yamada and Shan[2]	§ 103(a)	3, 6
Yamada and Kobayashi[3]	§ 103(a)	10, 11, 13, 14, 17
Yamada, Kobayashi, and Shan	§ 103(a)	12, 15

Paper 7 ("Dec. on Inst."), 22.

[1] Japanese Publication No. JPH7–99193 A, published April 11, 1995 (Ex. 1004). We refer to "Yamada" as the English translation of the original reference. Petitioner provided an affidavit attesting to the accuracy of the translation. Ex. 1004, 15; *see* 37 C.F.R. § 42.63(b).
[2] US 6,187,667 B1, issued February 13, 2001 (Ex. 1006).
[3] US 5,925,227, issued July 20, 1999 (Ex. 1005).

After institution of trial, Patent Owner filed a Patent Owner Response (Paper 17, "PO Resp."), and Petitioner filed a Reply (Paper 23, "Reply"). In addition, Patent Owner filed a Motion to Amend (Paper 16, "Mot."), which was opposed by Petitioner (Paper 25, "Opp."). Patent Owner submitted a Reply in Support of its Motion to Amend (Paper 29, "PO Reply"), and Petitioner filed a Sur-Reply supporting its Opposition (Paper 34, "Sur-Reply").

In support of its Motion to Amend, Patent Owner provides a Second Declaration of Dhaval Brahmbhatt (Ex. 2127). Petitioner provides the Second and Third Declarations of Dr. Gary Rubloff (Ex. 1009; Ex. 1012) to support its Opposition and Sur-Reply, respectively.

An oral hearing was held on January 11, 2018. A transcript of the hearing is included in the record. Paper 40.

B. Related Proceedings

The parties indicate that the ’789 patent is asserted in *ProMOS Techs., Inc. v. Samsung Elecs. Co., Ltd.*, No. 1:15–cv-00898-SLR-SRF (D. Del.). Pet. 1; Paper 5, 1.

C. The ’789 Patent

The ’789 patent, titled "Metallization Process to Reduce Stress Between Al-Cu Layer and Titanium Nitride Layer," is directed to semiconductor processes generally, "and, more particularly, to a metallization process for reducing the stress existing between the Al-Cu layer and the titanium nitride (TiN) layer, and solving a galvanic problem." Ex. 1001, 1:13–16. The ’789 patent states that, in the conventional metallization process, the TiN, Al-Cu, and titanium layers are deposited sequentially on a wafer in the same high-vacuum system in different sputtering chambers at different temperatures, such that the Al-Cu layer is deposited at 270° C and the TiN layer is deposited at room temperature. *Id.* at 1:21–32. Because the wafer with the Al-Cu layer is still in a high-temperature state when the sputtering of TiN begins, thermal stress is produced between the Al-Cu layer and the TiN layer, resulting in cracks on the TiN layer that lead to galvanic corrosion in the wiring layer and, thus, defective circuits. *Id.* at 1:32–40. According to the ’789 patent, the invention described therein solves this galvanic corrosion problem “by cooling the vacuum apparatus where the metallization process is performed after formation of the Al-Cu layer and before the formation of the TiN layer . . . by fanning the wafer with an inert gas.” *Id.* at 1:56–61.

Figures 1 and 3A of the ’789 patent are reproduced below.

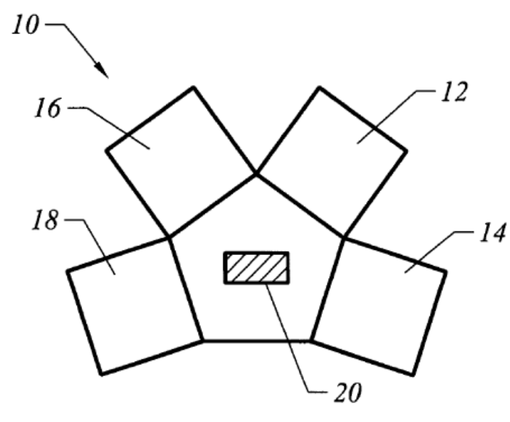

FIG. 1

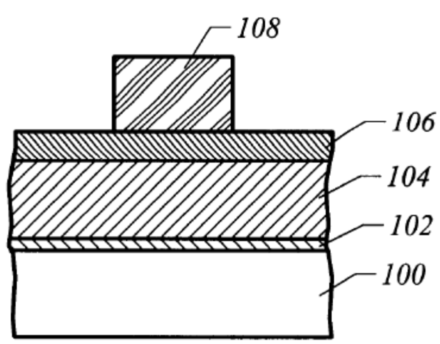

FIG. 3A

Figure 1 is a simplified schematic view of a sputtering apparatus used in the metallization process according to an embodiment described in the ’789 patent, and Figure 3A is a cross-sectional view showing the metallization process to form a wiring line on a substrate. *Id.* at 2:54–56, 59–62. Physical vapor deposition is performed in Ti sputtering chamber 12 to form Ti layer 102 on wafer 100. *Id.* at 3:13–16. Wafer 100 is then transferred to Al-Cu sputtering chamber 14, and high-temperature physical vapor deposition is performed to form Al-Cu layer 104 on Ti layer 102, typically at a temperature of about 260–280° C. *Id.* at 3:16–20. Next, wafer 100 is transferred to TiN sputtering chamber 16, and inert gas is injected into TiN sputtering chamber 16 for fanning wafer 100 until the temperature of the wafer is reduced to about 60–80° C. *Id.* at 3:21–24. The inert gas, which may be nitrogen or argon, is typically provided at about room temperature, at a flow rate of about 80–120 sccm, for about 20–30 seconds. *Id.* at 3:24–30.

After the temperature of wafer 100 is reduced, the flow of inert gas is terminated, and physical vapor deposition is performed at room temperature to form TiN layer 106 on Al-Cu layer 104. *Id.* at 3:32–36. According to the ’789 patent, because the temperature of wafer 100 is decreased prior to the deposition of TiN layer 106 to a temperature selected to prevent cracks from forming in TiN layer 106, thermal stress between TiN layer 106 and Al-Cu layer 104 is reduced and the formation of cracks in the TiN layer is substantially avoided. *Id.* at 3:36–51.

Claims 1, 10, and 18 are independent claims. Claims 2–6, 8, and 9 depend directly from claim 1, which is reproduced below.

> 1. A metallization process comprising:
>
> placing a wafer in an Al-Cu sputtering chamber to form an Al-Cu layer on the wafer;
>
> transferring the wafer to a titanium nitride sputtering chamber;
>
> introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer; and

forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride sputtering chamber after cooling the wafer.

Ex. 1001, 4:2–14.

Claims 11–15 depend directly from claim 10, which is reproduced below.

10. A method for forming a wiring line, comprising:

placing a wafer in a Ti sputtering chamber to form a Ti layer on the wafer;

transferring the wafer to an Al-Cu sputtering chamber to form an Al-Cu layer on the Ti layer;

transferring the wafer to a titanium nitride sputtering chamber;

introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer; and

forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride sputtering chamber after cooling the wafer.

Id. at 4:41–55.

Claims 19 and 20 depend, directly or indirectly, from claim 18, which is reproduced below.

18. A metallization process performed in a vacuum sputtering apparatus which includes an Al-Cu sputtering chamber and a titanium nitride sputtering chamber, the metallization process comprising:

placing a wafer in an Al-Cu sputtering chamber to form an Al-Cu layer on the wafer;

cooling the wafer in the vacuum sputtering apparatus to a preset temperature by fanning the wafer with inert gas;

transferring the wafer to a titanium nitride sputtering chamber; and

> forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride sputtering chamber after cooling the wafer, the preset temperature being sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer so as to substantially prevent cracks from forming in the titanium nitride layer.

Id. at 5:12–6:10.

II. ANALYSIS

A. Claim Interpretation

We interpret claims of an unexpired patent using the "broadest reasonable construction in light of the specification of the patent in which [the claims] appear[]." 37 C.F.R. § 42.100(b); *see Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). The Board, however, may not "construe claims during IPR so broadly that its constructions are *unreasonable* under general claim construction principles." *Microsoft Corp. v. Proxyconn, Inc.*, 789 F.3d 1292, 1298 (Fed. Cir. 2015) (citation omitted). "Rather, 'claims should always be read in light of the specification and teachings in the underlying patent'" and "[e]ven under the broadest reasonable interpretation, the Board's construction 'cannot be divorced from the specification and the record evidence.'" *Id.* (citations omitted). Only those terms in controversy need to be construed, and only to the extent necessary to resolve the controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) ("[W]e need only construe terms 'that are in controversy, and only to the extent necessary to resolve the controversy'.") (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

For purposes of the Decision on Institution, we addressed the interpretation of "fanning the wafer with the inert gas" as set forth in claims

1 and 10, and "fanning the wafer with inert gas" as set forth in claim 18, and determined that the terms did not need to be construed expressly. Dec. on Inst. 6–10. Based on our review of the complete record and the claim construction arguments raised by the parties, for purposes of this Final Written Decision we determine it is necessary to expressly construe "fanning the wafer."

Petitioner asserts that "the terms of the challenged claims should be given their plain and ordinary meaning under the broadest reasonable interpretation (BRI) standard." Pet. 14 (citing Ex. 1002 ¶ 31). Patent Owner proposes that we construe "fanning the wafer" to mean "cooling by directing a gas or gases over the front surface of the wafer." PO Resp. 8. In support of its construction, Patent Owner contends that the Specification describes "fanning" as "a process where gases are injected 'directly onto the wafer 100 or near the wafer' to cool the wafer.'" *Id.* at 9 (quoting Ex. 1001, 3:20–31). Patent Owner further contends that "during prosecution, the applicant expressly defined 'fanning' to exclude cooling processes where gas is blown under the rear surface of the wafer." *Id.* (citing Ex. 2003 ¶¶ 49–52). Petitioner responds that the statements in the prosecution history upon which Patent Owner relies "are amenable to multiple reasonable interpretations and do not constitute a clear and unmistakable disclaimer." Reply 5.

1. Prosecution History

The applicants for the '789 patent introduced the claim language "fanning the wafer" in a February 24, 2003 Amendment. Ex. 1003, 62–72.[4] The applicants were facing rejections to the then-pending claims based on

[4] The cited page numbers in Ex. 1003 refer to the numbers added by Petitioner in the bottom left corner of the page.

Endo.[5] *Id.* at 50–55. In particular, the Examiner stated that Endo "discloses a method for forming a semiconductor contact structure that includes" a process step wherein "[t]he wafer is transferred to a different chamber and cooled in an argon atmosphere by flowing gas under the rear surface of the wafer," and that "[t]he cooling alleviates thermal stresses formed in the second Al-Cu layer (35)." *Id.* at 50–51.

To overcome these rejections, the applicants added the following underlined language to independent claims 1 and 10:

> introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer <u>by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer</u>;

Id. at 63, 64, 71. The applicants also argued that Endo

> does not teach or suggest introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer.
>
> Endo et al. discloses cooling the substrate after depositing two coating layers 34, 35 by sputtering an aluminum-copper alloy. "[T]he substrate is gradually cooled at a low cooling speed in an argon atmosphere while the material that forms second film 35 is not solidified. When the substrate is slowly cooled after second film 35 is formed, thermal stresses generated in the surface of second film 35 are alleviated and generation of whiskers is restricted." Column 9, lines 20–26. Nothing in Endo et al. discloses or suggests fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer. Because Endo et al. discloses slow cooling the substrate to alleviate thermal

[5] US 6,458,703 B2, issued Oct. 1, 2002 ("Endo," Ex. 2001).

> stresses generated in the surface of the second film 35, there is no motivation to fan the substance with the inert gas.

Id.

The applicants added the following underlined language to independent claim 18: "cooling the wafer in the vacuum sputter apparatus to a preset temperature <u>by fanning the wafer with the inert gas</u>." Ex. 1003, 65, 72. The applicants argued:

> Endo et al. fails to teach or suggest cooling the wafer in the vacuum sputtering apparatus to a preset temperature by fanning the wafer with the inert gas. Endo et al. further fails to disclose or suggest forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride chamber after cooling the wafer, the preset temperature being sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer so as to substantially prevent cracks from forming in the titanium nitride layer.
>
> As discussed above, Endo et al. is directed to slow cooling the substrate to alleviate thermal stresses generated in the surface of the second film 35 formed by sputtering an aluminum-copper alloy, and is devoid of any teaching or suggestion of fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer.

Id. at 66–67.

2. Analysis of Prosecution History Disclaimer

"[The Federal Circuit has] recognized that a 'clear and unmistakable' disavowal during prosecution overcomes the 'heavy presumption' that claim terms carry their full and ordinary customary meaning." *Biogen Idec, Inc. v. GlaxoSmithKline LLC*, 713 F.3d 1090, 1095 (Fed. Cir. 2013) (quoting *Omega Eng'g, Inc. v. Raytek Corp.*, 334 F.3d 1314, 1323, 1326 (Fed. Cir. 2003)). As the party seeking to invoke prosecution history disclaimer, Patent Owner "bears the burden of proving the existence of a 'clear and unmistakable' disclaimer that would have been evident to one skilled in the art." *Trivascular, Inc. v. Samuels*, 812 F.3d 1056, 1063–64 (Fed. Cir. 2016). We note that alleged disavowals of claim scope during prosecution are closely scrutinized. *See, e.g., In re Bigio,* 381 F.3d 1320, 1325–26 (Fed. Cir. 2004) ("Absent claim language carrying a narrow meaning, the PTO should only limit the claim based on the specification or prosecution history when those sources expressly disclaim the broader definition."); *In re Am. Acad. of Sci. Tech Ctr.*, 367 F.3d 1359, 1365 (Fed. Cir. 2004) ("[A] patentee 'may demonstrate an intent to deviate from the ordinary and accustomed meaning of a claim term by including in the specification expressions of manifest exclusion or restriction, representing a clear disavowal of claim scope.'" (quoting *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1325 (Fed. Cir. 2002))). The Federal Circuit has cautioned that "prosecution history comments cannot trump the plain language of the claims and the direct teaching of the specification." *Telecordia Techs., Inc. v. Cisco Sys., Inc.*, 612 F.3d 1365, 1375 (Fed. Cir. 2010) (citation omitted).

This caution in finding a disclaimer is especially warranted here, where a patentee is relying on its own self-serving arguments made during prosecution, and has had an opportunity to amend its claims to avoid any ambiguity. The Federal Circuit has observed "that the PTO is under no obligation to accept a claim construction proffered as a prosecution history disclaimer, which generally only binds the patent owner." *Tempo Lighting, Inc. v. Tivoli, LLC*, 742 F.3d 973, 978 (Fed. Cir. 2014).

We do not find that there has been an unambiguous disclaimer or disavowal of claim scope as suggested by Patent Owner. With respect to claims 1 and 10, the first sentence of applicants' statement about Endo is a general allegation that Endo does not disclose the claim element "introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer." Ex. 1003, 66. This statement cannot be read to disclaim cooling processes where gas is blown under the rear surface of the wafer.

The applicants describe Endo as disclosing "cooling the substrate after depositing two coating layers 34, 35 by sputtering an aluminum-copper alloy." Ex. 1003, 66. In particular, the applicants rely on Endo's teaching that

> [t]he substrate is gradually cooled at a low cooling speed in an argon atmosphere while the material that forms second film 35 is not solidified. When the substrate is slowly cooled after second film 35 is formed, thermal stresses generated in the surface of second film 35 are alleviated and the generation of whiskers is restricted.

Id. (quoting Ex. 2001, 9:20–26). The applicants then distinguish Endo by stating that it "discloses slow cooling the substrate to alleviate the thermal stresses generated in the surface of the second film 35" and, therefore, "there is no motivation to fan the substrate with the inert gas." *Id.* Notably, the applicants did not expressly define "fanning the wafer" when they added that term to the claims, and did not reference or discuss Endo's teaching that the substrate is "cooled while a gas that serves as a heat conductive medium is supplied in the space between" the stage and the substrate, i.e., under the rear surface of the wafer. Ex. 2001, 7:22–25.

The applicants' argument is amenable to multiple reasonable interpretations. For example, this argument could be read to mean that cooling the wafer by fanning the wafer is not slow cooling, which says nothing about the directionality of the inert gas with respect to the wafer, only the rate of cooling. It could also be read to mean that the applicants' claimed process does not cool the substrate after the second film is formed (and before it is solidified), which is directed to when the cooling occurs and, again, not the directionality of the inert gas. Additionally, it could be read to mean that Endo teaches cooling to alleviate the thermal stresses on the surface of the second film, as opposed to alleviating the thermal stresses between the titanium nitride layer and the Al-Cu layer as claimed.

Similarly, with respect to claim 18, the applicants make general allegations that Endo does not teach the precise combination of elements set forth in the claim, which cannot be read to disclaim cooling processes where gas is blown on the rear surface of the wafer. Ex. 1003, 66–67. The applicants then reiterate their argument that Endo "is directed to slow cooling the substrate to alleviate thermal stresses generated in the surface of the second film 35" and "is devoid of any teaching or suggesting of fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer." *Id.* at 67. The applicants' argument with respect to claim 18, therefore, is amenable to multiple reasonable interpretations for at least the same reasons set forth above with respect to claims 1 and 10.

Moreover, we are not persuaded by Patent Owner's argument that the applicants "did not distinguish Endo based on a failure to disclose cooling the wafer to reduce thermal stresses between the Al-Cu and TiN layers" because "the Examiner had explicitly found to the contrary" and "[t]his conclusion was not disputed by" the applicants. PO Resp. 13 (citing

Ex. 1003, 50–51, 68). Specifically, the Examiner stated that Endo teaches that "[t]he cooling alleviates thermal stresses formed in the second Al-Cu layer (35)." Ex. 1003, 51 (citing Ex. 2001, 9:24–27). Although the applicants stated (in response to the Examiner's obviousness rejection of the claims based on the combined teachings of Endo and a second reference (Liu)) that Endo "discloses slow cooling the substrate to alleviate thermal stresses generated in the surface of the second film formed by sputtering an aluminum-copper alloy" (*id.* at 68), the applicants also repeatedly stated that Endo does not disclose cooling "to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer" (*id.* at 66, 67).

Furthermore, with respect to claim 18 (which, as originally filed, included a limitation that required cooling the wafer to a preset temperature "sufficiently low to reduce the thermal stresses between the titanium nitride layer and the Al-Cu layer so as to substantially prevent cracks from forming in the titanium nitride layer" (Ex. 1003, 16)), the applicants argued that Endo

> fails to disclose or suggest forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride sputter chamber after cooling the wafer, the preset temperature being sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer so as to substantially prevent cracks from forming in the titanium nitride layer.

Id. at 66–67. This statement suggests that the applicants did not agree with the Examiner that Endo's teaching of cooling to alleviate thermal stresses generated in the surface of the second film discloses cooling to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer as claimed.

Accordingly, we do not adopt Patent Owner's position that "fanning the wafer" excludes cooling processes where gas is blown under the rear surface of the wafer.

3. "fanning the wafer"

The claim term "fanning the wafer" is not expressly defined in the Specification. The Specification, however, does describe "the metallization process according to an embodiment of the present invention" as including a step of fanning the wafer:

> Next, at step 34, the wafer 100 is transferred to the titanium nitride sputtering chamber 16 and **inert gases are injected into the chamber 16 for fanning the high-temperature wafer 100** until the temperature of the wafer 100 is reduced to about 60–80º C. The inert gas is introduced into the chamber 16 at a temperature of substantially less than 260–280º C., and is typically provided at about room temperature. The inert gas may be nitrogen or argon. In specific embodiments, the flow rate is about 80–120 sccm, and the flow time is about 20–30 seconds. **The inert gas may be injected directly onto the wafer 100 or near the wafer to fan the wafer until it is cooled to the desired temperature.**

Ex. 1001, 3:20–31 (emphasis added). The Specification also teaches that, "[i]n some embodiments," "[t]he inert gas is injected into the titanium nitride sputtering chamber to fan the wafer until the wafer is cooled to a temperature of about 60–80º C." *Id.* at 2:10–16; *see also id.* at 2:48–52 ("The wafer may be cooled after transferring the wafer to the titanium nitride sputtering chamber, for instance, by introducing the inert gas into the titanium nitride sputtering chamber to fan the wafer with the inert gas.").

Accordingly, we determine based on the Specification, claim language, and evidence from the complete record before us that, under the broadest reasonable interpretation and giving the words their plain and ordinary meaning consistent with the Specification, "fanning the wafer" means "injecting gas directly onto or near the wafer."

B. Level of Ordinary Skill in the Art

Petitioner argues that a person of ordinary skill in the art at the time of the '789 patent "would have had at least a master's degree or higher in materials science, physics, electrical engineering, or related disciplines, and two to three years of experience in the semiconductor processing and manufacturing industry" and that "[m]ore education can supplement practical experience and vice versa." Pet. 4–5 (citing Ex. 1002 ¶ 19).

Patent Owner does not dispute Petitioner's assessment in its Response. Patent Owner's Declarant Dhaval Brahmbhatt, however, provides his own assessment regarding a person of ordinary skill in the art relevant to the '789 patent. Ex. 2003 ¶ 38. Mr. Brahmbhatt opines that a person having ordinary skill in the art would have "a Bachelor's of Science degree in material science, physics, electrical engineering, or chemical engineering and three to four years of practical experience in the development, design, processing, and manufacturing/testing of semiconductor chips and technology," and that a person with an advanced degree in any of the identified fields "would require less experience," for example, two to three years. *Id.*

We do not observe meaningful differences between the parties' assessments of a person having ordinary skill in the art. We further note that both assessments appear consistent with the level of ordinary skill in the art at the time of the invention as reflected in the prior art in this proceeding. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (explaining that specific findings regarding ordinary skill level are not required "where the prior art itself reflects an appropriate level and a need for testimony is not shown" (quoting *Litton Indus. Prods., Inc. v. Solid State Sys. Corp.*, 755 F.2d 158, 163 (Fed. Cir. 1985))). Our determination regarding the patentability of the challenged claims does not turn on the minor differences between these definitions. We adopt Petitioner's assessment, but note that our conclusions would be the same under Mr. Brahmbhatt's assessment.

C. Principles of Law

To prevail on its challenges to the patentability of the claims, a petitioner must establish facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). "In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). This burden of persuasion never shifts to the patent owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378–79 (Fed. Cir. 2015) (discussing the burdens of persuasion and production in *inter partes* review).

To establish anticipation, each and every element in a claim, arranged as recited in the claim, must be found in a single prior art reference. *NetMoneyIN, Inc. v. Verisign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008); *Karsten Mfg. Corp. v. Cleveland Golf Co.*, 242 F.3d 1376, 1383 (Fed. Cir. 2001). Although the elements must be arranged in the same way as in the claim, "the reference need not satisfy an *ipsissimis verbis* test," i.e., identity of terminology is not required. *In re Gleave*, 560 F.3d 1331, 1334 (Fed.

Cir. 2009); *In re Bond*, 910 F.2d 831, 832 (Fed. Cir. 1990). A prior art reference that does not expressly disclose "a claim limitation may nonetheless anticipate by inherency." *Perricone v. Medicis Pharm. Corp.*, 432 F.3d 1368, 1375–76 (Fed. Cir. 2005); *see also Kennametal, Inc. v. Ingersoll Cutting Tool Co.*, 780 F.3d 1376, 1381 (Fed. Cir. 2015) ("[A] reference can anticipate a claim even if it 'd[oes] not expressly spell out' all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would 'at once envisage' the claimed arrangement or combination." (citing *In re Petering*, 301 F.2d 676, 681 (CCPA 1962))). A limitation is "inherent and in the public domain if it is the 'natural result flowing from' the explicit disclosure of the prior art." *Schering Corp. v. Geneva Pharms., Inc.*, 339 F.3d 1373, 1379 (Fed. Cir. 2003).

A claim is unpatentable under 35 U.S.C. § 103 if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art to which the subject matter pertains. *KSR Int'l Co. v. Teleflex, Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is 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) objective evidence of nonobviousness. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

A patent claim "is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art." *KSR*, 550 U.S. at 418. An obviousness determination requires finding "both 'that the skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.'" *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367–68 (Fed. Cir. 2016) (citation omitted); *see KSR*, 550 U.S. at 418 (for an obviousness analysis, "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does"). Further, an assertion of obviousness "cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *KSR*, 550 U.S. at 418 (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)); *In re Nuvasive, Inc.*, 842 F.3d 1376, 1383 (Fed. Cir. 2016) holding that a finding of a motivation to combine "must be supported by a 'reasoned explanation'" (citation omitted)).

D. Overview of the Prior Art

1. Yamada

Yamada is directed to methods for manufacturing semiconductor devices using Al wiring. Ex. 1004 ¶ 1. Yamada states that in the conventional method for forming a substrate device, the Al alloy film is formed at 150° C or higher, so when the TiN film is formed thereafter, unreacted nitrogen in the TiN film forms trace amounts of aluminum nitride (AlN) in the surface of the Al alloy film, worsening the electromigration resistance of the Al wiring. *Id.* ¶¶ 14, 16. In contrast, Yamada describes a manufacturing method wherein "the substrate is cooled to room temperature prior to formation of the TiN film, after which the TiN film is formed, so while the temperature rises a bit when TiN film formation starts, the temperature remains no higher than 100°C.” *Id.* at ¶ 39.

Yamada Figure 1 is reproduced below.

FIG. 1

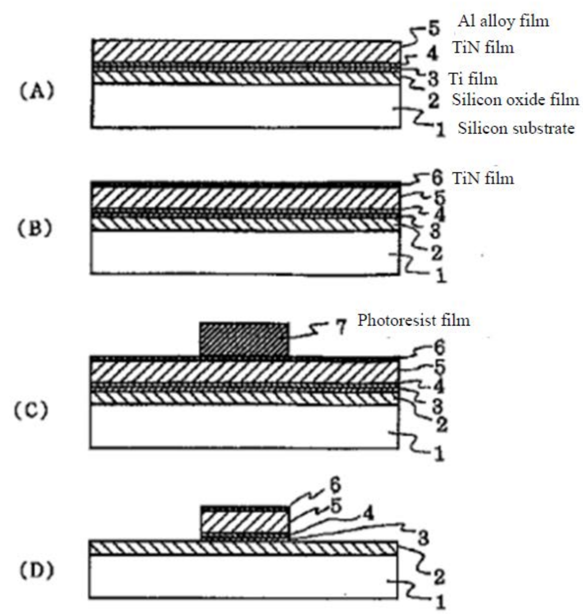

Figure 1 is a cross-sectional view of the principal steps showing one embodiment described in Yamada. In Figure 1(A), Ti film 3 and TiN film 4 are formed by sequential sputtering on silicon substrate 1 “in which surfaces are covered by a silicon oxide film 2, and then an Al alloy film 5” and “with the silicon substrate 1 maintained at a temperature of 150–500°C.” *Id.* ¶ 27. Silicon substrate 1 is then moved to a separate processing chamber in a vacuum, where room-temperature argon (Ar) gas is released over the rear face of silicon substrate 1 for 1 to 3 minutes, cooling silicon substrate 1 to room temperature. *Id.* ¶28.

As shown in Figure 1(B), silicon substrate 1 is moved to another processing chamber where TiN film 6 is formed using reactive sputtering, and, in Figure 1(C), photoresist film 7 is formed on TiN film 6 and patterned into a desired shape using photolithographic techniques. *Id.* ¶¶ 29–30. Figure 1(D) shows that dry etching is used to etch TiN film 6, Al alloy film 5, TiN film 4, and Ti film 3, and photoresist film 7 is removed, completing the Al wiring. *Id.* ¶ 32.

2. Shan

Shan is directed to the formation of a titanium- and/or tungsten-containing antireflective coating ("ARC") on an aluminum- or aluminum alloy-containing metallization layer in an integrated circuit. Ex. 1006, 1:11–15. Shan describes a process that includes the steps of: (1) "forming a first layer comprising a first metal on the substrate;" (2) "cooling the first layer for a period of time sufficient to suppress formation of an intermetallic phase;" and (3) "forming a second layer comprising a second metal distinct from said first metal on the first layer." *Id.* at 2:8–16.

With respect to the cooling step, Shan teaches that the first metallization layer is cooled by introducing into the process chamber an inert gas (such as nitrogen, helium, or argon) "at a temperature lower than the desired, target and/or effective temperature of the cooling step (e.g., room or ambient temperature)," where it is "impinged onto the metallization layer and/or directed to the backside of the wafer as the wafer is supported in the process chamber by a mechanical or electrostatic chuck." *Id.* at 4:22–30. Shan states that the "the cooling of the metallization layer prior to the ARC layer or coating formation may be carried out until the metallization layer reaches a temperature of about 300° C. or below," and, "[m]ore preferably, the metallization layer is cooled to a temperature less than or equal to about 250° C." *Id.* at 4:64–5:3. Shan further teaches that "the temperature to which the metallization layer is to be cooled, as well as the period of time during which the metallization layer is to be cooled[,] will vary depending upon the application at hand." *Id.* at 5:4–7. According to Shan, "[f]actors that affect the cooling times and desired cooling temperature include the composition, topography, and thickness of the metallization layer, the temperature at which the metallization layer is formed or deposited, the pressure within the process chamber, and the thermal conductivity characteristics of the metallization layer." *Id.* at 5:7–13.

3. Kobayashi

Kobayashi is directed to "an improvement of the productivity of a multichamber sputtering apparatus which is used for manufacturing a semiconductor device and the like." Ex. 1005, 1:6–8. Kobayashi's multichamber sputtering apparatus comprises "a transfer chamber and a plurality of process chambers which are airtightly connected to and arranged around the transfer chamber, in which processes are continuously conducted in a vacuum," the process chambers including "a sputter chamber for sputtering" and "a degas chamber for degassing a substrate." *Id.* at 2:23–29.

Kobayashi includes an example of a specific sputtering process occurring in the described multichamber sputtering apparatus. In the example, a substrate is transferred to sputter chamber 1A where a Ti film is deposited thereon. *Id.* at 7:52–55. The substrate is then transferred to sputter chamber 1B "and subjected to high-temperature Al sputtering." *Id.* at 7:56–57. The substrate subsequently is transferred to sputter chamber 1D, where the substrate "is cooled to a predetermined temperature," and a TiN film is then deposited "in order to prevent mutual diffusion of the film and a further upper layer from occurring." *Id.* at 7:67–8:5.

E. Anticipation by Yamada

Petitioner asserts that claims 1, 2, 4, 5, 8, 9, and 18–20 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Yamada, and relies on the Declaration of Dr. Gary Rubloff (Ex. 1002, "Rubloff Declaration"). Pet. 15–39; Reply 4–16. Patent Owner disagrees with Petitioner's assertions, and relies on the Declaration of Dhaval Brahmbhatt (Ex. 2003, "Brahmbhatt Declaration"). PO Resp. 15–24.

The parties focus their arguments on three elements in the challenged claims: (1) "fanning the wafer" in independent claims 1 and 18; (2) "temperature [being] sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer" in independent claims 1 and 18; and (3) "the wafer is cooled to a temperature of about 60–80º C" in dependent claims 5 and 19. As to the other elements of the challenged claims, we have reviewed the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that those elements are disclosed as arranged in the claims. Pet. 15–39. We address the arguments regarding the disputed elements in turn.

1. Fanning the wafer

Petitioner contends that Yamada discloses this element of independent claims 1 and 18 because it teaches introducing an inert gas into the TiN processing chamber to cool silicon substrate 1 by blowing the inert gas against silicon substrate 1. Pet. 18–19 (citing Ex. 1004 ¶¶ 21, 22, 28, 32, 39, 43); *see id.* at 33. Patent Owner responds that Yamada does not meet the "fanning the wafer" limitation of claims 1 and 18 because "Yamada does not disclose directing a gas over the front surface of the wafer." PO Resp. 18 (citing Ex. 1004 ¶¶ 28, 32; Ex. 2003 ¶ 66). Patent Owner's argument is premised on its contention that "the term 'fanning the wafer' is properly construed to mean cooling by directing a gas or gases over the front surface of the wafer." *Id.* We do not agree that the claim term should be interpreted in that manner, for the reasons explained above, and construe "fanning the wafer" to mean "injecting gas directly onto or near the wafer." *See supra* Section II.A.

We agree with Petitioner that Yamada teaches "fanning the wafer" as recited in claims 1 and 18. In particular, Yamada describes an embodiment where silicon substrate 1 is cooled by releasing argon gas "over the rear face of the silicon substrate 1." Ex. 1004 ¶ 28; *see also id.* ¶ 32 ("[I]t is also possible, after moving the substrate to the processing chamber for forming the TiN film 6, to release just the room-temperature Ar gas across the rear face of the silicon substrate 1 prior to forming the TiN film 6."). Yamada further describes its method as "proactively cool[ing] the substrate by blowing a low-temperature inert gas against it." *Id.* ¶ 35.

Accordingly, we determine that Yamada discloses "fanning the wafer" as recited in independent claims 1 and 18.

2. Temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer

Petitioner contends that Yamada discloses this element of claims 1 and 18 because it teaches blowing the inert gas against silicon substrate 1 to cool silicon substrate 1 "to 150º C or less and in a more specific example, to room temperature." Pet. 18–19 (citing Ex. 1004 ¶¶ 21, 22, 28, 32, 39, 43); *see id.* at 35–37. Petitioner further contends that a person having ordinary skill in the art "would have recognized based on the disclosure of *Yamada* and the '789 patent, that cooling the substrate 1 to a temperature of 150° C or less, and in particular down to room temperature, encompasses the temperature ranges that the ’789 patent describes” as sufficient to reduce thermal stresses between the Al-Cu layer and the TiN layer. *Id.* at 20 (citing Ex. 1002 ¶ 50); *see also id.* at 34 (arguing that because Yamada “specifically discloses the 150° C or less temperature range down to room temperature as the desired temperature to which the silicon substrate 1 should be cooled,” a person having ordinary skill in the art “would have understood the specified temperature as a preset temperature to which the silicon substrate 1 is cooled” (citing Ex. 1002 ¶ 79)).

Patent Owner argues that, because Yamada does not explicitly disclose a process for reducing thermal stresses between the titanium nitride layer and the Al-Cu layer, Petitioner “is arguing that the process is anticipated inherently” by Yamada. PO Resp. 19–20. In that regard, Patent Owner argues that Petitioner does not establish that Yamada inherently discloses a temperature “sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer” as required by claims 1 and 18 because Petitioner does not show that the Yamada temperature range “necessarily reduces thermal stress between the Al-Cu layer and the titanium nitride layer.” *Id.* at 20.

Patent Owner argues that “Yamada is directed to a different problem from that described and claimed in the ’789 patent,” specifically, “prevent[ing] unwanted nitridation of the aluminum oxide layer” by cooling the silicon substrate to a temperature below 150º C. PO Resp. 20 (citing Ex. 1004 ¶¶ 14–19, 43; Ex. 2003 ¶¶ 67–68). Patent Owner argues that the ’789 patent teaches that reducing thermal stress requires a temperature around 60–80º C, which is “far lower” than the “just below 150º C” taught by Yamada. *Id.* at 21 (citing Ex. 1001, 3:36–42; Ex. 2003 ¶¶ 67–69). Patent

Owner further argues that the "one embodiment [in Yamada] where the wafer is cooled to room temperature" "merely indicates that there is a broad range of temperatures where Yamada's goal of preventing [aluminum nitride] formation can be achieved," and "this broad range for achieving a different purpose . . . does not anticipate the claimed invention." *Id.* at 21–22.

Petitioner replies that "Patent Owner does not dispute that in the implementation in *Yamada* where the substrate is cooled to room temperature, thermal stresses between the Al-Cu layer and the titanium nitride layer are reduced as recited in claims 1 and 18." Reply 13. Petitioner further argues that "none of the independent claims [of the '789 patent] recite the 60–80º C temperature range," and Patent Owner did not "present any argument or evidence as to why those claims should be interpreted to be limited to that temperature range." *Id.* at 11.

We agree with Petitioner that Yamada teaches a temperature "sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer" as recited in claims 1 and 18. Yamada discloses a method wherein "the temperature for forming the Al or Al alloy film is 150ºC or higher," and "includes a step in which the substrate is cooled to 150ºC or less prior to forming the high-melting point metal nitride film." Ex. 1004 ¶ 21. Yamada describes a specific embodiment in which an aluminum alloy film is formed by sputtering "with the silicon substrate 1 maintained at a temperature of 150–500ºC." *Id.* ¶ 27. Silicon substrate 1 is then cooled "until the temperature of the silicon substrate 1 reaches room temperature." *Id.* ¶ 28. Yamada notes that "[t]he the prior art and the present invention are exactly the same" up to the point when the aluminum alloy film is formed and the temperature of the substrate reaches 450ºC or above, and that "[t]hereafter, in the prior art, the substrate is moved to the processing chamber for forming the TiN film," and "the formation of the TiN film starts at 400ºC or higher." *Id.* ¶ 38. Yamada goes on to explain:

> In contrast, in the present invention the substrate is cooled to room temperature prior to formation of the TiN film, after which the TiN film is formed, so while the temperature rises a bit when the TiN film formation starts, the temperature remains no higher than 100ºC.
>
> In the present invention, the substrate temperature is limited to 150ºC or lower during formation of the TiN film on the Al alloy film because when we examined whether or not AlN had formed due to connection resistance when forming the Al double-layer wiring as shown in FIG. 2(G), while there was variation in the connection resistance at temperature of 150ºC and above, the connection resistance was low and stable between room temperature and 150ºC.

Id. ¶¶ 38–39.

Considered in its entirety, Yamada discloses cooling a substrate with an aluminum alloy from a temperature typically above 400ºC to room temperature before forming a TiN layer thereon, and that the temperature of the substrate remains no higher than 100ºC during TiN film formation. These disclosures indicate that the Yamada process provides the desired results when the temperature of the substrate is between room temperature and 100ºC when the TiN film is formed.

In light of these express disclosures in Yamada, Patent Owner does not provide sufficient objective evidence or analysis to support its contention that although Yamada describes "one embodiment where the wafer is cooled to room temperature, this does not change the fact that the teaching of Yamada is that this level of cooling is not necessary, nor does it disclose cooling to a temperature to relieve thermal stress." PO Resp. 21–22. As set forth above, Yamada does teach the benefits of cooling to room temperature, and also repeatedly describes its process as including the step of cooling the wafer to room temperature.

Moreover, although Patent Owner argues that "reduction of thermal stress requires a far lower temperature—around 60–80ºC" (PO Resp. 21), as Petitioner notes, claims 1 and 18 do not recite a specific temperature or temperature range that qualifies as "sufficiently low" (Reply 11). Dependent claims 5 and 19, however, do specifically recite that the wafer is cooled to 60–80º C. Ex. 1001, 4:22–25, 6:11–12. These dependent claims suggest that the temperature range that satisfies the "sufficiently low" limitation in claims 1 and 18 is broader than 60–80º C. *See Comark Comm's, Inc. v. Harris Corp.*, 156 F.3d 1182, 1187 (Fed. Cir. 1998) (Claim differentiation "create[s] a presumption that each claim in a patent has a different scope."). This is consistent with the Specification of the '789 patent, which teaches that "[i]n some embodiments" "the wafer is cooled to a temperature of about 60–80º C" (Ex. 1001, 2:10–16) and that "[s]ince the temperature of the wafer 100 is decreased prior to the deposition of the titanium nitride layer 106, the thermal stress between the titanium nitride layer 106 and the Al–Cu layer 104 is reduced" (*id.* at 3:36–39). *See also id.* at 3:7–42 (describing "an embodiment" where "[t]he permissible temperature range is selected so as to prevent cracks from forming in the titanium nitride layer" which "is typically about 60–80º C").

The '789 patent teaches that thermal stresses between the Al-Cu layer and the titanium nitride layer are reduced by decreasing the temperature of the wafer prior to forming the titanium nitride layer. It also teaches that 60–

80º C "is typically" a permissible temperature range to prevent cracks from forming in the titanium nitride layer. Ex. 1001, 3:36–42. Because Yamada similarly teaches cooling the wafer to room temperature, and that wafer temperatures up to 100ºC during the formation of the titanium nitride film give the desired results, we are persuaded that the temperature range taught by Yamada is "sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer" as required by independent claims 1 and 18.

3. The wafer is cooled to a temperature of about 60–80º C

Claims 5 and 19 depend from claims 1 and 18, respectively, and further recite "the wafer is cooled to a temperature of about 60–80º C." Petitioner asserts that Yamada discloses this element because "cooling the substrate until the substrate temperature is reduced to 150 ºC or less and down to room temperature discloses the claimed range of cooling the wafer "to a temperature of about 60–80º C." Pet. 28; *see id.* at 38. Petitioner relies on the same arguments it made with respect to the "temperature sufficiently low to reduce thermal stresses" limitation set forth above. *Id.* at 27–29, 37–38. Patent Owner responds that "[n]othing about the Yamada disclosure would tell a person having ordinary skill in the art to cool the wafer between 60–80ºC, which is what is required by claims 5 and 19." PO Resp. 23–24.

For the same reasons set forth above with respect to the temperature "sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer," we are persuaded that Yamada discloses "cooling the wafer to a temperature of about 60–80º C." In particular, Yamada discloses cooling a substrate with an aluminum alloy from a temperature typically above 400ºC to room temperature before forming a

TiN layer thereon, and that the temperature of the substrate remains no higher than 100ºC during TiN film formation. Ex. 1004 ¶¶ 27–28, 38–39. These disclosures indicate that the Yamada process provides the desired results when the temperature of the substrate is between room temperature (approximately 20 ºC) and 100ºC when the TiN film is formed, which encompasses the claimed "temperature of about 60–80º C." *See, e.g., ClearValue, Inc. v. Pearl River Polymers, Inc.*, 668 F.3d 1340, 1345 (Fed. Cir. 2012) (Finding that prior art that discloses "150 ppm or less" anticipates claim that requires "less than or equal 50 ppm" where "there is no allegation of criticality or any evidence demonstrating any difference across the range.").

4. Conclusion

After considering Petitioner's and Patent Owner's positions, as well as their supporting evidence, we determine that Petitioner has shown, by a preponderance of the evidence, that independent claim 1, and claims 2, 4, 5, 8, and 9 that depend directly therefrom, and independent claim 18, and claims 19 and 20 that depend, directly or indirectly, therefrom, are unpatentable under 35 U.S.C. § 102(b) as anticipated by Yamada.

F. Obviousness over Yamada and Shan

Petitioner contends that the subject matter of claims 3 and 6 is unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada and Shan. Pet. 39–49; Reply 16–20. Petitioner relies on the Rubloff Declaration in support of its contentions. *Id.* Patent Owner disagrees with Petitioner's assertions, and relies on the Brahmbhatt Declaration. PO Resp. 24–31.

1. Claim 3

Claim 3 depends from claim 1, and further requires that "the inert gas comprises nitrogen." Petitioner contends that Yamada discloses all of the limitations of claim 1, but "does not explicitly disclose that the inert gas used to cool the wafer could be nitrogen." Pet. 39. Petitioner contends that Shan "discloses using nitrogen to cool the wafer instead of argon and thus remedies the deficiencies in *Yamada*." *Id.* at 39–40 (citing Ex. 1002 ¶ 92). In particular, Petitioner contends that "*Shan* discloses that nitrogen can be used as a substitute for argon for cooling a substrate after forming a metal layer thereon, and in the similar manner as disclosed in *Yamada* (i.e., by blowing the inert gas against the wafer)." *Id.* at 41 (citing Ex. 1002 ¶ 94). Petitioner further contends that a person having ordinary skill in the art "would have looked to *Shan* to refine the teachings of *Yamada* because *Shan* discloses a method of cooling the substrate in between formation of the metal layer (wiring layer) and the ARC layer, like *Yamada*." *Id.* at 41 (citing Ex. 1002 ¶ 96). According to Petitioner, it would have been obvious to a person having ordinary skill in the art "to substitute argon from *Yamada*'s wafer cooling technique with nitrogen from *Shan*'s wafer cooling technique because the two techniques were known design choices and the modification would have produced the expected result of cooling the wafer to a desired temperature." *Id.* at 41–42.

Patent Owner argues that "[a] person of ordinary skill in the art would not be motivated to combine the Yamada and Shan references because they address completely different problems." PO Resp. 25 (citing Ex. 2003 ¶ 78). Patent Owner argues that "Yamada addresses a problem of unreacted nitrogen in the titanium nitride ARC layer reacting with the aluminum of the aluminum alloy layer—a problem involving the reaction of a metal (Al) and a non-metal (N)." *Id.* at 25–26 (citing Ex. 1004 ¶¶ 14–19; Ex. 2003 ¶ 78). Patent Owner further argues that "Shan describes a reaction that is designed to reduce the formation of an intermetallic species caused by the reaction of the aluminum in the first metal layer with the metal (Ti and/or W) of the ARC layer—a problem involving the reaction between two metals." *Id.* at 26 (citing Ex. 2003 ¶ 75). According to Patent Owner:

> These are very different types of reactions that are influenced by different factors and have different solutions. A person looking to solve the problem of Yamada, suppressing reactions between nitrogen and aluminum, would not look to Shan which deals with suppressing reactions between two metals. Thus, a person skilled in the art would not combine the references as argued by [Petitioner], and the claims would not have been obvious.

Id. at 26–27 (internal citations omitted).

Patent Owner's argument is not persuasive. Prior art references must be considered as a whole for all that they teach, regardless of the specific problems to which they are directed. *See KSR*, 550 U.S. at 420–21 (stating that "[t]he idea that a designer hoping to [solve one problem] would ignore [a reference] because [the reference] was designed to solve [a different] problem makes little sense," since "[a] person of ordinary skill in the art is also a person of ordinary creativity, not an automaton"); *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1166 (Fed. Cir. 2006) (explaining that in an obviousness analysis, "the prior art must be considered *as a whole* for what it teaches"); *EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898, 907 (Fed. Cir. 1985) ("A reference must be considered for everything it teaches by way of technology and is not limited to the particular invention it is describing or attempting to protect. On the issue of obviousness, the combined teachings of the prior art as a whole must be considered." (emphasis omitted)); *In re Heck*, 699 F.2d 1331, 1333 (Fed. Cir. 1983) (stating that the "use of patents as references is not limited to what the patentees describes as their own inventions or to the problems with which they are concerned").

Moreover, we do not view Yamada and Shan as so different that an ordinarily skilled artisan would not have thought to combine them. Both references pertain to processes for forming metallic layers on a substrate, and both evince a desire to reduce detrimental interactions between those layers during their formation by cooling the substrate before depositing the second layer. *See* Ex. 1004 ¶¶ 14–19, 21; Ex. 1006, 1:61–2:16, 6:33–37; *KSR*, 550 U.S. at 418 ("Often, it will be necessary for a court to look to interrelated teachings of multiple patents . . . to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue."). The fact that they are suppressing different inter-layer reactions—nitriding of aluminum surfaces when a TiN film is formed on an Al alloy film in Yamada, or formation of an intermetallic phase when a titanium- and/or tungsten-containing layer is formed on an aluminum- or aluminum-alloy containing layer in Shan—does not indicate that a person having ordinary skill in the art would not have considered using elements of Shan's wafer-cooling process in Yamada's process to cool the wafer to a desired temperature, as Petitioner contends.

Accordingly, we find that a person having ordinary skill in the art would have looked to Shan when determining cooling conditions suitable for use in Yamada's process. We also have reviewed the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that all of the elements of claim 3 are disclosed in the combined teachings of Yamada and Shan. Pet. 39–44. Consequently, we determine that Petitioner has shown by a preponderance of the evidence that claim 3 is unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada and Shan.

2. Claim 6

Claim 6 also depends from claim 1, and further recites that "the inert gas is introduced into the titanium nitride sputtering chamber at a flow rate of about 80–120 sccm and a flow time of about 20–30 seconds." Petitioner contends that Yamada discloses all of the elements of claim 1, but notes that Yamada "does not explicitly disclose the claimed flow rate and flow time for the inert gas" recited in claim 6. Pet. 45 (citing Ex. 1002 ¶ 102). Petitioner contends that Shan "discloses that the flow rate and flow time for the inert gas used to cool the substrate are variables that a person of ordinary skill in the art would have been able to derive based on the stated objective of the application." *Id.* Specifically, Petitioner contends that Shan discusses various factors that affect the cooling temperature and cooling time, including the composition, topography, and thickness of the metallization layer, the temperature at which the metallization layer is formed, the process chamber pressure, and the thermal conductivity characteristics of the metallization layer. *Id.* at 47 (citing Ex. 1006, 5:7–18).

Petitioner argues that a person having ordinary skill in the art "would have recognized that the flow time and flow rate of the inert gas used for cooling the wafer are both result-effective variables for achieving a recognized result," such as "cooling *Yamada*'s substrate to 150° C or less, and to room temperature in one implementation of *Yamada*." Pet. 47 (citing

Ex. 1002 ¶¶ 105–106). According to Petitioner, an ordinarily skilled artisan "would have necessarily determined the optimum or workable ranges of the flow rate and flow time for the inert gas to achieve the desired objective stated above, and such a determination would have been within the capability of an ordinarily skilled artisan" because "both the flow rate and the flow time of the inert gas affect the time it takes for a wafer to be cooled to a desired temperature." *Id.* at 47–48.

Patent Owner contends that "although adjusting parameters may have been within the skillset of a person of ordinary skill, the reference still must provide some guidance as to how those parameters should be adjusted," and "[n]either Yamada nor Shan provides such guidance." PO Resp. 28. In particular, Patent Owner contends that the factors in Shan upon which Petitioner relies "are not even directed at determining flow rate," and instead "are non-flow rate related factors that can be used to calculate the cooling temperature and time." *Id.* at 29–30 (citing Ex. 1006, 5:4–23; Ex. 2003 ¶ 83). Patent Owner contends that Shan does not "explain how any of the factors (composition, topography, metallization thickness, deposition temperature, chamber pressure, or conductivity) affect what flow rate should be selected or whether the flow rate should be higher or lower." *Id.* at 30 (citing Ex. 2003 ¶ 84). Patent Owner further contends that "even if a person of ordinary skill in the art would look to Shan and could determine flow rates to be used with Yamada, nothing suggests that those flow rates would fall within 80–120 sccm" as required by claim 6. *Id.* (citing Ex. 2003 ¶ 85).

Petitioner responds that "[n]either Patent Owner nor its expert presents any arguments to dispute that the flow time and flow rate are result-effective variables" and "Patent Owner has not presented any evidence demonstrating that the claimed ranges are critical." Reply 18–19. Petitioner also reiterates that "*Shan* does disclose the flow time of the inert gas for cooling the substrate as ranging from 15 seconds to 90 seconds, which encompasses the range of 20–30 seconds recited" in claim 6. *Id.* at 18.

It is well established that "discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art." *In re Boesch*, 617 F.2d 272, 276 (CCPA 1980); *In re Antonie*, 559 F.2d 618, 620 (CCPA 1970). A "recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective." *In re Applied Materials, Inc.*, 692 F.3d 1289, 1297 (Fed. Cir. 2012). Shan demonstrates that flow rate and time are result-effective variables, as they are recognized to vary depending upon the application. In that regard, Shan states that "the length of time the cooling step S2 is carried out is generally for a period of time sufficient to suppress the subsequent formation of intermetallic species on the metallization layer upon formation of a second layer including a second metal distinct from the first metal." Ex. 1006, 4:6–11. Shan further states that the flow rate of the inert gas used to cool the wafer "may be selected within a range of about 15 to about 65 sccm." *Id.* at 4:30–32. Shan goes on to state:

> It should be noted that the temperature to which the metallization layer is to be cooled, as well as the period of time during which the metallization layer is to be cooled will vary depending upon the application at hand. Factors that affect the cooling times and the desired cooling temperature include the composition, topography and thickness of the metallization layer, the temperature at which the metallization layer is formed or deposited, the pressure within the process chamber and the thermal conductivity characteristics of the metallization layer, among other factors. Thus, the period of time during which the metallization layer is to be cooled and/or the temperature to

> which the metallization layer is to be cooled will vary depending upon the application envisaged[.]

Id. at 5:4–17.

We further credit Dr. Rubloff's testimony that, in view of these teachings in Shan, "a person of ordinary skill in the art would have recognized that the flow time and flow rate of the inert gas used for cooling the wafer are both result-effective variables for achieving" the recognized result of cooling Yamada's substrate to room temperature, "at least because both the flow rate and the flow time of the inert gas affect the time it takes for a wafer to be cooled to a desired temperature." Ex. 1002 ¶ 106; *see also id.* ¶ 107 (explaining that a skilled artisan would have considered "the composition, topography and thickness of the Al alloy film 5, the temperature at which the Al alloy film 5 was deposited, the pressure within the process chamber (1 Torr as disclosed by *Yamada*) and the thermal conductivity characteristics of the Al alloy film 5, to determine the optimum or workable ranges of the flow rate and flow time of the inert gas to meet the objective of cooling the wafer to 80º C or less.").

Moreover, we agree with Petitioner that the '789 patent does not support Patent Owner's argument that the claimed flow rates and times are critical. *See Applied Materials*, 692 F.3d at 1297 ("The outcome of optimizing a result-effective variable may still be patentable if the claimed ranges are 'critical' and 'produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art.'" (quoting *In re Aller*, 220 F.2d 454, 456 (CCPA 1955)). Patent Owner argues that "[t]he 80–120 sccm range was cited by the '789 patent specifically to address the '789 objective of reducing thermal stress between the Al-Cu layer and the TiN ARC layer, which caused cracking in the TiN layer." PO

Resp. 30 (citing Ex. 1001, 3:20–29, 3:36–42; Ex. 2003 ¶ 85). The portions of the ’789 patent upon which Patent Owner relies state that “[i]n specific embodiments, the flow rate is about 80–120 sccm, and the flow time is about 20–30 seconds,” and that

> [s]ince the temperature of the wafer 100 is decreased prior to the deposition of the titanium nitride layer 106, the thermal stress between the titanium nitride layer 106 and the Al-Cu layer 104 is reduced. The permissible temperature range is selected so as to prevent cracks from forming in the titanium nitride layer 106. That temperature range is typically about 60–80° C.

Ex. 1001, 3:27–28, 36–42. Taken together, these passages indicate that decreasing the temperature of the wafer is critical to decreasing thermal stresses between the titanium nitride layer and the Al-Cu layer, while also providing the preferred flow rate and time ranges for specific embodiments. They do not, however, provide evidence that there is criticality in the recited flow rates and times.

Accordingly, we determine that the discovery of an optimum value of a result-effective variable in a known process, e.g., inert gas flow rates and flow times, would have been obvious in view of the lack of sufficient evidence indicating that the specific ranges cited in claim 6 were critical. Based on the record before us, we conclude that Petitioner has established by a preponderance of the evidence that claim 6 is unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada and Shan.

G. Obviousness over Yamada and Kobayashi, or Yamada, Kobayashi, and Shan

Petitioner contends that claims 10, 11, 13, 14, and 17 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of

Yamada and Kobayashi, and that the subject matter of claims 12 and 15 would have been obvious over the combined teachings of Yamada, Kobayashi, and Shan. Pet. 49–60. Petitioner relies on the Rubloff Declaration in support of its contentions. *Id.* Patent Owner responds that "Kobayashi and Shan are cited to address specific issues raised by independent claim 10, or the specific dependent claims, such as the nature of the inert gas used for fanning." PO Resp. 31.

With respect to these grounds, Patent Owner argues generally that Petitioner does not identify any evidence in Kobayashi or Shan "that cures the fundamental deficiencies in Yamada" with respect to the "fanning the wafer" and "to a temperature sufficiently low to reduce thermal stress between the titanium nitride layer and the Al-Cu layer" limitations of claim 10 and, "[t]hus, these claims would not have been obvious over the combined art." PO Resp. 11. We already determined that Yamada discloses these limitations. *See supra* Sections II.E.1 and II.E.2. As discussed below, after considering Petitioner's evidence with respect to claims 10–15 and 17, we find that Petitioner has shown, by a preponderance of the evidence, that these claims are unpatentable.

1. Claims 10, 11, 13, 14, and 17

Petitioner has presented sufficient evidence showing that the combined teachings of Yamada and Kobayashi teach or suggest all of the elements of claims 10, 11, 13, 14, and 17. Pet. 49–59. For example, with respect to "placing a wafer in a Ti sputtering chamber to form a Ti layer on the wafer" limitation of independent claim 10, Petitioner asserts, with supporting testimony from Dr. Rubloff, that Yamada teaches "forming a Ti film 3 ('Ti layer') on the silicon substrate 1 ('wafer')" and using "multiple processing chambers for its various disclosed sputtering steps." *Id.* at 50 (citing Ex. 1002 ¶¶ 111–117). Petitioner argues that, because Yamada "suggests carrying out sputtering steps in separate processing chambers (but is silent regarding where the Ti film 3 is formed in its sputtering device)," and Kobayashi teaches "that it was well-known to place a wafer in a separate sputtering chamber 1A to form" the Ti film on the wafer, "it would have been obvious to a person of ordinary skill in the art to modify *Yamada*'s sputtering technique such that *Yamada*'s silicon substrate 1 is first placed in a Ti processing chamber ('Ti sputtering chamber') to form the Ti film 3." *Id.* at 52. Petitioner argues that a person having ordinary skill in the art would have looked to Kobayashi "to improve or refine the techniques" taught in Yamada "because both references disclose techniques for the fabrication of semiconductor devices." *Id.* (citing Ex. 1002 ¶ 116).

Petitioner further argues that "[t]he skilled artisan would have recognized that providing separate chambers for depositing different layers increases the efficiency of the deposition process because it allows different deposition processes to be carried out in parallel." Pet. 53. According to Petitioner, "such a modification would have been within the realm of knowledge and capability of an ordinarily skilled artisan, and would have provided the benefit of increased process efficiency." *Id.* We have also reviewed Petitioner's arguments and evidence for claims 11, 13, 14, and 17, and are persuaded that Petitioner has met its burden of demonstrating that those claims would have been obvious by a preponderance of the evidence. *Id.* at 58–59.

Consequently, based on all of the evidence of record, we determine that Petitioner has shown, by a preponderance of the evidence, that the subject matter of claims 10, 11, 13, 14, and 17 would have been obvious over the combined teachings of Yamada and Kobayashi.

2. Claims 12 and 15

Petitioner has presented sufficient evidence showing that the combined teachings of Yamada, Kobayashi, and Shan teach or suggest all of the elements of claims 12 and 15. Pet. 59–60.

Claim 12 depends from claim 10 and further requires that "the inert gas comprises nitrogen." Petitioner contends that "*Yamada* and *Kobayashi* in combination with *Shan* disclose or suggest this feature for at least the reasons discussed above with respect to claim 3." Pet. 59 (citing Ex. 1002 ¶¶ 129–130). Therefore, for the same reasons described in Section II.F.1, *supra*, we determine, based on all of the evidence of record, that Petitioner has shown, by a preponderance of the evidence, that the subject matter of claim 12 would have been obvious over the combined teachings of Yamada, Kobayashi, and Shan.

Claim 15 also depends from claim 10, and further recites that "the inert gas is introduced into the titanium nitride sputtering chamber at a flow rate of about 80–120 sccm and a flow time of about 20–30 seconds." Petitioner contends that "*Yamada* and *Kobayashi* in combination with *Shan* disclose or suggest this feature for at least the reasons discussed above with respect to claim 6." Pet. 60 (citing Ex. 1002 ¶ 131). Consequently, for the same reasons set forth in Section II.F.2, *supra*, we determine, based on all of the evidence of record, that Petitioner has shown, by a preponderance of the evidence, that the subject matter of claim 15 would have been obvious over the combined teachings of Yamada, Kobayashi, and Shan.

III. MOTION TO AMEND

Having concluded that claims 1–6, 8–15, and 17–20 are unpatentable, we address Patent Owner's contingent Motion to Amend.

In an *inter partes* review, amended claims are not added to a patent as of right, but rather must be proposed as a part of a motion to amend. 35 U.S.C. § 316(d). The Board must assess the patentability of the proposed substitute claims "without placing the burden of persuasion on the patent owner." *Aqua Prods., Inc. v. Matal*, 872 F.3d 1290, 1328 (Fed. Cir. 2017). Patent Owner's proposed substitute claims, however, must still meet the statutory requirements of 35 U.S.C. § 316(d) and the procedural requirements of 37 C.F.R. § 42.121. *See* "Guidance on Motions to Amend in view of *Aqua Products*" (Nov. 21, 2017).[6] Accordingly, Patent Owner must demonstrate (1) the amendment responds to a ground of unpatentability involved in the trial; (2) the amendment does not seek to enlarge the scope of the claims of the patent or introduce new subject matter; (3) the amendment proposes a reasonable number of substitute claims; and (4) the original disclosure sets forth written description support for each proposed claim. *See* 37 C.F.R. § 42.121.

A. Proposed Substitute Claims

Patent Owner proposes substitute claims 21–38 in its Motion to Amend, with claims 21, 29, and 36 being independent (corresponding to original independent claims 1, 10, and 18, respectively). *See* Claims App'x. Patent Owner characterizes each of the substitute independent claims as

[6] The guidance memorandum is publicly available at https://www.uspto.gov/sites/default/files/documents/guidance_on_motions_to_amend_11_2017.pdf.

retaining all of the limitations of the original independent claims and further adding "the limitation of 'wherein fanning the wafer with [the] inert gas comprises fanning the Al–Cu layer.'" Mot. 6. Patent Owner states that "[t]he substitute dependent claims correspond to the original dependent claims and are only amended to reflect their new dependency from the amended independent claims." *Id.* at 2. Patent Owner also indicates that the substitute claims are responsive to a ground of unpatentability involved in the proceeding. *Id.*

Proposed substitute claim 21 is representative of the proposed substitute independent claims, and is reproduced below, with underlined material indicating language added to original claim 1.

> 21. A metallization process comprising:
>
> placing a wafer in an Al-Cu sputtering chamber to form an Al-Cu layer on the wafer;
>
> transferring the wafer to a titanium nitride sputtering chamber;
>
> introducing an inert gas into the titanium nitride sputtering chamber to cool the wafer by fanning the wafer with the inert gas to a temperature sufficiently low to reduce thermal stresses between the titanium nitride layer and the Al-Cu layer; and
>
> forming a titanium nitride layer on the Al-Cu layer of the wafer in the titanium nitride sputtering chamber after cooling the wafer,
>
> wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer.

Claims App'x, ii.

B. Scope of Amended Claims and Written Description Support

A motion to amend may not present substitute claims that enlarge the scope of the claims of the challenged patent or introduce new subject matter. 35 U.S.C. § 316(d); 37 C.F.R. § 41.121(a)(2)(ii). New matter is any addition to the claims without support in the original disclosure. *See TurboCare Div. of Demag Delaval Turbomach. v. Gen. Elec. Co.*, 264 F.3d 1111, 1118 (Fed. Cir. 2001) ("When [an] applicant adds a claim . . . the new claim[] . . . must find support in the original specification."). Normally, a claim element without support in the original disclosure (i.e., the application as originally filed) merits a rejection under 35 U.S.C. § 112 for lack of written description support. *See, e.g.*, *In re Rasmussen*, 650 F.2d 1212, 1214 (CCPA 1981) ("The proper basis for rejection of a claim amended to recite elements thought to be without support in the original disclosure, therefore, is § 112, first paragraph . . . .").

Thus, in connection with a motion to amend, a patent owner must set forth "support in the original disclosure of the patent for each claim that is added or amended." 37 C.F.R. § 42.121(b)(1). The test for determining compliance with the written description requirement is whether the disclosure of the application as originally filed reasonably conveys to a person of ordinary skill in the art that the inventor had possession of the claimed subject matter at the time of filing of the claimed subject matter, rather than the presence or absence of literal support for the claim language in the specification. *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010) (en banc); *Vas-Cath, Inc. v. Mahurkar*, 935 F.2d 1555, 1563 (Fed. Cir. 1991; *In re Kaslow*, 707 F.2d 1366, 1375 (Fed. Cir. 1983). Possession of the invention is shown "by describing the invention, with all its claimed limitations, not that which makes it obvious." *Lockwood v. American Airlines, Inc.*, 107 F.3d 1565, 1572 (Fed. Cir. 1997).

Patent Owner argues that the "wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer" limitation is supported by the original disclosure provided with U.S. Patent Application No. 10/113,705 ("the '705 Application," Ex. 1003). Mot. 2–6, 8–9; PO Reply 1–4. Patent Owner asserts that "[t]he original disclosure describes the deposited layers in association with FIG. 2 and 3A," and that "[c]onsistently, these layers are described as being formed 'on' the wafer or other layers." *Id.* at 4 (citing Ex. 1003, 12 ¶¶ 16–18; *id.* at 17 (Abs.)). Patent Owner specifically points to paragraphs 16–18 of the '705 Application, which teach forming "a Ti layer 102 ***on*** a wafer 100," "an Al-Cu layer 104 ***on*** the Ti layer 102," "a titanium nitride layer ***on*** the Al-Cy layer 104," and a patterned photoresist layer 108 "***on*** the titanium nitride layer 106." *Id.* at 4–5 (quoting Ex. 1003, 12 ¶¶ 16–18 (emphasis added by Patent Owner)). Patent Owner contends that these disclosures, "read in concert with the corresponding steps in FIG. 1 and FIG. 3A," inform a person having ordinary skill in the art ("POSITA") "that the word 'on' is used to describe a particular orientation of the wafer 100 with respect to the process being performed and with respect to the processes already completed." *Id.* at 5 (citing Ex. 2127 ¶¶ 33–35).

Patent Owner asserts that "the orientation of wafer 100 and layers 102/104/106/108 in FIG. 3A indicates that a layer 'formed on' wafer 100 is deposited onto the uppermost exposed surface of the wafer 100," and a "POSITA would have interpreted other instances of the word 'on' in the '789 patent consistently with this usage." Mot. 5–6 (citing Ex. 2127 ¶ 34). Therefore, Patent Owner continues, a POSITA would have understood the '705 Application's disclosure that "[t]he inert gas may be injected directly ***onto*** the wafer 100 or near the wafer to fan the wafer until it is cooled to the desired temperature" to mean "the inert gas may be injected directly ***onto*** the Al-Cu layer 104, which corresponds to the uppermost exposed surface of the wafer 100 during the cooling step, to fan the Al-Cu layer 104 on the wafer 100." *Id.* at 6 (quoting Ex. 1003, 12 ¶ 16; citing Ex. 2127 ¶ 35).

Patent Owner further asserts that "[t]he specification consistently refers to the 'wafer' as including the substrate and any layers formed thereon during the fabrication process," such as, for example, when it "describes how 'the wafer' is transferred without separately identifying the layers formed thereon." PO Reply 2–3 (citing Ex. 1003, 10–12 ¶¶ 5–6, 8–9, 14, 16). Patent Owner contends that, because "the specification refers to fanning by injecting gas 'directly onto the wafer' or 'near the wafer,'" and, "[a]t this point in the process, the Al-Cu layer is formed on the wafer," "injecting gas 'directly onto' the wafer, to fan it, establishes that the gas fans the Al-Cu layer." *Id.* at 3.

In response, Petitioner argues that the '705 Application "plainly states that the inert gas is injected 'directly' onto the wafer 100, not the Al-Cu layer 104," and that, "when the cooling is to occur, the top surface of the wafer 100 is covered by layers 102 and 104." Opp. 2 (citing Ex. 1003, 12 ¶ 16; Ex. 1009 ¶¶ 18–19). Petitioner contends that "a POSITA would have understood that if the inert gas is injected 'directly' on the wafer 100, the inert gas would be directed only at the exposed portion of the wafer 100 (i.e., the rear surface of the wafer 100) and not at the Al-Cu layer 104." *Id.* at 2–3 (citing Ex. 1009 ¶ 19); *see also* Sur-Reply 2 ("[T]he use of the term 'directly' would have made it clear to a POSITA that the specific layer being acted upon is 'wafer 100,' which refers simply to the substrate.").

Petitioner argues that the portions of the ’705 Application upon which Patent Owner relies with respect to the use of the word “on” “explicitly refer[] to the specific layer being operated upon, which undercuts [Patent Owner’s] position.” Opp. 3–4 (citing Ex. 1003, 12 ¶¶ 16–18). Petitioner also asserts that “[t]he meaning of ‘wafer 100’ in the wafer-transfer context cannot be applied to the phrase ‘injected directly onto the wafer 100,’ because in the latter, a particular layer is being acted upon, which is not the case in the wafer-movement example.” *Id.* at 2 (internal citation omitted).

We agree with Petitioner that the entirety of the record fails to establish proper written description support for “wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer.” The ’705 Application consistently refers to the wafer separately from the layers deposited thereon when discussing operations relating to the layers. For example, in the “Brief Summary of the Invention” section, the ’705 Application describes

> a metallization process [that] comprises placing a wafer in an Al-Cu sputtering chamber to form an Al-Cu layer on the wafer, and transferring the wafer to a titanium nitride sputtering chamber. An inert gas is introduced into the titanium nitride sputtering chamber to cool the wafer. A titanium nitride layer is formed on the Al-Cu layer of the wafer in the titanium nitride sputter layer (sic) after cooling the wafer.

Ex. 1003, 10 ¶ 6; *see also id.* ¶ 8 (describing forming a Ti layer “on the wafer,” then forming “an Al-Cu layer on the Ti layer,” and a titanium nitride layer “on the Al-Cu layer of the wafer” after cooling the wafer). In this way, the ’705 Application differentiates processes that occur directly on the wafer (i.e., forming an Al-Cu layer on the wafer) from those that occur on the layers formed on the wafer (i.e., forming a titanium nitride layer on the Al-Cu layer).

This understanding is confirmed by the portion of the original disclosure relied upon by Patent Owner as disclosing "wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer," which describes an embodiment of the claimed metallization process depicted in Figure 3A with reference to a flow chart provided in Figure 2, both of which are reproduced below.

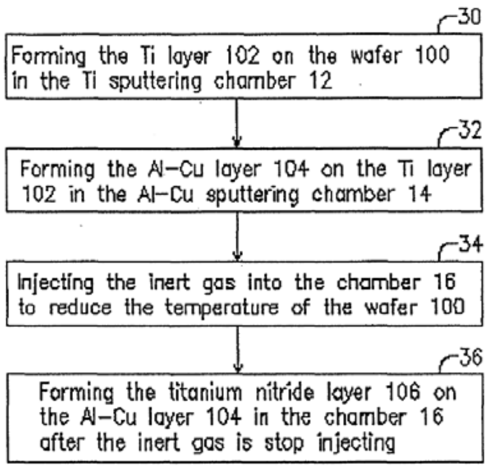

FIG. 2

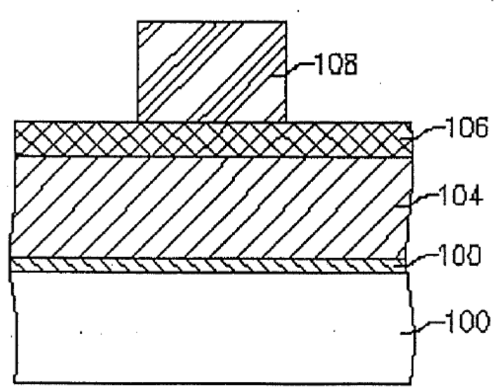

FIG. 3A

Figure 2 is a flow chart of the metallization process according to an embodiment of the invention described in the '789 patent, and Figure 3A is a cross-sectional view of the metallization process. Ex. 1003, 11 ¶¶ 12–13. The '705 Application describes that, in step 32, Al-Cu layer 104 is formed on Ti layer 102 (which was formed on wafer 100 in step 30). *Id.* at 12 ¶ 16. Similarly, the '705 Application describes step 36 as "form[ing] a titanium nitride layer 106 on the Al-Cu layer 104." *Id.* ¶ 17. In step 34, however, the '705 Application describes "fanning the high-temperature *wafer 100*" until the temperature is reduced, and does not specify fanning Al-Cu layer 104 that was formed in the previous step. *Id.* ¶ 16 (emphasis added).

The ’705 Application further indicates an intent to differentiate processes that act on wafer 100 from those that act on the layers deposited on wafer 100 when it states that “[s]ince the temperature of the wafer 100 is decreased prior to the deposition of the titanium nitride layer 106, the thermal stress between the titanium nitride layer 106 and the Al-Cu layer 104 is reduced.” *Id.* ¶ 17. For these reasons, the statement in the ’705 Application that “[t]he inert gas may be injected directly onto the wafer 100 or near the wafer to fan the wafer until it is cooled to the desired temperature” describes a process that occurs specifically to wafer 100, and not to a layer deposited on wafer 100, such as Al-Cu layer 104, as Patent Owner contends.

Consequently, after considering the parties’ arguments, and based on the entirety of the record before us, we find that the original disclosure in the ’705 Application does not provide written description support for “wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer” limitation recited in proposed substitute independent claims 21, 29, and 36. Thus, Patent Owner’s proposed amendment seeks to introduce new matter, contrary to the statutory requirement of 35 U.S.C. § 316(d)(3). Patent Owner’s Motion to Amend with respect to proposed substitute independent claims 21, 29, and 36, as well as proposed dependent claims 22–28, 30–35, 37, and 38, does not satisfy the requirements of 35 U.S.C. § 316(d)(3) and 37 C.F.R. §§ 42.121(a)(2) and 42.121(b)(1). Because this determination is dispositive with respect to the amended claims, we need not address Petitioner’s argument as to whether the added limitation enlarges the claim scope. *See* Opp. 7–8.

For these reasons, we deny Patent Owner's Motion to Amend with respect to the proposed substitute claims.

C. Unpatentability

As a separate, independent reason, we also determine based on a preponderance of the evidence that substitute claims 21–28 and 36–38 are unpatentable at least under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada and Shan, and that substitute claims 29–35 are unpatentable at least under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada, Shan, and Kobayashi.

1. Substitute Claims 21–28 and 36–38

As discussed *supra* in Section II.E, Petitioner has shown by a preponderance of the evidence that claims 1, 2, 4, 5, 8, 9, and 18–20 are unpatentable under 35 U.S.C. §102(b) as anticipated by Yamada. We also determined that a person having ordinary skill in the art would have looked to Shan when determining cooling conditions suitable for use in Yamada's process (*supra* Section II.F.1) and that claims 3 and 6 would have been obvious over the combined teachings of Yamada and Shan (*supra* Section II.F.1 and II.F.2). Upon review of substitute claims 21–28 (corresponding to original claims 1–6, 8, and 9) and 36–38 (corresponding to original claims 18–20), the disclosures of Yamada and Shan, and Patent Owner's and Petitioner's positions as well as their supporting evidence, we are persuaded that the subject matter of substitute claims 21–28 and 36–38 would have been obvious over the combined teachings of Yamada and Shan.

Petitioner argues that it would have been obvious to modify Yamada's process to include fanning the Al-Cu layer as required by the substitute claims in light of Shan. Opp. 10–12 (citing Ex. 1009 ¶¶ 62–78). Petitioner argues that Shan discloses three methods of cooling the metallization layer with inert gas (introduced into the process chamber and/or impinged onto the metallization layer and/or directed against the backside of the wafer) that can be used independently or together in various combinations. *Id.* at 11–12 (citing Ex. 1006, 4:22–30; Ex. 1009 ¶¶ 65–66). According to Petitioner, "*Shan*'s 'impinging' of the inert gas onto the metallization layer constitutes top-side cooling." *Id.* at 12. Petitioner argues that,

> when read in context, "impinging the inert gas onto the metallization layer" must mean something other than merely undirected flow of inert gas molecules to the metallization layer, because *Shan* distinguishes between introducing the inert gas into the process chamber and impinging the inert gas onto the metallization layer. (Ex. 1009, ¶ 67.) Hence, in the context of *Shan*'s disclosures, a [person having ordinary skill in the art] would have understood *Shan*'s impinging the inert gas onto the metallization layer means directing the inert gas onto the metallization layer—**i.e., top side cooling**. (*Id.*, ¶ 69.) Such an understanding is also consistent with the dictionary previously relied upon by Mr. Brahmbhatt, in which the relevant definition of "impinge" is "to strike; dash; collide (usually fol. by on, upon or against); rays of light impinging on the eye." (Ex. 1001, 961; Ex. 1009, ¶ 67.)

Id. at 13.

Petitioner further argues that a person having ordinary skill in the art ("POSITA") "would have looked to *Shan* because both *Yamada* and *Shan* are directed to cooling an aluminum alloy layer prior to forming another metal layer (e.g., TiN) on it and are attempting to solve similar problems." *Id.* (citing Ex. 1009 ¶ 71). Petitioner argues that, based on Shan, a POSITA would have been motivated to either replace Yamada's backside cooling with Shan's top-side cooling, or to modify Yamada so that the wafer is cooled from the back side and from the top-side. *Id.* at 14 (citing Ex. 1009

¶¶ 72–76). According to Petitioner, a POSITA would have modified Yamada to use top-side cooling alone "because cooling the Al-Cu layer from the top side would have been more efficient than backside cooling," and that "cooling from the top side and backside were design choices, and substituting one for another would have been obvious given that the substitution would have provided the same result—cooling of the Al-Cu layer." *Id.* (citing Ex. 2127 ¶ 37; Ex. 1009 ¶¶ 72–73).

Patent Owner asserts that "Shan distinguishes between a directed flow of gas 'against the backside of the wafer' and the undirected impinging of gas onto the metallization layer," and that "[a] POSITA would not interpret the latter to disclose 'fanning the Al-Cu layer.'" Mot. 17 (citing Ex. 2127 ¶¶ 83–86). Instead, Patent Owner contends, "a POSITA would understand a gas impinging onto the metallization layer, rather than 'directed against' as with the rear cooling method, to be the result of Brownian movement or movement of inert gas in the process chamber, without directed fanning onto the metallization layer." *Id.* at 17–18 (citing Ex. 2127 ¶ 84). Patent Owner further contends that "[u]nder Petitioner's interpretation, option (2)'s 'impinging onto' and option (3)'s 'directed against' have the same interpretation of 'directed onto,'" and "Dr. Rubloff was unable to explain why Shan used different verbs to describe these two options." PO Reply 9 (citing Ex. 2129, 77:16–78:6). According to Patent Owner, "nothing in Petitioner's definition of 'impinge' or in Shan's option (2) teaches such an intentional or directed act." *Id.* at 10 (citing Ex. 1011, 6).

We agree with Petitioner that Shan's method of impinging the inert gas onto the metallization layer teaches "wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer" as recited in substitute independent claims 21 and 36. Shan describes a process wherein a metallization layer is formed in step one, and is cooled in step two "by cooling the metallization layer and/or the wafer in the process chamber and/or by cooling the entire process chamber." Ex. 1006, 4:3–6. Shan teaches that,

> [t]o cool the metallization layer and/or the wafer and/or the process chamber, an inert gas (such as, for example, nitrogen, helium or argon) at a temperature lower than the desired target and/or effective temperature of the cooling step (e.g., room or ambient temperature) may be introduced into the process chamber and/or impinged on the metallization layer and/or directed against the backside of the wafer as the wafer is supported in the process chamber by a mechanical or electrostatic chuck.

Id. at 4:22–30.

Read in context, these disclosures in Shan indicate that that the metallization layer can be cooled in three different ways: (1) by cooling the process chamber by introducing inert gas into the process chamber; (2) by cooling the metallization layer by impinging the inert gas onto the metallization layer; and (3) by cooling the wafer by directing the inert gas against the backside of the wafer. Shan, therefore, describes each cooling method with respect to the target to which the inert gas is directed (i.e., the process chamber, the metallization layer, and the backside of the wafer). In this regard, we credit Dr. Rubloff's testimony that

> Brownian motion corresponds to undirected movement of the gas, whereas gas that is "impinged" would have been understood by a person having of ordinary skill in the art to correspond to gas that is specifically directed at a target. Indeed, such an understanding is consistent with the relevant dictionary definition of "impinge." (Ex. 1011 at 6, "impinge . . . 3. "to strike; dash; collide (usually fol. by on, upon or against); rays of

> light impinging on the eye.") *Shan* discloses that impinging is different than simply introducing gas into the chamber as "impinging" and "introducing" of the gas are listed as separate options for cooling. Therefore, when read in context, inert gas "impinged onto the metallization layer" must mean something different than having an undirected flow of inert gas molecules, because *Shan* distinguishes between introducing the inert gas into the process chamber and impinging the inert gas onto the metallization layer.

Ex. 1009 ¶ 67.

That Shan uses "impinged onto" with respect to cooling the metallization layer and "directed against" with respect to cooling the backside of the wafer does not change the result. Both methods include targeting the inert gas to a specific surface, i.e., the metallization layer or the backside of the wafer. The identification of the specific surface being acted upon indicates that Shan intended that the inert gas has a directional component in each method. *See* Ex. 1009 ¶ 69 ("Such an understanding is consistent with *Shan's* description of three different cooling methods, where the inert gas being impinged onto the metallization layer is demonstrated to be different than undirected flow of gas into the chamber.").

For these reasons, and because Shan's metallization layer is the top-most layer when the impinging occurs, we determine that Shan teaches directing the inert gas onto the upper surface of the coated wafer. Accordingly, in light of the foregoing and the discussions in Sections II.E and II.F, *supra*, we determine that the preponderance of the evidence demonstrates that substitute claims 21–28 and 36–38 would have been obvious based on the combined teachings of Yamada and Shan.

2. Substitute Claims 29–35

Substitute claim 29 corresponds to original claim 10, and substitute claims 30–35 correspond to original claims 11–15 and 17. As discussed *supra* in Section II.G, Petitioner has shown by a preponderance of the evidence that claims 10, 11, 13, 14, and 17 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada and Kobayashi, and that claims 12 and 15 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combined teachings of Yamada, Kobayashi, and Shan. Upon review of substitute claims 29–35, the disclosures of Yamada, Kobayashi, and Shan, and Patent Owner's and Petitioner's positions as well as their supporting evidence, we are persuaded that substitute claims 29–35 would have been obvious over the combined teachings of Yamada, Kobayashi, and Shan.

Petitioner contends that the combination of Yamada and Kobayashi "renders obvious the features of claim 29 that track those of claim 10," but does not "explicitly disclose 'wherein fanning the wafer with the inert gas comprises fanning the Al-Cu layer.'" Opp. 18. For this limitation, Petitioner turns to Shan's disclosure of cooling the metallization layer by impinging inert gas onto the metallization layer. *Id.* at 18–19 (citing Opp. 9–17). Petitioner argues that Yamada, Kobayashi, and Shan "are all in the same field (metallization processes in a semiconductor fabrication process) and are directed to solving similar problems." *Id.* at 19 (citing Ex. 1009 ¶¶ 148–152). According to Petitioner, "a POSITA would have been motivated to modify the *Yamada-Kobayashi* combination to use top-side cooling based on *Shan* in the same manner (i.e., replace backside cooling with top-side or implement cooling from both sides)" for the same reasons set forth with respect to substitute claim 21. *Id.*

Patent Owner asserts that "the prior art (alone or in combination) fails to teach or suggest all elements of" substitute claim 29 "for the same reasons provided" with respect to substitute claim 21. Mot. 23–24. In particular, Patent Owner asserts, for the same reasons set forth with respect to substitute claim 21, that Shan's teaching of impinging inert gas onto the metallization layer does not disclose "fanning the Al-Cu layer" as recited in substitute independent claim 29 even if Shan is combined with Yamada. PO Reply 8–11.

For the same reasons described above with respect to proposed substitute claim 21, and in light of the discussions in Sections II.G, *supra*, we determine that the preponderance of the evidence demonstrates that substitute claims 29–35 would have been obvious based on the combined teachings of Yamada, Kobayashi, and Shan.

3. Conclusion

Accordingly, we determine based on a preponderance of the evidence that proposed substitute claims 21–28 and 36–38 are unpatentable as obvious under 35 U.S.C. § 103(a) over the combined teachings of Yamada and Shan, and that proposed substitute claims 29–35 are unpatentable as obvious under 35 U.S.C. § 103(a) over the combined teachings of Yamada, Kobayashi, and Shan. For these additional reasons, Patent Owner's Motion to Amend is denied.

IV. CONCLUSION

For the foregoing reasons, we determine that Petitioner has demonstrated, by a preponderance of the evidence, that the challenged claims of the ’789 patent are unpatentable based on the following grounds:

Challenged Claims	Basis	Reference(s)
1, 2, 4, 5, 8, 9, and 18–20	§ 102(b)	Yamada
3 and 6	§ 103(a)	Yamada and Shan
10, 11, 13, 14, and 17	§ 103(a)	Yamada and Kobayashi
12 and 15	§ 103(a)	Yamada, Kobayashi, and Shan

Additionally, we determine that (1) Patent Owner’s Motion to Amend does not meet the requirements set forth in 37 C.F.R. § 42.121 with respect to proposed substitute claims 21–38; and (2) the entirety of the record demonstrates, by a preponderance of the evidence, that proposed substitute claims 21–28 and 36–38 are unpatentable as obvious under 35 U.S.C. § 103(a) over the combined teachings of Yamada and Shan, and that proposed substitute claims 29–35 are unpatentable as obvious under 35 U.S.C. § 103(a) over the combined teachings of Yamada, Kobayashi, and Shan.

V. ORDER

Accordingly, it is

ORDERED that claims 1–6, 8–15, and 17–20 of the ’789 patent are determined to be *unpatentable*;

FURTHER ORDERED that Patent Owner’s Motion to Amend is *denied*; and

FURTHER ORDERED that because this is a Final Written Decision, parties to the proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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