

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO. LTD.,
SAMSUNG ELECTRONICS AMERICA, INC.,
SAMSUNG TELECOMMUNICATIONS AMERICA, LLC,
SAMSUNG SEMICONDUCTOR, INC., and
SAMSUNG AUSTIN SEMICONDUCTOR, LLC,¹
Petitioner,

v.

HOME SEMICONDUCTOR CORPORATION,
Patent Owner.

Case IPR2015-00467
Patent 6,030,893

Before JONI Y. CHANG, JON B. TORNQUIST, and
BETH Z. SHAW, *Administrative Patent Judges*.

TORNQUIST, *Administrative Patent Judge*.

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

¹ Samsung Telecommunications America LLC, originally a real party-in-interest at the time of filing the Petition, no longer exists as a separate corporate entity, because it has merged with and into Samsung Electronics America, Inc. Paper 9.

I. BACKGROUND

Samsung Electronics Co. Ltd., Samsung Electronics America, Inc., Samsung Telecommunications America, LLC, Samsung Semiconductor, Inc., and Samsung Austin Semiconductor, LLC (collectively “Petitioner”) filed a Petition (Paper 1, “Pet.”) requesting an *inter partes* review of claims 1–3, 5–19, and 28 of U.S. Patent No. 6,030,893 (Ex. 1001, “the ’893 patent”). Home Semiconductor Corporation (“Patent Owner”) did not file a Preliminary Response. Upon consideration of the Petition, we determined that the information presented in the Petition demonstrated a reasonable likelihood that Petitioner would prevail with respect to claims 1–3, 5–19, and 28 of the ’893 patent. Paper 11 (“Dec. Inst.”). Thus, pursuant to 35 U.S.C. § 314(a), we instituted trial with respect to those claims. *Id.*

Following institution of trial, Patent Owner filed a Patent Owner Response (Paper 17, “PO Resp.”), to which Petitioner filed a Reply (Paper 21, “Reply”). An oral hearing was held on February 25, 2016, and a transcript of the oral hearing is included in the record. Paper 31 (“Tr.”).

We have jurisdiction under 35 U.S.C. § 6(c). This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons set forth below, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, 5–9, 11–19, and 28 of the ’893 patent are unpatentable.

A. *Related Matters*

The parties indicate that the ’893 patent is being asserted in *Home Semiconductor Corp. v. Samsung Electronics Co. Ltd.*, No. 1:13-cv-02033 (D. Del.), filed December 16, 2013. Pet. 1–2 (citing Ex. 1018, 4); Paper 7, 1. The ’893 patent is also at issue in IPR2015-00466. Paper 7, 1. A Final

Written Decision in IPR2015-00466 is entered concurrently with this Decision.

B. The '893 Patent

The '893 patent is directed to a method for forming interconnects on a semiconductor wafer. Ex. 1001, 1:7–10, Abstract. In particular, the '893 patent is directed to a method of growing low stress, void-free interconnects by depositing two separate conductive layers—the first layer having a high stress level and good step coverage, and the second layer having a lower stress level than the first conductive layer. *Id.* at 2:9–18, 3:29–45.

Figures 2 and 5, reproduced below, illustrate the deposition process of the '893 patent:

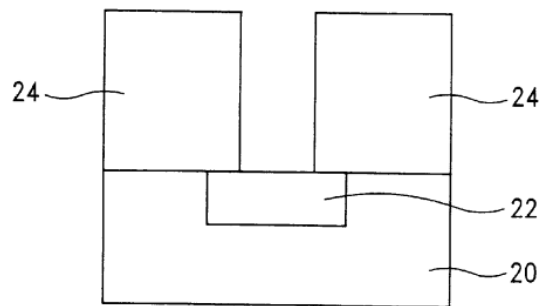


FIG.2

Figure 2 is a cross section view of a portion of a semiconductor wafer.

As depicted in Figure 2, conductive area 22, which can be a metal layer, a polysilicon layer, or a source/drain/gate, is formed in substrate 20. *Id.* at 2:47–51. Dielectric layer 24 is then deposited on substrate 20 and conductive area 22 and etched selectively to expose conductive area 22. *Id.* at 2:51–55.

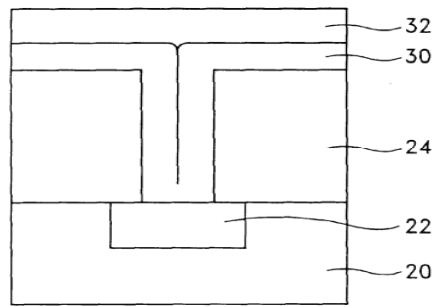


FIG. 5

Figure 5 is a cross section view illustrating the first and second conductive layers.

As depicted in Figure 5, first conductive layer 30 is then formed on dielectric layer 24 and conductive layer 22 to completely fill the hole previously etched in dielectric layer 24. *Id.* at 2:60–2:67. Second conductive layer 32 is then deposited over first conductive layer 30 to fabricate interconnect lines. *Id.* at 3:15–21.

In the method of the '893 patent, the first and second conductive layers are formed in two different chambers. *Id.* at 2:60–63, 3:15–17. The deposition conditions selected for use in the first chamber, including deposition temperature, gas flow rate, and deposition time, result in a “void-free” conductive layer having “high stress” and “good step coverage.” *Id.* at 3:2–13. The deposition conditions used in the second chamber, including a lower gas flow rate and higher deposition temperature, result in a conductive layer with lower film stress. *Id.* at 3:38–41. The '893 patent instructs that the use of two separate conductive layers, the first having high stress and good step coverage and the second having low stress but poor step coverage, avoids the problem of wafer bending present in prior art systems. *Id.* at 1:54–63, 2:15–18.

C. Illustrative Claim

Challenged claims 1 and 28 are independent, with claims 2, 3, and 5–19 depending, directly or indirectly, from claim 1. Claim 1 is illustrative of the challenged claims and is reproduced below:

1. A chemical vapor deposition of tungsten (W-CVD) process for growing low stress and void free interconnect, the method comprising:

forming a dielectric layer on a substrate, said substrate having a conductive area, said dielectric layer covering said conductive area;

forming a hole through said dielectric layer to uncover at least a portion of said conductive area;

forming a first conductive layer with a thickness of about 500 to 9000 Å on said dielectric layer and completely filling in said hole, wherein said first conductive layer is formed in a first chamber; and

forming a second conductive layer on said first conductive layer, wherein said second conductive layer is formed in a second chamber, wherein the temperature of said second chamber is different from the temperature of said first chamber.

Ex. 1001, 3:54–4:3.

D. Instituted Grounds of Unpatentability

We instituted the instant trial to determine:

1. Whether claims 1–3, 5–9, 11–19, and 28 would have been obvious under 35 U.S.C. § 103 over Emesh² and Mak;³ and

² U.S. Patent No. 5,407,698, iss. April 18, 1995 (Ex. 1009, “Emesh”).

³ A. Mak et al., *An Integrated Tungsten Plug Fabrication Process*, CONFERENCE PROCEEDINGS ULSI-VII MATERIALS RESEARCH SOCIETY 453–462 (1992) (Ex. 1010, “Mak”).

2. Whether claim 10 would have been obvious under 35 U.S.C. § 103 over Emesh, Mak, and Miyazaki.⁴

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, “[a] claim in an unexpired patent shall be given its broadest reasonable construction in light of the specification of the patent in which it appears.” 37 C.F.R. § 42.100(b). In determining the broadest reasonable construction, we presume that claim terms carry their ordinary and customary meaning. See *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). This presumption may be rebutted when a patentee, acting as a lexicographer, sets forth an alternate definition of a term in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

In the Decision on Institution, consistent with Petitioner’s proposed construction, we construed the term “on” to mean “in or into the position of being supported from beneath by the upper surface of something.” Dec. Inst. 6–7; Pet. 4–5. Patent Owner does not dispute that this construction satisfies the broadest reasonable construction standard (PO Resp. 8) and, based on our analysis of the full record developed during trial, we discern no reason to change the claim construction for purposes of this Final Written Decision.

B. Principles of Law

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the

⁴ U.S. Patent No. 5,843,840, iss. Dec. 1, 1998 (Ex. 1005, “Miyazaki”).

invention was made to a person having ordinary skill in the art to which said 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;⁵ and (4) if in the record, objective evidence of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

*C. Obviousness of Claims 1–3, 5–7, 9, 11–19, and 28
over Emesh and Mak*

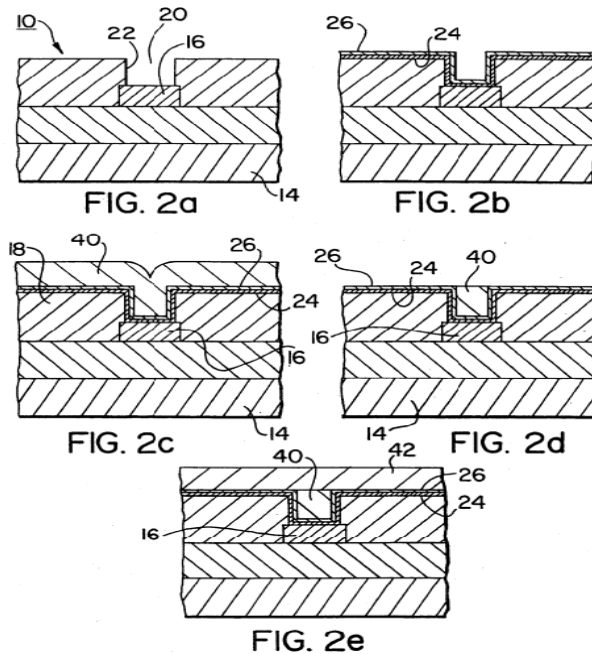
Petitioner contends that claims 1–3, 5–7, 9, 11–19, and 28 of the ’893 patent would have been obvious under 35 U.S.C. § 103(a) over Emesh and Mak. Pet. 12–32, 35–49. In support of this argument, Petitioner relies upon the testimony of Dr. Gary Rubloff. Ex. 1003.

1. Emesh

Emesh is directed to a method for defining interconnects on an integrated circuit using a chemical vapor deposition (CVD) of tungsten. Ex. 1009, 4:66–5:8, Abstract. In this method, two tungsten films are deposited. The first tungsten film fills via and contact holes and the second tungsten film forms interconnects. Ex. 1009, 6:16–43, 9:4–46.

⁵ The level of ordinary skill in the art in this case is reflected by the prior art of record. See *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). Moreover, although the parties disagree slightly as to the precise education and experience level possessed by a person of ordinary skill in the art, neither party asserts that resolution of the level of skill in the art between these two competing definitions would impact the outcome of this case. See Ex. 1003 ¶ 11; Ex. 2002 ¶ 40.

Figures 2a–e of Emesh are depicted below:



Figures 2a–e show schematic cross-sectional views of an integrated circuit structure at successive stages of the deposition process.

In Figure 2a, silicon dioxide dielectric insulating layer 18 (as identified in Figure 2c) is etched selectively to form via hole 20 and to expose conductive metal layer 16. *Ex.* 1009, 5:50–55, 8:62–66. Figure 2b depicts adhesion layer 24 (~800 Å TiN) and nucleation layer 26 (~1000 Å tungsten) deposited over dielectric layer 18 and conductive metal layer 16. *Id.* at 5:55–5:59, 8:66–9:3.

Figure 2c depicts tungsten layer 40 filling via hole 20. *Id.* at 9:4–12. This first tungsten layer has a thickness of about 5000 angstroms and is deposited at a temperature of 430° C using an H₂/WF₆ ratio of about 6 to 8. *Id.* at 9:7–17. Figure 2d depicts the semiconductor wafer after the first tungsten layer has been planarized, leaving tungsten plug 40 filling via hole 20. *Id.* at 9:24–30. Finally, Figure 2e depicts second layer of tungsten 42 deposited on the planarized tungsten surface. *Id.* at 9:30–46. This second

layer of tungsten is approximately 5000 angstroms thick and is deposited at a temperature of 480° C using an H₂/WF₆ ratio of approximately 20. *Id.*

In the disclosed embodiment, the first layer of tungsten is deposited under conditions that result in a film with very high step coverage, which Emesh discloses is “advantageous in filling small via holes.” *Id.* at 9:47–51. The second tungsten layer is deposited at a higher H₂/WF₆ ratio and temperature so as to form a layer having lower stress than the first tungsten layer. *Id.* at 7:57–65, 8:29–33, 9:30–46.

2. Mak

Mak discloses the use of an AMAT 5000 mainframe to deposit tungsten plugs on a semiconductor wafer. Ex. 1010, 453.⁶ In this method, a tungsten layer is deposited on a semiconductor wafer in a first CVD chamber. *Id.* at 453–454. This tungsten layer is then etched back in a different chamber to form individual tungsten plugs. *Id.* After the tungsten plugs are formed, an aluminum layer is deposited (in an undisclosed manner) over the plugs to form interconnects. *Id.* at 453, 458.

Figure 1 of Mak, reproduced below, depicts the “integrated deposition and etchback system configuration” of the AMAT 5000 mainframe:

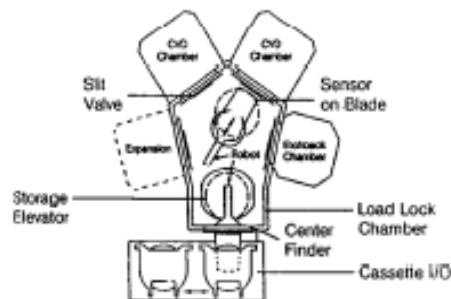


Fig. 1 AMAT P5000 integrated deposition and etchback system configuration.

⁶ Mak contains two sets of page numbers. Our citations are to the page numbers found in the upper corners of the reference.

As shown in Figure 1, “[u]p to four process chambers can be attached” to the AMAT 5000 mainframe. Mak reports, however, that because the “throughput of the etchback chamber is twice that of the deposition chamber,” two deposition chambers (CVD) and one etchback chamber are typically used. *Id.* at 453–454.

Mak also reports that the AMAT 5000 mainframe permits a user to deposit a tungsten nucleation or seed layer “at low pressure (4.5 torr or below), followed by the deposition of H₂-reduced [tungsten] at a higher pressure (usually around 80 torr).” *Id.* at 456.

Mak instructs that use of the disclosed integrated system to form tungsten plugs “offers several unique advantages,” including:

1. Simplification of the process flow: since two key processes are carried out in one step of the process log.
2. Reduced particle contamination of the wafer: since the wafers are not exposed to atmosphere between steps.
3. Reduced costs per wafer: since only one mainframe is used. The incorporation of capability to perform an additional process requires only a process chamber and not the whole system.

Id. at 453.

3. Analysis

i. Petitioner’s Arguments

With respect to independent claims 1 and 28, Petitioner asserts that Emesh discloses: (1) etching a hole in silicon dioxide layer 18 to expose conductive layer of metal 16; (2) depositing a first conductive layer of tungsten, with a thickness of 5000 Å (within the 500 to 9000 Å range of claims 1 and 28), on⁷ the dielectric layer so as to completely fill the contact

⁷ Claim 1 requires that the first conductive layer is formed “on said dielectric layer.” Ex. 1001, 3:62–63. Although the first conductive layer of

hole; and (3) forming a second conductive layer of tungsten on the first conductive layer using a different chamber temperature. Pet. 16–26 (citing Ex. 1009, 5:43–50, 8:62–66, 9:4–46; Ex. 1003 ¶¶ B9–13); see *Titanium Metals Corp. v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985) (noting that a prior art reference discloses a claimed range if it discloses a single point within that claimed range). Petitioner also notes that Emesh’s second conductive layer of tungsten has a thickness of 5000 angstroms, which is within the “300 to 8000 [angstrom]” range recited in claim 28. Pet. 41–42, 48 (citing Ex. 1009, 9:40–46).

With respect to dependent claims 2, 3, 5–7, 9, and 11–19, Petitioner shows where Emesh discloses filling both “via and contact holes” with a first conductive layer, as required in claims 2 (contact holes) and 3 (via holes). *Id.* at 26–27 (citing Ex. 1009, 8:62–66, Abstract; Ex. 1003 ¶ B11). Petitioner also shows where Emesh discloses: a silicon dioxide (or “oxide”) dielectric layer (claim 5); a “conductive area” made of metal (claim 6); depositing a first conductive layer using a chemical vapor deposition process (claim 7) at a temperature between 400° C and 450° C (claim 9); depositing first (claim 11) and second (claim 12) conductive layers of tungsten on a dielectric layer; and depositing a second conductive layer of tungsten using a chemical vapor deposition (CVD) process (claim 13). *Id.* at 27–28, 31–32, 35–38 (citing Ex. 1009, 4:66–5:3, 8:62–66, 9:4–17, 9:24–31, Abstract; Ex. 1003 ¶¶ B9–11, 14, 15). Finally, Petitioner shows where Emesh discloses deposition temperatures, deposition times, deposition thicknesses,

tungsten in Emesh is not in contact with the silicon dioxide layer, it is supported from below by this layer. Accordingly, we are persuaded that the first conductive layer is “on” the silicon dioxide layer, as we have construed that term.

and WF₆ vapor flow rates that fall within the ranges set forth in claims 14–19. *Id.* at 35–45 (citing Ex. 1009, 4:66–5:3, 9:4–7, 9:17, 9:24–46, Example 2; Ex. 1003 ¶¶ B9, 14, 15, 22–25, 30, 31).

Although Emesh does not disclose depositing the two tungsten layers in different chambers, Petitioner contends that one of ordinary skill in the art “would have been led to implement the two-stage tungsten deposition of Emesh in the multi-chamber integrated system of Mak” in order “to improve the stability and throughput of Emesh’s process.” *Id.* at 13–14 (citing Ex. 1003 ¶ B4). In support of Petitioner’s argument, Dr. Rubloff explains that in a single chamber system a temperature increase from 430° C to 480° C or a temperature decrease from 480° C to 430° C, “would require wait time to heat up, cool down, or stabilize the processing temperature.” Ex. 1003 ¶¶ B5, B29. In a multi-chamber system, however, each chamber remains under fixed conditions, which Dr. Rubloff testifies would provide “a more stable and consistent processing environment.” *Id.* In addition, Dr. Rubloff testifies that “by having all three steps, i.e., two tungsten depositions and the etchback” occur in a multi-chamber device, “undesirable device contamination may be decreased.” *Id.* ¶ B30; Ex. 1010, 453.

With respect to improved throughput, Dr. Rubloff testifies that the use of two chambers “allows one or more devices to be undergoing the first tungsten deposition stage at the same time that one or more other devices are undergoing the second deposition stage.” Ex. 1003 ¶¶ B5, 29 (citing Ex. 1010, 453–454). According to Dr. Rubloff, this parallel processing can “greatly reduce or eliminate” the wait time between process steps, “thereby increasing the throughput of the system.” *Id.* ¶ 29.

ii. Patent Owner's Arguments

Patent Owner contends the combination of Emesh and Mak would not have rendered the subject matter of claims 1–3, 5–7, 9, 11–19, and 28 of the '893 patent obvious because Emesh relates to a “low pressure CVD process” for depositing tungsten at a pressure up to 10 Torr, whereas Mak discloses “a high pressure (around 80 Torr)” deposition of tungsten with a subsequent PVD deposition of *aluminum* as an interconnect layer. PO Resp. 14–15 (citing Ex. 2002 ¶¶ 81–82). According to Patent Owner, one of ordinary skill in the art would “not combine a process forming a tungsten interconnect over tungsten plugs at low pressure with a reference for forming an aluminum interconnect over tungsten plugs formed at high pressure” as “[t]here is simply no benefit” to such a combination. *Id.* at 15 (citing Ex. 2002 ¶ 82).

Patent Owner further argues that even if one sought to combine the two references, it would not result in the claimed invention, as neither Emesh nor Mak discloses depositing tungsten on an individual wafer in more than one deposition chamber. *Id.* at 16–17, 19 (citing Ex. 2005, 457:16–458:8). According to Patent Owner, Emesh discloses the use of a single chamber to deposit two tungsten layers and Mak discloses the use of two deposition chambers to apply a single tungsten layer to two different semiconductor wafers. *Id.* at 13, 16–17.

iii. Discussion

As noted by Patent Owner, Mak discloses the use of a multi-chamber tool to deposit a single tungsten layer on two different wafers. Ex. 1009, 8:55–9:46; Ex. 1010, 456–458; Ex. 2005, 457:16–458:8. Thus, we agree with Patent Owner and Mr. Maltiel that simply “combining the teachings of

Emesh with the teachings of Mak,” without modification, would not result in “the use of multiple deposition chambers for a two-step CVD deposition of tungsten.” PO Resp. 18 (citing Ex. 2002 ¶ 77). Petitioner does not propose, however, to combine Emesh and Mak in the manner argued by Patent Owner. Petitioner contends, instead, that one of ordinary skill in the art would have sought to use Mak’s well-known, multi-chamber semiconductor fabrication tool to implement Emesh’s process in two chambers. Pet. 13–15, 24; Ex. 1003 ¶¶ B4–7; Ex. 1019 ¶ 2B.

“A claimed invention may be obvious even when the prior art does not teach each claim limitation, so long as the record contains some reason why one of skill in the art would modify the prior art to obtain the claimed invention.” *Nike, Inc. v. Adidas, AG*, 812 F.3d 1326, 1335 (Fed. Cir. 2016); *Ormco Corp. v. Align Tech., Inc.*, 463 F.3d 1299, 1307 (Fed. Cir. 2006) (“A claim can be obvious even where all of the claimed features are not found in specific prior art references, where ‘there is a showing of a suggestion or motivation to modify the teachings of the [prior art] to the claimed invention.’”).

On this record, Petitioner persuasively articulates—supported by the testimony of Dr. Rubloff—that one of ordinary skill in the art would have sought to implement Emesh’s two layer tungsten deposition process within two chambers of Mak’s multi-chamber fabrication tool in order to improve process stability and throughput. Pet. 13–15; Ex. 1003 ¶¶ B4–6, 29–30; Ex. 2005, 457:19–459–15. Petitioner also persuasively articulates that because Mak’s cold wall CVD chamber is similar to the Varian 5101 cold wall system used in Emesh, and because Mak discloses the deposition of tungsten over a broad range of pressures, one of ordinary skill in the art would have

understood that Emesh's tungsten deposition process could be performed in Mak's multi-chamber tool. Pet. 13–15; Reply 12; Ex. 1003 ¶¶ B6–8 (citing Ex. 1010, 453–454; Ex. 1009, 4:66–5:8, 9:4–46); Ex. 1019 ¶ 2A.

Patent Owner does not contend that one of ordinary skill in the art could not use Mak's tool to implement Emesh's process. Patent Owner argues instead that one of ordinary skill in the art would not seek to do so. PO Resp. 13–15. This argument is not persuasive, however, because it fails to address Petitioner's arguments related to improved stability and throughput, and addresses only the physical combination of Emesh and Mak and not what the two references would have suggested to one of ordinary skill in the art. PO Resp. 15 (citing Ex. 2002 ¶ 82); see *In re Mouttet*, 686 F.3d 1322, 1332–33 (Fed. Cir. 2012) (noting that a determination of obviousness “does not require an actual, physical substitution of elements,” as the “test for obviousness is what the combined teachings of the references would have suggested to those having ordinary skill in the art”).

In its Motion for Observations, Patent Owner contends Dr. Rubloff testified during cross-examination that despite searching “patents, non-patent literature, textbooks, and journal articles,” he was able to identify only one prior art publication, Miyazaki, that discloses the use of multiple chambers to deposit two layers of tungsten. Paper 25, 1–3; Ex. 1005 (Miyazaki). Patent Owner asserts this testimony is relevant because it shows the use of cluster tools to deposit two layers of tungsten on a semiconductor wafer was not widespread, as asserted by Dr. Rubloff. Paper 25, 2. We do not find this observation persuasive, however, as there is no particular number of prior art publications necessary to support a proposed reason to modify prior art references and, upon review of Miyazaki as a whole, we are

persuaded that the reference supports Dr. Rubloff's testimony that one of ordinary skill in the art would have understood that two layers of tungsten could be deposited in a multi-chambered tool. *See* Ex. 1005, 9:55–58 (noting that the two tungsten layers could be formed in “different chambers or in different deposition machines”).

Based on the foregoing, and upon review of the parties' arguments and supporting testimony as a whole, we credit the testimony of Dr. Rubloff and find that one of ordinary skill in the art would have sought, with a reasonable expectation of success, to implement Emesh's process in Mak's multi-chamber fabrication tool. Accordingly, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, 5–7, 9, 11–19, and 28 of the '893 patent would have been obvious over Emesh and Mak.

D. Obviousness of Claim 8 over Emesh and Mak

Claim 8 requires “a WF_6 vapor with a gas flow of about 50–90 sccm.” Ex. 1001, 4:18–21.

Petitioner concedes that Emesh's WF_6 flow rate of 10–40 sccm is below the 50-90 sccm rate required in claim 8. Petitioner argues, however, that based on the H_2 flow rate of 240–800 sccm and the H_2/WF_6 ratio of 6 disclosed in Emesh, one of ordinary skill in the art would have understood that an increased WF_6 vapor flow rate of 40 to 133 sccm could be used to deposit the first conductive layer in Emesh. Pet. 29–30 (citing Ex. 1009, 3:63–66, 5:39–40; Ex. 1003 ¶¶ B16–17). Petitioner further argues that one of ordinary skill in the art would have sought to make this modification in order to decrease the residence time of reaction products within the reaction

chamber—including the highly corrosive compound hydrogen fluoride (HF). *Id.* (citing Ex. 1003 ¶¶ B16–17); Ex. 1009, 5:36–42.

Patent Owner counters that neither Emesh nor Mak discloses a WF_6 vapor flow rate of 50–90 sccm and one of ordinary skill in the art, “absent impermissible hindsight reconstruction,” would not ignore the “specific teachings of the WF_6 flow provided by Emesh” and “determine the WF_6 flow rate using only the H_2 gas flow and H_2/WF_6 ratio disclosed in the reference.” PO Resp. 22. Patent Owner further contends that departing from Emesh’s teaching could require adjusting the flow rates of SiH_4 , nitrogen, or inert gas in an undefined way. *Id.*; Ex. 2002 ¶ 91. In support of Patent Owner’s arguments, Mr. Maltiel testifies that a person of ordinary skill in the art, “[g]iven the specific guidance of Emesh to keep gas flow of the WF_6 between 10-40 sccm,” would not seek to deviate from this teaching by adjusting the WF_6 gas flow higher. Ex. 2002 ¶ 92.

Petitioner agrees in reply that the undisputed testimony of Dr. Rubloff shows that preserving the H_2/WF_6 flow rate is more critical in achieving a desired step coverage than the flow rates of the H_2 and WF_6 constituents and, contrary to Patent Owner’s arguments, the flow rates of the other gases in Emesh would not need to be altered to achieve the desired tungsten layers. Reply 14–17; Ex. 1019 ¶ 4A. Petitioner also notes that Patent Owner does not dispute any of the advantages Dr. Rubloff sets forth in his declaration related to increasing H_2/WF_6 vapor flow rates. Reply 16–17.

On this record, we are persuaded by Dr. Rubloff’s testimony that one of ordinary skill in the art would have sought to increase the WF_6 flow rate of Emesh in order to decrease the residence time of CVD reaction products in the chamber, including HF, and would have understood that this increase

in WF₆ flow rate could be applied without changing the overall tungsten deposition rate, the H₂/WF₆ ratio, or the flow rate of the other gases in Emesh's process. Ex. 1003 ¶ B16; Ex. 1019 ¶ 4A.

With respect to Mr. Maltiel's counter testimony that "Emesh specifically requires a WF₆ flow rate of 10–40 sccm," see Ex. 2002 ¶¶ 89–90, we note that the discussion of predetermined flow rates in Emesh is in relation to the "preferred embodiment," and not the invention as a whole. Ex. 1009, 4:63–65, 5:36–42. Moreover, dependent claim 2 recites that "the flow rate of WF₆ is maintained in the range 10 to 40 sccm," raising a presumption that the WF₆ flow rates of Emesh may be broader than 10 to 40 sccm. *Id.* at 12:39–41; see *Bancorp Services v. Sun Life Assur. Co. of Canada*, 687 F.3d 1266, 1275 (Fed. Cir. 2012) (noting that "the presence of a dependent claim that adds a particular limitation raises a presumption that the limitation in question is not found in the independent claim"). Thus, we are not persuaded that Emesh teaches away from, or would otherwise discourage one of ordinary skill in the art from modifying, the disclosed WF₆ flow rate.

Based on the foregoing, we credit the testimony of Dr. Rubloff and find that one of ordinary skill in the art would have sought to modify the WF₆ flow rate of Emesh within the range of 40 to 133 sccm (while maintaining a H₂/WF₆ ratio of 6) with a reasonable expectation of success.

"Where a claimed range overlaps with a range disclosed in the prior art, there is a presumption of obviousness." *Ormco*, 463 F.3d at 1311. This "presumption can be rebutted if it can be shown that the prior art teaches away from the claimed range, or the claimed range

produces new and unexpected results.” *Id.* A rate of 40 to 133 sccm fully encompasses the 50–90 sccm rate of claim 8, and Patent Owner does not assert that the prior art teaches away from the claimed range or that the recited range produces new and unexpected results.

Accordingly, we find that Petitioner has demonstrated by a preponderance of the evidence that claim 8 of the ’893 patent would have been obvious under 35 U.S.C. § 103 over Emesh and Mak.

E. Obviousness of Claim 10 over Emesh, Mak, and Miyazaki

Claim 10 depends indirectly from claim 1 and further requires that the chemical vapor deposition of the first tungsten layer be accomplished within “about 10 to 100 seconds.” Ex. 1001, 4:16–18, 4:25–27. Petitioner contends the subject matter of this claim would have been obvious over Emesh, Mak, and Miyazaki. Pet. 32–34.

Petitioner calculates that the deposition rate for the first tungsten layer of Emesh is 25 angstroms per second. *Id.* at 33. Using this deposition rate, Petitioner concedes that the 5000 angstrom conductive layer of Emesh would require more than 100 seconds to deposit. Petitioner contends, however, that one of ordinary skill in the art would have understood from Miyazaki that the 0.5 μm contact holes of Emesh could be filled with a film thickness of 0.2 μm (or 2000 Å), which would require only 80 seconds to deposit. *Id.* at 33–34; Ex. 1005, 7:59–63; Ex. 1003 ¶ B19. With respect to the reason to combine Emesh and Miyazaki, Petitioner states: “[g]iven that the thickness of the deposited film can be thinner than 5000 angstroms, it would have been obvious to a skilled artisan to deposit a layer of

tungsten of 2000 angstroms using the process as disclosed in Emesh.”
Pet. 33 (citing Ex. 1003 ¶ B19).

We are not persuaded by Petitioner’s argument. Emesh indicates that the disclosed method is “advantageous in filling small via holes, $\sim 0.5\ \mu\text{m}$,” which is the same diameter contact hole as Miyazaki. Ex. 1009, 9:50–51; Ex. 1005, 7:59–61. Petitioner does not explain adequately why one of ordinary skill in the art, presented with Emesh’s teaching that the disclosed deposition process is “advantageous” in filling $0.5\ \mu\text{m}$ contact holes, would then seek to reduce the thickness of the first tungsten layer by 3000 angstroms for the same diameter contact hole. Nor does Petitioner demonstrate persuasively that use of Miyazaki’s 2000 angstrom tungsten layer would have yielded predictable results when applied using the deposition process of Emesh, which involves a different set of deposition conditions and an etchback step. *See KSR*, 550 U.S. at 416.

Accordingly, on this record, we are not persuaded that claim 10 of the ’893 patent would have been obvious over Emesh, Mak, and Miyazaki.

F. Conclusion

In view of the foregoing, we determine that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, 5–9, 11–19, and 28 of the ’893 patent would have been obvious under 35 U.S.C. § 103 over Emesh and Mak. We are not persuaded, however, that Petitioner has demonstrated by a preponderance of the evidence that claim 10 of the ’893 patent would have been obvious over Emesh, Mak, and Miyazaki.

III. ORDER

For the foregoing reasons, it is:

ORDERED that claims 1–3, 5–9, 11–19, and 28 of U.S. Patent No. 6,030,893 are held unpatentable; 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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Patent 6,030,893

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