Trials@uspto.gov
571-272-7822

Paper 52
Date: February 9, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONCIS CO. LTD.,
Petitioner,

v.

ACORN SEMI, LLC,
Patent Owner.

IPR2020-01183
Patent 9,209,261 B2

Before BRIAN J. McNAMARA, JOHN R. KENNY, and AARON W. MOORE, *Administrative Patent Judges.*

McNAMARA, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
Denying Petitioner's Motion to Exclude Testimony of Dr. Clifton
Dismissing Patent Owner's Motion to Exclude Testimony of Dr. Kuhn
Denying Patent Owner's Motion to Exclude Testimony of Dr. Goodnick
35 U.S.C. § 318(a)

I. BACKGROUND

On February 10, 2021, we instituted an *inter partes* review of claims 1–3, 17–18, and 21–24 (the "challenged claims") of U. S. Patent No. 9,209,261 B2 (Ex. 1001, "the '261 Patent") challenged in a Petition (Paper 2, "Pet.") filed by Samsung Electronics Co., Ltd ("Petitioner"). *See* Paper 17 ("Dec. to Inst."). Acorn Semi LLC ("Patent Owner") filed a Patent Owner Response (Paper 25, "PO Resp."), Petitioner filed a Petitioner Reply (Paper 33, "Pet. Reply") and Patent Owner filed a Patent Owner Sur-reply (Paper 38,"PO Sur-reply"). Petitioner and Patent Owner also filed respective Motions to Exclude certain testimony. *See* Section VI herein. A transcript of an oral hearing held on October 31, 2021 (Paper 51, "Hr'g. Tr.") has been entered into the record.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. §318(a). We base our decision on the preponderance of the evidence. 35 U.S.C. § 316(e) (2018); 37 C.F.R. § 42.1(d).

Having reviewed the arguments of the parties and the supporting evidence, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the challenged claims are unpatentable.

II. THE '261 PATENT

The '261 patent "relates to a process for depinning the Fermi level of a semiconductor at a metal-interface layer-semiconductor junction and to devices that employ such a junction." Ex. 1001, 1:27–29. The '261 patent explains that Schottky's theory concerning the ability of a junction to conduct current in one direction more favorably than in the other direction, i.e., the rectifying behavior of a metal/semiconductor junction (e.g., an aluminum/silicon junction) depends upon a barrier at the surface of the

contact between the metal and the semiconductor. *Id.* at 1:33–48. As the barrier height at the metal/semiconductor interface determines the electrical properties of the junction, controlling the barrier height is an important goal. *Id.* at 3:4–10.

The ’261 patent further explains that Schottky’s theory postulates the height of the barrier, as measured by the potential necessary for an electron to pass from the metal to the semiconductor, is the difference between the work function of the metal (i.e., the energy required to free an electron at the Fermi level (the highest occupied energy state of the metal at T=0)) and the electron affinity of the semiconductor (i.e., the difference between the energy of a free electron and the conduction band of the semiconductor); but experimental results indicate a weaker variation of barrier height with work function than implied by this model. *Id.* at 1:49–2:2. To explain the discrepancy between the predicted and observed behavior, Bardeen introduced the concept of semiconductor surface states, i.e., energy states within the bandgap between the valence and conduction bands at the edge of the semiconductor crystal that arise from incomplete covalent bonds, impurities, and other effects of termination. *Id.* at 2:3–17, Fig. 1 (showing dangling bonds that may be responsible for surface states that trap electrical charges). Although Bardeen’s model assumes that surface states are sufficient to pin the Fermi level in the semiconductor at a point between the valence and conduction bands, such that the barrier height should be independent of the metal’s work function, in experiments, this condition is observed rarely. *Id.* at 2:18–24.

Further, according to the ’261 patent, Tersoff proposed that the Fermi level of a semiconductor is pinned near an effective “gap center” due to metal induced gap states (MIGS), which are energy states in the bandgap of

the semiconductor that become populated with metal. *Id.* at 2:33–42. Thus, the wave functions of electrons in the metal do not terminate abruptly at the surface of the metal, but decay in proportion to the distance from the surface, extending inside the semiconductor. *Id.* at 2:44–48.

> To maintain the sum rule on the density of states in the semiconductor, electrons near the surface occupy energy states in the gap derived from the valence band such that the density of states in the valence band is reduced. To maintain charge neutrality, the highest occupied state (which defines the Fermi level of the semiconductor) will then lie at the crossover point from states derived from the valence band to those derived from the conduction band. This crossover occurs at the branch point of the band structure.

Id. at 2:46–54. The ’261 patent also notes one further surface effect on diode characteristics is inhomogeneity, i.e., “if factors affecting the barrier height (e.g., density of surface states) vary across the plane of the junction, the resulting properties of the junction are found not to be a linear combination of the properties of the different regions.” *Id.* at 2:59–64.

According to the ’261 patent, “a classic metal-semiconductor junction is characterized by a Schottky barrier, the properties of which (e.g., barrier height) depend on surface states, MIGS and inhomogeneities.” *Id.* at 2:64–67. “Before one can tune the barrier height, however, one must depin the Fermi level of the semiconductor.” *Id.* at 3:7–9. The ’261 patent seeks to depin the Fermi level of the semiconductor while still permitting substantial current flow between the metal and the semiconductor. *Id.* at 3:9–11. The ’261 patent describes depinning the Fermi level as follows:

> By depinning the Fermi level, the present inventors mean a condition wherein all, or substantially all, dangling bonds that may otherwise be present at the semiconductor surface have been terminated, and the effect of MIGS has been overcome, or at least

> reduced, by displacing the semiconductor a sufficient distance from the metal.

Id. at 3:25–31. The ’261 patent achieves this goal using thin interface layers disposed between a metal and a silicon based semiconductor to form a “metal-interface layer-semiconductor junction” whose thickness varies with a corresponding minimum specific contact resistance, which depends on the materials used and allows for depinning the Fermi level while permitting current to flow when the junction is appropriately biased. *Id.* at 3:15–25; *see also id.* at 12:53–14:17, 14:24–45, Figs. 6, 8. “Minimum specific contact resistances of less than or equal to approximately 10 Ω-μm^2 or even less than or equal to approximately 1Ω-μm^2 may be achieved for such junctions in accordance with the present invention.” *Id.* at 3:31–35. Such low contact resistances are achieved by selecting a metal with a work function near the conduction band of the semiconductor for n-type semiconductors, or a work function near the valence band for p-type semiconductors. *Id.* at 5:12–16.

Figure 8 of the ’261 patent is reproduced below.

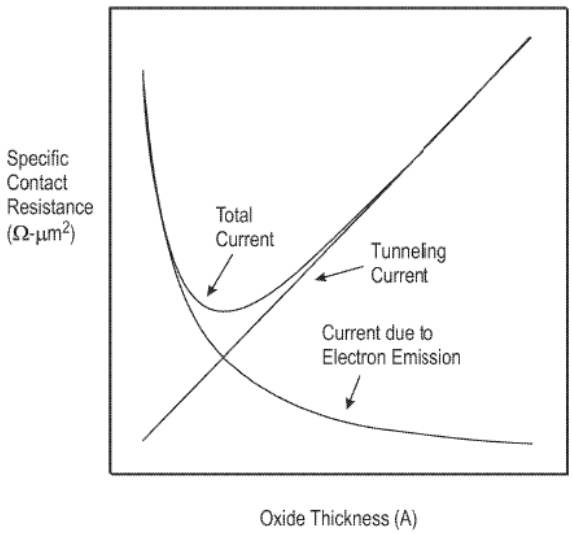


Figure 8 of the ’261 patent

Figure 8 of the ’261 patent is a graph of interface specific contact resistance versus interface thickness for a structure where the work function of the metal is the same as the electron affinity of the semiconductor, such that the Fermi level of the metal lines up with the conduction band of the semiconductor. *Id.* at 14:1–7. According to the ’619 patent, Figure 8 shows that at large thicknesses, the interface layer poses significant resistance to current, but as interface layer thickness decreases, resistance falls due to increased tunneling current. *Id.* at 14:7–10. However, at some point, as the interface layer gets thinner, the effect of MIGS increasingly pulls the Fermi level of the metal down towards the mid-gap of the semiconductor, creating a Schottky barrier and increasing resistance. *Id.* at 14:10–14. Thus, there is an optimum thickness where the resistance is at a minimum and the effect of MIGS has been reduced to depin the metal and lower the Schottky barrier, but the layer is sufficiently thin to allow significant current across the interface layer, such that specific contact resistances of less than or equal to approximately 2500 Ω-m^2, 1000 Ω-m^2, 100 Ω-m^2, 50 Ω-m^2, 10 Ω-m^2, or less than 1 Ω-m^2 can be achieved. *Id.* at 14:14–23.

In one embodiment, the interface layer may be a monolayer or several monolayers of passivating material (e.g., a nitride, oxide, oxynitride, arsenide, hydride and/or fluoride) and may include a separation oxide layer, and the specific contact resistance of the electrical device is less than 10 Ω-μm^2. *Id.* at 3:42–43. In another embodiment, the interface layer is made up of a passivation layer fabricated by exposing the semiconductor to nitrogenous material (e.g., ammonia (NH3), nitrogen (N2) or unbound gaseous nitrogen (N) generated from a plasma process) while heating the semiconductor in a vacuum chamber. *Id.* at 3:43–56. Another embodiment uses an interface layer of passivating material disposed between the surface

of a semiconductor and a conductor in which the interface is of sufficient thickness to reduce the effect of MIGs in the semiconductor and passivates the semiconductor but, because the thickness of the interface layer is chosen to provide minimum, or near minimum, specific contact resistance for the junction, significant current may flow between the conductor and the semiconductor. *Id.* at 3:56–4:3. In other embodiments, the interface layer is configured to allow a Fermi level of the conductor to (i) align with a conduction band of the semiconductor, (ii) align with a valence band of the semiconductor, and (iii) be independent of the Fermi level of the semiconductor, allowing current to flow between the conductor and the semiconductor when the junction is biased because the thickness of the interface layer corresponds to a minimum or near minimum contact resistance for the junction. *Id.* at 4:4–14. Specific contact resistances of less than or equal to approximately 2500 Ω-m^2, 1000 Ω-m^2, 100 Ω-m^2, 50 Ω-m^2, 10 Ω-m^2, or less than 1 Ω-m^2 can be achieved. *Id.* at 4:19–22, 14:14–18.

III. ILLUSTRATIVE CLAIM

Independent claim 1, reproduced below to include the subject matter of a Certificate of Correction issued on May 15, 2018 (Ex. 1001, 21), and including claim element designations (i) through (vii) used in the Petition, is representative of the subject matter of the ’261 patent:

> 1. (i) An electrical junction comprising
> (ii) a metal oxide interface layer disposed between a contact metal and a group IV semiconductor,
> (iii) the semiconductor comprising a source or drain of a transistor,
> (iv) the interface layer configured to reduce a height of a Schottky barrier between the contact metal and the semiconductor from that which would exist at a contact junction between the contact metal and the semiconductor without the interface layer disposed therebetween, and

(v) wherein the interface layer has a thickness of approximately 0.1 nm to 5 nm.

Ex. 1001, 17:66–18:5.

IV. GROUNDS OF INSTITUTION

In the Decision to Institute, trial was instituted on all grounds asserted in the Petition (*see* Dec. to Inst. 2–3). The grounds asserted in the Petition are as follows:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1–3, 17–18, 21–24	102	Grupp[1]
1–3, 17–18	103	Jammy[2]
21–24	102	Jammy

V. ANALYSIS OF PRIOR ART CHALLENGES

A. Introduction

"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 Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (discussing the burden of proof in *inter partes* review).

Anticipation is a question of fact, as is the question of what a prior art reference teaches. *In re NTP, Inc.*, 654 F.3d 1279, 1297 (Fed. Cir. 2011). "A claim is anticipated only if each and every element as set forth in the

[1] U.S. Patent No. 7,176,483 B2, issued Feb. 13, 2007 (Ex. 1015).
[2] U.S. Patent No. 6,724,088 B1, issued Apr. 20, 2004 (Ex. 1016).

claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. Inc., v. Union Oil Co.*, 814 F.2d 628, 631 (Fed. Cir. 1987); *see also Finisar Corp. v. DirecTV Group, Inc.*, 523 F.3d 1323, 1334 (Fed. Cir. 2008) (to anticipate a patent claim under 35 U.S.C. § 102, "a single prior art reference must expressly or inherently disclose each claim limitation"). Moreover, "[b]ecause the hallmark of anticipation is prior invention, the prior art reference—in order to anticipate under 35 U.S.C. § 102—must not only disclose all elements of the claim within the four corners of the document, but must also disclose those elements 'arranged as in the claim.'" *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008) (quoting *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983)).

Whether a reference anticipates is assessed from the perspective of an ordinarily skilled artisan. *See Dayco Prods., Inc. v. Total Containment, Inc.*, 329 F.3d 1358, 1368 (Fed. Cir. 2003) ("[T]he dispositive question regarding anticipation [i]s whether one skilled in the art would reasonably understand or infer from the [prior art reference's] teaching that every claim element was disclosed in that single reference." (quoting *In re Baxter Travenol Labs.*, 952 F.2d 388, 390 (Fed. Cir. 1991))).

Additionally, under the principles of inherency, if the prior art necessarily functions in accordance with, or includes, the claimed limitations, it anticipates. *MEHL/Biophile Int'l Corp. v. Milgraum*, 192 F.3d 1362, 1365 (Fed. Cir. 1999); *In re Cruciferous Sprout Litig.*, 301 F.3d 1343, 1349–50 (Fed. Cir. 2002).

As set forth in 35 U.S.C. § 103(a),

> [a] patent may not be obtained . . . 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 at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

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. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

Additionally, the obviousness inquiry typically requires an analysis of "whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (requiring "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness")); *see In re Warsaw Orthopedic, Inc.*, 832 F.3d 1327, 1333 (Fed. Cir. 2016) (citing *DyStar Textilfarben GmbH & Co. Deutschland KG v. C. H. Patrick Co.*, 464 F.3d 1356, 1360 (Fed. Cir. 2006)).

An obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 550 U.S. at 418; *accord In re Translogic Tech., Inc.*, 504 F.3d 1249, 1259 (Fed. Cir. 2007). Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016). Instead, Petitioner must articulate a reason why a person of ordinary skill in the art would have combined the prior art references. *In re NuVasive*, 842 F.3d 1376, 1382 (Fed. Cir. 2016).

A reason to combine or modify the prior art may be found explicitly or implicitly in market forces; design incentives; the "'interrelated teachings of multiple patents'"; "'any need or problem known in the field of endeavor at the time of invention and addressed by the patent'"; and the background knowledge, creativity, and common sense of the person of ordinary skill. *Perfect Web Techs., Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1328–29 (Fed. Cir. 2009) (quoting *KSR*, 550 U.S. at 418–21).

Before determining whether a claim is obvious in light of the prior art, we consider any relevant evidence of secondary considerations of non-obviousness. *See Graham*, 383 U.S. at 17. Notwithstanding what the teachings of the prior art would have suggested to one of ordinary skill in the art at the time of the invention, the totality of the evidence submitted, including objective evidence of non-obviousness, may lead to a conclusion that the challenged claims would not have been obvious to one of ordinary skill. *In re Piasecki*, 745 F.2d 1468, 1471–72 (Fed. Cir. 1984).

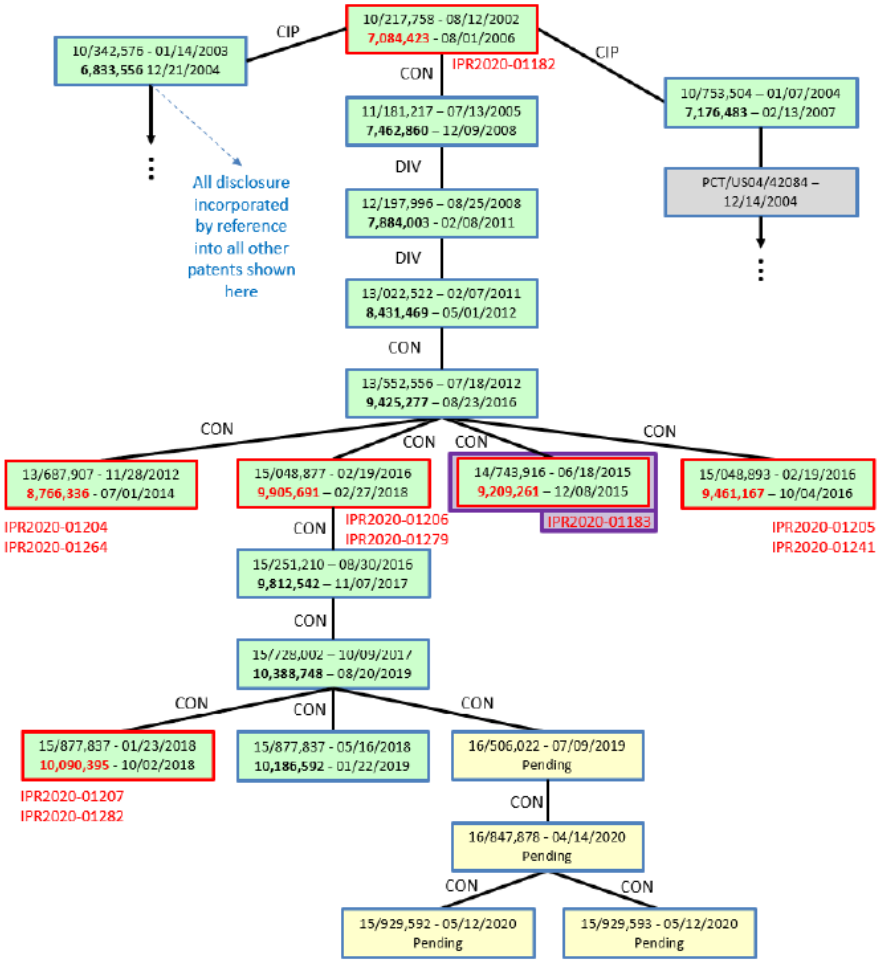
We analyze the asserted grounds of unpatentability in accordance with these principles to determine whether Petitioner has met its burden to establish a reasonable likelihood of success at trial.

B. Priority Issues

Petitioner argues that no challenged claim is entitled to any priority date before February 7, 2011 because none of the priority applications filed before February 7, 2011 ("pre-2011 priority applications") have written description support for a metal oxide interface layer as recited in, or incorporated by dependency, in all challenged claims. Pet. 17–21. Grupp '438 would be prior art to the challenged claims if those claims have an effective filing date of no earlier than February 7, 2011. Ex. 1015, code (45).

Petitioner also argues that the priority applications do not have written description support for a "group IV semiconductor" as recited in, or incorporated through dependency, in all challenged claims.[3,4] Pet. 21.

A chart provided in the Patent Owner showing a partial view of the family tree including the '261 patent is provided below.



Partial Family of Patents Including the '261 patent

---

[3] These limitations are also recited or incorporated by dependency into claims 3 and 24, but Patent Owner has disclaimed those claims. Ex. 2002.
[4] Petitioner also argues that the priority applications lack of support in the priority applications for other recitations in claims 3 and 21–24. Pet. 21–24. Patent Owner, however, has disclaimed claims 3 and 21–24. Ex. 2002.

See Dec. to Inst. 16. Petitioner contends that patentee did not describe the genus of the "metal oxide layer" as recited in the claims of the '261 patent until the patentee filed the claims of U.S. Application 13/022,522 ("the '522 application") on February 7, 2011. Pet. 17 (citing Ex. 1010, 48; Ex. 1017, First Declaration of Dr. E. Fred Schubert, ("Schubert Decl.") ¶¶ 99–100).

Petitioner contends that Grupp '483 discloses each of the limitations of claims 1–3, 17–18, and 21–24. Pet. 26–37. Patent Owner does not dispute Petitioner's assertion that Grupp '483 discloses all of the limitations of the challenged claims, but asserts that Grupp '483 cannot be applied as a prior art reference because the '261 patent is entitled to priority over Grupp '483 based on U.S. Patent 7,084,423 (Ex. 1003, "the '423 patent"), filed on August 12, 2002. *See* PO Resp. 9–10, 22–23.

1. Contentions Concerning 35 U.S. C. § 311(b)

As an initial matter, we consider Patent Owner's contention that Petitioner's assertion of Grupp '483 is improper under 35 U.S.C. § 311(b) because it is "fundamentally an assertion of unpatentability under 35 U.S.C. § 112, ¶ 1, not 35 U.S.C. § 102." *See* PO Resp. 22–24. According to Patent Owner, "[t]here are no disputes in this IPR regarding whether 'prior art' references ([Patent Owner's] own Grupp '483 patent) teaches any of the claim limitations. For all intents and purposes this IPR is a § 112 battle, just as if it were a PGR (for which the pre-AIA '261 Patent is not eligible)." *Id.*

Although the issue of whether challenged claims have written description support in the specification of the challenged patent is beyond the scope of an *inter partes* review (35 U.S.C. § 311), whether a patent is entitled to the benefit of earlier filed applications under 35 U.S.C. §§ 119 or 120 is properly an issue to be addressed in an *inter partes* review. *See Indivior UK Ltd. v. Dr. Reddy's Lab'ys S.A.*, 18 F.4th 1323, 1326–1330

(Fed. Cir. 2021). The benefit of an earlier filed application requires written description support for the challenged claims in the earlier filed application. *See id.* at 1381–1382. Therefore, we consider the details of the pertinent priority issues below.

2. Metal Oxide Interface Layer

Every challenged claim of the ’261 patent recites a metal oxide interface layer. Referring to limitation (ii) of claim 1 (“a metal oxide layer”) Petitioner argues that Grupp ’483 anticipates claim 1 because, among other things, it discloses a separation layer that can be an oxide (Pet. 27 (citing Ex. 1015, 11:35–38 (“in some cases such passivation layers are combined with separation layers (e.g., made of an oxide) to complete the interface layer”))) and the separation can be a spacer layer of TiO_2 (*id.* (citing Ex. 1015, 18:65–67 (“[s]pacer layers may be used with lower barriers (e.g., TiO_2 has a barrier of less than 1eV”))). Thus, according to Petitioner, Grupp ’483 “discloses a metal oxide interface layer: titanium dioxide.” *Id.* (citing Ex. 1017, Schubert Decl. ¶ 128). At the same time, Petitioner argues that Grupp ’483 can be applied as a reference because the exact same language in the pre-2011 priority applications fails to provide a written description of the genus of the recited “metal oxide layer.” Pet. 19–21; *see, e.g.*, *Yeda Research and Dev. V. Abbot GmbH & Co. KG*, 837 F.3d 1341, 1344–45 (Fed. Cir 2016).

According to Petitioner, the first time any of the applications “arguably disclosed a generic ‘metal oxide’ interface layer is in the originally filed claims of U.S. Patent App. No. 13/022,522 filed on February 7, 2011.” Pet. 18 (citing Ex. 1010, 48 [*see* claims 15, 16]; Ex. 1017, Schubert Decl. ¶ 100). Petitioner acknowledges that earlier applications described a “possible example of a metal oxide interface layer” in the form of a TiO_2 spacer layer. *Id.* (citing Ex. 1001, 17:26–28; Ex. 1017, Schubert

Decl. ¶ 101); *see, e.g.*, Ex. 1002 ¶¶ 82–85. According to Petitioner, however, the disclosed TiO_2 spacer layer fails to describe the genus of the recited metal oxide interface layer even though that same description anticipates the challenged claims. *See In re Curtis*, 354 F.3d 1347, 1358 (Fed. Cir. 2004) ("A patentee will not be deemed to have invented species sufficient to constitute the genus by virtue of having disclosed a single species.").

According to Patent Owner, the '423 patent Specification filed in 2002 supports the subgenus "metal oxide" in two ways: (1) by its disclosure of titanium dioxide (TiO_2) as a species and (2) by its disclosure of oxide spacer/separation layers in more general terms. PO Resp. 12 (citing Ex. 1003, 10:49–50, 17:59–61; Ex. 2070, Declaration of Dr. Kelin Kuhn ("Kuhn Decl.") ¶¶ 97–113)).

Patent Owner argues that a person of ordinary skill would understand that the spacer layer is adjacent to the metal and would recognize that a desirable embodiment for the spacer layer (i.e., the MIGs separation layer) is an oxide of whatever metal is used as the metal in the metal-semiconductor junction. *Id.* (citing Ex. 2070, Kuhn Decl. ¶ 98).

Patent Owner argues that a person of ordinary skill would understand from the Specification that the oxide/separation layer, when present, is distinct from the passivation layer. *Id.* at 14 (citing Ex. 2070, Kuhn Decl. ¶¶ 101–105). According to Patent Owner, the placement of a metal adjacent to an oxide of that metal is very likely to be chemically more stable than having the metal adjacent to some other oxide that is not an oxide of the same metal. *Id.* at 12–13 (quoting Ex. 2070, Kuhn Decl. ¶ 98). Patent Owner asserts that (1) the metal-metal oxide relationship of Ti-TiO_2 and (2) the fact the metal and the space layer are adjacent are structural features

common to the metal oxide genus such that a person of ordinary skill would visualize and recognize members of the genus. *Id.* at 13. Patent Owner also argues that a person of ordinary skill would understand from the Specification that the oxide spacer/separation layer should be a dielectric and that, from the list of metals in the patent, a person of ordinary skill would realize "appropriate dielectrics that do not passivate semiconductors and are oxides are metal oxides in the families such as aluminum oxides, titanium oxides, tantalum oxides, and zinc oxides." *Id.* at 14 (citing Ex. 2070, Kuhn Decl. ¶ 110).

Petitioner notes that the priority applications disclose only one species (TiO_2) of the titanium oxide genus. Pet. Reply 3. Petitioner asserts that the single disclosed species TiO_2 is not representative of the entire genus of metal oxides and does not describe features common to all members of the claimed genus. *Id.* at 3. Petitioner further argues that its position is even more compelling when the number of metal oxides is compounded to include multiple metals. *Id.* at 3–4 (citing Ex. 1056, Transcript of Deposition of Dr. Kelin Kuhn ("Kuhn Tr.") 49:13–14, 211:8–212:3, Ex. 1061, Second Declaration of Dr. Fred Schubert ("Second Schubert Decl.") ¶¶ 18–20 (identifying examples of metal oxides in the metal oxide genus)); *see also* Ex. 1056, Kuhn Tr. 114:10–18 (Dr. Kuhn testifying that she did not know how many chemical compounds exist in the titanium oxide family).

Petitioner compares the characteristics of three metal oxides commonly used in semiconductor devices as illustrating disparate bandgap, melting point, and electron affinity properties. Pet. Reply 4–5 (citing Ex. 1061, Second Schubert Decl. ¶ 51). Petitioner cites the testimony of Dr. Kuhn confirming that such characteristics are not discussed in the patent, as evidence that the patent fails to explain which properties one should consider

when determining what would be encompassed by the claimed structures (*see id.* at 4, citing Ex. 1056, Kuhn Tr., 108:5–19 (concerning conductivity), 109:9–11, 110:12–15 (concerning melting point), 110:17–20 (concerning bandgap energy), 112:16–113:7 (concerning electron affinity), 111:20–112:1 (concerning diffusivity); 112:2–9 (concerning hardness), 112:10–15 (concerning optical properties), 51:15–24 (concerning crystal structure)).

Patent Owner argues that the patent's disclosure of TiO_2 supports claiming the metal oxide genus because "the metal oxide is the spacer layer, and one important structural feature common to metal oxides in that role is that they are dielectrics, according to the specification." PO Sur-reply 16 (citing Ex. 2070, Kuhn Decl. ¶¶ 107, 109 as "concluding that Acorn specification teaches POSITA to use a dielectric as the spacer layer"). Stating that Petitioner "has not disputed that fact," Patent Owner contends that Petitioner's arguments concerning the many possible metal oxides lacks "any analysis narrowing those metal oxides to relevant ones that are solid non-passivating dielectrics." *Id.* (citing *In re Smythe*, 480 F.2d 1376, 1385 (CCPA 1973); *In re Myers*, 410 F.2d 420, 426 (CCPA 1969)).

Patent Owner further cites four "blazemarks" in addition to the TiO_2 example in the Specification as "sufficient for a POSITA to recognize from the disclosure that the oxide spacer layer could be (most likely is) a metal oxide.)" *See* PO Resp. 14–15. According to Patent Owner:

> the patent teaches that the MIGS separation layer [1] is an optional layer added in addition to the passivation layer, [2] is sandwiched between the metal and the passivation layer, [3] is not itself a passivation layer, and [4] has the function of providing the proper thickness and band structure so that the MIGS states arising in the metal cannot pin the Fermi level of the junction. A POSITA would recognize that insulating metal oxides in families such as aluminum oxide, titanium oxide,

> tantalum oxide, and zinc oxide, which are generally considered to be non-passivating, would be appropriate choices for the MIGS separation layer that the inventors had contemplated as part of a two-layer (passivation layer + separation layer) interface.

I*d*. (quoting Ex. 2070, Kuhn Decl. ¶ 112). As Petitioner notes, however, these four purported blazemarks are not found in the Specification. Pet. Reply 9. Moreover, Petitioner points out that under cross-examination, Dr. Kuhn conceded that she has not opined on whether the metal oxide separation layer cannot have a passivation function. *Id.* at 9–10 (citing Ex. 1056, Kuhn Tr. 47:15–22; Ex. 1061, Schubert Decl. ¶¶ 52–57).

Petitioner contends that allowing Patent Owner to claim priority back to 2002 based on the disclosure of TiO_2 "would result in the challenged claims impermissibly encompassing metal oxide interface layers in metal-semiconductor junctions that were only later invented" and "***to this day*** have not yet been invented and could not have been in the inventors' possession in 2002." *See* Pet. Reply 6–7 (citing Ex. 1056, Kuhn Tr. 99:6–23, 82:15–21 (asserting the claims would cover a newly invented species of titanium oxide or a gold oxide currently though to be unsuitable)).

"The goal [of] the written description doctrine [is to] giv[e] the incentive to actual invention and not 'attempt[s] to preempt the future before it has arrived." *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1353 (Fed. Cir. 2010) (en banc) (last alteration in original). It is undisputed that the pre=2011 priority applications disclose only a single metal oxide species, i.e., TiO_2. As Petitioner points out, the first mention of a metal oxide was in U.S. Patent Application No. 13/022,522, filed on Feb. 7, 2011. Pet. 17; Ex. 1010, 48 (*see* claim 15, depending from independent claim 3). Patent Owner has identified no discussion of generically using a metal oxide in the

specification of any pre-2011 priority application. As detailed above, Patent Owner relies solely on its assertions about what a person of ordinary skill would have understood in the relevant context.

A review of Dr. Kuhn's Declaration testimony that forms the basis for Patent Owner's responsive arguments concerning written description in the '423 patent (the patent issuing from the first application submitted in August 2002) is illustrative of the extent to which Patent Owner relies on the understanding of a person of ordinary skill, rather than actual written description in the '423 patent. Dr. Kuhn begins her analysis with the disclosure in the '423 patent that TiO_2 as an example of a "spacer layer" or "separation layer" (the terms being used synonymously) with Ti as a possible metal for the metal-semiconductor junction. Ex. 2070, Kuhn Decl. ¶ 97. Referring to the spacer layer as the "MIGS separation layer," Dr. Kuhn asserts that a person of ordinary skill would recognize from the TiO_2 layer example that an oxide of whatever metal is used as the metal in the metal-semiconductor junction would be desirable. *Id.* ¶ 98. Dr. Kuhn cites no teaching in the '423 patent supporting this assertion, but states that a person of ordinary skill would recognize the value of a configuration in which the placement of a metal next to an oxide of that metal "is very likely to be more chemically stable than having the metal adjacent to some other oxide." *Id.*

According to Dr. Kuhn, the fact that the "'423 patent states that the separation layer may be an oxide in general, would have directed a person of ordinary skill to metal oxides in particular." *Id.* ¶ 100. Nevertheless, after stating that metals other than titanium are disclosed in the patent, Dr. Kuhn acknowledges that "not all of these metals have oxides that would be acceptable as a spacer layer, many of them do have such oxides." *Id.* ¶ 99.

Noting that the interface layer may be a passivation layer or a single or compound layer including both a passivating material and an additional separation material, Dr. Kuhn states the layers should be well-behaved materials not displaying deleterious effects that would prevent their use in electrical devices. *Id.* ¶¶ 101–102. Dr. Kuhn next notes that patent states "the interface layers serve to (i) chemically passivate the semiconductor from the metal surface 540 and (ii) to displace the semiconductor sufficiently to eliminate or at least reduce the effect of MIGS." *Id.* (quoting Ex. 1003, 9:50–53). According to Dr. Kuhn, because the patent explains that the passivation layer alone may not be sufficient to provide MIGS separation, an additional MIGS separation may be required. *Id.* ¶ 104. Dr. Kuhn states: "From this description, a POSITA would understand that the separation layer, when paired with a passivation layer, does not itself perform a passivation function, but is solely intended to provide the proper thickness and band structure so that the MIGS states arising in the metal cannot pin the Fermi level of the junction." *Id.*

Dr. Kuhn next notes that the '423 patent discloses passivation layers using N and/or O may not require distinct separation layers and asserts that "[f]rom this a POSITA would understand that a passivation material that is *also* an oxide (such as silicon dioxide or silicon oxy-nitride) would not be considered the distinct separation layers recited in the challenged claims, but rather a passivation layer." *Id.* ¶ 105 (citing Ex. 1003, 10:5–7). Based on the '423 patent's disclosure that "in some cases such passivation layers are combined with separation layers (e.g., made of an oxide) to complete the interface layer" (Ex. 1003, 10:48–50), Dr. Kuhn asserts that "a POSITA would understand that the separation layer is intended to be an oxide, but not one with the function of passivation." *Id.* ¶ 106.

Noting that "the patent provides extensive teachings on metals versus non-metals" and the relationship between metals, conductive materials, and conductors (*id*. ¶ 108), Dr. Kuhn posits that a person of ordinary skill would have understood or recognized the following:

> (i) that "using a metal for MIGS separation would ***not*** provide MIGS separation (the metal would simply make more MIGS states)";
>
> (ii) that "using metal-like materials for the MIGS separation layer (i.e., metals, semi-metals (metalloids), and semiconductors would carry a similar risk of not fully suppressing MIGS states due the band structure of the materials";
>
> (iii) that "the desired embodiments for the MIGS separation layer in a two-layer (passivation layer + separation layer) arrangement would be dielectrics and additionally would include (as per the patent's clarification that a passivation layer is distinct from a separation layer) dielectrics that do not passivate or only weakly passivate the semiconductor";
>
> (iv) that "the position of the MIGS separation layer (always between the metal and the passivation layer) suggests metal oxides of the parent metal to improve chemical stability";
>
> (v) that looking to "the complete list of metals provided in the patent (Al, In, Ti, Cr, Ta, Cs, Mg, Er, Yb, Mn, Pb, Ag, Y, Zn, Pt, Au, W, Ni, Mo, Cu, Co and Pd) . . . the most appropriate metal oxides would be conventional insulators with significant preexisting data due to the world-wide emphasis on high-k dielectrics at the time of the patent (families such as aluminum oxide, titanium oxide, and tantalum oxide)";
>
> (vi) that there was "the possibility of using insulators from materials well-established in the semiconductor industry, although perhaps not as well-researched as the high-k materials (families such indium oxide, magnesium oxide, zinc oxide, tungsten oxide, molybdenum oxide and yttrium oxide)";
>
> (vii) that "certain materials might have appropriate insulating properties but would not be appropriate for semiconductor fabrication due either to well-known mismatches between materials properties and typical semiconductor processing conditions (e.g. families such as

> silver oxide and gold oxide) or environmental issues (e.g. families such as lead oxide)"; and
>
> (viii) that "[t]he remaining oxides would be recognized as inappropriate choices as they are semiconductors or semimetals (metalloids)."

Id. ¶¶ 109–110.

Petitioner's expert, Dr. Schubert, identifies a large number of metal oxides and multiple metal oxides that is expanded by multiple equilibrium species and notes that the metal oxide genus would be even further expanded to include non-equilibrium species. Ex. 1061, Second Schubert Decl. ¶¶ 18–22. Dr. Schubert further emphasizes the significant variation in physical and chemical properties of such metal oxides. *Id.* ¶¶ 27–51.

Much of Dr. Kuhn's analysis is premised on her assessment of the mental steps that an ordinarily skilled artisan theoretically might have taken after reviewing the minimal disclosure in the '423 patent. The '423 patent does not discuss any properties of metal oxides (other than the lower barrier of the metal oxide TiO_2) or design considerations concerning the selection of particular oxides to use in the claimed structure, particularly in the context of MIGS separation. Dr. Kuhn cites very little, if any, evidence to support her testimony regarding the knowledge of an ordinarily skilled artisan. Thus, we do not credit this analysis as showing that an ordinarily skilled artisan would have found that the inventors of the pre-2011 priority applications possessed the recited genus. *See Ariad*, 593 F.3d at 1352 (a description that merely renders the invention obvious does not satisfy the written description requirement); *PowerOasis Inc. v. T-Mobile USA*, 522 F.3d 1299, 1306 (Fed. Cir. 2008) ("Entitlement to a filing date does not extend to subject matter which is not disclosed, but would be obvious over what is expressly disclosed.") (quoting *In re Huston,* 308 F.3d 1267, 1277 (Fed. Cir. 2002),

quoting *Lockwood v. Am. Airlines, Inc.,* 107 F.3d 1565, 1571–72 (Fed. Cir. 1997)); *Martin v. Mayer,* 823 F.2d 500, 505 (Fed. Cir. 1987) (holding that the written description requirement is "not a question of whether one skilled in the art *might* be able to construct the patentee's device from the teachings of the disclosure" but "[r]ather, it is a question whether the application necessarily discloses that particular device") (emphasis in original).

Patent Owner also argues that policy "concerns about overclaiming – the policy concerns that animate the written description requirement" are inapplicable here because the patentee purportedly had written description support for claiming even broader subject matter than the recited genus, i.e., the broader "oxide" genus. *See* PO Sur-reply 15–16. We disagree. First, the written description for priority is a statutory requirement that cannot be avoided based merely on policy arguments. 35 U.S.C. § 120 (2018). Second, even with respect to the concern of over-claiming, the mere fact that the patentee purportedly had written description support for subject matter broader than claim 1 would not alleviate that concern. The requirement for written description support is only one of a number of requirements for patentability, and it would still be over-claiming for a patentee to seek a claim that it did not describe to avoid a prior art rejection for a broader claim that it described.

Patent Owner further argues that, because in a similar patent application Petitioner took the position "that the genus 'metal oxide having a small conduction band offset with respect to the source/drain area' was supported by just TiO_2, Ta_2O_5, and ZnO," Petitioner's position in that case is inconsistent with its position here. PO Sur-reply 17–18 (citing Ex. 2099, claims 2–3). On this record, we do not reach such a conclusion. Patent Owner cites to the publication of the involved application (Ex. 2099), which

shows that Petitioner has filed such claims and that the involved application discloses TiO_2, Ta_2O_5, and ZnO, but Patent Owner acknowledges that "exhibit 2099 is not perfectly analogous to the metal-oxide written description issue here," and provides no analysis of how the purported support for a genus based on the disclosure of three species would conflict with an alleged lack of a support for a genius based on one species. *Id.* at 18. Patent Owner further does not set forth any arguments that have been made in the prosecution of the involved application (Ex. 2099). *See id.*

In sum, after considering all the arguments and evidence, we find that the pre-2011 priority applications do not describe the recited genus. Thus, Patent Owner is not entitled to the benefit of any pre-2011 priority applications for claims 1–3, 17–18, and 21–24, and Grupp '483 is prior art for those claims.

C. Anticipation of Claim 1–3, 17–18, and 21–24 by Grupp '483

Independent claim 1 recites an electrical junction comprising "a metal oxide interface layer disposed between a metal contact and a group IV semiconductor." Ex. 1001, 17:64–66. Claims 2 and 17–18 depend from claim 1. *Id.* at 18:6–8, 18:44–47. Independent claim 21 and dependent claims 22–24 recite an "interface layer comprising a metal oxide" and "a semiconductor selected from a list consisting of Si, Ge, C (a crystal structure of which is selected from a list comprising a diamond lattice, a fulleride or a polymer), an alloy of GE and Si, Ge, and C." *Id.* at 18:63–19:13. Patent Owner acknowledges that Grupp '483 has the same specification as that of the '423 patent, except for minor typographical errors and "slightly more disclosure of semiconductor materials and metals that the '423 patent." PO Resp. 8. Patent Owner does not dispute Petitioner's assertion that all of the

limitations of challenged claims 1–3, 17–18, and 22–24 are disclosed in Grupp '483. *See* Pet. 25–26.

As discussed above, Petitioner has demonstrated Grupp '483 is prior art to challenged claims 1–3, 17–18, and 21–24 of the '261 patent. It is undisputed that the priority applications disclose at least some group IV semiconductors. Thus, claims reciting the metal oxide interface layer and Group IV semiconductor are anticipated under *In re Slayter*, 276 F.2d 408, 411 (CCPA 1960) ("It is well settled that a generic claim cannot be allowed to an applicant if the prior art discloses a species falling within the claimed genus; in other words, whatever would infringe if subsequent will anticipate if prior.") and *In re Gosteli*, 872 F. 2d 1008, 1010 (Fed. Cir. 1989). The additional limitations of the challenged dependent claims are also disclosed in Grupp '483. *See* Pet. 25–26.

For the reasons discussed above, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, 17–18, and 21–24 are anticipated by Grupp '483.

D. Claims 1–3 and 17–18 as Obvious Over Jammy

1. Jammy

Jammy discloses "improved contact between conductive studs and shallow diffusion regions by incorporation of a quantum conductive barrier layer at the interface between the conductive stud and shallow diffusion region." Ex. 1016, 3:18–21. An annotated version of Figure 1 of Jammy is shown below.

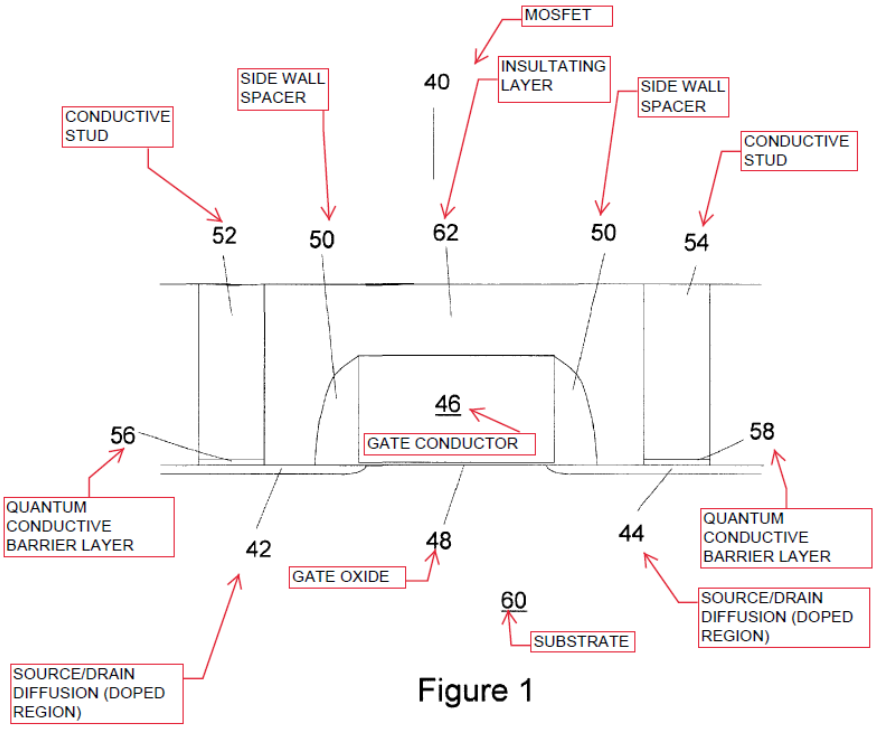


Figure 1

Ex. 1016, Fig. 1. Annotated Figure 1 shows MOSFET 40 in which shallow source/drain diffusions, i.e., doped regions 42, 44, formed in substrate 60 contact conductive studs 52, 54 through quantum conductive barriers 56, 58. *Id.* at 4:9–18. Jammy's quantum conductive layers 56, 58 are thin films of less than 50 Å (more preferably about 5–30 Å, most preferably about 5–15 Å) of materials that in their bulk properties would be considered dielectrics, but in thin layers become electrically conductive, such that resulting layers preferably have a film resistance of less than about 1 K-ohm-μm^2, more preferably less than about 100 ohm-μm^2. *Id.* at 3:23–40. Jammy's thin layers also prevent or slow diffusion of chemical species from one side of the layer to the other. *Id.* at 3:27–29.

Jammy incorporates Cote by reference. Cote seeks to minimize contact resistance by increasing the contact region between a contact stud and a semiconductor structure by contacting the stud along a sidewall of the structure using a manufacturing process that self-aligns the contact stud

along the sidewall. Ex. 1032, 2:1–11. Cote discloses forming a diffusion contact opening or window, i.e., a void having boundaries defined by an insulating oxide layer (deposited, e.g., by chemical vapor deposition), a silicided junction, and a spacer that prevents the gate conductor from shorting to the diffusion region through the silicided junction when the contact window is backfilled with appropriate conductive stud material, such as titanium, titanium nitride, or tungsten. *See id.* at 7:3–8:36.

2. Claims 1–3

Petitioner cites Jammy as disclosing an electrical junction (preamble, identified in Petition as claim limitation 1(i)), that seeks to provide improved electrical contacts to improve transistor (claim limitation 1(iii)) reliability. Pet. 40–41 (citing Ex. 1016, 2:27–29, 2:36–41, 3:16–22; Ex. 1017, Schubert Decl. ¶¶ 175–178).

Petitioner further contends that Jammy discloses a metal oxide layer disposed between a contact metal and a Group IV semiconductor as recited in claim limitation 1(ii), noting that Jammy "enables improved contact between conductive studs and shallow diffusion regions ***by incorporation of a quantum conductive barrier layer at the interface between the conductive stud and shallow diffusion region.***" Pet. 41 (citing Ex. 1016, 2:38–41; Ex. 1017, Schubert Decl. ¶ 180). Citing Figure 1 of Jammy, Petitioner argues that Jammy's metal conductive studs 52, 54 of tungsten, titanium, or titanium nitride make contact with source/drain diffusions 42, 44 (n or p type doped regions doped regions in a silicon substrate, which is a group IV semiconductor). *Id.* at 41–42. Petitioner further cites Jammy as disclosing quantum conductive barriers 56, 58 made of a metal oxide, i.e., alumina (aluminum oxide, Al_2O_3). *Id.* at 42 (citing Ex. 1016, 3:50–57; Ex. 1017, Schubert Decl. ¶ 181). Noting that the alumina quantum conductive

barrier is deposited on the exposed source/drain diffusions by chemical vapor deposition after cleaning with hydrofluoric acid (HF), Petitioner contends that the result is a SiO_2 monolayer between the Al_2O_3 and the silicon surface, such that a metal oxide interface layer exists between the contact metal of the conductive studs and the group IV semiconductor of the doped source/drain regions. *See id.* at 43.

Claim limitation 1(iv) recites "the interface layer configured to reduce a height of a Schottky barrier between the contact metal and the semiconductor from that which would exist at a contact junction between the contact metal and the semiconductor without the interface layer disposed therebetween." Ex. 1001, 17:67–18:4. As to claim limitation 1(iv), Petitioner argues that "an ordinarily skilled artisan would have understood that Jammy's metal oxide interfacial layer would have reduced the Schottky barrier height between the contact metal and the semiconductor compared to an intimate contact, *i.e.*, a contact with no interfacial oxide layer." Pet. 44 (citing Ex. 1017, Schubert Decl. ¶ 188). According to Petitioner, a person of ordinary skill would have recognized Jammy to have an Al_2O_3-SiO_2 interfacial oxide layer that includes a thin layer of SiO_2 between the silicon substrate and the Al_2O_3 and understood that this thin layer is the result of Si-O bonds on the Si surface satisfying dangling silicon bonds at the surface of the silicon. *Id.* at 45 (citing Ex. 1016, 4:61–67, 6:1–3; Ex. 1040 ("Stesmans"), 3; Ex. 1017, Schubert Decl. ¶ 189). Petitioner next cites Goodnick (Ex. 1020) and Taubenblatt 1984 (Ex. 1023) to argue "it was known that satisfying dangling bonds of an n-type silicon surface—such as the surfaces of the n-type source/drain diffusions disclosed in Jammy—could passivate the n-type silicon surface and decrease the barrier height of a junction between metal and the n-type silicon." *Id.* (citing Ex. 1016, 4:33–

38; Ex. 1023, 3; Ex. 1020, 949; Ex. 1017, Schubert Decl. ¶ 190). According to Petitioner, a person of ordinary skill would have understood that "[f]or each of those conductive studs, Jammy's Al_2O_3–SiO_2 interface layer would have reduced the barrier height from that which would have existed in the absence of the interface layer" and that this effect can be demonstrated by applying the barrier height equation described in the Rhoderick reference (Ex. 1018). *Id.* at 45–46 (citing Ex. 1017, Schubert Decl. ¶ 190); *see also id.* at 45–48.

Based on this analysis, Petitioner argues, as a matter of routine optimization, a person of ordinary skill "would have been motivated to optimize the thickness of the interface layer over the thicknesses disclosed in Jammy—5 Å to 50 Å, or 0.5 nm to 5 nm—and would have expected to obtain a lower barrier height than could be achieved via intimate metal-semiconductor contact." Pet. 49 (citing Ex. 1016, 3:35–37; Ex. 1017, Schubert Decl. ¶ 198).

Finally, Petitioner argues that an ordinarily skilled artisan would have been motivated to reduce barrier height to reduce specific contact resistance that deteriorates transistor characteristics, such as switching frequency, and to reduce power consumption. Pet. 49 (citing Ex. 1041 ("Sakurai"), 6; Ex. 1042 ("Yeh"), 2:54–64; Ex. 1043 ("Takehashi"), 4:57–59; Ex. 1017, Schubert Decl. ¶ 198).

As to claim element 1(v), which recites that the interface layer thickness is between approximately 0.1 nm and 5 nm, Petitioner notes that "[e]ach thickness range that Jammy discloses overlaps or falls entirely within the claimed range, which suffices to satisfy the claimed range for obviousness." Pet. 50–51 (citing *In re Wertheim*, 541 F.2d 257, 271 (CCPA 1976)).

Patent Owner notes that the purpose of Jammy's barrier layer is to "prevent or inhibit diffusion of dopants from the studs [52/54] to the diffusions [42/44] and further into substrate 60." PO Resp. 25 (quoting Ex. 1016, 4:22–24) (alterations in original). Citing Jammy's explanation that conductive studs, typically made of tungsten or doped polycrystalline silicon, are prone to spike through ultra-shallow junctions, thereby disrupting the performance of a transistor as designed, Patent Owner asserts that the primary objective of Jammy's quantum conductive barrier is to prevent such spike through of metal into the shallow source/drain diffusion regions, while remaining conductive. *Id.* at 26 (citing Ex. 1016, 4:32–33). Patent Owner contends that there are several flaws in Petitioner's challenge of claims 1–3 and 17–18 as obvious over Jammy.

First, Patent Owner emphasizes that Jammy "never illustrates or mentions" the SiO_2 layer Petitioner describes. PO Resp. 26–27. Patent Owner references Petitioner's reliance on Stesmans to assert that Jammy's quantum conductive layer is alumina and that Jammy's process would yield a layer of SiO_2 between alumina and the source/drain regions. *Id.* According to Patent Owner, Petitioner "seems to be alleging that Jammy inherently discloses that SiO_2 layer," but "the petition fails to even attempt to demonstrate inherency" by showing the reference necessarily, inevitable, or invariably discloses a claimed feature that is not expressly disclosed. *Id.*

Petitioner contends that it does not rely on inherency because "Jammy explicitly discloses a silicon dioxide layer." Pet. Reply 14 (citing Ex. 1016, 5:7–11 ("[t]he choice of the method [to form the quantum conductive layers] may depend on the composition of the surface on which the layer is to be formed and/or the desired quantum conductive layer composition"), 5:32–39 ("the exposed diffusion surface may be pre-cleaned . . . to remove some or

all of any pre-existing oxide surface layer . . . techniques described in U.S. Patent 5,194,397 may also be used to control the presence of oxide film"); Ex. 2076, Transcript of Deposition of Dr. E. Fred Schubert ("Schubert Tr."), 106:2–9 ("Jammy contemplates to remove some or all of any preexisting oxide surface layer. Oxide surface layer refers to silicon oxide . . . Jammy contemplates the possibility to leave some of the silicon oxide on the silicon substrate before depositing the quantum conductive barrier layer.").

Patent Owner correctly notes that Jammy does not identify a Figure that labels a layer of silicon dioxide. PO Resp. 26; *see* Ex. 2076, Schubert Tr. 102:10–14 (testifying that Jammy does not include labels on its sole figure). Nevertheless, we agree with Petitioner that Jammy discloses an embodiment in which a silicon oxide layer exists on the semiconductor surface between the alumina oxide and the source/drain regions of the semiconductor. Pet. Reply 15; s*ee* Ex. 1016, 5:7–40; Ex. 2076, Schubert Tr. 98:12–102:14, 104:18–106:9 (stating at 106:2–9 "Jammy contemplates to remove some or all of any preexisting pre-existing oxide surface layer," "oxide surface layer refers to silicon oxide," and "Jammy contemplates the possibility to leave some of the silicon oxide on the silicon surface before depositing the quantum conductive barrier"); *see also* Ex. 1061, Second Schubert Decl. ¶ 130 (citing Ex. 1016, 5:32–39).

Patent Owner next argues that, because Jammy does not mention Schottky barrier heights and is unrelated to lowering Schottky barrier height, Petitioner fails to establish the obviousness of claim limitation 1(iv), i.e., "the interface layer configured to reduce a height of a Schottky barrier between the contact metal and the semiconductor from that which would exist at a contact junction between the contact metal and the semiconductor without the interface layer disposed therebetween." PO Resp. 28–29. Patent

Owner emphasizes that Jammy addresses a different issue, i.e., providing a diffusion barrier that prevents atoms (not electrons) from spiking through into the source/drain diffusion regions. *Id.* at 28.

Patent Owner further argues that Jammy fails to account for MIGS. *Id.* at 30. According to Patent Owner the "Schottky-barrier-height reduction (allegedly provided by Jammy) is just due to passivation, according to the petition [but] that is not consistent with the meaning of Schottky-barrier-height reduction in the '261 Patent." *Id.* (citing Pet. 45–46) According to Patent Owner, in its patents, including the '261 patent, Fermi-level depinning requires both passivation of dangling semiconductor surface bonds and reduction of MIGS, but noting in Jammy or the other references citied in the petition indicates a person of ordinary skill would have understood Fermi-level depinning and Schottky barrier height reductions without having first seen Patent Owner's patents. *Id.* at 30–31.

Citing the Decision on Institution, Patent Owner also argues that improper hindsight underlies Petitioner's assertion that a person of ordinary skill would have understood from Jammy that the presence of an interface layer reduces Schottky barrier height. PO Sur-reply 2–5 (citing Dec. to Inst. 32–33).

Although we agree with Patent Owner that Jammy does not mention and is not directed to reducing Schottky barrier height, the issue before us is what a person of ordinary skill would have understood from the presence of such an oxide layer. As discussed below, the testimony of both Petitioner's and Patent Owner's expert witnesses developed at trial indicates that a person of ordinary skill would have understood that the structure disclosed by Jammy would have resulted in a reduction of Schottky barrier height, as claimed.

Petitioner points out that Patent Owner's expert, Dr. Goodnick, agrees that a thin silicon dioxide layer passivates the semiconductor by satisfying dangling bonds. Pet. Reply 16 (citing Ex. 1060, Transcript of Deposition of Dr. Steven Goodnick ("Goodnick Tr.") 99:10–15). Dr. Goodnick testified that

> at a silicon surface you have dangling bonds . . . instead of having a nice bandgap, you have a large number of . . . interface states that . . . . can result in Fermi level pinning. These can be removed - - for example, when you grow silicon dioxide - - this is the basis of the whole MOS technology field - - that those dangling bonds can be passivated.

Goodnick Tr. 99:2–13. Petitioner emphasizes that, quoting Dr. Goodnick's paper, the Patent Owner Response acknowledges that a thin oxide layer alone is sufficient to reduce Schottky barrier height as claimed. Pet. Reply 16 (citing PO Resp. 31, quoting Ex. 1020, 949 ("A thin interfacial oxide also may significantly reduce the density of interface states by satisfying silicon dangling bonds. As a result, the Fermi level at the surface may become unpinned and the barrier height is more directly determined by the metal work function."); *see also* Ex. 1061, Second Schubert Decl. ¶ 131).

Turning to the issue of MIGS, Petitioner notes that the claims recite only reducing the Schottky barrier height and are not limited to reducing the effect of MIGS. Pet. Reply 16. Petitioner further points out that, even if the claims were interpreted to require reducing MIGS to reduce the Schottky barrier height, Patent Owner's experts acknowledge it was known that displacing a metal farther away from the semiconductor reduces MIGS. *Id.* at 17 (citing Ex. 1060, Goodnick Tr. 100:24–101:16; Ex. 1056, Kuhn Tr. 189:14–21; *see also* Ex. 1056, Kuhn Tr. 189:21–190:13; *see also* Ex. 1061, Second Schubert Decl. ¶¶ 131–133 ("a POSITA would have understood

Jammy's interface layer also reduces MIGS. Indeed, it is undisputed that an interface layer that separates the metal and semiconductors of Jammy reduces the effect of MIGS.").

In view of the experts' consistent testimony that the presence of a thin oxide layer would reduce the Schottky barrier, we find that Petitioner has demonstrated a person of ordinary skill would have known that the structure taught by Jammy, which includes an oxide layer, would have resulted in reducing the Schottky barrier height as claimed. In light of these findings, we conclude that Petitioner has demonstrated that Jammy would have suggested all the limitations of claim 1 to a person of ordinary skill in the art.

Claim 2 depends from claim 1 and recites that the semiconductor comprises an n-type doped source or drain of a transistor. Ex. 1001, 18:6–8. Petitioner notes that Jammy discloses the substrate in which a MOSFET's source/drain regions are formed is silicon doped with an n-type dopant. Pet. 51 (citing Ex. 1016, 4:33–38; Ex, 1017, Schubert Decl. ¶¶ 203–206). Other than the arguments discussed above, Patent Owner does not respond to Petitioner's contentions concerning this limitation.

Claim 3 depends from claim 1 and recites that "the contact metal is a metal stack or a stack of metals deposited on the interface layer." Ex. 1001, 18:9–11. Petitioner cites Jammy as disclosing that conductive studs 52, 54 may be metals, such as tungsten (Pet. 42 (citing Ex. 1016, 2:38–41, 4:32–33)), or titanium, or titanium nitride (*id.* (citing Ex. 1016, 4:5–8 (incorporating by reference Ex. 1032[5], 8:24–27); Ex. 1017, Schubert Decl.

[5] U.S. Patent No. 5,126,282 (Ex. 1032).

¶ 183)). Other than the arguments discussed above, Patent Owner does not respond to Petitioner's contentions concerning claim 3.

Having considered the arguments and the evidence of record, we find that Petitioner also has demonstrated that Jammy would have suggested the subject matter recited in claims 2 and 3 to a person of ordinary skill in the art.

3. Claims 17 and 18

Claim 17 depends from claim 1 and recites that the contact metal does not form a silicide. Ex. 1001, 18:44–45. Petitioner cites Jammy's incorporation by reference of Cote as disclosing the use of titanium and titanium nitrides as conductive studs. Pet. 38 (citing Ex. 1016, 4:5–8; Ex. 1032, 8:24–37; Ex. 1017, Schubert Decl. ¶¶ 85–87). Petitioner notes that titanium nitride does not form a silicide because it is energetically unfavorable for titanium to react with silicon to form a silicide. *Id.* at 53–54 (citing Ex. 1017, Schubert Decl. ¶ 214). As to claim 18, which also depends from claim 1 and recites that the contact metal does not react with the group IV semiconductor, Petitioner notes that titanium nitride does not react with group IV semiconductor silicon for similar reasons. *Id.* at 54. Petitioner further notes Patent Owner's assertion in litigation that "the titanium nitride contact metal, by its nature, cannot form a silicide" and "does not react with the silicon (which is a group IV semiconductor)". *Id.* (citing Ex. 1049, 17).

Patent Owner contends that Jammy's incorporation by reference of Cote at column 4, lines 1–8 concerns transistors other than MOSFETs and that Cote's passage at column 8, lines 24–32, which Petitioner relies upon, does not cite to Jammy. PO Resp. 35. Referring to Figures 1F and 1G of Cote, Patent Owner asserts that Cote seeks to minimize contact resistance by forming a diffusion contact opening or window defined by an insulating

oxide layer, a silicided junction, and a spacer that prevents the gate conductor from shorting to the diffusion region through the silicided junction when the contact window is backfilled with conductive stud material such as titanium, titanium nitride, or tungsten. *Id.* at 34. According to Patent Owner, Cote lacks a teaching that links Cote's embodiments with titanium studs to Jammy's embodiments with a quantum conductive barrier layer. *Id.* at 36.

Petitioner notes that Patent Owner's arguments concern embodiments of Cote for forming a stud for a gate conductor that Petitioner does not rely upon. Pet. Reply 18 (citing Ex. 1032, 2:61–63). Petitioner emphasizes its reliance on Cote's teachings at column 8, lines 24–27, which are directed to Figures 2A–2H of Cote. Petitioner asserts this is the same structure taught by Jammy. *Id.* at 19 (quoting Ex. 1032, 5:64–66, "FIGS, 2A–2H illustrate the use of a spacer as an alignment structure for a forming a **stud for a diffusion region**."). Patent Owner does not respond to Petitioner's responsive arguments. *See generally* PO Sur-reply.

Jammy states "the structures of the invention are preferably incorporated into a MOSFET", and cites Cote as one of several "[e]xamples of various transistor structures . . . which are incorporated . . . by reference." Ex. 1016, 4:1–7. Jammy further states that it "is not limited to any specific device configuration incorporating the structures of the invention." Therefore, we agree with Petitioner that Jammy's incorporation of Cote, which includes a discussion of Figures 2A–2H explicitly drawn to a diffusion region, would have suggested to a person of ordinary skill in the art using a metal, e.g., titanium, to arrive at a structure that does not form a silicide (as recited in claim 17) or react with a Group IV semiconductor (as recited in claim 18).

4. Objective Indicia of Non-Obviousnes

a) Introduction

As discussed above, we find that Petitioner has demonstrated that Jammy would have suggested the limitations of challenged claims 1–3 and 17–18 to a person of ordinary skill in the art. Before determining whether claims 1–3 and 17–18 would have been obvious in light of the prior art, we consider any relevant evidence of secondary or objective considerations of non-obviousness, as such evidence may lead to a conclusion that the challenged claim would not have been obvious to one of ordinary skill. *See Graham*, 383 U.S. at 17; *In re Piasecki*, 745 F.2d at 1471–72. Objective criteria constitute independent evidence of nonobviousness and may include any of the following: long-felt but unsolved needs, failure of others, unexpected results, commercial success, copying, licensing, and praise. *See Mintz v. Dietz & Watson, Inc.*, 679 F.3d 1372, 1378 (Fed. Cir. 2012).

According to Patent Owner, based on (1) long-felt but unmet need, (2) unexpected results, and (3) industry praise "[t]he objective evidence of non-obviousness overwhelmingly weighs in favor of the '691 Patent claims." PO Resp. 39 (citing Ex. 2090, Declaration of Dr. Paul Clifton ("Clifton Decl.") ¶¶ 8–102).

b) Presumption of Nexus

It is well established that to accord substantial weight to secondary considerations in an obviousness analysis, the evidence of secondary considerations must have a nexus to the challenged claim, i.e., there must be a legally and factually sufficient connection between the evidence and the patented invention. *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019). A patentee is entitled to a presumption of nexus when the patentee shows that the asserted objective evidence is tied to a specific

product and that product embodies the claimed features and is coextensive with them. *Id.* Even where nexus cannot be presumed, "the patent owner is still afforded an opportunity to prove nexus by showing that the evidence of secondary considerations is the 'direct result of the unique characteristics of the claimed invention.'" *Id.* (quoting *In re Huang*, 100 F.3d 135, 140 (Fed. Cir. 1996)).

c) Long felt but unmet need

According to Patent Owner, "the claimed invention addressed a long-felt need prominently felt in the semiconductor industry." PO Resp. 39. Patent Owner cites multiple assertions from the International Technology Roadmap for Semiconductors (ITRS) concerning the incentive to reduce the contact resistance at metal-semiconductor junctions while scaling the contact area and notes that the 2001 ITRS stated achieving this goal via conventional approaches "may also require that the metal/semiconductor barrier height be reduced." *Id.* at 39–40 (quoting Ex. 2093, 28). We note that this quotation indicates a person of ordinary skill would have understood the relationship between ohmic resistance and barrier height. Patent Owner further cites statements in the 2001 and 2003 ITRS concerning increasing complexity and interdependence of the doping and contact shunting processing, such that controlling the contact resistivity associated with the interface between the silicide and doped contact silicon requires maximizing dopant concentration or using lower barrier height material as the contact junction. *Id.* (citing Ex. 2093, 28; Ex. 2094, 35; Ex. 2090, Clifton Decl. ¶¶ 9–14; Ex. 2070, Kuhn Decl. ¶¶ 54–55).

Citing Dr. Clifton's testimony that ITRS Roadmap represents an opinion and that many of its statements may not turn out to be correct, Petitioner argues that we cannot rely upon such conjecture. Pet. Reply 20

(citing Ex. 1059, Transcript of Deposition of Dr. Paul Clifton ("Clifton Tr.") 274:24–275:6, 276:20–277:2). Citing testimony by Dr. Clifton that technology categories mentioned in the 2001 and 2003 ITRS do not anticipate that invention, Petitioner further notes that the 2001 and 2003 ITRS lays out a broad industry strategy to 2019 to achieve lowered contact resistance using technologies that are different from those of the challenged patents. *Id.* at 21 (citing Ex. 1059, Clifton Tr., 272:14–21).

Petitioner asserts that the reference to other technologies indicates an absence of a specific long felt need or the absence of existing solutions to the problem of reducing specific resistance. *Id.*

On this record Patent Owner has not provided sufficient evidence of a nexus between the long felt and the specific limitations recited in claims 1–3 and 17–18, e.g., the structure recited in independent claim 1, in which a metal oxide interface layer interposed between a metal and a group IV semiconductor comprising the source or drain of a transistor has a thickness between 0.1 nm and 5 nm.

d) Unexpected results

Patent Owner contends that, prior to the invention claimed in the '261 patent, the conventional approach to achieving low ohmic resistivity contacts was to remove the oxide layer and use metals capable of reacting with the native oxide during the sintering or bonding step—thereby removing the native oxide from the metal-silicon interface. PO Resp. 40–41. Patent Owner contends that its introduction of an interface oxide layer, i.e., inserting a dielectric into a metal-semiconductor contact in order to reduce resistivity was hailed as counter-intuitive. *Id.* at 41–42 (citing Ex. 2095, 2928; Ex. 2096, 3; Ex. 2097, 5; Ex. 2070, Kuhn Decl. ¶ 49).

Petitioner argues an absence of nexus because the challenged claims do not require a reduction in contact resistivity. Pet. Reply 23. Petitioner further argues absence of nexus because, even if lowering contact resistance were recited in the challenged claims, "lowering contact resistance by inserting an interface layer between the metal and the semiconductor was already known in the art." *Id.* Petitioner notes that Patent Owner's expert, Dr. Kuhn, testified she had not studied whether the concepts in Patent Owner's inventions were unique or novel and had not considered background prior art references, submitted by Petitioner that disclose inserting an insulating layer between a metal and a semiconductor to achieve low contact resistance. *Id.* at 23–24 (citing Ex. 1057, Kuhn Tr. 254:4–9). According to Petitioner, in view of Dr. Schubert's unrebutted testimony that using an interface layer to achieve low contact resistance was known, there is no nexus between the claims and any purported unexpected results. *Id.* at 24 (citing Ex. 1017, Schubert Decl. ¶¶ 63–67 (citing Ex. 1027, "Iwagaro")).

Patent Owner notes that in related IPR2020-01264 Petitioner was unsuccessful in relying on Kim, cited at page 11 of the Petition and in the Schubert Declaration, but not relied upon in Petitioner's challenge, and PO Sur-reply 7–8. In IPR2020-01264, we agreed with Patent Owner that Petitioner had not shown Kim discloses a layer of titanium oxide disposed between a tungsten contact and the silicon diffusion regions. *See Samsung Electronics Co. Ltd. v. Acorn Semi LLC,* IPR2020-01264 (PTAB Jan. 13, 2021) Paper 20 Decision Denying Institution at 17–19. Kim is not related to Patent Owner's unexpected results arguments, because we found Kim did not disclose the structure recited in the claims of U.S. Patent 8,766,336 challenged in that proceeding.

Patent Owner also notes that Petitioner has not has not tried to rely on Schroen and Iwagaro, also cited at page 11 of the Petition, in this proceeding or the district court litigation. PO Sur-reply 7–8. Patent Owner characterizes Schroen and Iwagaro as marginally relevant references that fail to disclose a two layer interface layer with a metal oxide layer, and, even if they disclose limited aspects of the invention, they do not suggest the inventors' novel combination. *Id.* at 8 (citing *Henny Penny Corp. v. Frymaster LLC*, 938 F.3d 1324, 1333 (Fed. Cir. 2019); Ex. 1056, Kuhn Tr. 87:16–88:1). Acknowledging that at least some of the clams do not recite reducing contact resistance, Patent Owner emphasizes that it is not necessary for the claims to recite the advantages of the invention. *Id.* at 6–7. Patent Owner asserts that it "was the first to understand, explain, and control the unexpected reduced-resistance effect. [Patent Owner] had the insight; Kim, Schroen, and Iwaguro had none." *Id.* at 8.

It is not clear how Patent Owner's alleged insight over that of Schroen and Iwagaor relate to the claims at issue in this proceeding. According to Dr. Schubert, "it was well-known before 2002 that interposing an interface layer between a metal and a semiconductor at a metal-semiconductor junction could reduce specific contact resistance." Ex. 1017 ¶ 63. Dr Schubert cites the abstract of Schroen as teaching "that the specific contact resistance that could be achieved using a thin insulating interfacial layer between a metal and a semiconductor was 'far smaller than the resistance one would observe in a structure consisting only of the semiconductor metallization layer because the resistance of the structure is dominated by the resistance of the Schottky barrier formed at the metal-semiconductor interface.'" *Id.* ¶ 64 (quoting Ex. 1024 (Schroen), Abstract. Similarly, Dr. Schubert cites Iwagaro as teaching a 0.3 to 2.5 nm silicon sub-oxide layer

between a metal and a semi-conductor and quote Iwagaro disclosure that "[b]y bringing a metal film into contact with this sub silicon oxide film, an ohmic junction exhibiting favorable low contact resistance can be obtained." *Id.* ¶ 67,

In this proceeding, Petitioner cites these references as information that would be known to one of ordinary skill, but does not include them as the basis of a challenge. Pet. 8. We do not speculate on the reasons Petitioner has not relied upon these references in this or other proceedings. Instead, we note that Patent Owner has not produced sufficient evidence to refute Petitioner's contentions. On this record, therefore, Patent Owner has not provided sufficient evidence of a nexus between any unexpected results and the limitations of challenged claims 1–3, and 17–18.

e) Industry praise

Patent Owner notes that in 2004 and 2006, the inventors published two papers describing the invention (Exs. 2045, 2046 (collectively "the Connelly Papers")) that have been cited over 270 times in the professional literature. PO Resp. 42. On this record, Patent Owner has not demonstrated a sufficient nexus between any praise in these papers and specific limitations of claims 1–3, and 17–18. Patent Owner does not identify how the structures described in those papers relate to claims 1–3 and 17–18, which all recite a metal oxide layer (see independent claim 1). Further, Petitioner provides evidence of the contrary. The Connolly papers disclose only a silicon nitride interface layer, which is not a metal oxide interface layer, as claimed. Pet. Reply 25 (citing Ex. 1058, 172:2–10, 175:19–25; Ex. 1061, Second Schubert Decl. ¶ 139). Thus, we give little weight to alleged praise for the Connelly Papers as objective evidence of nonobviousness for claims 1–3 and 17–18.

f) Alleged suspicious behavior

Patent Owner alleges that, in an abstract in 2017, Petitioner's researchers cited the Connelly papers as a basis for their work, but removed the citation when the paper was published in full in 2018. *See* PO Resp. 45–50 (citing Ex. 2047, 1; Ex. 2048, 4879). According to Patent Owner, Petitioner's abstract focused on how contact resistance limits performance in scaling silicon MOSFETs and states that, instead of increased doping, the researchers studied an alternate option, i.e. a metal-interface-semiconductor (MIS) structure that mirrors the challenged independent claims. *Id.* at 47. Patent Owner states that the paper published by Petitioner's researchers in 2018 that did not cite the Connelly Papers "describes in positive terms reducing ρ_c, reducing the height of the Schottky barrier, depinning the Fermi level, and tuning the SBH (Schottky barrier height) between a low work-function metal and n-type silicon." *Id.* at 47–48. According to Patent Owner, there is a nexus between Petitioner's actions and claim 1 of the '261 patent, which recites reducing the Schottky barrier. *Id.* Patent Owner also alleges that Petitioner filed its own patent applications based on Patent Owner's technology. *Id.* at 48–50 (noting the similarity between a graph showing the thickness of the insulating mater and contact resistivity in Petitioner's patent and a graph showing oxide thickness and specific contact resistance in Patent Owner's patents).

Noting that the sentence citing the Connelly Papers in the abstract is not present in the final published paper, Petitioner contends that "[o]mitting a citation when there is no longer relevant information in a paper is ***not*** evidence of any suspicious behavior—it is what authors routinely do" and "even Dr. Kuhn did not cite to the Connelly Papers in her related work," even though she was aware of the Connelly Papers. Pet. Reply 27 (citing

Ex. 1056, Kuhn Tr. 34:4–23). Petitioner further points out that its "graph merely presents what was known in the literature long before [Patent Owner's] patents." *Id.* at 28.

"Suspicious behavior" is not an objective criteria cited in Federal Circuit precedent. Patent Owner provides no testimony concerning the motivations of the authors of the abstract or the published paper and we draw no inferences from the difference in the citations concerning the Connelly Papers.

g) Summary

In consideration of the above, we do not find that the objective evidence supports a conclusion of nonobviousness. Thus, we determine that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, and 17–18 would have been obvious over Jammy.

E. Anticipation of Claims 21–24 by Jammy

1. Claims 21–22

Independent claim 21 recites an electrical junction comprising a conductor, a semiconductor comprising a source or drain of a transistor, and an interface layer disposed therebetween, where the interface layer comprises a metal oxide and has a thickness of approximately 0.1nm to 5nm; and the semicocnductor is selected from a list consisting of Si, Ge, C (a crystal structure of which is selected from a list comprising a diamond lattice, a fulleride or a polymer). Ex. 1001, 18:63–19:4. Unlike claims 1–3 and 17–18 discussed above, challenged as obvious over Jammy, independent claim 21 does not recite that the interface layer is configured to reduce a height of a Schottky barrier between the contact metal and the semiconductor from that which would exist at the contact junction between the metal and the semiconductor without the interface layer.

Petitioner cites Figure 1 of Jammy as disclosing a side view of MOSFET 40 with metal conductive studs 52 and 54 making contact with shallow source/drain diffusion regions 42, 44 (i.e., n or p type doped regions in semiconductor 60), through quantum conductive barrier layers 56, 58. Pet. 57–58. Petitioner notes that Jammy discloses the semiconductor can be one of the claimed semiconductors on the claimed list, i.e., silicon. *Id.* at 58. (citing Ex. 1016, 4:33–38; Ex. 1017, Schubert Decl. ¶ 231). Petitioner cites its earlier discussions of Jammy to support its contentions that Jammy discloses an interface layer comprising a metal oxide having a thickness between 0.1 nm and 5 nm. *Id.* at 59; *see* Ex. 1017, Schubert Decl. ¶¶ 234–235. Claim 22, similar to claim 3, recites that the semiconductor is an n-typed doped source or drain of a transistor. Ex. 1001, 19:5–7.

Patent Owner does not respond to Petitioner's contentions concerning claims 21 and 22 individually. Having reviewed the evidence and arguments of record and in view of our findings concerning claims 1 and 2 discussed above, we find that Petitioner has demonstrated that Jammy discloses all the limitations of claims 21 and 22.

2. Claims 23–24

Claim 23 depends from claim 21 and, similar to claim 3, recites that contact metal is a metal or a stack of metals deposited on the interface layer. Ex. 1001, 19:8–10. Patent Owner does not address claim 23 individually. *See generally* PO Response. In our analysis of claims 1–3 above, we found that Petitioner has demonstrated Jammy discloses that the contact metal is metal or stack of metals. Therefore, we find that Petitioner has demonstrated that Jammy discloses all the limitations of claim 23.

Claim 24 depends from claim 23 and recites that the semiconductor comprises an n-type doped group IV semiconductor. 19:11–13. Patent

Owner does not address claim 24 individually. In our analysis of claims 1 and 2, we found that Jammy discloses that the semiconductor comprises an n-type doped group IV semiconductor. There, we find that Petitioner has demonstrated that Jammy discloses all the limitations of claim 24.

VI. PETITIONER'S MOTION TO EXCLUDE

Petitioner filed a Motion to Exclude. Paper 40 ("Pet. Mot. To Exclude"). Patent Owner filed an Opposition. Paper 42 ("PO Opp."), and Petitioner filed a Reply. Paper 46 ("Pet. Reply to Opp.").

Petitioner moves to exclude paragraphs 8–15, 19–25, 36–45, 47–50, 52–63, 67, 69–70, 72, 76–77, and 81–107 (the "Objected Paragraphs") of Exhibit 2090, the Clifton Declaration, because "during Dr. Clifton's deposition, it became clear that Acorn was offering Dr. Clifton only as a fact witness, not an expert witness and, accordingly, it became apparent that the expert opinions offered in Dr. Clifton's declaration are improper." Pet. Mot. To Exclude 3. Patent Owner offered Dr. Clifton's testimony in support of its objective considerations arguments. *See* Section V.D.4.

Patent Owner contends that Petitioner misconstrues comments made by Patent Owner's counsel during Dr. Clifton's deposition indicating that Dr. Clifton was a fact witness, that Dr. Clifton testified as a hybrid fact-expert witness, that Petitioner failed to timely object to Dr. Clifton's testimony, and that Petitioner's motion is mostly moot because the objective indicia that was the subject of Dr. Clifton's testimony is established independently from the documentation in evidence. *See generally* PO Opp.

Patent Owner asserts that, in *inter partes* reviews, the Board's rules do not specifically distinguish between experts and fact witnesses and that all witnesses (whether fact witnesses or expert witnesses) provide their direct

testimony in the form of declarations. PO Opp. 2. This is in contrast to procedures in district courts, where expert witnesses must be designated and special discovery procedures apply. *Id.* (citing Fed. R. Civ. P. 26(a)(2)). Although, as a procedural matter, Patent Owner correctly characterizes the difference between district court proceedings and those before the Board, we do not endorse a standard that would allow a party to re-characterize a witness's testimony after the fact. In this case, however, we need not decide that issue.

At his deposition, Dr. Clifton stated that he understood himself to be testifying as a fact witness, not an expert (Pet. Reply to Opp. 1, citing 1058, Clifton Tr. 100:2–12) and Dr. Clifton's declaration includes information that demonstrates sufficient knowledge of facts for admissibility (*see* Ex. 2090, Clifton Decl. ¶¶ 3–6 (describing his education, his technical research in MIS junctions (although not specifically concerning contact resistance), his years of experience, his employment by Patent Owner since 2004, and his current role as Vice President of Semiconductor Technologies)). We do not agree with Petitioner that Dr. Clifton's occasional use of the expression "I believe" itself transforms his testimony from fact to opinion concerning the objective criteria. *See* Pet. Mot. To Exclude 6. Much of the testimony in Dr. Clifton's declaration concerning the long felt need in the industry, what the patents describe, the Connelly papers, the work that led up to the structures Patent Owner developed, the reactions of other researchers in the field, and the unexpected nature of the results, is based on events that occurred shortly before or while Dr. Clifton was employed by Patent Owner and derive from Dr. Clifton's personal knowledge. In light of his background and the largely factual nature of his testimony, Petitioner's arguments for excluding Dr.

Clifton's testimony concern the weight that we should accord his testimony, rather than its admissibility.

In consideration of the above, we deny Petitioner's Motion to Exclude the testimony of Dr. Clifton.

VII. PATENT OWNER'S MOTION TO EXCLUDE

Patent Owner filed a Motion to Exclude. Paper 39 ("PO Mot. To Exclude"). Petitioner filed an Opposition. Paper 43 ("Pet. Opp."). Patent Owner filed a Reply to Petitioner's Opposition. Paper 45 ("PO Reply to Opp.").

A. Patent Owner's Motion to Exclude the Goodnick Testimony

Patent Owner moves to exclude portions of the deposition testimony of its own expert, Dr. Stephen Goodnick, as outside the scope of the challenged claims. PO Mot. To Exclude 1. In particular, Patent Owner moves to exclude testimony elicited on cross examination concerning whether certain metal oxides fall within the scope of the challenged claims. *Id.* (citing Ex. 1060, Goodnick Tr., 65:20–66:17, 113:20–117:23, and 137:17–141:10 (collectively, the "Goodnick Metal-Oxide Testimony")). According to Patent Owner "that questioning bears no relation to any issue in this IPR." *Id.* Patent Owner argues that "nothing in Dr. Goodnick's declaration even remotely addresses the interpretation of 'metal oxide' in the challenged claims, what is or is not a 'metal oxide,'" but that his "declaration instead concerns primarily the Goodnick paper, particularly whether a person of ordinary skill in the art (POSITA) would understand it as disclosing distinct stratified layers of Al_2O_3 and SiO." *Id.* at 2.

In opposition, Petitioner argues that Dr. Goodnick's first declaration (Ex. 2043), which in its entirety is incorporated by reference in Dr. Goodnick's second declaration (Ex. 2080), includes statements directed to

the composition of the various layers in a prior art structure, including a metal oxide layer. Pet. Opp. 2 (citing Ex. 2043, Goodnick Decl. ¶ 53). Noting Dr. Goodnick's testimony that the Goodnick Paper does not teach distinct layers, but instead that Al_2O_3 and SiO_2 form a "checkerboard" pattern, Petitioner asserts that questioning Dr. Goodnick on what constitutes a distinct metal oxide layer was proper. *Id.* at 2–3.

Patent Owner contends that Dr. Goodnick's declaration did not open the door for general questioning about metal oxides. PO Reply to Opp. 2–3. Petitioner argues that the proper scope of cross examination includes Dr. Goodnick's understanding of what constitutes a distinct metal oxide layer. Pet. Opp. 3. Although Petitioner's challenges in this proceeding do not rely on Goodnick, Petitioner cites Goodnick as one of several references that teach "interface layers that depin a Fermi level by passivating the semiconductor surface (thereby satisfying dangling bonds and reducing Bardeen states) and reducing the effects of metal-induced gap states." Pet. 11; PO Resp. 28.

In the context of this proceeding, Petitioner acknowledges that Dr. Goodnick did not consider Jammy. Pet. Reply 14. We agree with Petitioner that, in this proceeding's briefing, Patent Owner does not discuss the subject matter of Dr. Goodnick's deposition that Patent Owner seeks to exclude. The subject testimony from Dr. Goodnick's deposition documented in Exhibit 1060 can be characterized as follows: (i) the subject testimony at pages 65 and 66 concerns whether the presence of trace amounts of oxygen in a silicide layer constitute a metal oxide, (ii) the subject testimony at pages 113:20–117:23 concerns the amount of oxygen present to form an oxide layer, and (iii) the subject testimony at pages 137:17–141:10 concerns the meaning of "metal oxide" in the context of Patent Owner's patents.

The issue before us is whether Jammy would have taught or suggested to a person of ordinary skill the limitations of the claims, which include claims drawn to a metal oxide interface layer. Although Dr. Goodnick's testimony is not relied upon specifically as to Jammy and therefore may have little weight in the context of this proceeding, his testimony about what constitutes a metal oxide is relevant, particularly concerning the effect such structures may have on dangling bonds and MIGs. Therefore, it was proper for Petitioner to explore Dr. Goodnick's views concerning the composition of a metal oxide layer during cross examination.

In consideration of the above, Patent Owner's motion to exclude the Goodnick Metal-Oxide testimony is denied.

B. Patent Owner's Motion to Exclude Dr. Kuhn's Cross Examination Testimony

Patent Owner also moves to exclude deposition testimony of its expert, Dr. Kuhn, about claim limitations that recite an "oxide of titanium." PO Mot. to Exclude 7. Patent Owner asserts that "the 'oxide of titanium' limitation was not substantively addressed in this or any other IPR petition, and Dr. Kuhn never addressed it in her declaration (Ex. 2070)." *Id.*

The Petition argues that "Grupp '483 discloses a metal oxide layer: titanium dioxide." Pet. 27 (citing Ex. 1017, Schubert Decl. ¶ 128), *see also id.* at 38, 42–43 (concerning Jammy's incorporation by reference of Cote). The Petitioner also notes that in the Related Litigation, Patent Owner asserts that titanium silicon oxide (TiSiO) is a metal oxide interface layer. *See id.* at 43 fn. 2. According to Petitioner "the Oxide-of-Titanium Testimony relates to Dr. Kuhn's understanding of the scope of the 'oxide of titanium' claim limitations, which Dr. Kuhn opined on in her declaration." Pet. Opp. 8 (citing Ex. 2070, Kuhn Decl. ¶ 114).

The parties do not identify any claims in this proceeding that recite an oxide of titanium. We do not address specifically claims drawn to an oxide of titanium in other proceedings and do not consider the testimony Patent Owner seeks to exclude concerning the titanium oxide genus and various species of titanium oxide. *See* PO Mot. to Exclude 7–11. For purposes of this proceeding, we dismiss Patent Owner's Motion to Exclude the Kuhn oxide of titanium testimony as moot.

VIII. OTHER ISSUES

A. Appointments Clause

Patent Owner contends that the America Invents Act (AIA) violated the appointments clause. PO Resp. 53.

The Supreme Court resolved this issue in *United States v. Arthrex, Inc.*, 141 S. Ct. 1970 (2021).

B. Structural Bias

Patent Owner argues that "[t]he Board's handling of this IPR is structurally biased in a way that has violated Acorn's due-process rights" because the Director's delegation of the authority determine whether to institute and try this case "results in an improper structural bias because the Board has a strong financial incentive to institute trials." *See* PO Resp. 53–54.

This argument was rejected by the Federal Circuit in *Mobility Workx, LLC v. Unified Patents*, LLC, 15 F.4th 1146 (Fed. Cir. 2021).

C. Petitioner's Stipulation

Patent Owner argues that "[t]he Board's eleventh-hour invitation to the petitioner to revise its stipulation regarding parallel validity challenges in the district court . . . violated *SAS Institute Inc. v. Iancu*, 138 S. Ct. 1348 (2018), due-process, and fundamental notions of fairness." PO Resp. 56–57.

Patent Owner contends that "Acorn invested its limited resources in these IPRs and the related litigation and chose which arguments to make based on the petition and the stipulation therein" but "after Acorn had made those significant investments, the Board allowed the petitioner to alter its case, indeed the Board invited and encouraged such revision." *Id.* at 57 (emphasis omitted).

This argument is unpersuasive. The stipulation did not change the contours of, or "curate," the Petition; instead, in accordance with the precedential case of *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB December 1, 2020), Petitioner simply stipulated not to bring the same arguments in the District Court.[6]

IX. CONCLUSION[7]

Having reviewed the arguments and evidence of records, for the reason discussed above, we find that Petitioner has demonstrated by a preponderance of the evidence that Grupp '483 is prior art to the challenged

---

[6] *Sotera Wireless* issued and was designated precedential (on December 1, 2020 and December 17, 2020, respectively) after the Petition and Petitioner's Preliminary Reply were filed (on July 18, 2020 and October 16, 2020, respectively).

[7] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding. See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

claims of the ’261 patent and that the challenged claims are anticipated by Grupp ’483.

, We also find that Petitioner has demonstrated by a preponderance of the evidence that claims 1–3, and 17–18 are obvious over Jammy and that claims 21–24 are anticipated by Jammy.

In summary:

Claims	**35 U.S.C. §**	**Reference(s)/Basis**	**Claims Shown Unpatentable**	**Claims Not shown Unpatentable**
1–3, 17–18, 21–24	102	Grupp ’483	1–3, 17–18, 21–24	
1–2, 17–18	103	Jammy	1–3, 17–18	
21–24	102	Jammy	21–24	
Overall Outcome			1–3, 17–18, 21–24	

X. ORDER

In consideration of the above it is:

ORDERED that claims 1–3, 17–18, and 21–24 are unpatentable;

FURTHER ORDERED that Petitioner’s Motion to Exclude Dr. Clifton’s testimony id DENIED;

FURTHER ORDERED that Patent Owner’s Motion to Exclude Dr. Goodnick’s testimony is DENIED;

FURTHER ORDERED that Patent Owner’s Motion to Exclude Dr. Kuhn’s testimony is DISMISSED as moot; and

FURTHER ORDERED that 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.

PETITIONER

Yung-Hoon Ha
Theodoros Konstantakopoulos
John M. Desmarais
Cosmin Maier
Christian Dorman
DESMARAIS LLP
yha@desmaraisllp.com
tkonstantakopoulos@desmaraisllp.com
jdesmarais@desmaraisllp.com
cmaier@desmaraisllp.com
cdorman@desmaraisllp.com

PATENT OWNER

Matthew Phillips
Tarek Fahmi
Kevin Laurence
Derek Meeker
Rachel Slade
LAURENCE & PHILLIPS IP LAW
mphillips@lpiplaw.com
tarek.fahmi@ascendalaw.com
klaurence@lpiplaw.com
dmeeker@lpiplaw.com
rslade@lpiplaw.com