

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
Petitioner,

v.

ACORN SEMI, LLC,
Patent Owner.

IPR2020-01282
Patent 10,090,395 B2

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

KENNY, *Administrative Patent Judge*.

DECISION

Final Written Decision

Determining Some Challenged Claims Unpatentable

Dismissing Patent Owner's Motion to Exclude

Denying Petitioner's Motion to Exclude

35 U.S.C. § 318(a)

I. INTRODUCTION

Samsung Electronics Co., Ltd. (“Petitioner”) filed a Petition, Paper 2 (“Petition” or “Pet.”), to institute an *inter partes* review of claims 1–6, 8–12, and 14–28 (“challenged claims”) of U.S. Patent No. 10,090,395 B2 (Ex. 1101, “’395 patent”). Acorn Semi LLC (“Patent Owner”) filed a Preliminary Response, Paper 10 (“Prelim. Resp.”), contending that the Petition should be denied as to all challenged claims.

On February 10, 2021, we instituted an *inter partes* review of all challenged claims. Paper 20 (“Institution Decision” or “Inst. Dec.”). Patent Owner filed a Patent Owner Response (Paper 28, “PO Resp.”) and an Updated Mandatory Notice reporting a jury verdict in a related district court litigation (Paper 30; Ex. 2121). Petitioner filed a Reply (Paper 37, “Pet. Reply”), and Patent Owner filed a Sur-reply (Paper 42, “PO Sur-reply”).

Petitioner filed a Motion to Exclude certain testimony by Dr. Paul Clifton. (Paper 44, “Pet. Mot. Excl.”). Patent Owner filed an Opposition to Petitioner’s Motion to Exclude (Paper 46, “Opp. to Pet. Mot. Excl.”), and Petitioner filed a Reply to Patent Owner’s Opposition to Petitioner’s Motion to Exclude (Paper 50, “Reply Pet. Mot. Excl.”).

Patent Owner filed a Motion to Exclude certain cross-examination testimony of its witnesses, Dr. Kelin J. Kuhn and Dr. Stephen Goodnick (Paper 43, “PO Mot. Excl.”). Petitioner filed an Opposition to Patent Owner’s Motion to Exclude (Paper 47, “Opp. to PO Mot. Excl.”), and Patent Owner filed a Reply to Petitioner’s Opposition to Patent Owner’s Motion to Exclude (Paper 49, “Reply Pet. Mot. Excl.”).

A transcript of an oral hearing held on October 13, 2021 (Paper 55, “Tr.”) has been entered into the record.

We have jurisdiction under 35 U.S.C. § 6. For the reasons discussed below, we determine that Petitioner has shown, by a preponderance of the evidence, that claims 1–5 and 8–10 are unpatentable. Petitioner, however, has not shown, by a preponderance of the evidence, that claims 6, 11, 12, and 14–28 are unpatentable.

A. Related Matters

The Petition states that the '395 patent is asserted in *Acorn Semi, LLC v. Samsung Electronics Co. Ltd.*, Civil Action No. 2:19-cv-347 (E.D. Tex.) (“Related Litigation”), and that the complaint was served on October 24, 2019. Pet. 3 (citing Ex. 1158).

Petitioner and Patent Owner identify IPR2020-01207 (“1207 IPR”) as also concerning the '395 patent. Pet. 3; Paper 4, 2. Petitioner and Patent Owner also identify *inter partes* reviews concerning patents related to the '395 patent that may be affected by the outcome of this proceeding. See Pet. 3, Paper 4, 2. Petitioner and Patent Owner also identify patents and patent applications that are related to the '395 patent. See Pet. 3, Paper 4, 1.

B. The '395 Patent

The '395 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. 1101, 1:32–35. The '395 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 1:52–64. Because 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 3:10–21.

The '395 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 the barrier height with the work function than implied by this model. Ex. 1101, 1:55–2:9. 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 2:10–24, Fig. 1 (showing dangling bonds 120). 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 2:25–31.

According to the '395 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. Ex. 1101, 2:41–47. 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 2:50–54.

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 2:54–63. The '395 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 3:2–6.

According to the '395 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.” Ex. 1101, 3:6–9. “Before one can tune the barrier height, however, one must depin the Fermi level of the semiconductor.” *Id.* at 3:16–18. The '395 patent seeks to depin the Fermi level of the semiconductor while still permitting substantial current flow between the metal and the semiconductor. *Id.* at 3:18–21. The '395 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 3:36–41. The '395 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” with minimum specific contact resistances. *Id.* at 3:25–29. “The interface layer thickness corresponding to this minimum specific contact resistance will vary depending upon the materials used.” *Id.* at 3:29–36. That thickness, however, “allows for depinning the Fermi level of the semiconductor while still permitting current to flow between the metal and semiconductor when the junction is biased.” *Id.* “Minimum specific contact resistances of less than or equal to approximately $10\ \Omega\text{-}\mu\text{m}^2$ or even less than or equal to approximately $1\ \Omega\text{-}\mu\text{m}^2$ may be achieved for such junctions in accordance with the present invention.” *Id.* at 3:42–45. 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 5:30–34.

Figure 8 of the '395 patent is reproduced below:

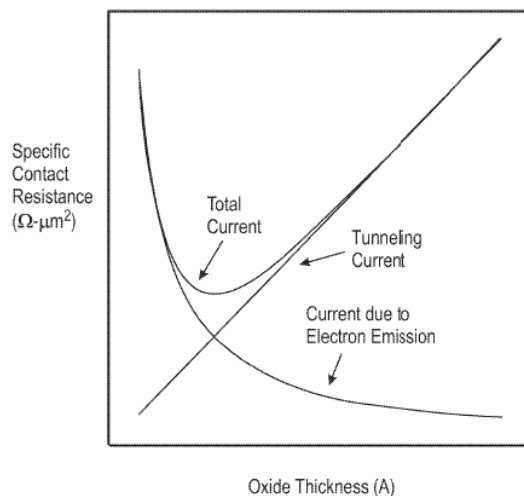


Figure 8 of the '395 patent

Figure 8 above 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.

Ex. 1101, 14:42–48. According to the '395 patent, Figure 8 shows that, at large thicknesses, the interface layer poses significant resistance to current, but as the interface layer thickness decreases, resistance falls due to increased tunneling current. *Id.* at 14:48–51. 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 14:51–55. 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 $2500\ \Omega\text{-}\mu\text{m}^2$, $1000\ \Omega\text{-}\mu\text{m}^2$, $100\ \Omega\text{-}\mu\text{m}^2$, $50\ \Omega\text{-}\mu\text{m}^2$, $10\ \Omega\text{-}\mu\text{m}^2$, or less than $1\ \Omega\text{-}\mu\text{m}^2$ reportedly can be achieved. *Id.* at 14:56–65.

In one embodiment, an electrical device has an interface layer that 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. Ex. 1101, 3:46–59. The specific contact resistance for this electrical device is reported to be less than $10\ \Omega\text{-}\mu\text{m}^2$. *Id.* at 3:52–53. In another embodiment, the interface layer consists of a passivation layer fabricated by exposing the semiconductor to nitrogenous material (e.g., ammonia (NH_3), nitrogen (N_2) or unbound gaseous nitrogen (N) generated from a plasma process). *Id.* at 3:60–64. Another embodiment uses an interface layer of passivating material disposed between the surface of a

semiconductor and a conductor, in which the interface layer is of a 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 4:1–14.

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) to 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. Ex. 1101, 4:15–26. Specific contact resistances of less than or equal to approximately $2500\ \Omega\text{-}\mu\text{m}^2$, $1000\ \Omega\text{-}\mu\text{m}^2$, $100\ \Omega\text{-}\mu\text{m}^2$, $50\ \Omega\text{-}\mu\text{m}^2$, $10\ \Omega\text{-}\mu\text{m}^2$, or less than $1\ \Omega\text{-}\mu\text{m}^2$ reportedly can be achieved. *Id.* at 4:27–30.

C. Claims

As mentioned, Petitioner challenges claims 1–6, 8–12, and 14–28, of which claims 1, 17, and 23 are independent. Claim 1 reads:

1. An electrical junction, comprising a region in a semiconductor substrate, a metal electrical contact to said region, and an interface layer between said region and said metal electrical contact, said region being electrically connected to said metal electrical contact through said interface layer and said interface layer comprising a metal oxide and a semiconductor oxide, and being in contact with said region in the semiconductor substrate and said metal electrical contact.

Ex. 1101, 18:45–52.

D. Asserted Grounds

Petitioner asserts that the challenged claims would have been unpatentable based on the following grounds (Pet. 9–10):

Ground	Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1	1–3, 8–10	102(b)	Goodnick ¹
2	4	103(a)	Goodnick, Jammy ²
3	5	103(a)	Goodnick
4	1, 11, 12, 15, 23–25, 28	103(a)	Goodnick, Taubenblatt 1982 ³
5	14, 17–19, 22	103(a)	Goodnick, Jammy, Taubenblatt 1982
6	6	103(a)	Goodnick, Jammy, Taubenblatt 1982, Chang ⁴
7	16, 26, 27	103(a)	Goodnick, Taubenblatt 1982, Kim ⁵
8	20, 21	103(a)	Goodnick, Jammy, Taubenblatt 1982, Kim

E. Level of Ordinary Skill in the Art

Petitioner describes an ordinarily skilled artisan as having any of the following combinations of education and experience:

¹ S.M. Goodnick et al., *Effects of a thin SiO₂ layer on the formation of metal-silicon contacts*, 18 J. VAC. SCI. & TECH. 949 (Apr. 1981) (Ex. 1121).

² U.S. Patent No. 6,724,088 B1 (Ex. 1122).

³ M.A. Taubenblatt and C.R. Helms, *Silicide and Schottky barrier formation in the Ti-Si and the Ti-SiO_x-Si systems*, 58 J. APPLIED PHYS. 6308 (1982) (Ex. 1123).

⁴ C.Y. Chang et al., *Specific contact resistance of metal-semiconductor barriers*, 15 SOLID STATE ELECS. 541 (1971) (Ex. 1124)

⁵ U.S. Patent No. 4,845,050 (Ex. 1125).

[i] a Ph.D. in electrical engineering, physics, materials science, or chemical engineering, with two years of practical experience with semiconductor research and design;

[ii] a Master's degree in electrical engineering, physics, materials science, or chemical engineering, with four years of practical experience with semiconductor research and design; or

[iii] a Bachelor's degree in electrical engineering, physics, materials science, or chemical engineering, with six to eight years of practical experience with semiconductor research and design.

Pet. 14 (citing Ex. 1126, Schubert Decl. ¶¶ 70–71).

The Patent Owner Preliminary Response did not comment on the level of ordinary skill in the art. In our Institution Decision, we were persuaded that Petitioner's description of the level of ordinary skill is appropriate for the subject matter of the '395 patent and applied it in that Decision. Inst. Dec. 9–10. The Patent Owner Response does not comment on the level of ordinary skill in the art. *See generally* PO Resp. Thus, we apply the description of the level of ordinary skill set forth in the Petition in this Decision. Ex. 1126, Schubert Decl. ¶ 66.

II. CLAIM CONSTRUCTION

For petitions filed after November 13, 2018, we interpret claim terms using “the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” 37 C.F.R. § 42.100(b) (2019). In this context, claim terms “are generally given their ordinary and customary meaning” as understood by a person of ordinary skill in the art in question at the time of the invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (citations omitted) (en banc). “In determining the meaning of the disputed claim limitation, we look principally to the intrinsic evidence of record, examining the claim language itself, the written

description, and the prosecution history, if in evidence.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 469 F.3d 1005, 1014 (Fed. Cir. 2006) (citing *Phillips*, 415 F.3d at 1312–17). Extrinsic evidence is “less significant than the intrinsic record in determining ‘the legally operative meaning of claim language.’” *Phillips*, 415 F.3d at 1317 (citations omitted).

Any special definition for a claim term must be set forth in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

We construe only those claim terms that require analysis to determine whether to institute *inter partes* review. See *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) (holding that “only those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy”).

A. Depin a Fermi Level of the Metal Electrical Contact in the Vicinity of the Junction

Petitioner proposes that the phrase “depin a Fermi level of the metal electrical contact in the vicinity of the junction,” recited in claim 5, should be construed as “passivate the semiconductor surface and reduce the effects of metal-induced gap states in the semiconductor.” Pet. 15. According to Petitioner, “[t]he specification consistently describes that depinning a Fermi level involves passivating the semiconductor surface and reducing the effects of metal-induced gap states in the semiconductor.” *Id.* In the Preliminary Response, Patent Owner supported this construction. Prelim. Resp. 44 (“In the Acorn patents, depinning the Fermi level requires two things: (1) passivating the semiconductor surface by satisfying dangling bonds and (2) reducing the effects of MIGs.”). The Specification supports

Petitioner's proposed construction by providing the following definition for the phrase "depinning the Fermi level":

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.

Ex. 1101, 3:36–41.

In view of this definition in the Specification and the parties' agreement in pre-institution briefing, we construed the phrase "depin a Fermi level of the metal electrical contact in the vicinity of the junction" as "passivate the semiconductor surface and reduce the effects of metal-induced gap states in the semiconductor" in our Institution Decision. Patent Owner has not requested that we modify that construction. *See generally* PO Resp. Thus, we maintain it.

B. Specific Contact Resistivity

Petitioner argues that the term "specific contact resistivity," recited in claims 5 and 6, should be construed as interchangeable with the term "specific contact resistance." Pet. 16–17. Petitioner asserts that the Specification of the '395 patent and the claims of the '395 patent use those terms interchangeably. *Id.* at 16 (citing Ex. 1101, 3:25–29, 3:42–45, 3:52–53, 4:22–30). Petitioner further asserts that those working in the art commonly used those terms interchangeably. *Id.* at 16–17 (citing Ex. 1134, 2; Ex. 1126, Schubert Decl. ¶¶ 74–76). In the Preliminary Response, Patent Owner did not respond to this proposed construction.

In our Institution Decision, we construed the terms "specific contact resistivity" and "specific contact resistance" to be interchangeable. Patent

Owner has not requested that we modify this construction. *See generally* PO Resp. Thus, we maintain it.

C. An Interface Layer Comprising a Metal Oxide and a Semiconductor Oxide

In its Preliminary Response, Patent Owner argued that, in the related litigation, Petitioner and Patent Owner agreed to construe the phrase an “interface layer comprising a metal oxide and a semiconductor oxide” as “said interface layer comprising a layer of a metal oxide and a *distinct* layer of a semiconductor oxide.” Prelim. Resp. 35 (citing Ex. 2009). Patent Owner asserted that the district court adopted that construction. *Id.* (citing Ex. 2053, 27). In our Institution Decision, we found that the record supported Patent Owner’s arguments. Inst. Dec. 13 (citing Ex. 2009; Ex. 2053, 27). Further, in our Institution Decision, we noted that no party argued that we should construe the phrase differently than the district court. *Id.* Thus, we construed “an interface layer comprising a metal oxide and a semiconductor oxide” as “said interface layer comprising a layer of a metal oxide and a distinct layer of a semiconductor oxide.” *Id.* No party has requested that we modify this construction. *See generally* PO Resp., Pet. Reply. Thus, we maintain it.

III. ANALYSIS OF ASSERTED GROUNDS

“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 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) (citation omitted); *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, however, 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 an ordinarily skilled artisan 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 an ordinarily skilled artisan. *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 would have been 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).

A. Ground 1: Asserted Anticipation by Goodnick

Petitioner asserts that Goodnick anticipates claims 1–3 and 8–10. Pet. 9.

1. Goodnick

Goodnick concerns experiments “to observe the influence of thin SiO₂ layers on the chemical formation of metal-silicon contacts.” Ex. 1121, 1.⁶

⁶ For this exhibit, we cite the page numbers added by Petitioner.

According to Goodnick, a thick interfacial oxide at a metal-silicon interface suppresses current, thereby reducing rectifying characteristics. *Id.* A sufficiently thin oxide, however, may sustain considerable current via tunneling and may reduce the density of interface states by satisfying dangling bonds. *Id.* Goodnick discloses that, as a result, with a sufficiently thin oxide:

the Fermi level at the surface may become unpinned and the barrier height is more directly determined by the metal work function. In addition, a thin interfacial layer may act as a barrier to the chemical reaction and interdiffusion that characterizes the intimate metal silicon contact. Thus, the presence of a thin oxide at the interface acts as a passivating influence, both from an electronic and a chemical standpoint.

Id.

Goodnick investigates three metals (aluminum, platinum, and gold) and grew SiO₂ at 700 degrees Celsius to approximately 30Å. Ex. 1121, 1. Goodnick reports that the 30Å thermally grown SiO₂ appeared as a complete barrier to the formation of platinum silicide and less of a barrier to the Au-Si reaction, where “widespread dissolution of the SiO₂ layer and reaction between the Au and Si appeared to occur.” *Id.* at 5. “Al partially reduces the thin SiO₂ layer to form Al₂O₃ and free Si. This reaction appeared to be self-limiting, with SiO₂ still present at the interface, even after heating at 400°C.” *Id.* Goodnick concludes:

a thermally grown SiO₂ layer appears effective in preventing or retarding the widespread interdiffusion of elemental Si. However, chemically etched surfaces react readily with the metal overlayer even though a thin native oxide grows prior to deposition. The different chemical nature of room temperature air grown oxides of Si is suggested as an explanation of these results.

Id.

2. *Claim 1*

a. An electrical junction

Petitioner asserts that, if the preamble of claim 1 is limiting, Goodnick discloses it by describing an Al–Al₂O₃–SiO₂–Si contact structure. Pet. 21 (citing Ex. 1121, Goodnick, 1–2, 5; Ex. 1126, Schubert Decl. ¶ 118). Petitioner further asserts that the Specification of the '395 patent uses the terms “contact” and “junction” interchangeably. *Id.* Patent Owner presents no counterargument regarding the preamble of claim 1. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses the preamble of claim 1.⁷

b. a region in a semiconductor substrate

Petitioner argues that Goodnick discloses “a region in a semiconductor substrate” by describing a silicon substrate. Pet. 22 (citing Ex. 1121, Goodnick, 1; Ex. 1126, Schubert Decl. ¶ 122). Patent Owner presents no counterargument regarding this limitation. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses this limitation.

c. a metal electrical contact to said region

Petitioner asserts that Goodnick discloses “a metal electrical contact to said region” by describing the “chemical formulation of metal-silicon contacts” and by describing aluminum as an example of a metal electrical contact. Pet. 22 (citing Ex. 1121, Goodnick, 1; Ex. 1126, Schubert Decl. ¶ 123). Patent Owner presents no counterarguments regarding this limitation. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses this limitation.

⁷ For this reason, we do not need to determine whether the preamble of claim 1 is limiting.

d. an interface layer between said region and said metal electrical contact

Petitioner asserts that Goodnick discloses “an interface layer between said region and said metal electrical contact” by describing a process that produces an Al_2O_3 – SiO_2 interface layer between the silicon substrate and the aluminum. Pet. 22 (citing Ex. 1121, Goodnick, 1–2, 5; Ex. 1126, Schubert Decl. ¶ 124). Patent Owner presents no counterargument regarding this limitation. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses this limitation.

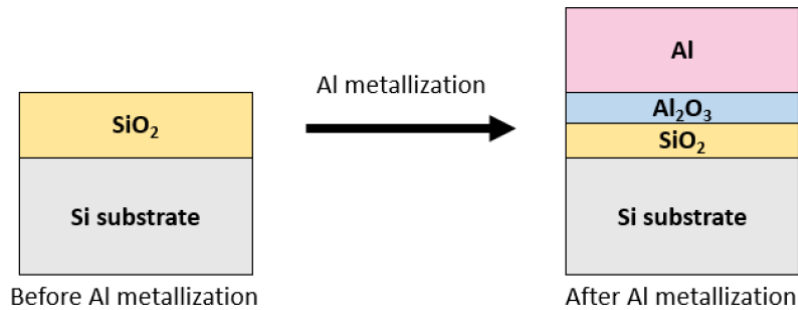
e. said region being electrically connected to said metal electrical contact through said interface layer

Petitioner asserts that Goodnick discloses “said region being electrically connected to said metal electrical contact through said interface layer” by characterizing its Al – Al_2O_3 – SiO_2 – Si contact as a “metal-silicon contact” and by describing that its interfacial oxide layers are thin while indicating that “an oxide layer that is sufficiently thin may sustain considerable current via tunneling.” Pet. 23 (citing Ex. 1121, Goodnick, 1, 5; Ex. 1126, Schubert Decl. ¶ 126). Patent Owner presents no counterargument regarding this limitation. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses this limitation.

f. said interface layer comprising a metal oxide and a semiconductor oxide

Petitioner asserts that Goodnick discloses this limitation by describing that the results from experiments indicated that SiO_2 and Al_2O_3 existed simultaneously at the interface, probably resulting from diffusion barrier formed by the Al_2O_3 layer to the transport of Al to the SiO_2 layer. Pet. 23 (citing Ex. 1121, Goodnick, 1, 5; Ex. 1126, Schubert Decl. ¶ 125–126).

Petitioner proposes the schematic depiction of the involved metallization process and the resulting contact shown below:



Petitioner's Depiction of Goodnick's Metallization Process

Id. at 18 (citing Ex. 1121, Goodnick, 1–2, 5; Ex. 1126, Schubert Decl. ¶¶ 80–86). As illustrated above, Petitioner contends that, after metallization, the contact has a distinct metal contact layer of Al and a metal oxide layer, Al_2O_3 . Petitioner's depiction is illustrative and is not reproduced from Goodnick.

Patent Owner argues that Goodnick does not disclose a stratified layer of Al_2O_3 distinct from SiO_2 , as depicted in the Petition. PO Resp. 60.

Patent Owner states that “[a]ll challenges in the petition utilize Goodnick as the primary reference and are based on Goodnick disclosing distinct stratified layers of different material, including a layer of Al_2O_3 , as shown in various petitioner-created diagrams in the petition.” PO Resp. 52. (citing Pet. 18, 21 and reproducing a portion of Petitioner's metallization diagram shown above).⁸ *Id.* Patent Owner argues that, notwithstanding Petitioner's diagrams that purport to illustrate Goodnick teaching clean

⁸ Patent Owner also references its Preliminary Response, which notes that in district court litigation the parties agreed that claim limitation 1(iii) and 1(iv) “require two distinct layers: (1) a passivating dielectric tunnel barrier layer (comprising semiconductor oxide) and (2) a metal oxide layer.” *Id.*, Prelim. Resp. 38–39.

stratification of distinct layers, Goodnick includes no such diagrams, only uses the term “layer” twice, and does not support the Petition’s assertions. *Id.* at 18 (citing Ex. 2043, Declaration of Dr. Stephen Goodnick (“Goodnick Decl.”); Ex. 2080, Second Declaration of Dr. Stephen M. Goodnick (“2nd Goodnick Decl.”)).

Dr. Goodnick, who authored the Goodnick reference, states that Petitioner and Dr. Schubert have “misinterpreted key aspects of my paper.” Ex. 2043, Goodnick Decl. ¶ 5. Noting the conventional understanding at the time of his paper was that imperfections in the surface layer, i.e. “dangling bonds,” caused the Fermi level to be pinned, Dr. Goodnick states that his reference to the Fermi level becoming unpinned “refer[s] only to the fact that dangling bonds in the silicon are passivated by the oxide layer.” *Id.* ¶ 43. Dr. Goodnick also states that, at the time of his paper, the phenomenon of MIGS was poorly understood and “the interaction of pinning due to MIGS and pinning due to dangling surface bonds had not been explored.” *Id.* ¶ 44. According to Dr. Goodnick, the inventors

realized that those two pinning mechanisms can be jointly addressed leading to better results . . . they were able to discover that there is an optimum thickness at which the beneficial reduction of pinning by MIGS suppression is negated by the adverse increase in tunneling resistance as the interfacial layer is made thicker.

Id. ¶ 45 (referring to Figure 8 of the ’395 patent).

The specific issue before us is what an ordinarily skilled artisan would have understood from the Goodnick reference. Dr. Schubert contends that such an artisan would have understood Goodnick to disclose the claimed layered structure. *See* Ex. 1126, Schubert Decl. ¶¶ 79–87 (at ¶ 82 quoting Goodnick’s description of Figure 8(b) that “[i]n contrast to the air exposed

sample, an Al_2O_3 layer exists at the Al-SiO₂-Si interface”). Dr. Goodnick indicates that an ordinarily skilled artisan at the time would not have understood his paper to mean there is a layer of Al_2O_3 on top of a layer of SiO₂, but only that Al_2O_3 and SiO₂ were found together in the interface region between the aluminum and the semiconductor. See Ex. 2043 ¶¶ 32–40; Ex. 2080, 2nd Goodnick Decl. ¶¶ 8–9.

Figure 8(a) of Goodnick shows “[p]eak to peak Auger sputter profile Al on room temperature oxidized Si, unheated” and Figure 8(b) of Goodnick shows “[p]eak to peak Auger profile of Al on 30 Å SiO₂, unheated.”

Ex. 1121, 5. Responding to Petitioner’s assertions concerning the case where 30Å of SiO₂ was first placed on the silicon before depositing the aluminum, Dr. Goodnick refers to Figure 8(b) of his paper, on which the X-axis is sputter time. Ex. 2043, Goodnick Decl. ¶¶ 32–34; Ex. 2080, 2nd Goodnick Decl. ¶ 8. Referring to Figures 8(a) and 8(b) of his paper, Dr. Goodnick testifies that the high levels of Al_2O_3 shown between 0 and 5 minutes represent Al_2O_3 ’s presence on the top surface of the aluminum, and the high level of aluminum between 10 minutes and 30 minutes corresponds to the aluminum deposition. Ex. 2043, Goodnick Decl. ¶ 33. According to Dr. Goodnick, the high level of silicon after 50 minutes corresponds to the silicon substrate, and the high levels of aluminum and silicon between 30 and 50 minutes is the aluminum-silicon interface. *Id.* Dr. Goodnick further testifies that Figure 8(b) shows that Al_2O_3 and SiO₂ were present at the aluminum silicon interface, but “it cannot be determined where Al_2O_3 is present with respect to SiO₂.” *Id.* ¶ 34. Dr. Goodnick asserts that the presence of a peak in the Al_2O_3 curve at about 40 minutes and the “O” curve (representing SiO₂) between 35 and 40 minutes and the fact that both curves have the same general shape “means that both compounds were found in the

same relative quantities in the interface region.” *Id.* According to Dr. Goodnick, “[an ordinarily skilled artisan] understanding this data would not conclude that there is a layer of Al_2O_3 on top of a layer of SiO_2 as Samsung claims . . . only that both Al_2O_3 and SiO_2 were found together in the interface region between the aluminum and the silicon.” *Id.*

Nevertheless, comparing Figures 8a and 8b, the Goodnick reference expressly states:

Figure 8(a) shows the peak-to-peak profile of an unheated sample with an air grown oxide. It appears that Si has diffused into the Al and collected at the Al_2O_3 -Al interface at the surface. No buildup of Al_2O_3 is seen at the Al-Si interface. Figure 8(b) is a profile of an unheated sample with 30Å SiO_2 at the interface. *In contrast to the air exposed sample, an Al_2O_3 layer exists at the Al- SiO_2 -Si interface.* This is suggestive of the reduction reaction seen previously, with the presence of SiO_2 necessary for formation of Al_2O_3 . Heat treatment of samples resulted in little change in the profiles with the exception of greater concentration of Si at the surface of the unoxidized samples.

Ex. 1121, 5 (emphasis added).

The Goodnick reference further states that, even at elevated temperatures, the results imply that the reaction is self-limiting “probably [as] a result of the diffusion barrier formed by the Al_2O_3 layer to the transport of Al to the SiO_2 layer.” Ex. 1121, 5. Dr. Goodnick now states that “[t]his statement was a speculation based on the fact that both SiO_2 and Al_2O_3 were still present at the interface, whereas thermodynamically it was expected that Al would completely reduce SiO_2 to form Al_2O_3 and free Si.” Ex. 2043, Goodnick Decl. ¶ 39.

Patent Owner argues that Goodnick’s two references to an Al_2O_3 layer do not state that the Al_2O_3 layer is distinct from SiO_2 and were not meant to

suggest the type of stratified distinct layers in the Petition. PO Resp. 52–53 (citing Ex. 2080, 2nd Goodnick Decl. ¶¶ 8–9).

Patent Owner further contends that the Auger profile data in Figure 8(b) does not support Petitioner’s stratified layer arguments. PO Resp. 53. Patent Owner states that, in addition to the Al_2O_3 hump corresponding to 35–55 minutes sputter time indicating an Al_2O_3 layer, the data also shows oxygen of unknown origin rising earlier and peaking to the left of the Al_2O_3 line, as well as aluminum and silicon in the same vicinity. *Id.* Thus, Patent Owner argues that “according to the Auger profile data, the ‘ Al_2O_3 layer’ is not a stratified distinct layer of Al_2O_3 as the petition asserts.” *Id.* at 54 (citing Ex. 1121, 953).

Patent Owner does not explain sufficiently, however, why the data it cites on the Auger profile does not support Petitioner’s contentions. PO Resp. 53–54. The Goodnick reference uses the term “layer” at least 40 times, and in no case does Goodnick ascribe a meaning to “layer” that is different from one layer being distinct from another. *See generally* Ex. 1121.

Patent Owner next argues that XPS measurements reported in Goodnick indicate that both SiO_2 and Al_2O_3 exist simultaneously at the interface, but reveal nothing about the spatial distribution of the Al_2O_3 and SiO_2 . PO Resp. 54–55 (citing Ex. 2080, 2nd Goodnick Decl. ¶ 10). Patent Owner also argues that the Goodnick reference speculated an Al_2O_3 diffusion barrier is the probable reason the $4 \text{ Al} + 3 \text{ SiO}_2 \rightarrow 2 \text{ Al}_2\text{O}_3 + 3 \text{ Si}$ reaction is self-limiting, but that speculation is an untested hypothesis insufficient to support Petitioner’s contentions. *Id.* at 55 (citing Ex. 2080, 2nd Goodnick Decl. ¶¶ 11–13).

Goodnick is entitled “Effects of a thin SiO₂ layer on the formation of metal-silicon contacts” and states “[t]he reactions that occur between different metals and silicon wafers with a thin oxide layer have been investigated.” Ex. 1121, cover page. Goodnick further states “a thin interfacial layer may act as a barrier to the chemical reaction and interdiffusion that characterizes the intimate metal silicon contact. Thus, the presence of a thin oxide at the interface act as a passivating influence, both from an electronic and a chemical standpoint.” Ex. 1121, 1.

Taken in context, we agree with Dr. Schubert that an ordinarily skilled artisan would have understood Goodnick to refer to Al₂O₃ as a distinct layer. Ex. 1126, Schubert Decl. ¶ 85; Ex. 1173, Schubert Reply Decl. ¶ 86. Referring to Fig. 8(a), Goodnick states that in an unheated sample with an air grown oxide “[i]t appears that Si has diffused into the Al and collected at the Al₂O₃-Al interface at the surface. No buildup of Al₂O₃ is seen at the Al-Si interface.” Ex. 1121, 5. Noting that Fig. 8(b) is a profile of an unheated sample with 30Å of SiO₂ at the interface, Goodnick states “[i]n contrast to the air exposed sample, an Al₂O₃ layer exists at the Al-SiO₂-Si interface.” *Id.*

Petitioner notes that, on cross-examination, Dr. Goodnick acknowledged (i) that the Al metal layer would diffuse into the SiO₂ interface layer and reduce the portion of the SiO₂ layer nearest the Al layer to Al₂O₃, (ii) that once the Al₂O₃ layer forms, it would be difficult for aluminum atoms to diffuse through the Al₂O₃ layer to continue reaction with the SiO₂ layer, and (iii) because the reaction is self-limiting, a portion of the original SiO₂ layer would remain once the reaction forming the Al₂O₃ layer stopped. Pet. Reply 6–7 (citing Ex. 1168, Goodnick Tr. 55:5–25, 57:19–58:8, 59:24–60:7, 81:4–8). In view of, *inter alia*, Dr. Goodnick’s cross-

examination testimony, we are persuaded by Dr. Schubert's testimony that an ordinarily skilled artisan would have understood that distinct layers of Al_2O_3 and SiO_2 are formed. Ex. 1173, Schubert Reply Decl. ¶¶ 85–98.

As to Patent Owner's arguments concerning speculation (PO Sur-reply), we note that our inquiry is what Goodnick would have disclosed to an ordinarily skilled artisan. The Goodnick reference's comments, even if Dr. Goodnick now deems them to be speculative, are consistent with the physical evidence. Ex. 1173, Schubert Reply Decl. ¶ 88–92. Further, Dr. Goodnick testified that the only hypothesis presented as of today for why some of the original silicon dioxide remained in his structure is that aluminum oxide formed a diffusion barrier that prevented aluminum from further diffusing into the silicon dioxide layer underlying the aluminum oxide. Ex. 1168, Goodnick Tr. 129:19–130:7. Moreover, no one has argued that it was beyond the skill of an ordinarily skilled artisan to create the described layer of Al_2O_3 . PO Resp. 52–60; Pet. Reply 6–8; PO Sur-reply 2–4.

In sum, we find that Petitioner has proven that Goodnick discloses the limitation of “said interface layer comprising a metal oxide and a semiconductor oxide.”

g. being in contact with said region in the semiconductor substrate and said metal electrical contact

Petitioner asserts that Goodnick discloses this limitation by describing evaporating aluminum onto a SiO_2 layer grown on a silicon substrate. Pet. 24. Patent Owner presents no counterarguments regarding this limitation. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses this limitation.

h. Summary

Petitioner has proven that Goodnick discloses all limitations of claim 1, and, thus, Petitioner has proven that Goodnick anticipates claim 1.

3. Claims 2, 3, and 8–10

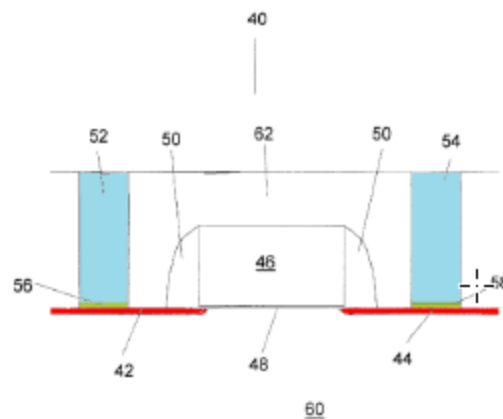
Petitioner sets forth how it contends Goodnick discloses all limitations that claims 2, 3, and 8–10 add to claim 1. Pet. 24–26 (and the exhibits cited therein). Patent Owner presents no counterarguments regarding those additional limitations. PO Resp. 60. After reviewing the record, we determine that Petitioner has proven that Goodnick discloses the limitations that claims 2, 3, and 8–10 add to claim 1. Thus, Petitioner has proven that Goodnick anticipates claims 2, 3, and 8–10.

B. Ground 2: Asserted Obviousness over Goodnick and Jammy

Petitioner asserts that claim 4 would have been obvious over Goodnick and Jammy. Pet. 9.

1. Jammy

Jammy generally describes a MOSFET (metal oxide semiconductor field effect transistor) that incorporates a quantum conductive barrier between a conductive stud and a semiconductor substrate. Ex. 1122, 2:42–53; 3:16–22. Figure 1 of Jammy, with color annotations added by Petitioner, is reproduced below:



Pet. 18. Figure 1 above shows MOSFET 40 in substrate 60. Ex. 1122, 3:9–11, 4:9–11. In Figure 1 above, conductive studs 52 and 54, quantum barrier layers 56 and 58, and shallow source/drain diffusions 42 and 44 are highlighted. Pet. 18; Ex. 1122, 3:11–18. Jammy discloses that “[p]referred quantum conductive materials are inorganic oxides or nitrides, more preferably silicon nitride compounds selected from the group consisting of silicon nitride or silicon oxynitride.” Ex. 1122, 3:51–54. Jammy also discloses that “studs 52 and 54 would typically be made of tungsten or a doped polycrystalline silicon.” *Id.* at 4:32–33.

Jammy states that its “invention is not limited to any specific device configuration . . . , however, the structures of the invention are preferably incorporated into a MOSFET or other transistor devices.” Ex. 1122, 4:1–4. Jammy identifies Cote (Ex. 1135) as disclosing relevant transistor structures and incorporates Cote by reference. *Id.* at 4:5–8. Cote discloses that “titanium, titanium nitride, tungsten, or other appropriate metallurgy” can be used to form a diffusion contact stud. Ex. 1135, 8:24–28.

2. Claim 4

a. Arguments

Petitioner sets forth its evidence and arguments that the combination of Goodnick and Jammy teach or suggest every element of claim 4 and provides reasons why an ordinarily skilled artisan would combine the teachings of those references. Pet. 27–29. In response, Patent Owner relies on the argument it presented for claim 1, that Goodnick does not disclose distinct metal oxide and semiconductor oxide layers. PO Resp. 60. As set forth in Section III.A.2.f above, we found that Petitioner has proven that Goodnick discloses distinct metal oxide and semiconductor oxide layers.

For Ground 2 and for all other obviousness grounds, Patent Owner further argues “[t]he objective evidence of nonobviousness overwhelmingly weighs in favor of the nonobviousness of the ’395 Patent claims.” PO Resp. 30 (citing Ex. 2090, Declaration of Dr. Paul Clifton (“Clifton Decl.”) ¶¶ 8–102). Petitioner disagrees. Pet. Reply 25–36.

We address the parties’ arguments about objective evidence of nonobviousness below.

b. Objective Indicia of Nonobviousness

Objective criteria constitute independent evidence of non-obviousness. *Mintz v. Dietz & Watson, Inc.*, 679 F.3d 1372, 1378 (Fed. Cir. 2012). The totality of the evidence submitted, including objective evidence of nonobviousness, may lead to a conclusion that the challenged claims would not have been obvious to an ordinarily skilled artisan. See *Piasecki*, 745 F.2d at 1471–1472. Secondary considerations may include any of the following: long-felt but unsolved needs, failure of others, unexpected results, commercial success, copying, licensing, and praise.

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)).

1. Commercial Success

Patent Owner argues that the products accused of infringement (and found to infringe) in the related litigation have been commercially successful. PO Resp. 37–47. Patent Owner argues that Petitioner has stipulated to the commercial success of its accused products. *Id.* at 41. Petitioner, in fact, made the following stipulation in this proceeding:

Samsung stipulates, solely for the purpose of, and for use in, this IPR proceeding, that the products accused of infringement in *Acorn Semi, LLC v. Samsung Electronics Co., Ltd. et al.*, No. 2:19-cv-00347-JRG (E.D. Tex.) have been commercially successful. Samsung disputes, however, that any commercial success achieved by the accused products is attributable, in any way, to the challenged claims of the Acorn patents

Ex. 2116, 2.

Further, the Patent Owner Response argues that infringement of the ’395 patent is being tried in the Related Litigation and that the verdict that the jury would reach would likely establish infringement of the challenged claims, thus establishing that the accused products embody the claimed features and are coextensive with them. PO Resp. 38–41 (citing Ex. 1150 as evidence that the jury would address infringement of the ’395⁹ claims). Patent Owner argues that the nexus is also established by the purported facts that: (i) the primary advantage of the Acorn inventions is reduced contact

⁹ Patent Owner expressly states that “the question of whether the accused products practice the Acorn patents, including this ’691 Patent, will be conclusively answered.” PO Resp. 40. This reference to the ’691 patent was presumably a clerical error because the Petition challenges the ’395 patent.

resistivity; (ii) there are billions of junctions in each accused product; (iii) reducing specific contact resistance provides significant technical benefits, and (iv) these benefits give chips that utilize Acorn's inventions a tangible market benefit. PO Resp. 42–43. Patent Owner argues the above features establish a nexus even for claims that do not recite reduced contact resistivity. *Id.* at 45.

After the Patent Owner Response was filed, the jury in the Related Litigation issued a verdict. Ex. 2121. The verdict, however, did not address alleged infringement of claim 4 and thus did not establish any presumption of nexus between any commercial success of accused products and claim 4. *Id.* at 4. As for Patent Owner's additional arguments regarding a nexus, claim 4 does not recite any specific contact resistance, and Patent Owner has not shown that lower specific contact resistivity is the "direct result of the unique characteristics of the claimed invention" of claim 4. Ex. 1101, 1:45–61; PO Resp. 45–46. Patent Owner does not specifically address claim 4. PO Resp. 45–46, 60. Instead, Patent Owner merely cites Figure 8 of the '395 patent and quotes Dr. Kuhn's testimony that:

[T]he key enabling disclosure of the Acorn Patents is Figure 8 . . . This figure sets forth the key idea that was not in the prior art, and upon which the asserted claims of the Acorn Patents are based. This counter-intuitive idea is clearly expressed in the abstract as [T]he interface layer thickness corresponding to this minimum specific contact resistance . . .

Id. at 45 (quoting Ex. 2070, Kuhn Decl. ¶¶ 50–51) (alterations original). This testimony, however, does not address the accused products or claim 4. It merely addresses Figure 8 of the '395 patent, which itself is merely an illustrative drawing and not one that provides any experimental data. Ex. 2070, Kuhn Decl. ¶ 75 ("Figure 8 is clearly intended to be illustrative of

the overall physics, *not* to be predictive of any exact values of resistivity.” (emphasis original)). Also, for the additional reasons discussed in Section III.B.2.b.3 below, Patent Owner does not establish a nexus for objective indicia of nonobviousness with respect to a reduction in contact resistance. Thus, Patent Owner has not established a nexus between the accused products and claim 4. Accordingly, we accord little weight to Patent Owner’s evidence of the commercial success of the accused products.

2. Time Lag

According to Patent Owner, although Goodnick and Taubenblatt 1982 were available in prominent journals for over 20 years, the inability of others to produce the claimed invention during that time “is consistent with the fact that those references do not, in fact, actually suggest the claimed invention.” PO Resp. 31. Patent Owner cites *Leo Pharmaceutical Products, Ltd. v. Rea*, 726 F.3d 1346, 1356–57, 1359 (Fed. Cir. 2013) for the proposition that the length of intervening time between the cited references and patent at issue “speaks volumes to the nonobviousness” of the invention. *Id.* Petitioner disagrees, citing *Iron Grip Barbell Co. v. USA Sports, Inc.*, 392 F.3d 1317, 1325 (Fed. Cir. 2004), for the proposition that “[a]bsent a showing of long-felt need or the failure of others, the mere passage of time without the claimed invention is not evidence of nonobviousness.” Pet. Reply 30.

The holdings of *Leo Pharmaceutical* and *Iron Grip Barbell* are consistent. In *Leo Pharmaceutical*, “[t]he record [] showed evidence of *long* felt but unsolved need.” 726 F.3d at 1359 (emphasis original). Thus, “the intervening time between the prior art’s teaching of the components and the eventual preparation of a successful composition” constituted objective evidence of non-obviousness. *Id.* Absent a showing of long-felt need or the failure of others, however, the mere passage of time without the claimed

invention is not evidence of nonobviousness. *Iron Grip Barbell Co.*, 392 F.3d at 1325; *see also Nike v. Adidas AG*, 812 F.3d 1326, 1338 (Fed. Cir. 2016) (“[O]ur decision in *Leo Pharmaceutical* is entirely consistent with established precedent that ‘[t]he mere age of the references is not persuasive of the unobviousness of the combination of their teachings, absent evidence that, notwithstanding knowledge of the references, the art tried and failed to solve the problem.’”), *overruled on other grounds by Aqua Prods., Inc. v. Matal*, 872 F.3d 1290, 1296 n.1 (Fed. Cir. 2017) (en banc); *In re Wright*, 569 F.2d 1124, 1127 (CCPA 1977). Thus, whether the passage of time between Goodnick’s and Taubenblatt 1982’s publications and the effective filing date of the ’395 patent constitutes objective evidence of nonobviousness depends on the evidence of a long-felt need or failure of others, which we address next.

3. Long Felt Need

Patent Owner argues that the claimed invention addressed a need long and prominently felt in the semiconductor industry of reducing contact resistance. PO Resp. 31–32. Patent Owner, however, does not demonstrate any nexus between the alleged satisfaction of that need and any limitation or combination of limitations that is novel in claim 4.

“Where the offered secondary consideration actually results from something other than what is both claimed and *novel* in the claim, there is no nexus to the merits of the claimed invention,” meaning that “there must be a nexus to some aspect of the claim not already in the prior art.” *In re Kao*, 639 F.3d 1057, 1068–69 (Fed. Cir. 2011). On the other hand, there is no requirement that “objective evidence must be tied exclusively to claim elements that are not disclosed in a particular prior art reference in order for that evidence to carry substantial weight.” *WBIP, LLC v. Kohler Co.*, 829

F.3d 1317, 1331 (Fed. Cir. 2016). A novel combination of limitations would also suffice. *Id.*

As set forth in Section III.A.2. above, Goodnick discloses all limitations of claim 1. Claim 4 recites the electrical junction of claim 1, “wherein said region in the semiconductor substrate comprises a source or drain of a transistor.” Ex. 1101, 18:59–61. Patent Owner has not argued or offered any evidence that this additional limitation of claim 4 by itself or in combination with the limitations recited in claim 1 lowers contact resistance. PO Resp. 32–34 (and the exhibits cited therein); PO Sur-reply 23–24. Thus, Patent Owner has not established any nexus between the purported satisfaction of long felt need and any novel aspect of claim 4.

Further, Patent Owner attributes the reduction of contact resistance to the allegedly counter-intuitive idea to add an insulating layer in a contact to reduce contact resistance. PO Resp. 33. Although Patent Owner offers evidence that certain individuals in the field indicated this concept was counter-intuitive and further offered the testimony of Dr. Kuhn that it was counter-intuitive, Dr. Schubert’s testimony that Iwaguro discloses this concept stands un rebutted. Ex. 1126, Schubert Decl. ¶ 55–59. Further, Dr. Kuhn did not consider Iwaguro before providing her declaration testimony. Ex. 1170, Kuhn Dep. Tr. 235:9–16, 237:19–24, 254:4–9. And there is no evidence that any of the other individuals quoted by Patent Owner had considered Iwaguro’s teachings before making their quoted statements. In the Sur-reply, Patent Owner contends via attorney argument that Iwaguro’s teachings are only marginally relevant to the claimed invention. Sur-reply 22–23. Attorney argument, however, is not evidence. Patent Owner had the opportunity to have its expert address Dr. Schubert’s contrary testimony, which was submitted with the Petition, but Patent Owner

did not. Pet. 12–13 (citing Ex. 1126, Schubert Decl. ¶¶ 50–63); Ex. 1170, Kuhn Dep. Tr. 235:9–16, 237:19–24, 254:4–9. We credit Dr. Schubert’s testimony regarding Iwaguro. Ex. 1126, Schubert Decl. ¶ 55–59.

Further, Patent Owner argues Iwaguro is only marginally relevant because it does not disclose the claimed invention and was not used to challenge any claim. Sur-reply 22–23. A prior art disclosure does not, however, need to disclose every claim element or even most claim elements to be relevant to the issues of objective evidence of nonobviousness. A prior art reference can be relevant because, like Iwaguro, it can demonstrate that the alleged indicia of obviousness results solely from an aspect of the claim that is not novel. *Kao*, 639 F.3d at 1068–69.

Patent Owner also does not address the full scope of claim 1 or claim 4. *Id.* at 31–32, 45–46. Patent Owner merely cites Figure 8 of the ’395 patent and quotes certain testimony by Dr. Kuhn and Dr. Clifton. *Id.* at 45 (citing Ex. 1101, Fig. 8; Ex. 2070, Kuhn Decl. ¶¶ 50–51, Ex. 2090, Clifton Decl. ¶¶ 9–14). That testimony, however, does not address claim 4. Ex. 2070, Kuhn Decl. ¶¶ 50–51; Ex. 2090, Clifton Decl. ¶¶ 9–14. Instead, the testimony by Dr. Kuhn merely addresses an illustrative drawing provided in the patent (Figure 8) without providing any evidence that that illustrative drawing is indicative of a property comprising the full scope of claim 1 or claim 4. Ex. 2070, Kuhn Decl. ¶¶ 50–51. Further, the testimony by Dr. Clifton does not address specific contact resistivity and claim 1 or claim 4. Ex. 2090, Clifton Decl. ¶¶ 9–14.

In sum, we determine that Patent Owner has not shown a requisite nexus between the purported long felt need and claim 4. Thus, we accord little weight to its evidence of long felt need and thus little weight to the

passage of time between Goodnick's and Taubenblatt 1982's publications and the effective filing date of the '395 patent.¹⁰

4. Unexpected results

As mentioned, Patent Owner argues that the “inventors had the counter-intuitive idea to intentionally introduce an insulating layer in [a] contact in order to reduce the contact resistance.” PO Resp. 33–34 (citing Ex. 2095, 2928; Ex. 2096, 3; Ex. 2097, 5, Ex. 2070, Kuhn Decl. ¶ 49). As discussed in Section III.B.2.b.3 above, Patent Owner has not demonstrated any nexus between this alleged reduction in contact resistance and any limitation or combination of limitations that is novel in claim 4. Further, as discussed above, Dr. Schubert's testimony regarding Iwaguro stands un rebutted. Ex. 1126 ¶ 55–59. As discussed above, Patent Owner also does not address the full scope of claim 1 or claim 4 with respect to contact resistance. Thus, we accord little weight to Patent Owner's evidence of unexpected results.

5. Industry praise

Patent Owner notes that in 2004 and 2006, the inventors published two papers (Exs. 2045, 2046 (collectively, “the Connelly Papers”)) that have been cited over 270 times in the professional literature. PO Resp. 34. On this record, however, Patent Owner has not demonstrated a sufficient nexus between any praise for these papers and specific limitations of claim 4. *Id.* Patent Owner does not identify how the structures described in those papers relate to claim 4. *Id.* Further, Petitioner provides evidence of the contrary. Pet. Reply 30. Claim 4, via its dependency from claim 1, recites a structure comprising a metal oxide layer. Ex. 1101, 1:45–61. The Connolly papers

¹⁰ Patent Owner does not separately argue that there was any failure by others. PO Resp. 30–51.

disclose only a silicon nitride interface layer, which is not a metal oxide interface layer. Ex. 1171, 172:2–10, 175:19–25; Ex. 1173, Schubert Reply Decl. ¶ 139. Thus, we accord little weight to Patent Owner’s evidence of industry praise.

6. 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. 47–51 (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 48. 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 49.

Patent Owner also alleges that Petitioner filed its own patent applications based on Patent Owner’s technology. PO Resp. 49–51 (arguing that a graph showing the thickness of the insulating mater and contact resistivity in Petitioner’s patent is similar to a graph showing oxide thickness and specific contact resistance in Patent Owner’s patents). Patent Owner further argues that U.S. Patent Publication No. 2014/0183434 A1 (Ex. 2100) (“Petitioner’s ’434 publication”) was filed by Petitioner and claim 6 of that application is similar to claims 1 and 20 of Patent Owner’s U.S. Patent 9,905,691 (“’691 patent”). PO Resp. 50–51. Patent Owner also argues that

various descriptions in Petitioner’s applications are similar to the descriptions in the ’691 patent. *Id.*

Regarding its researchers’ papers, 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 30 (citing Ex. 1169, Kuhn Tr., 34:4–23). Petitioner further argues that the graph at issue in its researchers’ papers “merely presents what was known in the literature long before [Patent Owner’s] patents.” *Id.* at 31.

The parties cite no Federal Circuit precedent where alleged suspicious behavior is objective criteria of nonobviousness. PO Resp. 47–51; Pet. Reply 31–34. Patent Owner further provides no testimony concerning the motivations of the authors of the abstract or the published paper, and we make no inferences from the difference in the citations concerning the Connelly Papers. PO Resp. 47–51.

Further, Patent Owner has not shown that any of the claims of the applications filed by Petitioner are similar to claim 4. PO Resp. 49–51. Patent Owner compares claim 6 of Petitioner’s ’434 publication to claims 1 and 20 of ’691 patent, but no makes no comparison to claim 4 or any other challenged claim in the ’395 patent. *Id.* at 50–51. Thus, no nexus has been established between the filing of claim 6 of the ’434 publication and any issues of patentability concerning challenged claim 4. Further, the fact that there may be an overlap in certain descriptions in the specifications of the cited applications by Petitioner and the ’691 patent is of no significance unless that overlap is tied to the invention of claim 4, and there is no evidence of such a tie. *Id.* at 49–51.

7. Summary

In consideration of the above, we accord little weight to Patent Owner's evidence of objective indicia of nonobviousness.

c. Conclusion Regarding Claim 4

After reviewing the record, including the evidence presented regarding objective indicia of nonobviousness, we determine that Petitioner has proven the claim 4 would have been obvious over Goodnick and Jammy.

C. Ground 3: Asserted Obviousness over Goodnick

Petitioner asserts that claim 5 would have been obvious over Goodnick. Pet. 9. Petitioner sets forth its evidence and arguments that the combination of Goodnick teaches or suggests every element of claim 5. Pet. 29–34. In response, Patent Owner relies on the argument it presented for claim 1, that Goodnick does not disclose distinct metal oxide and semiconductor oxide layers. PO Resp. 60. As set forth in Section III.A.2.f above, we found that Petitioner has proven that Goodnick discloses distinct metal oxide and semiconductor oxide layers.

Patent Owner further argues that objective indicia of nonobviousness support a determination of nonobviousness of claim 5. PO Resp. 30–51. For claim 5, the parties present the same arguments and evidence regarding objective evidence of nonobviousness as for claim 4. *Id.*; Pet. Reply 25–34.

Our analysis of objective evidence of nonobviousness for claim 5 is essentially the same as for claim 4. As with claim 4, the jury verdict in the Related Litigation does not give rise to a presumption of nexus between the commercial success of the products found to infringe in the Related Litigation and claim 5 because the jury verdict does not address whether claim 5 is infringed. Ex. 2121, 2. For essentially the same reasons discussed for claim 4, Patent Owner does not establish a nexus between the

commercial success, alleged long felt need, alleged unexpected results, and alleged industry praise and claim 5 (i.e., none of its evidence and arguments are tied to claim 5). PO Resp. 30–51.

One difference regarding the analysis of objective evidence of nonobviousness between claims 4 and 5 is that the limitation of claim 5 adds to claim 1 and that Goodnick does not teach is different than for claim 4. In particular, Goodnick suggests, but does not teach, the following limitation in claim 5: “yet thin enough to provide the junction with a specific contact resistivity that is generally dependent on: a workfunction of the metal electrical contact, a Fermi energy of the semiconductor in the region, or both the workfunction of the metal electrical contact and the Fermi energy of the semiconductor in the region.” Ex. 1126, Schubert Decl. ¶ 184. Patent Owner, however, does not tie this limitation in isolation or in combination with other limitations to the reduction in specific contact resistance that purportedly gives rise to the purported unexpected results, satisfaction of long felt need, or commercial success. PO Resp. 31–34 (and the exhibits cited therein). Further, for the other reasons discussed for claim 4, Patent Owner does not establish a nexus between the commercial success of the accused products, alleged long felt need, alleged unexpected results, and alleged industry praise and claim 5 (i.e., none of its evidence and arguments are tied to claim 5). PO Resp. 30–51; PO Sur-reply 23–25.

Similarly, Patent Owner does not establish a nexus between any claim of Petitioner’s ’434 publication and claim 5. *Id.* Nor has Patent Owner tied any of the alleged common disclosures between Petitioner’s ’434 publication and other cited applications by Petitioner and claim 5. *Id.* Thus, for the reasons explained in Section III.B.2.b above, we accord little weight to that evidence of objective indicia of nonobviousness for claim 5.

After reviewing the evidence of record, we determine that Petitioner has proven that claim 5 would have been obvious over Goodnick.

D. Ground 4: Asserted Obviousness over Goodnick and Taubenblatt 1982

Petitioner asserts that claims 1, 11, 12, 15, 23–25, and 28 would have been obvious over Goodnick and Taubenblatt 1982. Pet. 10.

1. Taubenblatt 1982

Noting the importance of silicides as Schottky barriers, ohmic contacts, and low resistivity interconnects in integrated circuits, Taubenblatt 1982 states that “[m]any silicides are commonly formed by the deposition of a metal layer on silicon via e-beam evaporation, chemical vapor deposition, or sputtering, and the reaction of the metal layer with the underlying silicon at 400-600 °C.” Ex. 1123, 1.¹¹ The purpose of Taubenblatt 1982 was “to characterize silicide formation for the Ti-Si system under ultrahigh vacuum (UHV) conditions with the controlled addition of surface oxides.” *Id.* Taubenblatt 1982’s “results show that the presence of SiO₂ at the Si surface, prior to Ti deposition, has a significant effect on the reaction of Ti and Si and that the thickness of the SiO₂ layer is especially important in determining the reaction end products.” *Id.* at 8. According to Taubenblatt 1982:

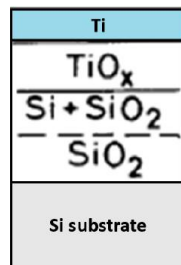
in the manufacture of circuit elements employing titanium disilicide, Ti will react through a thin silicon dioxide layer with the SiO₂ remaining at the surface. But in the reaction of Ti with a thicker SiO₂ layer, Ti oxide forms, which can act as a diffusion barrier to prevent further reduction of the oxide by unreacted Ti metal or in the formation of silicide.

Id.

¹¹ We cite to the pages added by Petitioner for this exhibit.

2. Proposed Combination of Goodnick and Taubenblatt 1982

Petitioner argues that Goodnick discloses an interface layer that includes a metal oxide layer (aluminum oxide (Al_2O_3)), but acknowledges that Goodnick does not expressly describe an interface layer that includes titanium dioxide, as recited in claims 11 and 23, or a metal electrical contact that includes titanium, as recited in claims 15 and 24. Pet. 34. Petitioner asserts, however, that, because Taubenblatt 1982 teaches (i) depositing titanium on a layer of SiO_2 thicker than 20 Å (2 nm) and (ii) that annealing at temperatures between 700°C–900°C forms a TiO_x – SiO_2 interface layer, an ordinarily skilled artisan would have understood that by depositing titanium on Goodnick’s 30 Å (3 nm) thick layer of thermally grown SiO_2 , “all that it would have taken to form a TiO_x – SiO_2 interface layer is annealing at 700C–900C as described in Taubenblatt 1982.” *Id.* at 36 (citing Ex. 1123, 7–8, Ex. 1126, Schubert Decl. ¶ 203). Petitioner contends that the combined teachings of Goodnick and Taubenblatt 1982 would have resulted in the structure shown below.



Pet. 36–37 (citing Ex. 1121, Goodnick, 1–2; Ex. 1123, 7–8; Ex. 1126, Schubert Decl. ¶ 204). The structure postulated by Petitioner includes a SiO_2 layer on top of a silicon substrate, a Si+ SiO_2 layer over the SiO_2 layer, a TiO_x layer on top of the Si+ SiO_2 layer, and a Ti layer over the TiO_x layer. *Id.* at 37.

3. Motivation to Combine Goodnick and Taubenblatt 1982

a. Parties' Arguments

According to Petitioner, an ordinarily skilled artisan would have had reason to provide Goodnick with an interface layer that includes both titanium oxide and silicon dioxide “because that interface layer would have been expected to reduce the specific contact resistivity of that junction.” Pet. 37 (citing, e.g., Ex. 1126, Schubert Decl. ¶¶ 205–206). Petitioner argues that it was known that a SiO₂ interface layer grown on silicon would passivate the surface of the silicon and “[t]hat passivation would have reduced the barrier height of a titanium to n-type silicon junction, such as the junction between Taubenblatt 1982’s titanium and Goodnick’s n-type source drain/drain silicon substrate.” *Id.* at 37–38 (citing Ex. 1121, Goodnick, 31; Ex. 1123, Taubenblatt 1982, 1–2; Ex. 1126, Schubert Decl. ¶ 207). Petitioner further states that, “[f]or a junction between titanium and n-type silicon with a SiO₂ interface layer, the SiO₂ interface layer reduces the barrier height more than 0.1 eV” and that “reducing the barrier height of a junction reduces its specific contact resistivity.” *Id.* at 38 (citing Ex. 1126, Schubert Decl. ¶ 207; Ex. 1124, Chang,¹² 5–6).

In summarizing what would have been known to an ordinarily skilled artisan at the relevant time, Petitioner’s expert, Dr. Schubert, cites another Taubenblatt reference, i.e., Taubenblatt 1984¹³. Ex. 1126, Schubert Decl. ¶ 54 (citing Ex. 1130, 3). Dr. Schubert cites a passage in Taubenblatt 1984

¹² Chang is not an asserted reference for this ground, but is an asserted reference for Ground 6.

¹³ M.A. Taubenblatt et al., *Interface effects in titanium and hafnium Schottky barriers on silicon*, 44 APPLIED PHYS. LETTERS 895 (Ex. 1130, “Taubenblatt 1984”).

that references teachings in Turner and Rhoderick¹⁴ as disclosing that an interfacial oxide reduces the pinning ability of the interface states in silicon, so that the barrier behaves more like an ideal Schottky barrier. Ex. 1126, Schubert Decl. ¶ 54 (citing Ex. 1130, 3). Dr. Schubert also testifies, “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.” *Id.* ¶ 55; *see also id.* ¶ 56 (asserting Schroen¹⁵ (abstract), discloses the specific contact resistance obtained by using a thin insulating interfacial layer between a metal and a semiconductor is far smaller than the resistance observed in a structure of only a semiconductor and a metallization layer), *id.* ¶ 59 (quoting Iwaguro¹⁶ ¶ 6, which states “[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”).

As to the use of titanium, Dr. Schubert cites a 1989 patent by Kim¹⁷ (Ex. 1125) as describing an interface layer formed by titanium reducing silicon dioxide to achieve a specific contact resistance as low as $8\ \Omega\text{-}\mu\text{m}^2$. Ex. 1126, Schubert Decl. ¶¶ 57–58 (citing Ex. 1125, 5:27–30). In the Decision to Institute, we noted that Kim discloses the use of an alloy of tungsten and titanium, and specifically identifies disadvantages to the use of titanium alone. Dec to Inst. 32 (citing Ex. 1125, 1:24–30).

Noting that Goodnick does not mention resistivity and Taubenblatt 1982 mentions resistivity only once, the Patent Owner Response contends

¹⁴ Ex. 1123, n.18 (citing M. J. Turner and E. H. Rhoderick, *Solid State Electron.* II, 291, (1968)); *see also* Ex. 1117, n.1.

¹⁵ U.S. Patent No. 3,983,264 (Ex. 1124, “Schroen”).

¹⁶ Certified Translation of Japanese Laid-Open App. No. JPH11162874A (June 18, 1999) (Ex. 1133, “Iwaguro”).

¹⁷ U.S. Patent No. 4,845,050 (Ex. 1125, “Kim”).

that an ordinarily skilled artisan would not have been motivated to combine the teachings of Goodnick and Taubenblatt 1982 in the manner proposed by Petitioner. PO Resp. 8–9. Patent Owner emphasizes that Goodnick “presents experimental results of research into the effects of a layer of silicon dioxide between silicon and three metals (gold, platinum, and aluminum), none of which is titanium,” that Taubenblatt 1982 “reports the results of several experiments depositing titanium on silicon under various conditions,” and that neither reference is concerned with building a low resistance junction. *Id.* at 9. Patent Owner further argues that “[n]othing in Goodnick suggests any reason to study titanium” and “[n]othing in Taubenblatt suggests studying aluminum.” *Id.*

According to Patent Owner, Petitioner’s reference to the teachings in other documents, such as Kim, is unavailing because the Petition fails to establish a link between the subject matter cited by Dr. Schubert and his assertion that an ordinarily skilled artisan would have substituted Taubenblatt 1982’s titanium for Goodnick’s aluminum. PO Resp. 10.

Patent Owner argues that the bulk resistivity of titanium is about sixteen times that of aluminum, suggesting that a person of ordinary skill would not have looked to replace aluminum with titanium. PO Resp. 11 (citing Ex. 2052, 4, 6; Ex. 2081, 1–2, 12; Ex. 2082, 1–2; Ex. 2083). Patent Owner asserts that Dr. Schubert tried to downplay this difference by testifying that the resistivity of the metal in the metal-insulator-semiconductor stack is insignificant when compared to the much larger resistivity of insulators and semiconductors. *Id.* at 12 (citing Ex. 2076, Transcript of Deposition of Dr. Schubert (“Schubert Tr.”), 65:21–67:9)). Patent Owner, however, argues that the bulk resistivity of an insulator is irrelevant when it is used as a tunneling interface layer, i.e., because

tunneling is a property of the barrier height at the junction and the physical thickness, not the material's bulk resistivity. *Id.* (citing Ex. 2070, Declaration of Dr. Keln Kuhn ("Kuhn Decl.") ¶ 117). According to Dr. Kuhn,

[I]t is not correct to say that a POSITA would ignore the bulk resistivity of the metal in a metal - insulator semiconductor stack of the type of interest here. That is especially true if the choice is between aluminum and titanium because, as I mentioned, aluminum is a significantly better electrical conductor than titanium (by a factor of about 16X).

Ex. 2070, Kuhn Decl. ¶ 120. In addition, Dr. Kuhn testifies that "considerable research in the semiconductor industry has been (and currently is) conducted to try to find conductors that have marginally lower resistivity." *Id.* ¶ 119. As a result, Patent Owner argues that the bulk resistivity of the metal is a factor an ordinarily skilled artisan would consider when trying to reduce resistance in the pertinent structure. PO Resp. 13.

Petitioner's Reply counters that reducing specific contact resistance in a junction had well known benefits including reducing power consumption. Pet. Reply 9 (citing Ex. 1126, Schubert Decl. ¶ 215). Petitioner also argues that Patent Owner fails to consider the resistivity of the entire structure, not just the metal layer. *Id.* at 10 (citing Ex. 1173, Schubert Reply Decl. ¶ 112). Petitioner notes that "[t]he proposed combination substitutes the Al-Al₂O₃ (in Goodnick) for Ti-TiO_x (in the proposed combination) (with the SiO₂ and Si layers the same in both structures)." *Id.* Petitioner argues that the semiconductor's bulk resistivity far outweighs the bulk resistivity of the metal layer, regardless of whether aluminum or titanium is used in the metal layer, and notes that, because the bulk resistivity of the semiconductor is largely fixed based on the doping concentration, the contributions from the

SiO₂-Si would be similar in both structures. *Id.* at 10–11. According to Petitioner, “that is precisely why a POSITA would have sought other means for reducing the junction’s *overall* resistivity, such as by reducing the resistivity of the interface layer by substituting TiO₂ for Goodnick’s higher-resistivity Al₂O₃ layer.” *Id.* at 11 (citing Ex. 1173, Schubert Reply Decl. ¶¶ 107–108 (emphasis original)).

According to Petitioner, TiO_x is substantially more conductive than Al₂O₃ because current can flow through TiO_x via electron tunneling and via conduction bands, but in the case of Al₂O₃, the tunneling barrier is higher, and current does not flow through Al₂O₃’s conduction bands. Pet. Reply 11–12 (citing Ex. 1173, Schubert Reply Decl. ¶¶ 109–111).

Patent Owner’s Sur-reply argues that Petitioner has not proven that its proposed Ti-TiO_x-SiO₂-Si structure has lower resistance than Goodnick’s Al-Al₂O₃-SiO₂-Si structure. PO Sur-reply 8–15. Patent Owner argues that the doped silicon used in the semiconductor industry does not have a bulk resistivity that is ten billion times greater than a metal. *Id.* at 8–9. Patent Owner also argues that Petitioner fails to account for the geometry of the materials used. *Id.* at 9–10. Further, Patent Owner asserts that the tunneling probability through TiO_x is not thirty times greater than that of Al₂O₃. *Id.* at 10–11. Patent Owner further argues that Petitioner does not quantify the conduction-band and thermionic current compared to the tunneling current. *Id.* at 12. Patent Owner also argues that Petitioner fails to account for the height of a metal layer. *Id.* at 13. Further, Patent Owner asserts that titanium is 16x more resistive to aluminum, whereas the tunneling probability of TiO₂ is only 1.66 times more. *Id.* at 14–15. Patent Owner asserts that thus an ordinarily skilled artisan would not have been motivated

to substitute titanium for aluminum. *Id.* at 15. Patent Owner also argues that Petitioner's reply arguments were belated. *Id.*

Patent Owner also argues that thermal expansion concerns teach away from both aluminum and titanium. PO Sur-reply 16–17.

b. Analysis

We determine that Petitioner has not proven that an ordinarily skilled artisan would have been motivated to make the proposed combination. Petitioner argues that an ordinarily skilled artisan would have been motivated to substitute Al-Al₂O₃ (in Goodnick) for Ti-TiO_x (in the proposed combination) (with the SiO₂ and Si layers the same in both structures) to reduce specific contact resistance. Pet. 37. Petitioner cites nothing from Goodnick that suggests using titanium and cites nothing from Taubenblatt 1982 that suggests substituting titanium for aluminum. *Id.* at 37–40; Pet. Reply 9–17. Petitioner also cites nothing from either reference suggesting that Ti-TiO_x would have produced a better specific contact resistance than Al-Al₂O₃. Pet. 37–40; Pet. Reply 9–17. Petitioner cites Kim as supporting its proposed combination (Pet. 37–39, citing Kim 4:63–5:1), but Kim discloses that pure titanium is not suitable for contacts, which teaches away from the proposed combination:

Pure titanium, however, is not suitable for contacts as direct contact between titanium and silicon has shown poor reproducibility due to the large difference in the linear thermal coefficient of expansions of titanium and silicon (the linear coefficient of expansion of titanium being three times the linear coefficient of expansion of silicon).

Ex. 1125, 1:24–30.

Addressing Patent Owner's arguments regarding this passage in Kim, Petitioner argues that thermal coefficients support its proposed substitution

because titanium has a better thermal coefficient match with silicon than aluminum. Pet. Reply 15–16 (citing PO Resp. 14–15). In making this contention, Petitioner does not specifically address Kim’s disclosure. *Id.* The above passage from Kim directly follows a discussion of the use of aluminum as a contact metal. Ex. 1125, 1:14–23. Kim then notes an advantage of titanium: it is a good agent for reducing silicon dioxide. *Id.* at 1:23–24. But then Kim teaches that pure titanium is not suitable for contacts due to the large difference in the linear thermal coefficient of expansions of titanium and silicon. *Id.* at 1:24–30. In light of these teachings, an ordinarily skilled artisan would not read Kim as supporting the use of pure titanium in place of aluminum due to titanium’s thermal coefficients. Rather, an ordinarily skilled artisan would recognize that Kim teaches that, instead of pure titanium or aluminum, an ordinarily skilled artisan should use an alloy of titanium and tungsten with a metal selected from the group of molybdenum and tungsten. *Id.* at 1:31–41, 2:32–35, 5:2–5 (“Alloys in the range of about 10% to 40% by weight of titanium and the remainder tungsten are particularly suitable for providing low resistance contacts to silicon.”). Such an alloy, however, is not part of Petitioner’s proposed combination for Ground 4. Pet. 36–37.

Petitioner argues that Kim addresses a direct contact between titanium and silicon, whereas Petitioner’s proposed combination has an intervening layer of TiO_x and thus Kim teaches away from pure titanium and is inapplicable to Petitioner’s proposed combination. Pet. Reply 16 n.1. Petitioner cites no expert testimony to support its contention that Kim only teaches away from direct contact between titanium and silicon. *Id.* We read Kim’s teachings more broadly. Kim states that “[p]ure titanium [] is not suitable for contacts.” Ex. 1125, 1:24–30. Although Kim mentions that

direct contact between titanium and silicon shows poor reproducibility, Kim does not limit its teaching away from pure titanium to structures with direct contact and does not suggest that an intervening layer would make pure titanium suitable for contacts. *Id.* Instead, Kim teaches that certain alloys should be used in place of pure titanium. *Id.* at 1:31–41, 2:32–35, 5:2–5. Further, Petitioner’s contention that the intervening layer would make pure titanium suitable for contacts, based on Kim’s teachings, rests solely on attorney argument, which is not persuasive. Pet. Reply 16 n.1.

Petitioner presents testimony by Dr. Schubert to demonstrate that TiO_x in the proposed combination would be less resistive than Al_2O_3 . Pet. Reply 11. Dr. Schubert does not dispute that the bulk resistivity of titanium is about sixteen times greater than the bulk resistivity of aluminum.

Ex. 1173, Schubert Reply Decl. ¶ 107. But Dr. Schubert testifies that:

even if the bulk resistivity of titanium is 16 times greater than the bulk resistivity of aluminum, Goodnick and Taubenblatt 1982’s Ti– TiO_x – SiO_2 –Si contact as a whole provides reduced resistivity based on at least: (1) the thirty-fold increase in tunneling probability at the Ti– TiO_2 interface as compared to the Al– Al_2O_3 interface; and (2) the lower barrier height of the Ti– TiO_2 interface allowing for current transport by means of thermionic emission.

Id. ¶ 112 (emphasis omitted). Dr. Schubert, however, has not provided any calculations or estimates for the resistivity or resistance differences that result from the increase in tunneling probability or lower barrier height. *Id.* ¶¶ 103–113. Dr. Schubert merely concludes that the Ti– TiO_x – SiO_2 –Si contact has reduced resistivity because the tunneling probability and lower barrier height for Ti– TiO_x would outweigh titanium’s increased resistivity without providing any evidence or calculations to support that assertion. *Id.* The absence of supporting calculations or other evidence to support his

testimony that the tunneling probability and lower barrier height would outweigh the increase bulk resistivity of titanium undermines that testimony.

Dr. Kuhn provides an illustrative example demonstrating how the resistance of a contact would differ for Ti and Al. Ex. 2070, Kuhn Decl. ¶ 119. In Dr. Kuhn's example, the resistance due to the metal for the contact was calculated to be $12.5\ \Omega$ for aluminum and $201.6\ \Omega$ for titanium. *Id.* Dr. Schubert has not disputed these calculations. Ex. 1173, Schubert Reply Decl. ¶¶ 103–113. Further, Dr. Schubert presents no calculations or estimates showing how in that example or in any other example the differences due to the change in tunneling probability or lower barrier height at the interface would outweigh the difference in resistance in the contact metal. *Id.* For instance, for Dr. Kuhn's example, Dr. Schubert does not set forth how the difference in resistance due to the increase in tunneling probability and the lowering of the barrier height with the Ti–TiO_x interface would outweigh the $189.1\ \Omega$ ($201.6\ \Omega - 12.5\ \Omega$) increase in resistance due to the metal in the contact. *Id.* Dr. Schubert provides no estimate for how the resistance of the junction would change due to the increase in tunneling probability and the lowering of the barrier height. *Id.*

Even if we were to assume that the thirty-fold increase in tunneling probability at the Ti–TiO₂ interface were to result in a thirty-fold decrease in the contribution of resistance from the interface and the lower barrier height would also result in a significant difference (e.g., factor of ten), that would not necessarily mean that the differences in these contributions would outweigh the difference due to the contact metal. For example, if the Al–Al₂O₃ interface were to contribute $30\ \Omega$ resistance to the overall resistance of the junction and the increased tunneling probability for Ti–TiO_x would decrease that resistance by a factor of 30 and the lower barrier height would

decrease it by another factor of 10, the resistance contribution from the Ti–TiO_x junction would be 0.1 Ω ($30 \Omega \times 1/30 \times 1/10$) versus 30 Ω with the aluminum structure. The decrease in resistance due to the Ti–TiO_x interface would be 29.9 Ω , but that would not outweigh the 189.1 Ω increase due to the increased resistance of Ti. Using this simple example with the same assumptions, however, one could arbitrarily pick numbers for the contributions for resistance from the interface where a decrease in the resistance at the interface would outweigh the increase in resistance due to the metal contact.¹⁸ Without being provided any evidence of what the resistance difference between Ti–TiO₂ interface is as compared to the Al–Al₂O₃ interface, we cannot determine whether that decrease in resistivity at the interface would outweigh the increase in resistance at the metal contact nor can we determine whether an ordinarily skilled artisan would so recognize it. And Dr. Schubert’s conclusory testimony that the resistance difference at the interface would outweigh the increase in resistance due to the metal contact is not persuasive, particularly when Dr. Schubert failed to account for metal contact resistance in his original analysis.¹⁹ In sum, we

¹⁸ This example is merely illustrative. For instance, it is based on mere assumptions as to how tunneling probabilities and decrease in barrier heights translate into changes in resistance. The example merely illustrates the fact that a thirty-times decrease in one effect (tunneling probability) and an unquantified difference in another effect (barrier height) does not necessarily mean such effect outweigh a sixteen-fold increase in resistance at the contact metal.

¹⁹ Patent Owner disputes that the tunneling probability at the TiO_x interface is 30 times greater than that of AlO₂. Sur-reply 10. Patent Owner argues that the electronic affinity for AlO₂ is 3.71 eV, rather than 3.28 eV that Dr. Schubert used in his calculations. *Id.* (citing Ex. 1143, 1190). Patent Owner further argues that, with a value of 3.71 eV, the tunneling probability

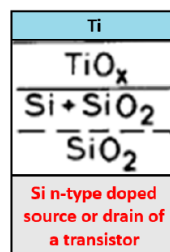
conclude that Petitioner has not proven that an ordinarily skilled artisan would have been motivated to make the proposed combination of Goodnick and Taubenblatt 1982. Thus, Petitioner has not proven that claim 1, 11, 12, 15, 23–25, and 28 would have been obvious over Goodnick and Taubenblatt 1982.²⁰ Pet. 10.

E. Ground 5: Asserted Obviousness over Goodnick, Jammy, and Taubenblatt 1982

Petitioner argues that claims 14, 17–19, and 22 would have been obvious over Goodnick, Jammy, and Taubenblatt 1982. Pet. 10.

1. Proposed Combination of Goodnick, Jammy, and Taubenblatt 1982

Petitioner proposes that an ordinarily skilled artisan would have (i) grown a 30 Å SiO₂ layer as taught in Goodnick on Jammy’s n-type doped source or drain of a transistor in a silicon substrate, (ii) deposited Taubenblatt 1982’s titanium on that 30 Å SiO₂ layer instead of Goodnick’s aluminum; and (iii) annealed the resulting structure at 700°C–900°C as taught by Taubenblatt 1982. Pet. 49. According to Petitioner, this combination would have yielded the following structure:



for Al₂O₃ would be 1.66 times greater than TiO₂. *Id.* In light of our other findings, we do not need to resolve this dispute.

²⁰ As set forth in Section III.A.2, we determined that Goodnick anticipates claim 1.

Pet. 51. Petitioner describes the above structure as having a $\text{TiO}_x - \text{SiO}_2$ interface layer between a titanium metal electrical contact and exposed n-type source/drain diffusions in a silicon substrate. *Id.* at 50–51.

2. Motivation to Combine Goodnick, Jammy, Taubenblatt 1982

Petitioner asserts that an ordinarily skilled artisan would have combined Goodnick and Taubenblatt 1982 to make a $\text{Ti-TiO}_x\text{-Si+SO}_2\text{-SiO}_2\text{-Si}$ contact to reduce specific contact resistivity for the reasons expressed for Ground 4. Pet. 49. Petitioner further argues that, in addition, an ordinarily skilled artisan would have substituted Jammy's n-type silicon substrate for Goodnick's n-type silicon substrate because (i) that substitution would not have materially altered the $\text{Ti-TiO}_x\text{-Si+SO}_2\text{-SiO}_2\text{-Si}$ contact formed by combining Goodnick and Taubenblatt 1982 and (ii) it would be desirable for Jammy's structure to have a contact with low specific contact resistivity. *Id.* at 49–50.

As discussed in Section III.D.3.b above for Ground 4, we determined that Petitioner has not proven that an ordinarily skilled would have been motivated to combine Goodnick and Taubenblatt 1982 to reduce specific contact resistivity. Thus, Petitioner has not proven that an ordinarily skilled artisan would have been motivated to make the proposed combination of Goodnick, Jammy, and Taubenblatt 1982 for this ground. Accordingly, Petitioner has not proven that claims 14, 17–19, and 22 would have been obvious over Goodnick, Jammy, and Taubenblatt 1982.

F. Ground 6: Asserted Obviousness over Goodnick Jammy, Taubenblatt 1982, and Chang

Petitioner asserts that claim 6 would have been obvious over the combination of Goodnick, Jammy, Taubenblatt 1982, and Chang. Pet. 10.

1. Chang

Chang addresses the specific contact resistance of metal-semiconductor barriers. Ex. 1124, 1. Chang discloses that the specific contact resistance at zero bias, R_c , is important as a measure of the ohmic or rectifying behavior of a metal-semiconductor barrier under operating conditions, and Chang calculates R_c for metal-Si and metal-GaAs barriers on p-type and n-type samples. *Id.* According to Chang, R_c decreases exponentially with increasing temperatures and with decreasing barrier height. *Id.* Chang also states that, for higher dopings where tunneling dominates, R_c decreases rapidly with increased doping. *Id.*

2. Proposed Combination of Goodnick, Jammy, Taubenblatt 1982, and Chang and Motivation for the Combination

Petitioner relies on its arguments for Ground 5 that an ordinarily skilled artisan would have combined Goodnick, Jammy, and Taubenblatt 1982 to produce a Ti–TiO_x–Si+SO₂–SiO₂–Si structure. Pet. 57. Petitioner further argues that an ordinarily skilled artisan would have been motivated by Chang to provide a specific contact resistivity in that structure of less than 10 $\Omega\text{-}\mu\text{m}^2$. *Id.*

As set forth in Section III.E.2 above, we determined that Petitioner has not proven that an ordinarily skilled artisan would have been motivated to combine Goodnick, Jammy, and Taubenblatt 1982 to produce a Ti–TiO_x–Si+SO₂–SiO₂–Si structure. Thus, Petitioner has not proven that an ordinarily skilled artisan would have been motivated to make the proposed combination of Goodnick, Jammy, Taubenblatt 1982, and Chang for this ground. Accordingly, Petitioner has not proven that claim 6 would have been obvious over the combination of Goodnick, Jammy, Taubenblatt 1982, and Chang.

*G. Ground 7: Asserted Obviousness over Goodnick,
Taubenblatt 1982, and Kim*

Petitioner argues that claims 16, 26, and 27 would have been obvious over the combination of Goodnick, Taubenblatt 1982, and Kim. Pet. 10.

1. Kim

Kim is directed to a method of making molybdenum/titanium-tungsten or tungsten/titanium-tungsten ohmic contacts to silicon. Ex. 1125, 1:2–3. Kim generally describes a low resistance contact between a titanium-tungsten alloy and silicon. *Id.* at 4:59–5:4. Kim explains that the titanium in the tungsten-titanium alloy is believed to reduce native silicon dioxide present on the silicon to form silicon and titanium dioxide, which reduces the interface resistance. *Id.* at 4:63–5:4. Kim describes achieving a specific contact resistance from 8 to 15 $\Omega\text{-}\mu\text{m}^2$ for a junction between that alloy and n-type doped silicon. *Id.* at 5:27–30.

*2. Proposed Combination of Goodnick, Taubenblatt 1982, and Kim
and Motivation to Combine*

Petitioner relies on its arguments for Ground 4 that an ordinarily skilled artisan would have been motivated to combine Goodnick and Taubenblatt 1982 in the manner proposed for Ground 4. Pet. 61. Petitioner further argues that an ordinarily skilled artisan would have been motivated to substitute Kim's titanium tungsten alloy for Taubenblatt 1982's titanium. *Id.* at 62.

As set forth in Section III.D.3.b above, we determined that Petitioner has not proven that an ordinarily skilled artisan would have been motivated to combine Goodnick and Taubenblatt 1982 in the manner Petitioner proposes. Thus, Petitioner has not proven that an ordinarily skilled artisan would have been motivated to combine Goodnick, Taubenblatt 1982, and Kim for this ground. Accordingly, Petitioner has not proven that claims 16,

26, and 27 would have been obvious over Goodnick, Taubenblatt 1982, and Kim.

H. Ground 8: Asserted Obviousness over Goodnick, Jammy, Taubenblatt 1982, and Kim

Petitioner argues that claims 20 and 21 would have been obvious over Goodnick, Jammy, Taubenblatt 1982, and Kim. Pet. 10. For this ground, Petitioner relies on its argument for Ground 5 that an ordinarily skilled artisan would have been motivated to combine Goodnick, Jammy, and Taubenblatt 1982 in the manner proposed for Ground 5. Pet. 64. In addition, Petitioner argues that an ordinarily skilled artisan would have been motivated to substitute Kim's titanium tungsten alloy for Taubenblatt 1982's titanium. *Id.*

As set forth in Section III.E.2 above, we determined that Petitioner has not proven that an ordinarily skilled artisan would have been motivated to combine Goodnick, Jammy, and Taubenblatt 1982 in the manner Petitioner proposed for Ground 5. Thus, Petitioner has not proven that an ordinarily skilled artisan would have been motivated to combine Goodnick, Jammy, Taubenblatt 1982, and Kim for this ground. Therefore, Petitioner has not proven that claims 20 and 21 would have been obvious over Goodnick, Jammy, Taubenblatt 1982, and Kim.

IV. MOTIONS TO EXCLUDE

A. Patent Owner's Motion to Exclude

1. Goodnick Cross-Examination Testimony

Patent Owner moves to exclude testimony elicited on cross-examination of Dr. Goodnick concerning whether certain metal oxides fall within the scope of the challenged claims. PO Mot. to Excl. 1 (citing Ex. 1168, Transcript of Deposition of Dr. Stephen Goodnick ("Goodnick

Tr.”) 65:20–66:17, 113:20–117:23, 137:17–141:10 (collectively, the “Goodnick metal-oxide testimony”). Patent Owner, however, acknowledges that Petitioner does not cite to any of the Goodnick-metal-oxide testimony in Petitioner’s papers. *Id.* at 6. Patent Owner argues that, nevertheless, we should not deem the motion to exclude this testimony as moot because Petitioner should not be allowed to use this testimony in the Related Litigation. *Id.* Petitioner argues that we should not exclude the involved testimony. Opp. to PO Mot. Excl. 1.

The motion to exclude the Goodnick metal-oxide testimony is moot. Neither party cites that testimony in its papers, and we do not independently consider it. Regarding the Related Litigation, trial has already occurred, so no decision here would affect the admissibility at that trial. Further, it not within our purview to determine admissibility in the Related Litigation.

In consideration of the above, Patent Owner’s motion to exclude the Goodnick-metal-oxide testimony is dismissed as moot.

2. Kuhn Cross-Examination Testimony

Patent Owner also moves to exclude testimony elicited on cross-examination of its expert, Dr. Kuhn, about claim limitations that recite an “oxide of titanium.” PO Mot. To Excl. 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.* Petitioner argues that questions regarding the scope of that limitation were within the realm of proper cross-examination. Opp. To Pet. Mot. Excl. 7–8.

The motion to exclude the Kuhn testimony is also moot. Neither party has identified where either side has relied on the testimony at issue in this proceeding. Further, the dispositive issue for the grounds (4–8) that

address claims that recite an oxide of titanium (i.e., claims 11–14, 17–28) is Petitioner’s failure to prove that an ordinarily skilled artisan would have been motivated to combine Goodnick and Taubenblatt 1982. *See* Section III.D–H above. The testimony at issue does not address Petitioner’s proffered motivation for combining those references. Thus, the motion to exclude cross-examination testimony by Dr. Kuhn is also moot.

B. Petitioner’s Motion to Exclude

Petitioner moves to exclude certain paragraphs of the direct testimony of Dr. Paul Clifton, i.e., paragraphs 8–15, 19–25, 36–45, 47–50, 52–63, 67, 69–70, 72, 76–77, and 81–107 of 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 Excl. 3. Patent Owner offered Dr. Clifton’s testimony in support of its objective considerations arguments. *See* Section III.B.2.b.

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* Opp. to Pet. Mot. to Excl.

Patent Owner further 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. Opp. to Pet. Mot. Excl. 2. Patent Owner argues that 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 1, citing Ex. 1117, Clifton Tr. 100:2–12) and Dr. Clifton's declaration includes information that demonstrates sufficient knowledge of facts for admissibility (Ex. 2090 ¶¶ 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 Excl. 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.

Petitioner’s Motion to Exclude is, therefore, denied.

V. OTHER ISSUES

A. *Appointments Clause*

Patent Owner argues that “[t]he AIA as written by Congress violates the Appointments Clause.” PO Resp. 60.

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

B. *Alleged 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 to 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.” PO Resp. 61.

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

C. *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. 64. 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.* (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 (December 1, 2020), Petitioner simply stipulated not to bring the same arguments in the District Court.²¹

²¹ *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 June 29, 2020 and November 23, 2020, respectively). Papers 2, 14.

VI. CONCLUSION

As set forth in the following table, Petitioner has shown, by a preponderance of the evidence, that claims 1–5 and 8–10 are unpatentable. Petitioner has not shown, by a preponderance of the evidence, that claims 6, 11, 12, and 14–28 are unpatentable.

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–3, 8–10	102(b)	Goodnick	1–3, 8–10	
4	103(a)	Goodnick, Jammy	4	
5	103(a)	Goodnick	5	
1, 11, 12, 15, 23– 25, 28	103(a)	Goodnick, Taubenblatt 1982		1, 11, 12, 15, 23–25, 28
14, 17– 19, 22	103(a)	Goodnick, Jammy, Taubenblatt 1982		14, 17–19, 22
6	103(a)	Goodnick, Jammy, Taubenblatt 1982, Chang		6
16, 26, 27	103(a)	Goodnick, Taubenblatt 1982, Kim		16, 26, 27
20, 21	103(a)	Goodnick, Jammy, Taubenblatt 1982, Kim		20, 21
Overall			1–5, 8–10	6, 11, 12, 14– 28

VII. ORDER

It is:

ORDERED that claims 1–5 and 8–10 of the '395 patent have been shown, by a preponderance of the evidence, to be unpatentable;²²

FURTHER ORDERED that claims 6, 11, 12, and 14–28 have not been shown, by a preponderance of the evidence, to be unpatentable;

FURTHER ORDERED, that Patent Owner's Motion to Exclude is dismissed; and

FURTHER ORDERED, that Petitioner's Motion to Exclude is denied; and

FURTHER ORDERED that because this is a Final Written Decision, the 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.

²² 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).

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