UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
Petitioner

v.

ACORN SEMI, LLC,
Patent Owner.

IPR2020-01279
Patent 9,905,691 B2

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

McNAMARA, *Administrative Patent Judge*.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314, 37 C.F.R. § 42.4

I. INTRODUCTION

Samsung Electronic Co., Ltd. ("Petitioner") filed a petition, Paper 2 ("Petition" or "Pet."), to institute an *inter partes* review of claims 1–4, 6, 8, 10–13, 15–20, 22, and 25–30 (the "challenged claims") of U.S. Patent No. 9,905,691 B2 ("the '691 patent"). 35 U.S.C. § 311. Petitioner also filed a Statement on Parallel Petitions. Paper 3 ("Pet. Statement"). Acorn Semi LLC ("Patent Owner") filed a Response to Petitioner's Statement on Parallel Petitions, Paper 9 ("PO Resp. to Pet. Statement"), and a Preliminary Response, Paper 10 ("Prelim. Resp."), contending that the Petition should be denied as to all challenged claims. Pursuant to our authorization, Petitioner filed a Preliminary Reply, Paper 13 ("Pet. Reply"), and Patent Owner filed a Preliminary Surreply, Paper 14 ("PO Surreply"). In response to an inquiry by the panel (Paper 17), Petitioner filed a Response to the Board's Order Regarding the Conduct of the Proceeding in which Petitioner agreed to be bound by a stipulation proposed by the Board. Paper 18 ("Pet. Stip."). Patent Owner filed Comments on Petitioner's Answer to Board's Stipulation Inquiry. Paper 19 ("PO Comments").

We have jurisdiction under 37 C.F.R. § 42.4(a) and 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted unless the information presented in the Petition "shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition."

A decision to institute under § 314 may not institute on fewer than all claims challenged in the petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1359–60 (2018). In addition, per Board practice, if the Board institutes trial, it will "institute on all grounds in the petition." PTAB Consolidated Trial Practice Guide, 5–6 (Nov. 2019); *see also PGS Geophysical AS v. Iancu*,

891 F.3d 1354, 1360 (Fed. Cir. 2018) (interpreting the statute to require "a simple yes-or-no institution choice respecting a petition, embracing all challenges included in the petition").

Having considered the arguments and the associated evidence presented in the Petition, the Preliminary Response, the Preliminary Reply, and the Preliminary Surreply, for the reasons described below, we institute *inter partes* review.

II. REAL PARTIES IN INTEREST

Petitioner identifies itself (Samsung Electronics Co., Ltd.); Samsung Electronics America, Inc.; Samsung Semiconductor, Inc.; and Samsung Austin Semiconductor, LLC as real parties-in-interest. Pet. 3. Patent Owner identifies itself as the sole real party-in-interest. Paper 4, 1.

III. RELATED MATTERS

The Petition states that the '691 patent is asserted in the following litigation: *Acorn Semi, LLC v. Samsung Electronics Co. Ltd.*, Civil Action No. 2:19-cv-347 (E.D. Tex.) ("the Acorn Litigation"), and asserts the complaint was served on October 24, 2019. Pet. 3–4 (citing Ex. 1032).

Patent Owner identifies IPR2020-01206 as also concerning the '691 patent. Paper 5, 2.

Petitioner and Patent Owner identify petitions for *inter partes* review concerning the following patents related to the '691 patent that have been asserted in the Acorn Litigation and may be affected by the outcome of this proceeding:

U.S. Patent No. 7,084,423 (IPR2020-01182);

U.S. Patent No. 8,766,336 (IPR2020-01204 and IPR2020-01264);

U.S. Patent No. 9,209,261 (IPR2020-01183);

U.S. Patent No. 9,461,167 (IPR2020-01205 and IPR2020-01241); and

U.S. Patent No. 10,090,395 (IPR2020-01207 and IPR2020-01282). Pet. 4, Paper 5, 2.

Petitioner identifies "the following patent and applications that purport to claim the benefit of the priority of the filing date of the '691 patent:"

Patent or Application No.	Filing Date
U.S. Patent No. 9,812,542	August 30, 2016
U.S. Patent No. 10,388,748	October 9, 2018
U.S. Patent No. 10,090,395	January 23, 2018
U.S. Patent No. 10,186,592	May 16, 2018
U.S. Patent App. No. 16/506,022	July 9, 2019
U.S. Patent App. No. 16/847,878	April 14, 2020
U.S. Patent App. No. 15/929,592	May 12, 2020
U.S. Patent App. No. 15/929,593	May 12, 2020

Pet. 4. In addition, Patent Owner identifies the following related patent applications:

U.S. Patent Appl. No. 15/418,360, filed Jan. 27, 2017; Paper 4, 1.

IV. THE '691 PATENT

The '691 patent "relates to a process for depinning the Fermi level of a semiconductor at a metal-interface layer-semiconductor junction and to devices that employ such a junction." Ex. 1001, 1:27–29. The '691 patent explains that Schottky's theory concerning the ability of a junction to conduct current in one direction more favorably than in the other direction, i.e., the rectifying behavior of a metal /semiconductor junction (e.g., an aluminum/silicon junction), depends upon a barrier at the surface of the contact between the metal and the semiconductor. *Id.* at 1:33–48. As the barrier height at the metal/semiconductor interface determines the electrical

properties of the junction, controlling the barrier height is an important goal. *Id.* at 3:4–10.

The ’691 patent further explains that Schottky’s theory postulates the height of the barrier, as measured by the potential necessary for an electron to pass from the metal to the semiconductor, is the difference between the work function of the metal (i.e., the energy required to free an electron at the Fermi level (the highest occupied energy state of the metal at T=0)) and the electron affinity of the semiconductor (i.e., the difference between the energy of a free electron and the conduction band of the semiconductor); but experimental results indicate a weaker variation of barrier height with work function than implied by this model. Id at 1:49–2:3.

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 2:4–18, Fig. 1 (showing dangling bonds that may be responsible for surface states that trap electrical charges). Although Bardeen’s model assumes that surface states are sufficient to pin the Fermi level in the semiconductor at a point between the valence and conduction bands, such that the barrier height should be independent of the metal’s work function, in experiments this condition is observed rarely. *Id.* at 2:19–25.

Further, according to the ’691 patent, Tersoff proposed that the Fermi level of a semiconductor is pinned near an effective “gap center” due to metal induced gap states (MIGS), which are energy states in the bandgap of the semiconductor that become populated with metal. *Id.* at 2:35–44. Thus, the wave functions of electrons in the metal do not terminate abruptly at the

surface of the metal, but decay in proportion to the distance from the surface, extending inside the semiconductor. *Id.* at 2:44–48.

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

Id. at 2:48–56. The '691 patent also notes one further surface effect on diode characteristics is inhomogeneity, i.e., "if factors affecting the barrier height (e.g., density of surface states) vary across the plane of the junction, the resulting properties of the junction are found not to be a linear combination of the properties of the different regions." *Id.* at 2:63–67.

According to the '691 patent, "a classic metal-semiconductor junction is characterized by a Schottky barrier, the properties of which (e.g., barrier height) depend on surface states, MIGS and inhomogeneities." *Id.* at 2:67–3:3. "Before one can tune the barrier height, however, one must depin the Fermi level of the semiconductor." *Id.* at 3:10–12. The '691 patent seeks to depin the Fermi level of the semiconductor while still permitting substantial current flow between the metal and the semiconductor. *Id.* at 3:12–15. The '691 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 3:30–35. The ’691 patent achieves this goal using thin interface layers disposed between a metal and a silicon based semiconductor to form a “metal-interface layer-semiconductor junction” whose thickness varies with a corresponding minimum specific contact resistance depending on the materials used and allows for depinning the Fermi level while permitting current to flow when the junction is appropriately biased. *Id.* at 3:19–30; *see also id.* at 12:59–14:17, 14:29–52, Figs. 6, 8. “Minimum specific contact resistances of less than or equal to approximately 10 Ω-μm^2 or even less than or equal to approximately 1Ω-μm^2 may be achieved for such junctions in accordance with the present invention.” *Id.* at 3:36–39. 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 5:19–23.

Figure 8 of the ’691 patent is reproduced below.

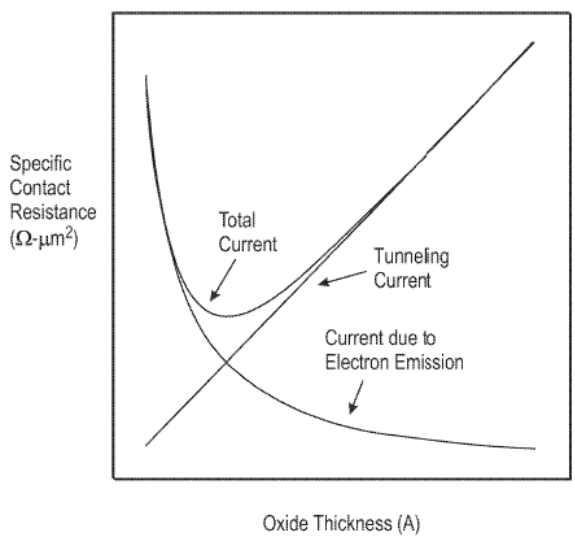


Figure 8 of the ’691 patent

Figure 8 of the ’691 patent is a graph of interface specific contact resistance versus interface thickness for a structure where the work function of the

metal is the same as the electron affinity of the semiconductor, such that the Fermi level of the metal lines up with the conduction band of the semiconductor. *Id.* at 14:29–35. According the '691 patent, Figure 8 shows that at large thicknesses, the interface layer poses significant resistance to current, but as interface layer thickness decreases, resistance falls due to increased tunneling current. *Id.* at 14:29–38. 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 14:38–42. 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 Shottky barrier, but the layer is sufficiently thin to allow significant current across the interface layer, such that specific contact resistances of less than or equal to approximately 2500 Ω-m^2, 1000 Ω-m^2, 100 Ω-m^2, 50 Ω-m^2, 10 Ω-m^2, or less than 1 Ω-m^2 can be achieved. *Id.* at 14:45–52

In one embodiment, the interface layer may be a monolayer or several monolayers of passivating material (e.g., a nitride, oxide, oxynitride, arsenide, hydride and/or fluoride) and may include a separation oxide layer, the specific contact resistance of the electrical device is less than 10 Ω-μm^2. *Id.* at 3:40–53; *see also* 10:43–54. In another embodiment, the interface layer is made up 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) and while heating the semiconductor in a vacuum chamber. *Id.* at 3:44–61. Another embodiment uses an interface layer of passivating material disposed between the surface of a semiconductor and a conductor in which the interface is of sufficient thickness to reduce the effect of MIGs in the

semiconductor and passivates the semiconductor but, because the thickness of the interface layer is chosen to provide minimum, or near minimum, specific contact resistance for the junction, significant current may flow between the conductor and the semiconductor. *Id.* at 3:62–4:8. In other embodiments the interface layer is configured to allow a Fermi level of the conductor to (i) align with a conduction band of the semiconductor, (ii) align with a valence band of the semiconductor, and (iii) be independent of the Fermi level of the semiconductor, allowing current to flow between the conductor and the semiconductor when the junction is biased because the thickness of the interface layer corresponds to a minimum or near minimum contact resistance for the junction. *Id.* at 4:8–18. Specific contact resistances of less than or equal to approximately 2500 Ω-m^2, 1000 Ω-m^2, 100 Ω-m^2, 50 Ω-m^2, 10 Ω-m^2, or less than 1 Ω-m^2 can be achieved. *Id.* at 4:19–22, 14:45–52.

V. ILLUSTRATIVE CLAIM

Independent claim 1, reproduced below to include the subject matter of a certificate of correction issued on May 15, 2018 (Ex. 1001, 21), and including claim element designations (i) through (vii) used in the Petition, is representative of the subject matter of the ’691 patent:

> 1. (i) A structure, comprising
>
> (ii) a semiconductor region in a substrate,
>
> (iii) a metal electrical contact to said semiconductor region,
>
> (iv) a metal oxide layer,
>
> (v) a passivating dielectric tunnel barrier layer between said semiconductor region and said metal electrical contact,
>
> (vi) said semiconductor region being electrically connected to said metal electrical contact through said passivating dielectric tunnel barrier layer and said metal oxide layer,

(vii) wherein said passivating dielectric tunnel barrier layer comprises a semiconductor oxide.

VI. ASSERTED GROUNDS

Petitioner asserts that the challenged claims would have been unpatentable on the following grounds:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1–3, 13	102(b)	Goodnick[1]
4	103(a)	Goodnick, Jammy[2]
1, 3, 6, 10–13, 15, 16, 19, 20, 22	103(a)	Goodnick, Taubenblatt 1982[3]
8, 17	103(a)	Goodnick, Jammy, Taubenblatt 1982
18, 25–30[4]	103(a)	Goodnick, Jammy, Taubenblatt 1982, Chang[5]

VII. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner describes a person of ordinary skill as having any of the following combinations of education and experience: "[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

[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. 1116).
[2] U.S. Patent No. 6,724,088. (Ex. 1115)
[3] M.A. Taubenblatt and C.R. Helms, *Silicide and Schottky barrier formation in the Ti-Si and the Ti-SiOx-Si systems*, 58 J. APPLIED PHYS. 6308 (1982). (Ex. 1117).
[4] Claim 30 has been disclaimed and is no longer a subject of this proceeding.
[5] C.Y. Chang et al., *Specific contact resistance of metal-semiconductor barriers*, 15 SOLID STATE ELECS. 541 (1971)

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. 15–16 (citing Ex. 1119, Declaration of Dr. E. Fred Schubert ("Schubert Decl.") ¶¶ 70−71). The Patent Owner's Preliminary Response does not comment on the level of ordinary skill.

Based on the current record, we are persuaded that Petitioner's description of the level of ordinary skill is appropriate to the subject matter of the '691 patent and we apply it in this Decision.

VIII. 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. Specific Contact Resistivity

Petitioner notes that the term "specific contact resistivity" appears in challenged claims 18 and 25–29, but is not used in the '691 patent Specification. Pet. 17. According to Petitioner, because the terms "specific contact resistance" and "specific contact resistivity" generally are used interchangeably, a person of ordinary skill in the art would have understood the term "specific contact resistivity" in claims 18 and 25–29 to refer to "specific contact resistance." *Id.* at 14–15 (citing Ex. 1016, Schubert Decl. ¶¶ 74–76). Patent Owner does not respond explicitly to Petitioner's assertion.

In consideration of the above, for purposes of this Decision we construe the terms "specific contact resistivity" and "specific contact resistance" to be interchangeable.

Patent Owner does not propose constructions for any specific terms. We note, however, that Patent Owner's arguments for denying institution on the merits emphasize that claim elements 1(iv)[6] "a metal oxide layer" and 1(v),[7] "a passivating dielectric tunnel barrier layer between said

[6] Referred to as claim limitation 1[c] in the Preliminary Response. Prelim. 38

[7] Referred to as claim limitation 1[d] in the Preliminary Response. Prelim. 38

semiconductor region and said metal electrical contact" be construed as two distinct layers. Prelim Resp. 38–39 (citing Ex. 2009 (construction proposed in corresponding district case)). We address these arguments in our discussion of claim 1 in Section X.B.2.

IX. DISCRETION TO DENY ISSUES

Patent Owner argues that we should exercise our discretion to deny institution in view of the pending litigation and in view of the parallel petition filed in IPR2020-01206.

A. Discretion Under 35 U.S.C. 314(a)

Institution is discretionary. *See* 35 U.S.C. §§ 314(a) (authorizing, but not requiring, institution); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2140 (2016) ("[T]he agency's decision to deny a petition is a matter committed to the Patent Office's discretion."). Several precedential and informative Board decisions guide our exercise of that discretion. *See NHK Spring Co. v. IntriPlex Techs., Inc.*, IPR2018-00752, Paper 8 (PTAB Sept. 12, 2018) (precedential) ("*NHK Spring*"); *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential) ("*Fintiv I*"); *Sand Revolution II, LLC v. Continental Intermodal Group – Trucking LLC*, IPR2019-01393, Paper 24 (PTAB June 16, 2020) (informative) (applying *Fintiv I* factors in light of ongoing, parallel district court litigation and instituting trial); *see also Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 15 (PTAB May 13, 2020) (informative) (denying institution in light of an ongoing, parallel district court proceeding) ("*Fintiv II*").

Patent Owner argues that we should exercise our discretion to not institute trial due to the Acorn Litigation. Prelim. Resp. 1.

In *NHK Spring*, the Board considered the advanced state of a parallel district court proceeding as a factor favoring denial of institution, and in

Fintiv I, the Board identified a non-exclusive list of factors to consider when applying NHK Spring. *See NHK Spring*, 11–18; *Fintiv I*, 5–16. We consider those factors below.

1. *Whether the court granted a stay or evidence exists that one may be granted if a proceeding is instituted.*

The Petition explained that Petitioner would "be promptly moving to stay the Acorn Litigation," which is before Judge Gilstrap, and that "[a]lthough [Judge Gilstrap] infrequently grants pre-institution motions to stay, [he] nonetheless invites defendants to renew their motions to stay once the Board institutes trial." Pet. 67. Petitioner argued that Judge Gilstrap "has granted those renewed motions to stay even when the stage of the case has significantly advanced in the interim—even after claim construction has occurred." *Id.* (citing *Image Processing Techs. LLC v. Samsung Elecs. Co., Ltd.*, Case No. 2:16-cv-505-JRG, 2017 WL 10185855 (E.D. Tex. Feb. 17, 2017)). Petitioner's motion to stay was denied, with leave to refile after the IPR institution decisions. *See* Ex. 2010.

Patent Owner argues that the stay factor "strongly favors denial in this case, as the court has already denied the petitioner's motion for a stay and is highly unlikely to enter a stay after the decisions on institution." Prelim. Resp. 18. Patent Owner points out that "the court made clear that it would not entertain a renewed motion to stay until after decisions on institution had been rendered in all ten of the IPRs." *Id*. Patent Owner also argues that the Image Processing case is an "outlier," and that Judge Gilstrap has since denied such motions in other cases. *See id*. at 18–21. Patent Owner asserts that "a complete review of the court's stay jurisprudence in similar circumstances shows that it would be shocking for the court to grant a stay even if IPR trials are instituted against all six . . . patents" and that "if trial is

instituted against only a subset of the six . . . patents, then the likelihood of a stay is extremely low." *Id.* at 21.

Petitioner's Reply reiterates that this factor "favors institution because Judge Gilstrap will likely stay the litigation upon institution," and cites another decision granting a renewed motion, *Seven Networks, LLC v. Apple Inc.*, No. 2:19-cv-00115, Dkt. 312 (E.D. Tex. Sept. 22, 2020) (Exhibit 1036). *See* Pet. Reply 1.

Patent Owner responds that "[n]othing in the terse *Seven [Networks]* opinion signals that [Judge Gilstrap] would do the same in this case." PO Surreply 1.

We consider this factor to be neutral. It appears that Judge Gilstrap is willing stay after IPR institutions in some cases, but not others, depending on the particular circumstances of a given case. We cannot reasonably speculate on how Judge Gilstrap may choose to manage his docket when it comes to the Acorn Litigation, particularly where the pandemic has caused such disruption. *See Sand Revolution II*, at 7 ("In the absence of specific evidence, we will not attempt to predict how the district court in the related district court litigation will proceed because the court may determine whether or not to stay any individual case, including the related one, based on a variety of circumstances and facts beyond our control and to which the Board is not privy.")

2. *Proximity of the court's trial date to the Board's projected statutory deadline for a final written decision.*

The Petition argued that "[w]hile the Acorn Litigation is scheduled for trial in April 2021 . . . , jury trial dates—to say nothing of dates for post-trial briefing—are inherently subject to change." Pet. 67–68.

The Preliminary Response argues that the trial date factor "strongly supports denial, as the court trial is scheduled to begin over nine months before the final written decision would be due in this case and over ten months before the last final written decision would be due in this set of IPRs." Prelim. Resp. 22 (emphasis omitted). According to Patent Owner, "[i]n comparable cases of such a far-advanced related litigation, the Board has routinely found that this factor favors discretionary denial." *Id*. at 23 (citing three cases). Patent Owner contends that "there is no evidence to suggest that the . . . Eastern District of Texas changes its trial dates in general, let alone in this case" and that "the court has a standing order 'to keep cases moving' despite the COVID-19 pandemic, characterizing trial dates as 'firm' notwithstanding the pandemic." *Id*. at 24 (citing Ex. 2016, 3).

Petitioner responds that "the April 5, 2021 trial date is not 'firm'" because "Judge Gilstrap currently has nineteen trials scheduled to begin on April 5, 2021, including four trials in which Samsung is a defendant," and the Acorn Litigation is number 9 in priority." Pet. Reply 1–2. Petitioner further argues that "the ongoing pandemic continues to disrupt trials in the Eastern District of Texas—increasing the probability that the Acorn Litigation trial date will change" and that "Judge Gilstrap recently continued all trials scheduled to begin between now and March 1, 2021, which will in turn likely delay the Acorn Litigation." *Id*. at 3 (citing *Solas OLED Ltd. v. Samsung Display Co., Ltd., et al.*, No. 2:19-cv-00152, Dkt. No. 302 (E.D. Tex. Nov. 20, 2020) (Ex. 1039)).

Patent Owner responds that "the reply presents no evidence – instead, just speculation – that the trial in this case will not begin as scheduled" and that a panel in *Google v. AGIS Software Dev*., IPR2020-00870, Paper 16 at

11 (Nov. 25, 2020), recently concluded that the April 5, 2021 trial date for the corresponding litigation in that case weighed in favor of denial. *See* PO Surreply 1–2. Patent Owner also argues that the "reply states that the court has continued all trials scheduled before March 1, 2020[,] [b]ut, the court has not delayed or rescheduled the trial in this case." *Id*. Patent Owner further argues that, "even assuming that the court trial is delayed slightly while coronavirus vaccines are rolled out, the court trial will still finish well before the IPR." *Id*. at 3.

We find this factor to favor denial of institution. However, we are cognizant of the impact of the court's trial schedule for April, and the potential impact of the pandemic on the court's schedule given its continuance of all in-person jury trials scheduled to begin during December, January, and February. These facts introduce some uncertainty to the schedule trial date, and, thus, prevent this factor from weighing strongly against institution.

3. *Investment in the parallel proceeding by the court and the parties.*

Regarding the timing of the IPRs, the Petition argued that Patent Owner "identified only one representative claim for each of six patents in its October 2019 complaint, including only one claim of the '691 Patent, Claim 25," that Patent Owner "served its infringement contentions—which collectively span 108 claims across those six patents, including 22 previously unidentified claims of the '691 Patent," and that "Petitioner promptly filed this petition . . . after receiving those infringement contentions." Pet. 68 (citing Ex. 1146 ¶¶ 63, 73, 83, 93, 103, 113; Ex. 1149; Ex. 1150).

Patent Owner argues that by the time the institution decision is due "the parties and the court will have invested significant time and energy in the case to complete" (a) infringement and invalidity contentions; (b) claim construction discovery, briefing, and argument; (c) fact discovery; (d) expert reports; (e) expert discovery; (f) dispositive motions and responses; and (g) Daubert motions and responses. Prelim. Resp. 25–26 (citing Ex. 2008). Patent Owner argues that "[w]hen the court has completed or nearly completed similar major milestones, the Board has found that [this factor] strongly favors denial." *Id*. at 26 (citing cases). Patent Owner also argues that "the petitioner waited over eight months after filing of the complaint to file its IPR petitions." *Id*. at 28.

We recognize that much work has been done by the parties in the District Court. However, we also find, as a countervailing consideration, that Petitioner acted diligently in filing this and the other IPRs. The record reflects that Patent Owner did not identify the full set of claims being asserted in the District Court until March 9, 2020 (*see* Exs. 1034–1035), and that Petitioner filed this Petition, and nine others, in less than four months. We, therefore, consider this factor to only slightly favor denial.

4. *Overlap between issues raised in the petition and in the parallel proceeding.*

The Petition acknowledged an overlap of claims and invalidity arguments with the litigation, but argued that instituting trial would make it possible for Judge Gilstrap to stay, that it was likely that Patent Owner would drop claims before trial, "leaving the Board as the only tribunal to assess them," and that "if the Board institutes trial here, Petitioner will promptly cease asserting Grupp '483 (and its pre-grant publication) against the challenged claims in the [TX Litigation]." Pet. 69.

Patent Owner dismissed Petitioner's "conditional representation" that it would drop instituted grounds from the district court contentions as "a ruse," arguing "petitioner is unlikely to be able to try two invalidity theories in court given the practical constraints of a court trial, the petitioner's representation is not a concession at all." Prelim. Resp. 29. Patent Owner also contended that the representation was "too narrow to be of much value" because it does not include any ground that could have been raised in this IPR. *See id*. at 30.

Petitioner's Reply clarified that "if the Board institutes review in either IPR2020-01206 or IPR2020-01279, Samsung will promptly cease asserting the prior art references relied upon in both petitions in the [Litigation]." Pet. Reply 3–4 (emphasis omitted).

After Petitioner filed its Reply, the Board designated as precedential Section II.A of *Sotera Wireless, Inc. v. Masimo Corporation*, IPR2020-01019, Paper 12 (Dec. 1, 2020). In that case, the Board found that a stipulation by Petitioner that it would not pursue in the co-pending litigation "the specific grounds . . . [in] the instituted [inter partes] review petition, or on any other ground . . . that was raised or could have been §§ 102 or 103 on the basis of prior art patents or printed publications)" was sufficient to "mitigate[] any concerns of duplicative efforts" and "ensure[] that an inter partes review is a 'true alternative' to the district court proceeding," and that it accordingly caused this factor to weigh "strongly in favor of not exercising discretion to deny institution." *Id*. at 19. We requested information from the parties based on the intervening precedential decision, inquiring whether Petitioner would agree to such a stipulation and gave Patent Owner an opportunity to submit its own comments. *See* Paper 19. Both parties responded. *See* Pet. Stip.; PO Comments.

Petitioner indicated that it would agree to the stipulation for all ten *inter partes* reviews, as follows:

> In the event one or more of these Petitions is granted on a given patent, Petitioner will not pursue in the Acorn Litigation [i.e., Acorn Semi, LLC v. Samsung Electronics Co. Ltd., Civil Action No. 2:19- cv-347 (E.D. Tex.)] any invalidity ground on that patent that was raised or that could have been reasonably raised in an IPR, i.e., any ground that could be raised under §§ 102 or 103 on the basis of prior art patents or printed publications.

Pet. Stip. 2. Petitioner states that it "will meaningfully abide by this stipulation and promptly notify the District Court about the Board's decisions." *Id*. at 3.

Patent Owner asserts that "inviting this third, revised stipulation is unprecedented, procedurally improper, prejudicial to Acorn, and sets a dangerous precedent that will invite future abusive gamesmanship by petitioners." PO Comments 1. According to Patent Owner, allowing Petitioner to agree to this stipulation "is like allowing the petitioner to place its bet on the race after the horses have made the final turn on the track." *Id*. Patent Owner contends that the stipulation "is informed not only by Acorn's preliminary responses, final expert reports on validity, and very nearly complete expert discovery, but the Board's own telegraphing of how it is handicapping the proceeding." *Id*. Patent Owner characterizes the stipulation as "a midstream change of rules" and as "shenanigans [that] violate due process." *Id*. at 2. Patent Owner argues that "[i]f a procedure like this is followed in other cases, petitioners will initially make no meaningful stipulation in their petitions, evaluate the patent owners' preliminary responses, see how related litigation develops in the interim,

wait for the Board to invite broader stipulations, and then decide whether to capitalize on those opportunities." *Id*.

In view of the stipulation, we conclude that, following *Sotera Wireless,* this factor strongly favors institution. As in *Sotera*, "Petitioner's stipulation mitigates any concerns of duplicative efforts between the district court and the Board, as well as concerns of potentially conflicting decisions." *Sotera*, Paper 12 at 19 (citing *Sand Revolution II, LLC v. Cont'l Intermodal Group – Trucking LLC*, IPR2019-01393, Paper 24 (PTAB June 16, 2020) (informative)). "Accordingly, Petitioner's broad stipulation ensures that an inter partes review is a 'true alternative' to the district court proceeding." *Id*.

We do not agree with Patent Owner that allowing the stipulation at this point is "procedurally improper" or "sets a dangerous precedent." Rather, Petitioner's stipulation meaningfully simplifies overlapping issues between the parallel district court proceeding and this proceeding. Furthermore, as a matter of procedure the Board routinely allows briefing from parties in the event of intervening precedential decisions. *See, e.g., Hunting Titan, Inc. v. DynaEnergetics Europe GmbH*, IPR2018-00600, Paper 67 at 4 (PTAB July 6, 2020) (precedential) (authorizing supplemental briefing from the parties to address an intervening precedential decision by the Court of Appeals for the Federal Circuit). Moreover, Patent Owner does not identify any Board procedures or rules that have been violated, and any effect our conduct of this case has on other cases would be minimal, as it would be limited to situations in which *Sotera Wireless* was made precedential both after the petitioner had a chance to address it and before the institution decision. Given this limited window, Petitioners will not be able to "initially make no meaningful stipulation in their petitions, evaluate

the . . . preliminary responses, see how related litigation develops . . . , wait for the Board to invite broader stipulations, and then decide whether to capitalize on those opportunities," as Patent Owner argues.

We are also unpersuaded by Patent Owner's arguments regarding prejudice, both procedurally, because we afforded Patent Owner an opportunity to address the issue, and substantively, because Patent Owner's allegations that it stands to be prejudiced are not particularized. Patent Owner does not identify any specific advantage Petitioner obtains by choosing to forego in the district court arguments that are addressed in this proceeding. We also find no due process problem, as Patent Owner has had ample opportunity to make its Section 314(a) arguments, including after the stipulation was accepted.

5. *Whether the petitioner and the defendant in the parallel proceeding are the same party.*

As Patent Owner observes, "the parties in this IPR and the related litigation are exactly the same." Prelim. Resp. 31. This factor thus favors denial. *See* Fintiv I, Paper 11 at 13–14.

6. *Other circumstances that impact the Board's exercise of discretion, including the merits.*

The Petition argued that this factor favors institution because "Petitioner has presented a compelling anticipation ground using Grupp '483." Pet. [64].

Patent Owner contends the Petition has "substantive weaknesses" but that "[e]ven assuming *arguendo* that the challenge had strong merits, the merits would be insufficient to outweigh the other factors in this case." Prelim. Resp. 31–32. Patent Owner further argues "the fact that the petitioner has filed parallel petitions against the '691 Patent is another reason

to deny institution," as is "the relative size and stature of the parties." *Id.* at 32. Patent Owner also finds unfairness in the "suspicious" timing of the IPRs, because "Acorn would be forced to prepare and file up to ten IPR responses in the critical weeks before and during the trial in the district court." *Id*. at 32–33. Finally, Patent Owner argues that the limited remaining term of the '691 patent also favors denial, because it means there is limited public interest in the patent's validity, and [that the] Board's resources [would be] better spent on patents having a longer lifespan and broader public impact." *Id*. at 33.

We weigh this factor as favoring institution. On the current record, find that Petitioner's unpatentability arguments in this case is strong. *See Fintiv I*, Paper 11 at 14–15 ("[I]f the merits of a ground raised in the petition seem particularly strong on the preliminary record, this fact has favored institution.").

We are not persuaded by Patent Owner's other arguments. We do not agree that the filing of the parallel petition favors denial. We are also unable to evaluate Patent Owner's argument regarding the "relative size and stature of the parties" because the record lacks evidence on that point, although we do note that Patent Owner made the decision to initiate the six patent Acorn Litigation, to which IPRs would have been a predictable response. We do not find the timing of the IPR filings to be "suspicious," because it appears to have been driven by Patent Owner's identification of the asserted claims. And the term expiration argument is undercut by the six-year statute of limitations for patent infringement damages. *See* 35 U.S.C. § 286.

We also note that the Office did not consider Goodnick, Taubenblatt, or Chang during prosecution of the '691 patent (*see* Pet. 65) and issues raised in this proceeding by Patent Owner, e.g., the existence or non-

existence of layers as discussed in the Goodnick Declaration, were not before the Examiner. We also note that, although Jammy was cited in an information disclosure statement, as there is no discussion of Jammy in the prosecution record (*Id*. (citing Ex. 1112, 319–392; Ex. 1114, 128)), there could be no discussion of Jammy in combination with other references cited in the Petition that were not considered by the Examiner.

7. *Conclusion*

The above factors are not a scorecard, but instead sketch a landscape that we are to view though a holistic lens. *See Fintiv II*, Paper 11 at 6. After considering all of the factors, we determine that we should not exercise our discretion to deny institution under 35 U.S.C. § 314(a) in view of the Acorn Litigation. We determine that Petitioner's stipulation has minimized any overlap with the parallel district court litigation such that both the duplication of efforts and the potential for conflicting decisions are minimized. Although the parties have invested in the litigation, Petitioner filed this proceeding on a timely basis after learning which of the eighty-four claims were being asserted. Accordingly, we conclude that the minimization of overlap and the strength of the merits outweigh the upcoming trial date. As such, we decline to exercise discretion to deny *inter partes* review.

B. Parallel Petitions

Petitioner filed two petitions challenging the '691 patent, i.e., IPR2020-01206 (the "Grupp'483 Petition") and IPR2020-01279 (the "Goodnick Petition"). Both Petitions challenge the same claims, i.e., claims 1–4, 6, 8, 10–13, 15–20, 22, and 25–29. Petitioner prioritizes IPR2020-01206, if we institute on only one Petition. Pet. Statement 4. Petitioner emphasizes that the "[b]oth petitions address the challenged claims under different priority dates." *Id.* at 3. Petitioner notes that the Grupp '483

Petition asserts anticipation on the basis that "Grupp '483 is prior art to the challenged claims under their correct priority date," while the Goodnick Petitinton "relies on references that qualify as prior art even under [Patent Owner's] alleged August 12, 2002 priority date." *Id.*

Patent Owner contends that "Grupp '483 is not asserted as prior art under § 102(a) or § 102(e), but under § 102(b). The two sets of challenges in the two petitions here are simply two different sets of § 102(b) references – not circumstances that justify parallel petitions." PO Resp. to Pet. Statement 3. Patent Owner argues that, under the Consolidated Trial Practice Guide and cases applying it, parallel petitions may be warranted where the patent owner can, but is unwilling, to simplify issues and reduce the need for petitioner to rely on alternative positions, e.g. by stipulating as to date of invention or the priority date of a reference or other matters. *Id.* Patent Owner states in this case, there is "no stipulation [Patent Owner] could possibly make that would reduce the number of issues without being tantamount to an admission that the claims are in violation of 35 U.S.C. § 112, ¶ 1." *Id.* at 3–4. Thus, Patent Owner argues Petitioner is not entitled to two bites at the '691 patent. *Id.* at 4.

We do not agree with Patent Owner that the only circumstances that can justify the existence of two petitions is a situation where Patent Owner can, but chooses not to, file a stipulation to simplify issues. Here, the parties dispute the priority date for the challenged patent, and such a dispute can also justify two petitions. Consolidated Trial Practice Guide 59. In the Grupp '483 IPR, we determine that, for purposes of institution, Petitioner demonstrated that the '691 patent is not entitled to priority before the disclosure of a generic metal oxide in the '522 application, and that Grupp '483 may be applied as an anticipating reference for purposes of claims

limitations drawn to the recited metal oxide layer. *See* Grupp '483 IPR, Decision to Institute, Section IX.E.1. On the other hand, the challenge advanced by Petitioner in the present Goodnick IPR does not depend on priority and asserts different prior art. Thus, in this particular case, we are persuaded the challenges are sufficiently different and premised on different priority positions that it is appropriate to allow parallel petitions, so that the issues can be addressed separately.

Having concluded that the pending litigation is not a reason to deny institution and that a parallel petition is appropriate in these circumstances, we turn to the merits.

X. ANALYSIS

A. Introduction

"In an [inter partes review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc*., 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring inter partes review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). This burden of persuasion never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (discussing the burden of proof in inter partes review).

Anticipation is a question of fact, as is the question of what a prior art reference teaches. *In re NTP, Inc*., 654 F.3d 1279, 1297 (Fed. Cir. 2011). "A claim is anticipated only if each and every element as set forth in the 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 cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016). Instead, Petitioner must articulate a reason why a person of ordinary skill in the art would have combined the prior art references. *In re NuVasive*, 842 F.3d 1376, 1382 (Fed. Cir. 2016).

A reason to combine or modify the prior art may be found explicitly or implicitly in market forces; design incentives; the "interrelated teachings of multiple patents"; "any need or problem known in the field of endeavor at the time of invention and addressed by the patent"; and the background

knowledge, creativity, and common sense of the person of ordinary skill. *Perfect Web Techs., Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1328–29 (Fed. Cir. 2009) (quoting *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418–21 (2007)).

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

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

B. Claims 1–3 and 13 As Anticipated By Goodnick (Petitioner's Ground 1)

Petitioner contends that Goodnick discloses each and every element of claims 1–3 and 13. Pet. 21–26.

1. *Goodnick (Ex. 1116)*

Goodnick concerns experiments in which "[t]he focus of the present investigation has been to observe the influence of thin SiO_2 layers on the chemical formation of metal-silicon contacts." Ex. 1116, 1.[8] According to Goodnick, a thick interfacial oxide at a metal-silicon interface suppresses current, thereby reducing rectifying characteristics, but a thin oxide later

[8] Page 1 of Ex. 1116 follows an un-numbered cover page.

sustains considerable current via tunneling and reduces the density of interface states by satisfying dangling bonds. *Id.* Goodnick discloses that:

> [a]s a result, 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 discloses experiments with aluminum, platinum, and gold in which thin SiO_2 oxide layers were grown in dry oxygen at 700 degrees Celcius in an open tube furnace to approximately 30Å. Ex. 1116, 1. The 30Å thermally grown SiO_2 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 SiO_2 layer and reaction between the Au and Si appeared to occur." *Id.* at 5. "Al partially reduces the thin SiO_2 layer to form Al_2O_3 and free Si. This reaction appeared to be self-limiting, with SiO_2 still present at the interface, even after heating at 400°C." *Id.* Goodnick concludes:

> a thermally grown SiO_2 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*

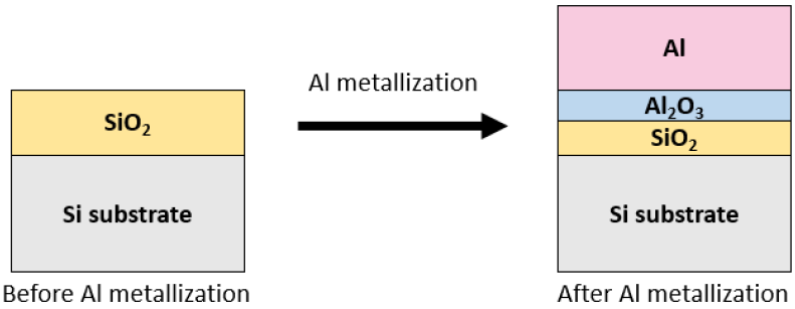
a) Preamble 1(i) and Claim Limitation 1(ii)

As to the preamble 1(i), Petition asserts that the preamble is not limiting, but cites Goodnick as disclosing an Al-Al_2O_3-SiO_2-Si contact structure. Pet. 22 (citing Ex. 1116 1–2, 5; Ex. 1119, Schubert Decl. ¶ 105).

As to claim limitation 1(ii), "a semiconductor region in a substrate," Petitioner cites Goodnick's silicon substrate doped with phosphorous (an n-type dopant) as an example of a semiconductor. *Id.* (citing Ex. 1116, 1; Ex. 1119,Schubert Decl. ¶ 106). Patent Owner does not dispute explicitly Petitioner's contentions concerning claim limitations 1(i) and 1(ii).

b) Claim Limitations 1(iii), 1(iv), and 1(v)

Petitioner identifies claim limitation 1(iii) as reciting "a metal electrical contact to said semiconductor region." *Id.* Petitioner cites Goodnick's disclosure of an aluminum metal electrical contact formed by evaporating aluminum onto a 30 Å layer of SiO_2 on a cleaned silicon substrate as disclosing this limitation. *Id.* (citing Ex. 1112, 1; Ex. 1119, Schubert Decl. ¶ 107). As to claim limitation 1(iv), "a metal oxide layer," Petitioner cites Goodnick's disclosure of an Al_2O_3 layer as teaching this limitation 1(iv). *Id.* (citing Ex. 1116, 5; Ex. 1119 Schubert Decl. ¶ 108). Noting that Goodnick discloses an apparent self-limiting reaction that results in both SiO_2 and Al_2O_3 existing simultaneously at the interface, Petitioner proposes the schematic depiction of the metallization process and the resulting Al-Al_2O_3-SiO_2-Si contact shown below.



Petitioner's Depiction of Goodnick's Metallization Process

Id. at 18 (citing Ex. 1116, 1–2, 5; Ex. 1119 Schubert Decl. ¶¶ 79–85). 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.

Petitioner identifies claim limitation 1(v), as reciting "a passivating dielectric tunnel barrier layer between said semiconductor region and said metal electrical contact." *Id.* at 23. Petitioner identifies the SiO_2 (silicon dioxide) layer as the claimed passivating dielectric tunnel barrier. *Id.* at 23. Petitioner notes Goodnick discloses that when thermally evaporating the aluminum metal contact onto the SiO_2 layer grown on the silicon substrate, the aluminum partially reduces SiO_2 to produce Al_2O_3 and some of the SiO_2 layer grown on the silicon surface remained. *Id.* at 23 (citing Ex. 1116, 5; Ex. 1119, Schubert Decl. ¶109). According to Petitioner, Goodnick discloses a layer of SiO_2 grown on the substrate lies between the silicon substrate and the aluminum and is a passivating layer from an electrical and chemical standpoint. *Id.* (citing Ex. 1116, 1; Ex. 1119, Schubert Decl. ¶ 110). Petitioner further asserts that the remaining thin SiO_2 layer grown on the surface of the substrate is a dielectric tunnel barrier. *Id.* at 23–24 (citing Ex. 1105, 7:60–61; Ex. 1001, 1:8–21; Ex. 1116, 1; Ex. 1119, Schubert Decl. ¶ 111).

In support of its counterargument that Goodnick does not disclose the distinct layers required by the claims, Patent Owner cites the Declaration of Dr. Stephen Goodnick, who authored the Goodnick reference, and who states that Petitioner and Dr. Schubert have "misinterpreted key aspects of my paper." Ex. 2043, Declaration of Dr. Stephen Goodnick ("Goodnick Decl.") ¶ 5.

Noting that 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." Ex. 2043 ¶ 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 bonds had not been explored." *Id.* ¶ 44. According to Dr. Goodnick, the inventors "realized the those two pining 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.* at ¶ 45 (referring to Figure of the '691 patent).

Noting 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," Patent Owner argues that, notwithstanding Petitioner's diagrams that purport to illustrate how Goodnick teaches clean stratification of distinct layers, Goodnick includes no such diagrams and does not support the Petition's assertions. Prelim. Resp. 38–39.

The specific issue before us is what one of ordinary skill in the art would have understood from the Goodnick reference. Dr. Schubert contends that a person of ordinary skill would have understood Goodnick to disclose the claimed layered structure. *See* Ex. 1119, Schubert Decl. ¶¶ 79–85 (at ¶ 80 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-SiO_2-Si interface"). Dr. Goodnick states that a person of ordinary skill 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 SiO_2, but only that Al_2O_3 and SiO_2 were found together in the interface region between the aluminum and the semiconductor. *See* Ex. 2043 ¶¶ 32–40.

Figure 8(a) of Goodnick shows "[p]eak to peak Auger sputter profile on room temperature oxidized Si, unheated" and Figure 8(b) of Goodnick shows "[p]eak to peak Auger profile of Al on 30 Å of SiO_2, unheated." Ex. 1116, 5. Responding to Petitioner's assertions concerning the case where 30Å of SiO_2 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 ¶¶ 32–34. Dr. Goodnick states that, in the period between 0 and 5 minutes, the high levels of Al_2O_3 represent its presence on the top surface of the aluminum, the high level of aluminum between 10 min and 30 minutes corresponds to the aluminum deposition, 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.* ¶ 33. According to Dr. Goodnick, Figure 8(b) shows that Al_2O_3 and SiO_2 were present at the aluminum silicon interface, but "it cannot be determined where Al_2O_3 is present with respect to SiO_2." *Id.* Dr. Goodncik asserts that the presence of a peak in the Al_2O_3 curve at about 40

minutes and the "O" curve (representing SiO_2) 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.* ¶ 34. According to Dr. Goodnick, "[a] POSITA 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. 1116, 5 (emphasis added). It is unclear from this text why a person of ordinary skill would not have understood Goodnick to mean the layers shown in the Petition's depiction of the metallization process and the resulting Al-Al_2O_3-SiO_2-Si structure. Pet. 18.

The Goodnick reference further states that, even at elevated temperatures, 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. 1116, 5 (emphasis added). 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 Al_2O_3 and free Si." Ex. 2043 ¶ 35. It is unclear from the language of the reference whether, in that reference, Dr. Goodnick was speculating about the possibility that other phenomena could explain the self-limiting nature of the reaction or the existence of an Al_2O_3 layer. In any case, given that the Goodnick reference expressly refers to a layer of Al_2O_3 more the once, on this record, we determine that Petitioner has set forth sufficient evidence for institution that the Goodnick reference discloses a layer of Al_2O_3 by at least raising a triable issue as to what a person of ordinary skill would have understood from Goodnick concerning claim limitations (iii), (iv), and (v). Based on Goodnick's specific mention of an Al_2O_3 layer , Petitioner has demonstrated a reasonable likelihood that it will prevail on this issue.

c) Claim limitations 1(vi) and 1(vii)

Petitioner identifies claim limitation 1(vi), as reciting "said semiconductor region being electrically connected to said metal electrical contact through said passivating dielectric tunnel barrier layer and said metal oxide layer." *Id.* at 24. Petitioner cites Goodnick as investigating "the influence of thin SiO_2 layers on the chemical formation of metal-silicon contacts." Pet. 24 (citing Ex. 1116, 1). Petitioner also cites Goodnick as describing its interfacial oxide layers as thin and stating "an oxide layer that is sufficiently thin may sustain considerable current via tunneling." *Id.* at 24–25 (citing Ex. 1116, 1; Ex. 1119, Schubert Decl. ¶ 112).

Petitioner identifies claim limitation 1(vii), as reciting "wherein said passivating dielectric tunnel barrier layer comprises a semiconductor oxide." *Id.* at 25. Referencing its earlier discussion of Goodncik, Petitioner cites that reference as describing a SiO_2 passivating dielectric tunnel barrier layer. *Id.* at 25 (citing Ex. 1116, 1–2, 5).

Other than asserting that Goodnick fails to disclose distinct layers, as discussed in detail above, Patent Owner does not respond to Petitioner's contentions concerning claim limitations 1(vi) and 1(vii).

In consideration of the above, on the current record, we are persuaded that Petitioner has demonstrated a reasonable likelihood it will succeed in its challenge to claim 1 as anticipated by Goodnick.

3. *Claims 2–3, 13*

Claim 2 depends from claim 1 and recites the additional limitation that "the semiconductor oxide comprises an oxide of the semiconductor region." Petitioner cites Goodnick as disclosing thermally growing a layer of SiO_2 on a silicon substrate, that some of the SiO_2 layer is reduced by aluminum to produce Al_2O_3, and that a layer of SiO_2 remaining on the silicon substrate is an oxide of the silicon substrate. Pet. 25.

Claim 3 depends from claim 1 and recites the additional limitation that "the semiconductor oxide of the dielectric tunnel barrier has a thickness of approximately 0.1 nm to 5 nm." Petitioner cites Goodnick as disclosing thermally growing a 30Å (3 nm) thick layer of SiO2 on a silicon substrate that is reduced partially by aluminum to produce Al_2O_3 with a remaining layer of SiO2, whose minimum thickness, i.e. the thickness of a monolayer (a layer one molecule thick), is 2 Å (0.2 nm). Pet. 26 (citing Ex. 1116, 1–2, Ex. 1119; Schubert Decl. ¶ 119).

Claim 13 depends from claim 3 and recites the additional limitation that "the semiconductor oxide comprises an oxide of silicon." Noting that SiO_2 is an oxide of silicon, Petitioner cites Goodnick as disclosing this feature. Pet. 27 (citing Ex. 1116, 5).

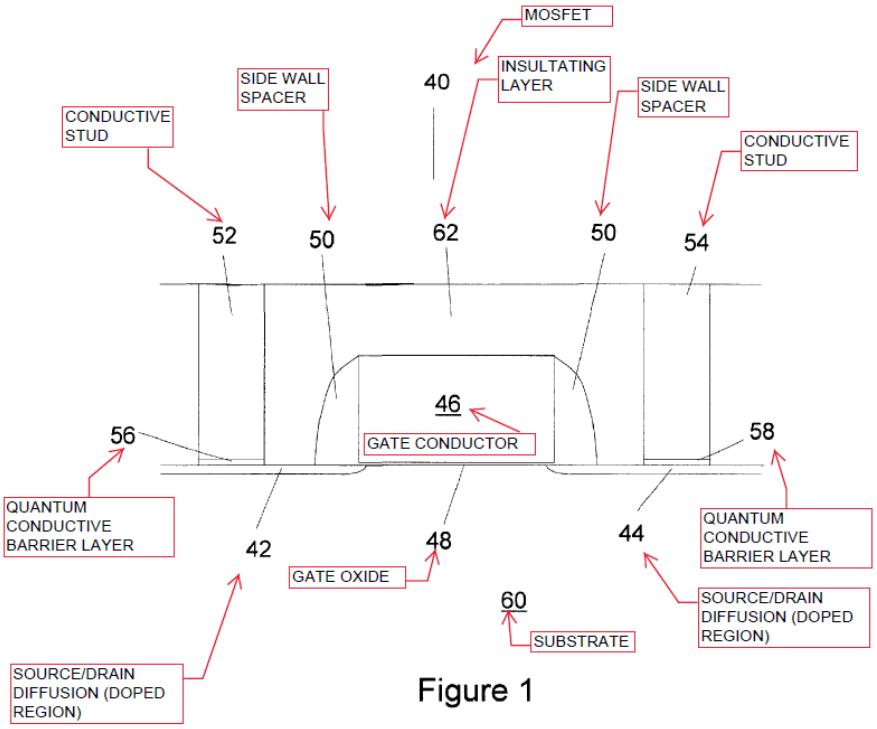
Patent Owner does not respond explicitly to Petitioner's contentions concerning the additional limitations recited in claims 2–3 and 13. In

consideration of the above, on the current record, we are persuaded that Petitioner has demonstrated a reasonable likelihood it will prevail in its challenges to claims 2–3 and 13 as anticipated by Goodnick.

C. Claim 4 As Obvious Over Goodnick in View of Jammy (Petitioner's Ground 2)

1. *Jammy (Ex. 1115)*

Jammy discloses "improved contact between conductive studs and shallow diffusion regions by incorporation of a quantum conductive barrier layer at the interface between the conductive stud and shallow diffusion region." Ex. 1115, 3:18–21. An annotated version of Figure 1 of Jammy is shown below.



Ex. 1115, Fig. 1. Annotated Figure 1 shows MOSFET 40 in which shallow source/drain diffusions, i.e., doped regions 42, 44, formed in substrate 60 contact conductive studs 52, 54 through quantum conductive barriers 56, 58. *Id*. at 4:9–18. Jammy's quantum conductive layers are thin films of less than

50Å (more preferably about 5–30 Å, most preferably about 5–15 Å) of materials that in their bulk properties would be considered dielectrics, but in thin layers become electrically conductive, such that resulting layers preferably have a film resistance of less than about 1 K-ohm-μm^2, more preferably less than about 100 ohm-μm^2. *Id.* at 3:23–40. Jammy's thin layers also prevent or slow diffusion of chemical species from one side of the layer to the other.

2. *Claim 4*

Claim 4 depends from claim 3 and recites the additional limitation that "the semiconductor region comprises an n-typed doped source or drain of a transistor." Acknowledging that Goodnick "does not expressly disclose that its n-doped silicon semiconductor region 'comprises an n-type source or drain of a transistor,'" Petitioner cites Jammy as disclosing this feature. Pet. 27. According to Petitioner a person of ordinary skill would have combined the teachings of Goodnick and Jammy because Goodnick describes contact metallization processes for semiconductor devices and Jammy describes a semiconductor device. *Id.* at 28.

Patent Owner argues that Petitioner's assertions concerning claim 4 under this ground fail for the same reasons as discussed above concerning clam 1. Prelim Resp. 47.

For the reasons discussed above with respect to Ground 1, and based on the cited disclosure in Jammy, we are persuaded that Petitioner has demonstrated a reasonable likelihood it will prevail in its challenge to claim 4 under Ground 2.

D. Claims 1, 3, 6, 10-12, 13, 15, 16, 19, 20, and 22 As Obvious Over Goodnick in view of Taubenblatt (Petitioner's Ground 3)

1. *Taubenblatt (Ex. 1117)*

Noting the importance of silicides as Schottky barriers, ohmic contacts, and low resistivity interconnects in integrated circuits, Taubenblatt 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. 1115, 1. Taubenblatt concerns experiments "to characterize silicide formation for the Ti-Si system under ultrahigh vacuum (UHV) conditions with the controlled addition of surface oxides." *Id.* Taubenblatt's "results show that the presence of SiO_2 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 SiO_2 layer is especially important in determining the reaction end products." Ex. 1115, 8. According to Taubenblatt:

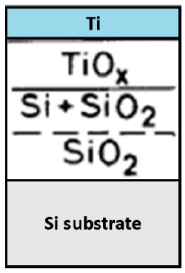
> in the manufacture of circuit elements employing titanium disilicide, Ti will react through a thin silicon dioxide layer with the SiQ2 remaining at the surface. But in the reaction of Ti with a thicker SiQ2 layer, Ti oxide forms, which can act as a diffusion barrier to prevent further reduction of the oxide by unreacted Ti metal or in the formation of silicide.

Id.

2. *Motivation to combine the teachings of Goodnick and Taubenblatt*

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 a metal oxide layer that comprises an oxide of titanium, as recited explicitly in claims 6, 10–12, and 16. Pet. 29. Petitioner states that, because Taubenblatt teaches (i) depositing

titanium on a layer of SiO_2 thicker than 20 Å (2nm) and (ii) annealing at temperatures between 700ºC–900ºC forms a TiO_x–SiO_2 interface layer, a person of ordinary skill would have understood that by depositing titanium on Goodnick's 30 Å (3 nm) thick layer of thermally grown SiO_2, "all it would have taken to form a TiO_x–SiO_2 interface layer is annealing at 700C–900C, as described in Taubenblatt 1982." *Id.* (citing Ex. 1117, 7–8, Ex. 1119, Schubert Decl. ¶ 137). Petitioner contends that the combined teachings of Goodnick and Taubenblatt would have resulted in the structure shown below.



Pat. 31–32 (citing Ex. 1115, 1–2; Ex. 1117, 7–8; Ex. 1119; Schubert Decl. ¶ 138). 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 32; *see also* Ex. 1117, Fig. 11, 8 (discussing Fig. 11 row 3 concerning the behavior of thin layers of SiO_2).

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." *Id.* at 32 (citing Ex. 1119, Schubert Decl. ¶ 39). Petitioner argues it was known that a SiO_2 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's titanium and Goodnick's n-type source drain/drain silicon substrate." *Id.* at 33 (citing Ex. 1115, 3; Ex. 1116 1–2; Ex. 1119, Schubert Decl. ¶ 141). Petitioner further states that for a junction between titanium and n-type silicon with a SiO_2 interface layer, the SiO_2 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.* (citing Ex. 1119; Schubert Decl. ¶ 141; Ex. 1118 (Chang)[9], 5–6).

Patent Owner states that, although Taubenblatt "reports the results of several experiments depositing titanium on silicon under various conditions" "nothing in Goodnick suggests any reason to study titanium." Prelim. Resp. 47. Noting Petitioner's argument that the motivating justification seems to be reducing contact resistivity, Patent Owner argues that "Goodnick never mentions resistivity." Acknowledging that Taubenblatt "mentions resistivity in passing once in his introduction," Patent Owner argues that neither Goodnick nor Taubenblatt is concerned with building a low resistivity junction; instead both references report on studies of basic material interactions, with both researchers performing experiments with different materials. *Id.* at 48.

Patent Owner further argues that because the bulk resistivity of titanium is 16 times greater than that of aluminum, a person of ordinary skill would not have had reason to use titanium to lower resistivity. *Id.* at 48–49. Patent Owner also asserts an ordinarily skilled artisan would have

[9] Chang is not a reference cited in this ground. Chang is cited in another ground.

recognized Ti as a poor choice because of the difference between the thermal coefficients of titanium and silicon. *Id.* at 49.

In summarizing what would have been known to one of ordinary skill at the relevant time, Petitioner's expert, Dr. Schubert, cites another Taubenblatt reference, i.e., (Taubenblatt 1984)[10]. Petitioner notes that Taubenblatt 1984 references teachings in Turner and Rhoderick[11] 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 Shottky barrier. Ex. 1119, Schubert Decl. ¶ 54 (citing Ex. 1123, 3). Dr. Schubert also states "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 (citing Schroen[12], issued in 1976 (Ex. 1124, Abstract)) as disclosing 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 Iwaguro[13] (Ex. 1127) ¶ 6, which states that "[b]y bringing a metal film into contact with this sub-silicon oxide film, an ohmic junction exhibiting favorable low contact resistance can be obtained."). As to the use of titanium, Dr. Schubert cites a 1989 patent by

[10] M.A. Taubenblatt et al., *Interface effects in titanium and hafnium Schottky barriers on silicon*, 44 APPLIED PHYS. LETTERS 895 (Ex. 1123, "Taubenblatt 1984").
[11] Ex. 1123, fn 18 (citing M. J. Turner and E. H. Rhoderick, Solid State Electron. II, 291 (1968)); *see also* Ex. 1117, fn 1.
[12] U.S. Patent No. 3,983,264 (Ex. 1124, "Schroen").
[13] Certified Translation of Japanese Laid-Open App. No. JPH11162874A (June 18, 1999) (Ex. 1127, "Iwaguro").

Kim[14] (Ex. 1125) as describing an interface layer formed by titanium reducing silicon dioxide to achieve a specific contact resistance as low as 8Ω-μm^2. Ex. 1119, Schubert Decl. ¶¶ 57–58 (citing Ex. 1125, 5:27–30). In its discussion of Ground 5, Petitioner also cites Kim as evidence that ordinarily skilled artisans had achieved contact resistivity below 10 Ω-μm^2 using an interface layer, stating that Kim "describes a specific contact resistance (resistivity) as low as 8 Ω-μm^2 for a junction between a Ti-W (titanium-tungsten) alloy and n-type silicon with an interfacial oxide the include titanium dioxide therebetween. Pet. 54 (citing Ex. 1125, 4:63–5:1, 5:27–30).

Patent Owner responds that Kim teaches the use of alloys of tungsten and titanium and away from the use of titanium alone, noting that Kim states:

> 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).

Prelim. Resp. 49 (citing Ex. 1125, 1:24–30).

Although Dr. Schubert's testimony and his citation of various references disclose an interface layer can reduce resistivity, it is not clear that the subject matter cited by Dr. Schubert supports his assertion that a person of ordinary skill would have substituted Taubenblatt's titanium for Goodnick's aluminum. In the structure disclosed by Kim, a sputtering apparatus places a first conductor, i.e., an 800 Å layer of an alloy consisting of about 10% titanium and the remainder tungsten by weight over the layer

[14] U.S. Patent No. 4,845,050 (Ex. 1125, "Kim").

of silicon dioxide. Ex. 1025, 4:17–21. Kim discloses that during the sintering step, at the interface between the conductor and the silicon member, titanium in the conductor reacts with native silicon dioxide present on the exposed surface of these conductors to form silicon and titanium oxide, thereby reducing the interface resistance. Ex. 1125, 4:59–5:1. According to Kim "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." *Id.* at 5:2–4. As Kim discloses the use of an alloy of tungsten and titanium, and specifically identifies disadvantages to the use of aluminum and titanium alone (Ex. 1025, 1:12–30), we are not persuaded that Petitioner has demonstrated a person of ordinary skill would have had reason to combine in the manner argued by Dr. Schubert the teachings in Goodnick's and Taubenblatt's documentation of experiments concerning the behavior of aluminum and titanium on silicon. As Patent Owner points out, Dr. Schubert's assertions that a person of ordinary skill would replace Goodnick's aluminum with Taubenblatt's titanium is inconsistent with Kim's disclosures concerning the use of a tungsten-titanium alloy consisting mostly of tungsten by weight. Thus, we are not persuaded that Petitioner has demonstrated a person of ordinary skill would have combined the references as Petitioner suggest.

3. *Claims 1, 3, 6, 10-12, 13, 15, 16, 19, 20, and 22*

Citing its discussion of Goodnick, Petitioner contends that, if one of ordinary skill had reason to combine their teachings, Goodnick and Taubenblatt teach a Ti-TiO_x-SiO_2-Si contact, as recited in claim 1 (Pet. 36–41) with a tunnel barrier thickness of 0.1 nm to 5 nm, as recited in claim 3 (*id.* at 42–43), wherein the metal oxide comprises titanium, as recited in claim 6, the semiconductor oxide comprises an oxide of silicon, as recited in

claim10, and the semiconductor oxide of the dielectric tunnel barrier is adjacent the semiconductor region, as recited in claim 11 (*id.* at 43–44). Noting that claim 13 depends from claim 3, which depends from claim 1, Petitioner contends that the combined teachings of Goodnick and Taubenblatt teach a structure in which the semiconductor oxide comprises an oxide of silicon, as recited in claim 13, that the metal oxide layer comprises an oxide of titanium, as recited in claim 15, and that the metal electrical contact comprises titanium, as recited in claim 16. Pet. 44–45.

Claim 19 depends from claim 1 and recites the added limitations that "the semiconductor region comprises silicon, the semiconductor oxide comprises an oxide of silicon, the metal oxide of the dielectric tunnel barrier layer comprises an oxide of titanium, and the metal electrical contact comprises titanium." In support of its argument that Goodnick and Taubenblatt disclose this combination of features, Petitioner cites its earlier discussion of these individual features. Pet. 46–47.

Claim 20 depends from claim 1 and recites the added limitations that "the dielectric tunnel barrier layer is configured to reduce a height of a Schottky barrier between the metal electrical contact and the semiconductor region from that which would exist at a contact junction between the metal electrical contact and the semiconductor region without the dielectric tunnel barrier layer disposed therebetween." In support of its argument that Goodnick and Taubenblatt disclose this combination of features, Petitioner cites its earlier discussion of claim limitation 1(vii) and argues that the SiO_2 layer also reduces the Schottky barrier height between the titanium (the metal electrical contact) and the n-type silicon substrate (the semiconductor region) from the barrier height that would have existed without the SiO_2 layer disposed between them. Pet. 47–48.

Claim 22 recites "the dielectric tunnel barrier layer is configured to reduce contact resistivity between the metal electrical contact and the semiconductor region from that which would exist at a contact junction between the metal electrical contact and the semiconductor region without the dielectric tunnel barrier layer disposed therebetween." In support of its argument that Goodnick and Taubenblatt disclose this combination of features, Petitioner cites its earlier discussion of claims 1 and 20, citing Carver (Ex. 1128, 2)[15], contends the terms "contact resistivity" and "specific contact resistivity" are interchangeable, and, citing Chang[16], argues that "[s]pecific contact resistivity depends on barrier height, so decreasing the barrier height between the metal electrical contact (titanium) and the semiconductor region (n-type silicon) would have decreased specific contact resistivity. Pet. 48–49 (citing Ex. 1119, Schubert Decl. ¶ 199; Ex. 1118, 5–6).

Patent Owner does not respond explicitly to Petitioner's contentions concerning each claim individually. As discussed above, however, we are not persuaded by Petitioner's arguments that a person of ordinary skill would have had reason to combine the teachings of Goodnick and Taubenblatt as proposed by Petitioner. Thus, we are not persuaded Petitioner has demonstrated a reasonable likelihood it will prevail in its challenge under Ground 3.

E. Claims 8 and 17 As Obvious Over Goodnick in View of Jammy and Taubenblatt (Petitioner's Ground 4)

Claim 8 depends from claim 6, and claim 17 depends from claim 15. Claims 6 and 15 recite that the metal oxide layer of the dielectric tunnel

[15] Carver is not cited as a reference in this ground.
[16] Chang is not cited as a reference in this ground.

barrier layer comprises an oxide of titanium. Claims 8 and 17 recite that the semiconductor comprises an n-type doped source or drain of a transistor. Petitioner contends that a person of ordinary skill would have had reason to grow Goodnick's 30 Å layer on Jammy's n-type doped source or drain of a transistor in a silicon substrate and then deposit aluminum. Pet. 49. Petitioner cites Taubenblatt as teaching depositing titanium instead of aluminum, arguing that swapping Goodnick's silicon substrate for Jammy's source or drain of a transistor and performing conventional processing steps, an ordinarily skilled artisan would have had a reasonable expectation of success in combining the teachings of the references. *Id.* at 49–50 (citing Ex. 1119, Schubert Decl. ¶¶ 203–204). Petitioner further argues that because Jammy discloses depositing conductive studs on its quantum conductive barrier and incorporates by reference Cote,[17] which teaches titanium conductive studs, depositing Jammy's conductive stud would have been equally suitable and would have yielded the same TiO_x-SiO_2 interface layer owing to the formation of the TiO_x diffusion barrier during Taubenblatt's annealing process. *Id.* at 50 fn.3 (citing Ex. 1115, 4:5–8, Fig.1; Ex. 1129, 8:24–28; Ex. 1119, Schubert Decl. ¶ 202 n. 13).

Noting that the challenge in Petitioner's Ground 4 builds on the challenge in Petitioner's Ground 3 by adding Jammy, Patent Owner contends that "challenge 4 fails for the same reason as challenge 3." Prelim. Resp. 49–50.

We are not persuaded that Petitioner's citation of Jammy in addition to Goodnick and Taubenblatt addresses the deficiencies noted in our discussion of Ground 3. As to Cote, incorporated by reference in Jammy,

[17] U.S. Patent No. 5,216,282 (Ex. 1129).

we note that Cote seeks to minimize contact resistance by increasing the contact region between a contact stud and a semiconductor structure by contacting the stud along a sidewall of the structure using a manufacturing process that self-aligns the contact stud along the sidewall. Ex. 1129, 2:1–11. Unlike the process followed in Taubenblatt, Cote discloses forming a diffusion contact opening or window, i.e., a void having boundaries defined by an insulating oxide layer (deposited, e.g., by chemical vapor deposition), a silicided junction, and a spacer that prevents the gate conductor from shorting to the diffusion region through the silicided junction when the contact window is backfilled with appropriate conductive stud material, such as titanium, titanium nitride, or tungsten. *See*, Ex. 1129, 7:3–8:36. Thus, we are not persuaded that Petitioner has demonstrated a reasonable likelihood it will prevail as to challenge Ground 4.

F. Claims 18 and 25–29 as Obvious Over Goodnick in View of Jammy, Taubenblatt, and Chang (Petitioner's Ground 5)

1. *Chang (Ex. 1118)*

Chang concerns the specific contact resistance of metal-semiconductor barriers. *See* Ex. 1118. Noting 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, Chang calculates R_c for metal-Si and metal-GaAs barriers on p-type and n-type samples. *Id.* at 1. 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 increasing doping. *Id.*

2. *Motivation to combine the teachings of Chang with those of Goodnick, Jammy, and Taubenblatt*

Petitioner states the "combination of Goodnick, Jammy, and Taubenblatt 1982 does not expressly describe any specific contact resistivity," but argues a person of ordinary skill "would have been motivated to provide an interface layer configured to provide a specific contact resistivity between the contact metal and the semiconductor of less than 1 Ω-μm^2, and would have had a reasonable expectation of achieving a specific contact resistivity in the claimed range based on the combined teachings of Goodnick, Jammy, Taubenblatt 1982, and Chang." Pet. 53 (citing Ex. 1119, Schubert Decl. ¶ 213). Acknowledging that Jammy does not disclose expressly any doping level for its n-type silicon/drain source diffusion region, Petitioner argues that an ordinarily skilled artisan "would have been motivated to use Chang's high doping levels for Jammy's n-type silicon source/drain diffusion regions to further reduce specific contact resistivity." *Id.* at 53–54 (citing Ex. 1119, Schubert Decl. ¶ 214).

Patent Owner contends that Petitioner has not demonstrated a person of ordinary skill would have combined the teachings of Goodnick, Jammy, Taubenblatt, and Chang to arrive at the subject matter recited in claims 18 and 25–29.

First, Patent Owner argues that an ordinarily skilled artisan would not have replaced Jammy's quantum conductive barrier with a 30 Å layer of SiO_2 as taught be Goodnick because Jammy does not mention SiO_2 as one of the materials for the quantum conductive barer and because Goodnick's investigation of platinum, gold, and aluminum does not mention titanium. Prelim Resp. 52–54.

Second, Patent Owner contends an ordinarily skilled artisan would not have looked to Taubenblatt to replace Jammy's tungsten or polycrystalline conductive studs with titanium because nothing in Jammy suggests the desirability of using titanium and nothing in Taubenblatt's study of the reaction between titanium and silicon or silicon dioxide suggests using titanium as a conductive stud in an electrical device. *Id.* at 54. As to Cote, Patent Owner contends Cote is incorporated by reference into Jammy as describing transistor structures—not as describing materials for conductive studs and not as a disclosure of actually using titanium for Jammy's conductive studs. *Id.* at 54–55. According to Patent Owner, other differences between tungsten and titanium, e.g., tungsten's well-known inertness and low bulk resistivity, and the large difference in in the linear thermal coefficeint of expansion of titanium and silicon, "would have strongly cautioned a POSITA against swapping" tungsten for titanium. *Id.* at 55.

Third, Patent Owner contends that Petitioner's proposed replacement of Jammy's quantum conductive barrier layer with Goodnick's 30 Å SiO_2 layer and the use of titanium studs is contrary to Taubenblatt's teaching that, for thin SiO_2 layers, titanium migrates through the SiO_2 to form titanium silicide, i.e., "exactly what Jammy seeks to prevent with the quantum conductive barrier layer." *Id.* at 56–57 (citing Ex. 1115, 4:19–25 for the proposition that Jammy's quantum conductive barrier acts to prevent deepening of shallow source/drain diffusions by preventing dopant migration from the conductive studs; Ex. 1117, 6313–14[18] and Fig. 11 for

[18] Patent Owner cites the original page numbers of the publication, rather than the page numbers of the Exhibit.

the proposition that Taubenblatt teaches titanium moves further into the bulk of the silicon). Patent Owner further argues a person of ordinary skill would not have been motivated to use thicker layers of SiO_2 to avoid the migration observed by Taubenblatt because "thick SiO_2 layers are insulators and do not meet Jammy's criteria that the quantum conductive barrier 56/58 have a low sheet resistance." *Id.* at 57. Thus, a person of ordinary skill would have been led towards thick layers, thereby increasing, rather than lowering resistivity. *Id.* at 58.

Fourth, as to Chang's doping the silicon to reduce resistivity, Patent Owner contends that an ordinarily skilled artisan would not have been motivated to apply this teaching in conjunction with Goodnick, Jammy, and Taubenblatt because Chang's study of metal-semiconductor junctions does not consider titanium and does not consider intermediate layers, e.g. oxide layers, such as a metal oxide and a semiconductor oxide as claimed. *Id.* at 60. Although Chang identifies a number of parameters on which contact resistance is dependent, Patent Owner contends that nothing in Chang teaches toward the claimed range. *Id.*

Having considered the evidence and arguments in the present record, we agree with Patent Owner that Petitioner has not demonstrated a person of ordinary skill would have had a reason to combine the teachings of the references as proposed. As discussed above, we are not persuaded by Petitioner's arguments that a person of ordinary skill would have had a reason to combine teachings of Goodnick with those of Taubenblatt to substitute titanium for aluminum. We also agree with Patent Owner that Petitioner has not explained sufficiently why a person of ordinary skill at the time would have had a reason to replace Jammy's tungsten or polycrystalline studs with titanium, given Taubenblatt's teachings that titanium migrates

into the silicon. As a result, we see no reason why a person of ordinary skill would have looked to Chang's resistivity teachings in combination with the other references cited by Petitioner in Ground 4.

3. *Claims 18, 25–29*

Claim 18 depends from claim 17 and recites the additional limitation that "a specific contact resistivity between the n-type doped source or drain and the metal electric contact is less than 1 Ω-μm^2." Independent claim 25 recites an electrical junction having an interface layer, comprising a metal oxide separation layer and a semiconductor passivation layer, between a contact metal and a semiconductor comprising a transistor having a source and drain, in which the specific contact resistivity between the contact metal and the semiconductor is less than 1 Ω-μm^2. Claims 26–29 depend directly or indirectly from claim 25 and recite additional features. Claim 26 recites the metal oxide comprises an oxide of titanium; claim 27 recites the semiconductor oxide passivation layer comprises an oxide of the semiconductor; claim 28 recites the semiconductor oxide passivation layer is between 0.1μm and 5nm thick; and claim 29 recites that the semiconductor oxide passivation layer is adjacent the semiconductor. In support of its challenges to claims 25–29, Petitioner references its discussion Goodnick, Jammy, Taubenblatt, and Chang concerning Grounds 1–4. Pet. 56–63. As discussed above, because we are not persuaded Petitioner has demonstrated a person of ordinary skill would have combined the references as proposed by Petitioner, on the current record, we are not persuaded Petitioner has demonstrated a reasonable likelihood that it will prevail in its challenge to claims 18 and 25–29.

G. Objective Indicia of Non-obviousness

Patent Owner states that in 2004 and 2006 the inventors published two papers (Ex. 2045 and 2046, "the Acorn Papers") describing their invention and that these "seminal papers" have been cited in professional literature over 130 and 140 times, respectively. Prelim. Resp. 62. Patent Owner further contends that researchers working for Petitioner cited at least one of the Acorn Papers in a 2017 abstract of an article (Ex. 2047), but the citation was removed in the article's final publication in 2018 (Ex. 2048). *Id.* at 62–63. According to Patent Owner, other references cited in the published article (Ex. 2049, 1; Ex. 2050, 1; and Ex. 2051, 1) credit the inventors' 2006 article with inserting a thin interfacial layer between the metal and semiconductor to alleviate Fermi level pinning attributed to metal induced gap states and to reduce the penetration of MIGS as first proposed by the inventors for Si MOSFETS. According to Patent Owner, "[e]ven at this preliminary stage, it is evident that objective indicia put a heavy thumb on the non-obviousness side of the scale, further showing that the petition's challenges are not reasonably likely to prevail." Prelim. Resp. 65.

Objective criteria constitute independent evidence of non-obviousness. *Mintz v. Dietz & Watson, Inc.*, 679 F.3d 1372, 1378 (Fed. Cir. 2013). 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 one with ordinary skill in the art. *In re Piasecki*, 745 F.2d 1468, 1471–1472 (Fed. Cir. 1984). Secondary considerations may include any of the following: long-felt but unsolved needs, failure of others, unexpected results, commercial success, copying, licensing, and praise. "In order to accord substantial weight to secondary considerations in an obviousness analysis, the evidence of secondary

considerations must have a nexus to the claims, 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) (internal quotations omitted).

Patent Owner provides a chart indicating that the '691 patent, filed on Feb 19, 2016 and issued on February 27, 2018, is one of a large family stemming from an application filed on August 12, 2002 and issued on Aug 1, 2006. Prelim. Resp. 9. On the current record, Patent Owner's reference to scientific papers published in 2004 and 2006 does not establish a clear nexus to the subject matter specifically claimed in the '216 patent. Therefore, we on the current record, we are not persuaded by Patent Owner's arguments concerning objective considerations.

XI. CONCLUSION

For the reasons discussed above, we are persuaded that Petitioner has demonstrated a reasonable likelihood that it will prevail on its challenges to patentability under Ground 1 (Claims 1–3 and 13 as anticipated by Goodnick) and Ground 2 (claim 4 as obvious over Goodnick in view of Jammy). On this record, we are not persuaded that Petitioner has demonstrated a reasonable likelihood it will succeed in its challenges under Ground 3 (claims 1, 3, 6, 10–12, 13, 15, 16, 19, 20, and 22 as obvious over Goodnick in view of Taubenblatt) and Ground 4 (claims 18 and 25–29 as obvious over Goodnick in view of Jammy, Taubenblatt, and Chang).

A decision to institute under § 314 may not institute on fewer than all claims challenged in the petition. *See SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1359–60 (2018), and, per Board practice, if the Board institutes trial, it will "institute on all grounds in the petition." PTAB Consolidated Trial Practice Guide, 5–6 (Nov. 2019); *see also PGS Geophysical AS v. Iancu*,

891 F.3d 1354, 1360 (Fed. Cir. 2018) (interpreting the statute to require "a simple yes-or-no institution choice respecting a petition, embracing all challenges included in the petition"). We accordingly institute trial on all grounds in the Petition.

XII. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314(a) an *inter partes* review of the '691 patent is hereby instituted, commencing on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial.

FURTHER ORDERED that the trial is authorized on all challenges grounds set forth in the Petition; and.

FURTHER ORDERED that the trial will be conducted in accordance with a corresponding Scheduling Order. In the event that an initial conference call has been requested or scheduled, the parties are directed to the Office Trial Practice Guide, 77 Fed. Reg. 48756, 48765–66 (Aug. 14, 2012), for guidance in preparing for the initial conference call, and should come prepared to discuss any proposed changes to the scheduling order entered herewith and any motions the parties anticipate filing during the trial.

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