

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SAMSUNG ELECTRONICS CO., LTD.,  
Petitioner

v.

ACORN SEMI, LLC,  
Patent Owner.

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IPR2020-01204  
Patent 8,766,336 B2

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

MOORE, *Administrative Patent Judge*.

JUDGMENT  
Final Written Decision  
Determining All Challenged Claims Unpatentable  
Dismissing Petitioner's Motion to Exclude  
*35 U.S.C. § 318(a)*

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## I. INTRODUCTION

### A. *Background*

Samsung Electronics Co., Ltd. (“Petitioner”) filed a Petition requesting *inter partes* review of claims 1–16 and 65–80 of U.S. Patent No. 8,766,336 B2 (Ex. 1001, “the ’336 patent”). Paper 2 (“Pet.”). Petitioner also filed a Statement on Parallel Petitions. Paper 4 (“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 11, “Prelim. Resp.”), contending that the Petition should be denied as to all challenged claims. Patent Owner also filed a disclaimer (Ex. 2001) of claims 9, 10, 11, 12, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, and 76, leaving claims 1–8, 13–16, and 77–80 to be addressed in this proceeding.

We instituted trial on January 13, 2021. *See* Paper 21 (“Decision”). Patent Owner filed a response (Paper 27, “PO Resp.”), Petitioner filed a reply (Paper 33, “Pet. Reply”), and Patent Owner filed a sur-reply (Paper 39, “PO Sur-Reply”).

Patent Owner also filed a motion to exclude. *See* Paper 40 (“Mot. to Exclude”). Petitioner filed an opposition (Paper 42, “Mot. to Exclude Opp.”) and Patent Owner filed a reply (Paper 43, “Mot. to Exclude Reply”).

An oral hearing was held on October 13, 2021, by video only, and a transcript of the hearing is included in the record. Paper 47 (“Tr.”). The demonstratives used in the oral hearing are in the record as Exhibit 2124 (Patent Owner) and Paper 45 (Petitioner).

The Board has jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73.

For the reasons that follow, we determine that Petitioner has shown claims 1–8, 13–16, and 77–80 to be unpatentable. We dismiss Patent Owner’s Motion to Exclude as moot.

*B. Related Matters*

The parties identify *Acorn Semi, LLC v. Samsung Electronics Co. Ltd.*, Civil Action No. 2:19-cv-347 (E.D. Tex.) (the “Acorn Litigation”), as a related matter.

Petitioner also filed a second Petition seeking inter partes review of claims 1–16 and 65–80 of the ’336 patent. *See* IPR2020-01264 (“the ’1264 IPR”), Paper 2. We did not institute a trial in that case.

Patent Owner further identifies the following IPRs concerning other members of the ’336 patent’s family as related IPRs: IPR2020-01182; IPR2020-01183; IPR2020-01205; IPR2020-01206; IPR2020-01207; IPR2020-01241; IPR2020-01264; IPR2020-01279; and IPR2020-01282. *See Id.* at 2.

Patent Owner also identifies the following as related patent applications: U.S. Patent Appl. No. 15/418,360; U.S. Patent Appl. No. 15/929,592; U.S. Patent Appl. No. 15/929,593; U.S. Patent Appl. No. 16/847,878; and U.S. Patent Appl. No. 16/506,022. *See* Paper 5, 1.

*C. The ’336 Patent*

The ’336 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, 1:26–28.

The patent explains how Schottky’s theory that 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. *See* Ex. 1001, 1:45–57. By controlling or adjusting the barrier height, one can produce electrical devices of desired characteristics. *See id.* at 3:3–5.

Schottky's theory postulates that 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, 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. However, experimental results indicated a weaker variation of barrier height with work function than implied by this model. *See* Ex. 1001, 1:63–2:2.

To explain the discrepancy between Schottky's predicted behavior 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. *See* Ex. 1001, 2:3–18, Fig. 1 (showing dangling bonds that may be responsible for surface states that trap electrical charges). But although Bardeen's model assumed 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, that condition was rarely observed in experiments. *See id.* at 2:17–25.

Tersoff then 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, such that the wave functions of electrons in the metal do not terminate at the surface of the metal, but decay in proportion to the distance from the surface, extending inside the semiconductor. *See id.* at 2:33–46.

The ’336 patent also notes that a further surface effect on diode characteristics is inhomogeneity: “if factors affecting the barrier height (e.g., the 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 2:60–64.

According to the ’336 patent, “a classic metal-semiconductor junction is characterized by a Schottky barrier, the properties of which (e.g., barrier height) depend on surface states, MIGS and inhomogeneities.” Ex. 1001, 2:64–67. “Before one can tune the barrier height, however, one must depin the Fermi level of the semiconductor.” *Id.* at 3:7–9. The ’336 patent seeks to depin the Fermi level of the semiconductor while still permitting substantial current flow between the metal and the semiconductor. *See id.* at 3:9–12. The ’336 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 3:26–32.

The ’336 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. *See id.* at 3:16–26; *see also id.* at 12:62–14:53. “Minimum specific contact resistances of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$  or even less than or equal to approximately  $1\ \Omega\text{-}\mu\text{m}^2$  may be achieved for such junctions in accordance with the present invention.” *Id.* at 3:32–36. 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. *See id.* at 5:13–17.

Figure 8 of the '336 patent is reproduced below.

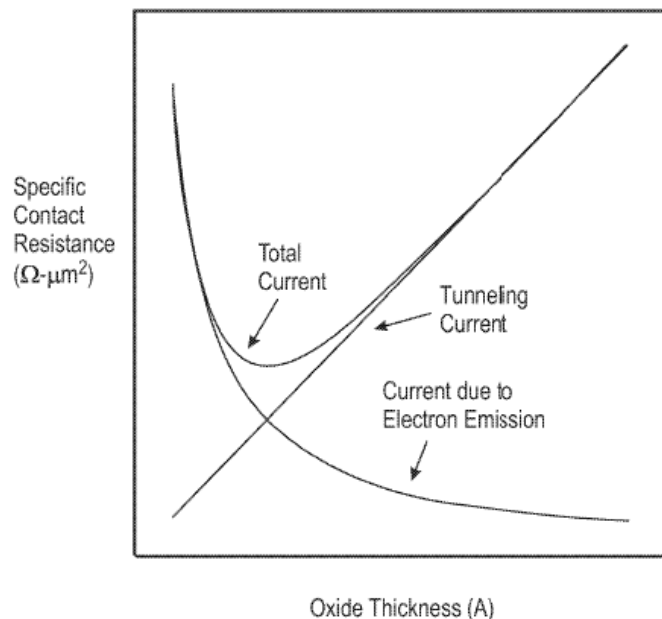


*Figure 8 of the '336 patent*

This graphs 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. *See* Ex. 1001, 14:9–15. According the '336 patent, the graph 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. *See id.* at 14:15–17. 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. *See id.* at 14:17–21. 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  $\Omega\text{-m}^2$ , 1000  $\Omega\text{-m}^2$ , 100  $\Omega\text{-m}^2$ , 50  $\Omega\text{-m}^2$ , 10  $\Omega\text{-m}^2$ , or 1  $\Omega\text{-m}^2$  can be achieved. *See id.* at 14:21–32.

*D. The Challenged Claims*

Independent claims 1 and 5, which are representative of the subject matter at issue, are reproduced below:

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

and wherein the electrical junction has a specific contact resistance of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$ .

5. An electrical junction comprising

an interface layer disposed between a contact metal and a semiconductor,

the semiconductor comprising a source or drain of a transistor,

the interface layer being a metal oxide and sufficiently thick to depin a Fermi level of the semiconductor, yet sufficiently thin to provide the junction with a specific contact resistance of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$ .

Ex. 1001, 18:7–17, 27–33 (formatting modified for readability).

## II. LEVEL OF ORDINARY SKILL IN THE ART

The level of skill in the art is a factual determination that commonly provides a primary guarantee of objectivity in an obviousness analysis. *See Al-Site Corp. v. VSI Int'l Inc.*, 174 F.3d 1308, 1323 (Fed. Cir. 1999) (citing *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966)). The level of skill in the art also informs the claim construction analysis. *See Teva Pharms. USA, Inc. v. Sandoz, Inc.*, 574 U.S. 318, 332 (2015) (explaining that claim construction seeks the meaning “a skilled artisan would ascribe” to the claim term “in the context of the specific patent claim”). In this case, the level of skill in the art provides the perspective from which to evaluate the written description and enablement issues.

Petitioner asserts that “[a]ny of the following combinations of education and experience would have qualified someone as an ordinarily skilled artisan in the field of the ’336 Patent”: (a) “a Ph.D. in electrical engineering, physics, materials science”; (b) “chemical engineering, with two years of practical experience with semiconductor research and design”;

(c) “a Master’s degree in electrical engineering, physics, materials science, or chemical engineering, with four years of practical experience with semiconductor research and design”; or (d) “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. 13 (citing Ex. 1016 ¶¶ 70–71). Petitioner further asserts that “[m]ore education could compensate for less practical experience, and vice versa” and that “[t]he same level of ordinary skill would have been applicable in August 2002, February 2011, or November 2012.” *Id.* Patent Owner does not address the level of skill in the art.

Because Petitioner’s proposal is consistent the disclosures of the ’336 patent and the cited art, we apply it in this Decision.

### III. CLAIM CONSTRUCTION

Neither party seeks any claim constructions, and we see no terms that need to be expressly construed to resolve the issues before us, so we do not engage in any formal claim construction. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (explaining that construction is needed only for terms that are in dispute, and only as necessary to resolve the controversy).

#### IV. PATENTABILITY

The sole ground now presented in this case is anticipation of claims 1–8, 13–16, and 77–80 by U.S. Patent 7,176,483 (Ex. 1015, “Grupp ’483”), which is a continuation-in-part of U.S. App. No. 10/217,758, the ultimate parent of the ’336 patent. *See* Pet. 6, 11. Petitioner argues that Grupp ’483 is prior art because it issued on February 13, 2007 and the claims at issue are entitled only to, at the earliest, a February 7, 2011 priority date. *Id.* at 6. Patent Owner argues that Grupp ’483 is not prior art because the claims are entitled to an earlier priority date.

##### *A. Priority*

Petitioner makes three arguments as to why the ’336 patent is not entitled to the filing date of the parent applications: (1) that the parent applications do not enable the full scope of limitations concerning specific contact resistance; (2) that the pre-2011 parent applications lack written description support for the “metal oxide” interface limitations, and (3) that the parent applications lack written description support for the “group IV semiconductor” limitations. We address these in turn.<sup>1</sup>

##### *1. Metal Oxide*

Independent claims 1, 13, and 77 recite an “interface layer comprising a metal oxide,” and independent claim 5 recites “the interface layer being a metal oxide.”

According to Petitioner, the first time any of the priority applications “even arguably disclosed a generic ‘metal oxide’ interface layer is in the

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<sup>1</sup> Petitioner also made other written description arguments concerning claims 9–12 and 65–76, but those claims have now been disclaimed.

originally filed claims of U.S. Patent App. No. 13/022,522 filed on February 7, 2011.” Pet. 22 (citing Ex. 1010, 48; Ex. 1016 ¶ 95). Petitioner acknowledges that the earlier-filed priority applications (those filed before 2011—“pre-2011 priority applications”) describe a “possible example of a metal oxide interface layer” in the form of a TiO<sub>2</sub> [titanium dioxide] spacer layer. *Id.* (citing Ex. 1001, 17:36–38; Ex. 1016 ¶ 96). In fact, Petitioner relies on this description when arguing that Grupp ’483 anticipates claim 1. *See id.* at 32 (citing Ex. 1016 ¶¶ 125). At the same time, Petitioner argues that Grupp ’483 can be applied as a prior art reference because the same language in the pre-2011 priority applications fails to provide a written description of the genus “metal oxide layer.” *See* Pet. 22–25.

Petitioner asserts that the relevant question for this written description/priority issue is whether the pre-2011 priority applications’ statement that “[s]pacer layers may be used with lower barriers (e.g., TiO<sub>2</sub> has a barrier of less than 1 eV)” provides a written description of the entire genus of metal oxide interface layers. Pet. 23 (citing Ex. 1001, 17:36–38). Petitioner contends that the answer is “no,” arguing that some metal oxides present considerably higher barriers than the “barrier of less than 1 eV” ascribed to TiO<sub>2</sub>. *Id.* In particular, Petitioner argues, “hafnium oxide and zirconium oxide are metal oxides with barriers to aluminum of 2 eV and 2.43 eV, respectively.” *Id.* (citing Ex. 1029, 4; Ex. 1030, 1; Ex. 1016 ¶ 100).

Patent Owner does not dispute that hafnium oxide and zirconium oxide have considerably higher barriers to metals than TiO<sub>2</sub>. Patent Owner, however, argues that the ’423 patent (from a pre-2011 priority application), as originally filed in 2002, nevertheless supports the genus of “metal oxide” in two ways. First, Patent Owner argues that the specification “discloses

TiO<sub>2</sub>” as a species. *See* PO Resp. 37 (citing Ex. 1003, 17:59–61). Second, Patent Owner argues that the specification discloses oxide spacer/separation layers as a more general genus. *Id.* at 37–38 (citing Ex. 1003, 10:49–50). Patent Owner argues that these two disclosures demonstrate that the Acorn inventors possessed the “metal oxide” genus or subgenus. *Id.* at 38 (citing Ex. 2070 ¶¶ 97–113). Patent Owner provides an analysis by Dr. Kuhn to support its argument that an ordinarily skilled artisan would have envisaged the metal oxide genus based on these disclosures. *Id.* at 38–41 (citing Ex. 2070 ¶¶ 97–113).

Patent Owner also argues that the disclosure in the pre-2011 priority applications of the use of TiO<sub>2</sub> as material with a lower barrier does not teach away from the use of materials with higher barriers. PO Resp. 39 (citing Ex. 1003, 17:61–64; Ex. 2070 ¶ 111).

Further, Patent Owner argues that, in an unrelated application, Petitioner sought a claim to a metal oxide genus after disclosing only three species of metal oxides. *Id.* at 41 (citing Ex. 2099, claim 2, ¶¶ 8, 33, 39, 86, 96, 99, 100, 111, 140, 156, 161).

In its Reply, Petitioner argues that there are countless materials that contain metal oxides with just one metal. Reply Br. 3. Further, Petitioner asserts that a metal oxide can include multiple metals. *Id.* (citing Ex. 1042 at 211:8–212:3; Ex. 1047 ¶¶ 18–20). Petitioner also argues that metal oxides have varying properties. *Id.* at 3–5 (citing Ex. 1047 ¶ 51). Further, Petitioner argues that the claims of the ’336 patent encompass metal oxides that were invented after the priority applications were filed. *Id.* at 6–8 (citing Ex. 1042, 99:6–23, 80:15–82:21).

In its Sur-reply, Patent Owner argues that the purpose of the written description requirement is to prevent over-claiming. PO Sur-reply 11. Patent Owner asserts that the pre-2011 priority applications describe the broader genus of oxides in general and that, because the patentee could have claimed the broader genus of oxides there is no concern in this case of the patentee over-claiming metal oxides. *Id.*

Patent Owner also asserts that the disclosure of TiO<sub>2</sub> is sufficient to support the genus of metal oxides because it discloses structural features common to members of the genus so that an ordinarily skilled artisan can recognize the member of the genus. PO Sur-reply 11. Patent Owner asserts that, here, the metal oxide is in the spacer layer and a common structural feature of metal oxides used for such a purpose is that they are dielectrics. *Id.* at 12. Further, Patent Owner argues that Petitioner argued for its own patent application that the genus “metal oxide having a small conduction band offset with respect to the source/drain area” was supported by just TiO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, and ZnO. *Id.* at 12 (citing Ex. 2099, claims 2–3).

We agree with Petitioner that the pre-2011 priority applications do not describe the recited genus.

To support a claim to a genus, a specification must disclose “either a representative number of species falling within the scope of the genus or structural features common to the members of the genus so that one of skill in the art can ‘visualize or recognize’ the members of the genus.” *Ariad Pharm., Inc. v. Eli Lilly & Co.*, 598 F.3d 1336, 1350 (Fed. Cir. 2010). Here, the recited genus is an interface layer comprising a metal oxide, where the interface layer is configured to provide a specific contact resistivity between a contact metal and a semiconductor of less than or equal to approximately

1  $\Omega \mu\text{m}^2$  or 1000  $\Omega \mu\text{m}^2$ . It is undisputed that the only species the pre-2011 priority applications disclose is  $\text{TiO}_2$ , as set forth in the following passage:

Two other properties of the dielectric deserve mention. First is the property of the height of the barrier compared to the semiconductor conduction band (for electrons). In making the barrier thinner than a silicide barrier, the tradeoff may be a higher tunnel barrier (e.g., 2 eV for nitride, compared with about half the gap of 0.6 eV for silicide). *Spacer layers may be used with lower barriers (e.g.,  $\text{TiO}_2$  has a barrier of less than 1 eV).* Nevertheless, even with the higher barrier to electrons, the present inventors have determined that the resistance can still be one hundred times lower than a contact to silicon with a silicide barrier.

Ex. 1001, 17:31–41 (emphasis added).

The pre-2011 priority applications incorporate by reference U.S. Patent No. 6,833,556, which describes the use of metal oxides to isolate a transistor's gate from its channel. Ex. 1005, 7:60–8:22, 13:44–14:20; *see e.g.*, Ex. 1001, 14:435–52, Ex. 1016 ¶ 97. It is undisputed, however, that this description in the '556 patent of metal oxides used to isolate a gate from its channel does not describe the recited genus, because the recited genus constitutes an interface layer that is conductive (a specific contact resistivity between the contact metal and the semiconductor of less than 1  $\Omega \mu\text{m}^2$  or 1000  $\Omega \mu\text{m}^2$ ). *Id.*

The disclosure in the pre-2011 priority applications that “spacer layers may be used with lower barriers (e.g.,  $\text{TiO}_2$  has a barrier of less than 1 eV)” does not describe structural features common to the members of the genus so that one of skill in the art can visualize or recognize the members of the genus. *See* Ex. 1016 ¶¶ 99–103. The disclosure describes one property of  $\text{TiO}_2$ —that it has a lower barrier of less than 1 eV. That, however, is not a property of the recited genus as a whole. For example, hafnium oxide and

zirconium oxide are metal oxides with barriers to the metal aluminum of 2 eV and 2.43 eV, respectively. *Id.* ¶ 100; Ex. 1029, 4; Ex. 1030, 1.

As mentioned, Patent Owner argues that the pre-2011 priority applications do not teach away from using materials with barriers of more than 1 eV, noting that the pre-2011 priority applications teach the disclosed techniques may be beneficial for such materials even if they are not as preferred as lower barrier materials. PO Resp. 39 (citing Ex. 1003, 17:61–64; Ex. 2070 ¶ 111). That argument, however, misses the point. Although the pre-2011 priority applications may not teach away from higher barrier materials, the desirable property that those priority applications taught for TiO<sub>2</sub> was that it has a barrier of less than 1 eV, and that is not a property shared by metal oxides as a class.

As mentioned, Patent Owner also argues that the structural feature that is common to the members of the genus of metal oxides to be used for spacer layers is that they are dielectrics. PO Sur-reply 11 (citing Ex. 2070 ¶¶ 107, 109). Even if we were to accept that argument, however, Patent Owner cites no evidence that an ordinarily skilled artisan would envision the recited genus merely from the fact that all metal oxides to be used as spacer layers are purportedly dielectrics. The cited testimony from Dr. Kuhn does not support such a contention, as Dr. Kuhn merely testifies that the '423 patent describes a MIGS separation layer as a dielectric and that dielectrics that do not passivate or only weakly passivate the semiconductor would be desirable. *See* Ex. 2070 ¶¶ 107, 109. Further, the '556 patent, which is incorporated by reference into the '336 patent and the pre-2011 priority applications, teaches that dielectrics are a broader class than metal oxides. *See* Ex. 1005, 7:60–8:5. The '556 patent describes that dielectrics can be

made from oxides of semiconductors, as well as from metals: “the insulator 280 (which may be made of a dielectric such as an oxide of the metal gate or an oxide of a semiconductor).” Ex. 1005, 7:60–8:5. Thus, the disclosed use of a dielectric by itself is not the disclosure of a property that would lead an ordinarily skilled artisan to envision the recited genus of metal oxides.

In sum, the only disclosed property for the  $\text{TiO}_2$  species—a lower barrier of less than 1 eV—would not cause an ordinarily skilled artisan to envision the recited genus.

$\text{TiO}_2$  is also not representative of the recited genus of metal oxides. The metal oxide genus encompasses many underlying species because there are many different metals that can form metal oxides, for example, alkali metals, alkaline earth metals, transition metals, ferrous metals, non-ferrous metals, noble metals, refractory metals, and common metals. Ex. 1047 ¶ 18. Further, metal oxides can be formed from more than one metal species. *Id.* ¶¶ 19, 20. Significantly, important properties for the various metal oxides, such as conductivity,<sup>2</sup> vary significantly. *Id.* ¶¶ 19, 20, 27–51.<sup>3</sup>

As discussed above, Patent Owner nevertheless argues that the pre-2011 priority applications describe the recited genus due to the disclosure of

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<sup>2</sup> The electrical conductivity of a metal oxide is an important property for the recited genus because claim 1 recites a range of specific contact resistivity for the recited interface layer, and electrical conductivity directly affects the specific contact resistivity of a junction. *See* Ex. 1047 ¶ 30.

<sup>3</sup> Dr. Schubert characterizes  $\text{TiO}_2$  as a semiconductor. *See* Ex. 1047 ¶ 51. Patent Owner argues that instead it is a dielectric. *See* PO Sur-reply 7. Even if we were to find that  $\text{TiO}_2$  is a dielectric, however, important properties of metal oxides would still vary significantly. *See* Ex. 1047 ¶ 51; *see also id.* ¶¶ 27–50; Ex. 1016 ¶ 102. For example,  $\text{HfO}_2$  is an insulator, whereas  $\text{InSnO}$  is a relatively good conductor. *See* Ex. 1047 ¶ 51.

oxide spacer/separation layers combined with the disclosure of an interface layer with TiO<sub>2</sub>. PO Resp. 37–38. To support that argument, Patent Owner provides an analysis by Dr. Kuhn of how an ordinarily skilled artisan would purportedly envision the recited genus from these disclosures. *Id.* at 38–40 (citing Ex. 2070 ¶¶ 97–113). We do not credit this analysis by Dr. Kuhn, however, because it relies on unsupported contentions regarding the knowledge of an ordinarily skilled artisan and on the premise that an ordinarily skilled artisan would take a series of mental steps that are not taught or suggested by the pre-2011 priority applications.

Dr. Kuhn begins her analysis with the disclosure in the '423 patent that TiO<sub>2</sub> is an example of a “spacer layer” or “separation layer” (the terms being used synonymously) with Ti as a possible metal for the metal-semiconductor junction. Ex. 2070 ¶ 97. Referring to the spacer layer as the “MIGS separation layer,” Dr. Kuhn asserts that a person of ordinary skill would recognize from the TiO<sub>2</sub> layer example that an oxide of whatever metal is used as the metal in the metal-semiconductor junction would be desirable. *Id.* ¶ 98. Dr. Kuhn cites no teaching in the '423 patent or in any other reference, but states that a person of ordinary skill would recognize the value of a configuration in which the placement of a metal next to an oxide of that metal “is very likely to be more stable than having the metal adjacent to some other oxide.” *Id.*

According to Dr. Kuhn, the fact that the “'423 patent states the separation layer may be an oxide in general, would have directed [an ordinarily skilled artisan] to metal oxides.” Ex. 2070 ¶ 100. Nevertheless, after stating that metals other than titanium are disclosed in the patent, Dr. Kuhn acknowledges that “not all of these metals have oxides that would be

acceptable as a spacer layer, many of them do have such oxides” *Id.* ¶ 99. Noting that the interface layer may be a passivation layer or a single or compound layer including both a passivating material and an additional separation material, Dr. Kuhn states the layers should be well-behaved materials not displaying deleterious effects that would prevent their use in electrical devices. *Id.* ¶¶ 101–102.

Dr. Kuhn next notes that the ’423 patent states “the interface layers serve to (i) chemically passivate the semiconductor surface . . . and (ii) to displace the semiconductor sufficiently to eliminate or at least reduce the effect of MIGS.” Ex. 2070 ¶ 103 (quoting Ex. 1003, 9:50–53). According to Dr. Kuhn, because the ’423 patent explains that the passivation layer alone may not be sufficient to provide MIGS separation, an additional MIGS separation may be required. *Id.* ¶ 104. Dr. Kuhn states that “[f]rom this description, [an ordinarily skilled artisan] would understand that the separation layer, when paired with a passivation layer, does not itself perform a passivation function, but is solely intended to provide the proper thickness and band structure so that the MIGS states arising in the metal cannot pin the Fermi level of the junction.” *Id.*

Dr. Kuhn next notes that the ’423 patent discloses that passivation layers using N and/or O may not require distinct separation layers and asserts that “[f]rom this [an ordinarily skilled artisan] would understand that a passivation material that is also an oxide (such as silicon dioxide or silicon oxy-nitride) would not be considered the distinct separation layers recited in the challenged claims, but rather a passivation layer.” Ex. 2070 ¶ 105 (citing Ex. 1003, 10:5–7). Based on the ’423 patent’s disclosure that “in some cases such passivation layers are combined with separation layers (e.g.,

made of an oxide) to complete the interface layer” (Ex. 1003, 10:48–50), Dr. Kuhn asserts that “[an ordinarily skilled artisan] would understand that the separation layer is intended to be an oxide, but not one with the function of passivation.” *Id.* ¶ 106.

Testifying that “the patent provides extensive teachings on metals versus non-metals” and the relationship between metals, conductive materials, and conductors (Ex. 2070 ¶ 108), Dr. Kuhn posits that an ordinarily skilled artisan would have understood or recognized that:

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

magnesium oxide, zinc oxide, tungsten oxide, molybdenum oxide and yttrium oxide)”;

(vii) “certain materials might have appropriate insulating properties but would not be appropriate for semiconductor fabrication due either to well-known mismatches between materials properties and typical semiconductor processing conditions (e.g. families such as silver oxide and gold oxide) or environmental issues (e.g. families such as lead oxide)”; and

(viii) “[t]he remaining oxides would be recognized as inappropriate choices as they are semiconductors or semimetals (metalloids).”

Ex. 2070 ¶¶ 109–110.

Much of Dr. Kuhn’s analysis is premised on her assessment of the mental steps that an ordinarily skilled artisan theoretically might have taken after reviewing the minimal disclosure in the ’423 patent. The ’423 patent does not discuss any properties of metal oxides (other than the lower barrier of the metal oxide TiO<sub>2</sub>) or design considerations concerning the selection of particular oxides to use in the claimed structure, particularly in the context of MIGS separation. And Dr. Kuhn cites very little, if any, evidence to support her testimony regarding the knowledge of an ordinarily skilled artisan.

Thus, we do not credit this analysis as showing that an ordinarily skilled artisan would have found that the inventors of the pre-2011 priority applications possessed the recited genus. *See Ariad*, 593 F.3d at 1352 (a description that merely renders the invention obvious does not satisfy the written description requirement); *Power Oasis Inc. v. T-Mobile USA*, 522 F.3d 1299, 1306 (Fed. Cir. 2008) (“Entitlement to a filing date does not extend to subject matter which is not disclosed, but would be obvious over what is expressly disclosed.”) (quoting *In re Huston*, 308 F.3d 1267, 1277 (Fed. Cir. 2002), quoting *Lockwood v. Am. Airlines, Inc.*, 107 F.3d 1565, 1571–72 (Fed. Cir. 1997)); *Martin v. Mayer*, 823 F.2d 500, 505 (Fed. Cir.

1987) (holding that the written description requirement is “not a question of whether one skilled in the art *might* be able to construct the patentee’s device from the teachings of the disclosure . . . . [but], [r]ather, it is a question whether the application necessarily discloses that particular device”) (emphasis in original).

As for Patent Owner’s argument that the policy concern for the written description requirement does not apply here because the patentee purportedly had written description support for even broader subject matter than the recited genus, we disagree. First, the written description for priority is a statutory requirement that cannot be avoided based merely on policy arguments. 35 U.S.C. § 120. Second, even with respect to the concern of over-claiming, the mere fact that the patentee purportedly had written description support for subject matter broader than claim 1 would not alleviate that concern. Written description support is only one of a number of requirements for patentability, and it would still be over-claiming for a patentee to seek a claim that it did not describe to avoid a prior art rejection for a broader claim that it did describe.

As mentioned, Patent Owner argues that because Petitioner sought claims to a “metal oxide having a small conduction band offset with respect to the source/drain area,” while purportedly only disclosing TiO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, and ZnO, Petitioner’s position in that case is inconsistent with its position here. *See* PO Resp. 41 (citing Ex. 2099, claim 2, ¶¶ 8, 33, 39, 86, 96, 99, 100, 111, 140, 156, 161); PO Sur-reply 12–13 (citing Ex. 2099, claims 2–3). On this record, we do not reach such a conclusion. Patent Owner merely cites to the publication of the involved application (Ex. 2099), which shows that Petitioner has filed such claims and that the involved application discloses

TiO<sub>2</sub>, Ta<sub>2</sub>O<sub>5</sub>, and ZnO, but provides no analysis of how the purported support for a genus based on the disclosure of three species would conflict with an alleged lack of a support for a genus based on one species. Patent Owner further does not set forth any arguments that have been made in the prosecution of the involved application (Ex. 2099).

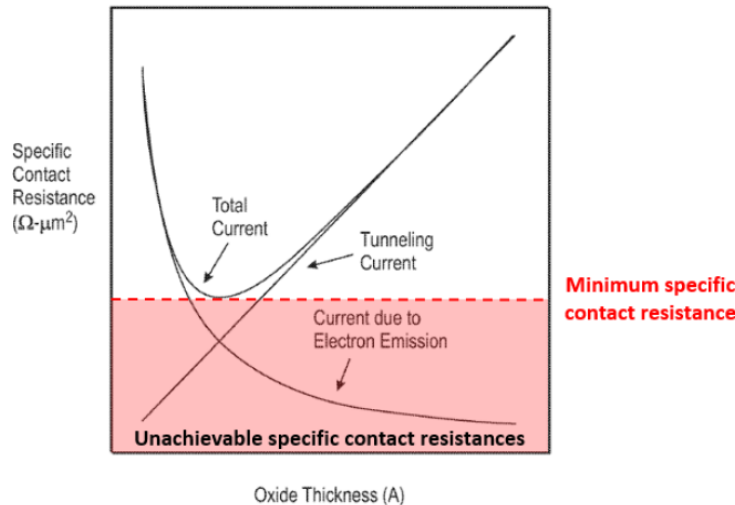
In sum, after considering all the arguments and evidence, we find that the pre-2011 priority applications do not describe the recited “metal oxide” genus. Thus, Patent Owner is not entitled to the benefit of any pre-2011 priority applications and Grupp ’483 is available as prior art for all of the challenged claims, all of which recite “a metal oxide.”

2. *Specific Contact Resistance*

Independent claims 1, 5, 9, and 13 recite that the electrical junction has “a specific contact resistance of less than or equal to approximately 10  $\Omega \cdot \mu\text{m}^2$ ,” and independent claims 65, 68, 71, 74, and 77 recite “a specific contact resistance of less than or equal to approximately 1000  $\Omega \cdot \mu\text{m}^2$ .”

Petitioner argues that the ’336 patent is not entitled to the filing dates of its parent applications because they do not enable the ranges of specific

contact resistances recited in the challenged claims. To illustrate the point, Petitioner offers an annotated version of Figure 8, as shown:



*Petitioner's Annotated Version of Figure 8*

Petitioner argues that this figure shows how “the nadir of [the] ‘total current’ curve indicates a range of specific contact resistances down to and including approximately zero that an ordinarily skilled artisan could not have attained by following the teachings of the ’336 Patent and its parent applications.” Pet. 18. Petitioner then argues that “the specific contact resistance ranges recited in the challenged claims of the ’336 Patent are not bounded by whatever minimum specific contact resistance is depicted in Fig. 8 or described in the specification” as “they encompass specific contact resistances down to and including approximately zero.” *Id.*

Petitioner relies on *MagSil Corp. v. Hitachi Global Storage Techs., Inc.*, 687 F.3d 1377 (Fed. Cir. 2012). In that case, the claims recited that “applying a small magnitude of electromagnetic energy to the junction . . . causes a change in the resistance by at least 10% at room temperature.” *Id.* at 1381. The *MagSil* patent owner offered testimony of an expert, who

opined that “a person of ordinary skill in the art could work from the . . . patent and make tunneling junctions with a resistive change between 100% and 120% without undue experimentation.” *Id.* at 1382. The Federal Circuit, however, found that the testimony suggesting a resistive change up to 120% “only reaches a lower-end of the claimed scope,” as “[t]he invention claims resistive changes from at least 10% up to infinity.” *Id.* The Court held that “the asserted claims are invalid for lack of enablement because their broad scope is not reasonably supported by the scope of enablement in the specification.” *Id.* at 1384.

Patent Owner asserts that “[t]he vertical axis in Figure 8 has neither a scale nor numbers and, therefore, cannot be meaningfully compared to the numerical values recited in the claims,” that Petitioner “failed to establish that the ‘[u]nachievable’ region in Figure 8 is an appreciable portion of the claimed range,” and that “[an ordinarily skilled artisan] would understand that the resistivity values achievable with the invention are quite low, perhaps even negligible or too low to measure. PO Resp. 13–14 (citing Ex. 2070 ¶¶ 75, 77).

Next, Patent Owner argues that “Figure 8 should not be understood, and would not have been understood by a POSITA, to imply zero specific contact resistivity as the petition asserts” because “a POSITA would understand from the shapes of the curves on Figure 8 that the vertical scale is logarithmic and therefore does not extend down to zero.” PO Resp. 15 (citing Ex. 2070 ¶¶ 76–77).

Patent Owner also argues that “Figure 8 is a ‘conceptual’ diagram meant to illustrate the principles of the physics involved, not any absolute values,” that “[t]he particular curves illustrated on Figure 8 are for one set of

materials (semiconductor, interface, and metal), and that “[i]f one or more of those materials is changed, then the curves would change.” PO Resp. 16 (citing Ex. 2070 ¶¶ 80–82). Patent Owner contends that “even if there is an unachievable region for one combination of materials, another set of materials would almost certainly have a minimum that is less (i.e., in the so-called ‘unachievable’ region). *Id.* at 18.

Patent Owner then argues that “[t]he fact that some values of specific contact resistance may not be possible would simply mean that there is an inherent lower limit, below which Acorn’s specification need not teach how to achieve.” PO Resp. 18. According to Patent Owner, “[t]he issue of enablement of open-ended ranges is a well-developed area of the law, and the controlling rule is that the specification need not enable the entirety of an open-ended range when there is an ‘inherent’ limit on the open end of the range.” *Id.* Patent Owner relies on *Andersen Corp. v. Fiber Composites, LLC*, 474 F.3d 1361 (Fed. Cir. 2007), *Rimfrost AS v. Aker Biomarine Antarctic AS*, PGR2018-00033, Paper 9 (PTAB Aug. 29, 2018), and *Ex parte Smith*, Appeal No. 2017-010042, 2019 WL 6173250 (PTAB Sept. 30, 2019). Patent Owner also asserts that its position “is a corollary to the related principle that a patentee need not show that non-operable embodiments are enabled.” PO Resp. 20.

Patent Owner contends that the Board and courts regularly decline to follow *MagSil* where, as here, there is an inherent limit on the open end of a range. PO Resp. 21 (citing *Snap-on Inc. v. Milwaukee Electric Tool Corp.*, IPR2015-01242, Paper 10 (PTAB Dec. 2, 2015); *Thermo Fisher Scientific Inc. v. Regents of University of California*, IPR2018-01347, Paper 10 (PTAB Jan. 22, 2019); *PerkinElmer Health Sciences, Inc. v. Agilent Technologies*,

*Inc.*, 962 F. Supp. 2d 304 (D. Mass. 2013)). Patent Owner additionally claims that “a POSITA would have understood there to be an inherent lower limit for specific contact resistivity for a given set of materials,” and that “Figure 8 . . . clearly illustrates that lower limit,” as “the minimum of the ‘Total’ curve.” PO Resp. 23.

Patent Owner further cites testimony from its expert that “Figure 8 conveys to a POSITA a simple experiment to find a minimum or near-minimum specific contact resistivity for a given set of materials” and that “a POSITA could have run simple experiments on ‘test chip[s]’ in a ‘development fab’ to vary the thickness of the interface layer, measure the specific contact resistance by well-known methods, and thereby determine the minimum or a near-minimum specific contact resistance and corresponding interface layer thickness.” PO Resp. 25–26 (citing Ex. 2070 ¶¶ 83–87). Patent Owner argues that a “POSITA could have repeated that experiment with different materials, aided by the teachings (materials and interface layer thickness ranges) in the . . . patents, until an acceptably low specific contact resistance was found” and that “[t]he amount of experimentation to do so would not have been undue.” *Id.* at 26 (citing Ex. 2070 ¶¶ 87–88).

Petitioner responds that Patent Owner “asks the Board to rewrite the claims to include some unspecified ‘inherent lower limit’ and that if the Patent Owner “wanted the claims to include some lower limit,” it “could have attempted to remedy the claims via Motion to Amend.” Pet. Reply 13. Petitioner argues that the disclosures “fail to even hint at what that purported ‘inherent lower limit’ may be or how achieve it” and that “[n]either Figure 8 nor anything else in the specification discloses exemplary materials,

thicknesses, or any other means for achieving the full range of claimed [specific contact resistivities] (e.g., lower than  $1\ \Omega\text{-}\mu\text{m}^2$  and approaching  $0\ \Omega\text{-}\mu\text{m}^2$ ).” *Id.* at 13, 15–16.

We begin our analysis by noting that Petitioner has the burden of proving that Patent Owner is not entitled to the benefit of its priority applications. *See Dynamic Drinkware, LLC v. National Graphics, Inc.*, 800 F.3d 1375, 1377–82 (Fed. Cir. 2015).

Neither party asks for a construction of the subject claim language and we determine that the plain meaning of “a specific contact resistance of less than or equal to approximately X” would encompass all specific contact resistances below X and down to zero.

As noted above, the parties both focus on Figure 8. Petitioner argues that it shows a region below the minimum of the Total Current curve that is not enabled. *See* Pet. 17; Ex. 1016 ¶ 86 (explaining that the sum of the resistance to tunneling current and resistance to current due to electron emission depicted in Fig. 8 “leaves a range of specific contact resistances that cannot be achieved using the techniques in the ’336 Patent”); *see also id.* ¶ 87 (“[T]he claims encompass something that cannot be achieved according to the ’336 Patent: specific contact resistances all the way down to and including approximately zero”).

As noted, Patent Owner argues that Figure 8 is not meaningful because it does not have scales on the axes, because it may be logarithmic, and because it may show resistivity values that are negligible or too low to measure. *See* PO Resp. 13–15. We find these arguments somewhat off the mark, because the issue we need to resolve is whether the disclosure enables the specific numerical ranges recited in the claims. As Dr. Kuhn observes,

Figure 8 merely illustrates how the tunneling resistivity increases as the thickness of the interface layer increases, the electron emission resistivity decreases as the thickness increases, and the how those behaviors affect the total current. *See* Ex. 2070 ¶¶ 73–75. We agree that one cannot discern any “numerical values of specific contact resistance” from Figure 8. *See id.* ¶ 75.

As for the specific recited ranges, Petitioner offers evidence that the disclosure does not enable specific contact resistance down to zero. *See* Ex. 1016 ¶¶ 86–88. Notably, Patent Owner does not dispute that the disclosure does not enable specific contact resistance down to zero. Instead, Patent Owner argues that one of skill in the art would have understood there to be an “inherent lower limit” and that the claims are enabled because one of skill in the art could achieve that lower limit through experimentation based on the disclosure of patent. We are not persuaded by Patent Owner’s argument, for two main reasons.

First, we do not agree that the cases cited by Patent Owner establish that the enablement requirement is satisfied if one of skill in the art could experiment in accordance with the disclosure to find a practical end of an open ended range recited in a claim. Patent Owner principally relies on *Andersen Corp. v. Fiber Composites*, but the Federal Circuit in that case affirmed the jury verdict of enablement because “the upper limit of the Young’s modulus of the structural member would lie somewhere between the Young’s modulus of the wood fiber and that of the polymer used in the composition.” 474 F.3d at 1377. In other words, there were two known quantities that provided a fixed range. That is not the case here, where Patent Owner does not point to any such predefined limits. Patent Owner

also cites a district court case, *PerkinElmer Health Scis., Inc. v. Agilent Techs., Inc.*, 962 F. Supp. 2d 304, 310 (D. Mass. 2013). That case is not directly on point, because it was considering claim construction and not enablement, but that court also found an existing practical upper limit to the claimed range of molecular weights, explaining that “the largest known proteins at the time of patenting had a high, but definite, mass.” *Id.*<sup>4</sup> Patent Owner, the proponent of this argument, has not explained how there would be a fixed lower limit akin to the limits in *Andersen* or *Perkin Elmer*.

We also disagree with Patent Owner’s suggestion that its position is supported by the principle that “a patentee need not show that non-operable embodiments are enabled.” PO Resp. 20. It would be both circular and contrary to the important policy underlying the enablement requirement to allow it to be avoided by argument that subject matter within the scope of the claims that is not enabled may simply be disregarded as “inoperable.” *See Alcon Research, Ltd. v. Apotex Inc.*, 687 F.3d 1362, 1368 (Fed. Cir. 2012) (“This is not how patent law works. When you claim a concentration range of 0.0001–5% w/v (as claim 2), you can’t simply disavow the invalid portion and keep the valid portion of the claim. If everything up to 0.001% w/v is admittedly not enabled, then the entire claim is invalid.”). *In re Cook*, 439 F.2d 730 (CCPA 1971), cited by Patent Owner, explains that the presence of inoperative embodiments within claim scope is permissible “so

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<sup>4</sup> Patent Owner additionally cites several Board decisions in *inter partes* reviews and an *ex parte* appeal. They are not binding on us, and we find them unpersuasive because they are based on different facts. *See Scripps Clinic & Research Found. v. Genentech, Inc.*, 927 F.2d 1565, 1572 (Fed. Cir. 1991) (explaining the “appropriateness [of open-ended claims] depends on the particular facts of the invention, the disclosure, and the prior art”).

long as it would be obvious to [a skilled artisan] how to make the embodiment operative rather than inoperative.” *Id.* at 734–35. *In re Cook* is inapplicable here because neither party has argued or offered any evidence that it would have been obvious to skilled artisan how to make the lower part of the recited range operative or enabled.

Second, even if Patent Owner could rely on experiments based on the disclosure to find an “inherent lower limit,” it has not alleged that the results would reveal a lower bound that would fall into the claimed ranges. Instead, Patent Owner and its expert assert that “Figure 8 conveys to a POSITA a simple experiment to find a minimum or near-minimum specific contact resistivity for a given set of materials” and that “[i]f desired, a POSITA could have repeated that experiment with different materials, aided by the teachings (materials and interface layer thickness ranges) in the . . . patents, until an acceptably low specific contact resistance was found” or, as described by Dr. Kuhn, until one reached “a suitable low SCR.” *Id.* at 25–26; Ex. 2070 ¶ 88. But even if we accept those assertions as true, they show only that the disclosure enables experimentation to determine a resistance that was “suitable” or “acceptably low,” and we fail to see how that identifies a specific contact resistance that would form an inherent lower end of the claimed ranges, which are less than or equal to approximately  $10 \text{ } \Omega \cdot \mu\text{m}^2$  and less than or equal to approximately  $1000 \text{ } \Omega \cdot \mu\text{m}^2$ .

We also find Dr. Kuhn’s “inherent lower limit” analysis flawed. We agree that the minimum of the “Total Current” curve in Figure 8 represents an inherent lower limit of the contact resistance for a specific set of materials. *See* Ex. 2070 ¶ 89. However, Dr. Kuhn asserts, with reference to the annotated version of Figure 8 below, that ““specific contact resistivity

less than X’ really means  $X > SCR \geq Y$ , where *Y is an inherent lower limit.*”  
*Id.* at ¶ 90 (emphasis added).

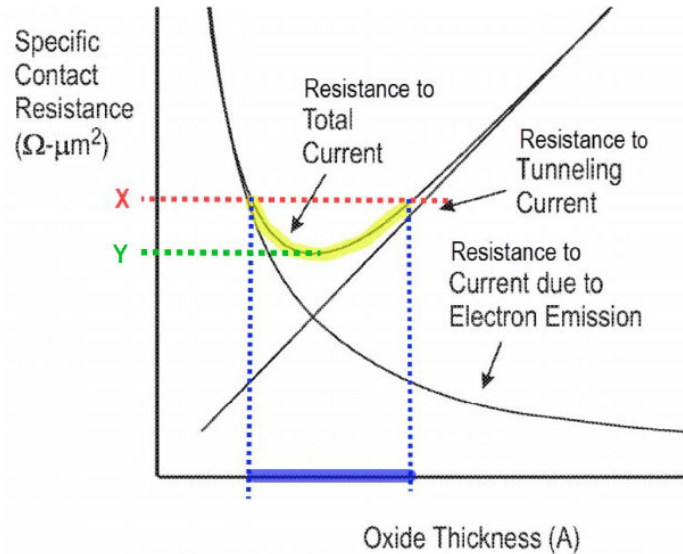


*Figure 8 as Annotated by Dr. Kuhn (Ex. 2070 ¶ 90).*

We find Dr. Kuhn’s interpretation of the claim language to present a claim construction issue that was not raised in the Patent Owner Response and is now waived. *See* Paper 22, 8 (“Patent Owner is cautioned that any arguments not raised in the response may be deemed waived.”). But we also disagree with it, at least to the extent it is represented in the Figure, because it considers only one physical system, where the claims are not so limited. We read the claim language—e.g., “interface layer . . . to provide the junction with specific contact resistance of less or equal to approximately  $10 \Omega \cdot \mu\text{m}^2$ ”—to mean that the claims encompass systems that are otherwise within their scope and in which the minimum of the “Total Current” curve falls between  $10 \Omega \cdot \mu\text{m}^2$  and zero. This means that any “inherent lower limit” would be the lowest resistance that could be achieved for *any physical system that meets the other limitations of the claims*. *See* Ex. 2070 ¶¶ 81–82 (describing and illustrating different curves for different physical systems).

Petitioner also provides evidence that “[e]ven two years after the earliest Priority Application was filed, [Patent Owner] had not achieved—and, accordingly, had not enabled—the full range of the claimed SCRs,” as “the lowest reported SCR values that [Patent Owner] was able to achieve was approximately  $300\ \Omega\text{-}\mu\text{m}^2$ ,” and that “those values were achieved with a silicon nitride interface layer (not the claimed metal oxide).” Pet. Reply 16 (citing Ex. 1049, Fig. 3; Ex. 1047 ¶¶ 80–81). Petitioner provides further evidence that “after over a decade of additional research and innovation, researchers in 2013 finally reported achieving an SCR value of about  $0.1\ \Omega\text{-}\mu\text{m}^2$  using an interface layer material—ZnO—not disclosed or contemplated by the Priority Applications.” Pet. Reply 17 (citing Ex. 1041, 2). Patent Owner responds that it “was not required to demonstrate the full range of its invention’s possibilities” and “[t]hat [it] did not continue to optimize its invention is irrelevant.” PO Sur-reply 10. We agree that Patent Owner had no obligation to optimize, or even practice, the patented inventions, but this evidence does tend to suggest that achieving at least some of the claimed ranges was not a simple matter of trying various combinations of disclosed materials. *Cf. MagSil*, 687 F.3d at 1382 (relying on the patent owner’s post-filing activities when assessing enablement).

Patent Owner also argues that “[r]eferring to a resistivity or resistance range with an unspecified lower end is ‘common in this art.’” PO Resp. 26 (quoting Ex. 2070 ¶ 91 and citing, *e.g.*, Ex. 2034, 3:27–39; Ex. 2035, 3:23–24). We conclude that unrelated patents, with entirely different disclosures and claims, are not pertinent to our analysis, particularly given that it has not been established that they do not also have enablement problems.

Finally, Patent Owner argues that a Primary Patent Examiner “having deep familiarity with this technology in general and [Patent Owner’s] patents in particular, recently allowed nine . . . claims reciting ‘a specific contact resistivity of less than 1 [or 10]  $\Omega \cdot \mu^2$ ’ after considering the arguments made in the petition.” PO Resp. 30. The record does show that the Examiner initialed the IDS entries for ten IPR petitions in this family and ten copies of the Schubert Declaration. *See* Ex. 2062, 349–355. However, we are unable to discern the extent to which she considered the enablement issue and, as such, we will reach our own result from our substantially more developed record on this issue.

For the reasons given above, we conclude that (1) the plain language of the challenged claims encompasses specific contact resistances down to zero, (2) Petitioner has proven with undisputed evidence that the disclosures of the priority applications do not enable resistances down to zero, (3) the record does not indicate there is an “inherent lower limit” for specific contact resistances that would avoid the requirement that the literal full scope of the claims be enabled in the priority applications, and (4) because the subject matter of the challenged claims is not enabled in the priority applications, the challenged claims are not entitled to the benefit of the filing dates of the priority applications and Grupp ’483 is available as prior art.

### 3. *Group IV Semiconductor*

Petitioner acknowledges that the parent applications “collectively describe or incorporate descriptions of Si, SiGe, SiC, SiGeC, and Ge as examples of semiconductors.” Pet. 25. Nevertheless, Petitioner contends “those examples are not enough to support a claim to the genus of group IV

semiconductors.” *Id.* (citing Ex. 1001, 3:16–18, 4:62–64, 5:5–10; Ex. 1005, 5:13–30, 8:26–28, Claims 2 and 25; Ex. 1016 ¶¶ 104–110).

Petitioner argues that, to support a genus, a specification must disclose either (i) a representative number of species falling within the scope of the genus or (ii) structural features common to the members of the genus so that one of skill in the art can visualize or recognize the members of the genus. *Id.* (citing *Ariad*, 598 F.3d at 1350). According to Petitioner, “[e]very parent application . . . falls short in both respects.” *Id.*

As to the number of species, Petitioner argues that the parent applications do not disclose at least two group IV semiconductors: carbon by itself and a germanium-carbon alloy. Pet. 25. According to Petitioner, “the absence of carbon, in particular, shows that the disclosed examples do not represent the genus of group IV semiconductors.” *Id.* Petitioner focuses on the bandgap of the semiconductors involved being between 0.1 eV and 4 eV, but notes that diamond, a form of carbon identified as a semiconductor in claim 9, has a bandgap of 5.4 eV, which is well outside the identified range of bandgaps for semiconductors. *Id.* at 25–26 (citing Ex. 1003, 8:65–9:1, claim 9; Ex. 1028, 2; Ex. 1016 ¶¶ 107–109).

According to Petitioner, Patent Owner disclosed carbon by itself, including carbon with a diamond lattice crystal structure, as a semiconductor in Grupp ’483, which was a continuation-in-part of the Grupp ’423 application. PO Resp. 26 (citing Ex. 1015, 3:18–28; Ex. 1027, 3–5); *see also* Ex. 1027, 1 (identifying the application as a CIP of Grupp ’423 and related to Grupp ’556). In particular, the continuation-in-part application identified by Petitioner states the following:

the present inventors have determined that for thin interface layers disposed between a metal and a silicon-based semiconductor (e.g., C, Ge, Si, SiC, and SiGe), so as to form a metal—interface layer—semiconductor junction, there exist corresponding minimum specific contact resistances. In various embodiments, the semiconductor may consist of any of Si, Ge, C, an alloy of Ge and Si, an alloy of Ge and C, an alloy of Si and C, or an alloy of Si, Ge, and C. If primarily C, the crystal structure may be either a diamond lattice, or another bonding scheme such as a fulleride (an example of which are carbon nanotubes) or polymer.

Ex. 1028, 5; *see also id.* at 9 (changing the disclosure “depinning the Fermi level of a silicon-based semiconductor at a metal-semiconductor junction” to “depinning the Fermi level of a semiconductor (e.g., Si, Ge, C (the crystal structure of which may be either a diamond lattice, or another bonding scheme such as a fulleride (an example of which are carbon nanotubes) or polymer), an alloy of Ge and Si, an alloy of Ge and C, an alloy of Si and C, or an alloy of Si, Ge, and C) at a metal-semiconductor junction”).

As to common structural features, Petitioner contends the priority applications do not describe any that are shared by all members of the genus of group IV semiconductors. *See* Pet. 26. Petitioner again emphasizes the difference in bandgap between carbon, in the form of diamond at 5.4 eV, and the semiconductors in the priority applications, adding that, although the parent applications described “silicon-based” semiconductors, neither carbon by itself nor a germanium-carbon alloy are silicon based semiconductors. *Id.* (citing Ex. 1003, 3:16–20; 8:65–9:1, Claim 9; 1028, 2; Ex. 1016 ¶¶ 107–109).

According to Petitioner, Patent Owner improperly identified a characteristic common to the example semiconductors in the parent applications, but not discussed in their shared specification, and tries to use

that characteristic to support claims to the entire genus of group IV semiconductors, including those absent from the parent applications. *See* Pet. 26–27 (citing *Purdue Pharma L.P. v. Faulding Inc.*, 230 F.3d 1320, 1326–27 (Fed. Cir. 2000)).

Patent Owner responds that “the earlier ’423 Patent specification provides supporting disclosure.” PO Resp. 45 (citing Ex. 1003, Title, 1:18–22, 1:28, 2:65–3:9, 3:56–4:2, 4:3–17). Patent Owner argues that the Summary of the Invention section describes embodiments that include a “semiconductor” and other embodiments that are limited to a “silicon-based semiconductor.” *Id.* (citing Ex. 1003, 3:56–4:2, 3:13–14, 3:36–37; 4:3–17). According to Patent Owner, “by providing disclosure of both a broader genus of semiconductors generally and specific species of silicon and silicon-based semiconductors, the ’423 Patent supports the intermediate genus recited in claim 1.” *Id.*

Patent Owner further argues that the ’423 patent’s “specification supports several species of the group IV class of semiconductors, including silicon and silicon-based semiconductors, e.g., Si, SiC, and SiGe, and that “[t]he incorporated-by-reference ’556 Patent adds germanium, another group IV semiconductor, and germanium-based semiconductors.” PO Resp. 46 (citing Ex. 1003, 4:63–64; Ex. 1005, 5:12–15).

Patent Owner criticizes the petition for “not even attempt[ing] to characterize the size of the group IV semiconductor genus or undertak[ing] any sort of analysis whether the disclosed species are adequately representative.” PO Resp. 27. Patent Owner asserts that “[a]ll the petition does is point out two species that are not specifically mentioned in Acorn’s specification,” which is “is a failure of proof by the petition.” *Id.*

Patent Owner contends that one of skill in the art “would have immediately recognized the applicability of the invention to all group IV semiconductors from the disclosure of silicon alone, let alone germanium and the other disclosed materials” because “[t]he chemical elements of group IV (having 4 outer shell electrons and a +4 valence state) are C, Si, Ge, Sn, Pb, Ti, Zr, Hf, and Rf” and “[o]f those, only the first three are recognized as semiconductors having practical use.” PO Resp. 47 (citing Ex. 2039, 365). “Thus,” argues Patent Owner, “a POSITA would have understood that the ‘group IV semiconductors’ are semiconductors made of C, Si, and Ge, either alone or combined in alloys or compounds” and that “the other six group IV elements are metals and therefore outside the genus ‘group IV semiconductors.’” PO Resp. 47. Patent Owner contends that a “POSITA would have further understood that elements within group IV can generally be readily interchanged, as they share the same outer shell electron configuration,” that “the number of elements in group IV semiconductors is low and discrete,” and that “[a]s a result, a POSITA would have immediately envisaged all members of the disclosed genus.” *Id.* (citing Ex. 2040, 513).

Patent Owner further asserts that “a POSITA would realize that the disclosed silicon and germanium semiconductors are “the prototype[s] of a large class of semiconductors with similar crystal structures” in which “each atom is surrounded by four nearest neighbor atoms (each atom is said to be four-fold coordinated) forming a tetrahedron” and that “[t]hese tetrahedrally bonded semiconductors form the mainstay of the electronics industry and the cornerstone of modern technology.” PO Resp. 47 (citing Ex. 2041, 5).

Patent Owner concludes that a “POSITA would read the examples listed in the specification as defining a class of four-fold coordinated (that is, tetravalent) and covalently bonded semiconductors, encompassing (i) all of the group IV elemental semiconductors, including C, Si, and Ge; (ii) all tetravalent alloys of those elements (SiGe, GeSn, etc., in all ranges of their alloy compositions, and also SiGeC of various germanium and carbon concentrations); and (iii) all of the tetravalent binary group IV compounds like SiC in its many crystalline polytypes.” *Id.* at 48.

Patent Owner adds that this case “presents a situation considerably different from *Purdue Pharma*, because its inventors did not “pick a characteristic possessed by two of their formulations . . . and then [make] it the basis of claims that cover . . . any formulation that has that characteristic.” PO Resp. 48–49 (quoting *Purdue Pharma*, 230 F.3d at 1327). Patent Owner asserts that it “[i]nstead . . . claimed a subgenus that is supported by disclosure of a larger genus as well as numerous species, including the prototype species of the subgenus.” *Id.*

Petitioner’s reply focuses on bandgaps, reiterating that “the group IV semiconductors disclosed in [the parent applications]—Si, SiC, SiGe, SiGeC, and Ge—all have bandgaps between 0.1 eV and 4 eV,” but that “claims 9, 19, 43, and 71 of the ’336 Patent claim carbon “comprising a diamond lattice,” which has a bandgap of 5.45 eV—well outside the upper range of the semiconductor materials disclosed in the parent applications. Pet. Sur-Reply 25.

Petitioner argues that “[a] generic reference to ‘semiconductor[s]’ or ‘silicon-based semiconductor[s]’ does not provide adequate written description for a particular genus of semiconductors (i.e., group IV

semiconductors)” and that “the undisclosed carbon and germanium-carbon alloys are not silicon-based semiconductors, so the generic disclosure of ‘silicon-based semiconductors’ would not encompass carbon and germanium-carbon alloys disclosed for the first time in a CIP application.” Pet. Sur-Reply 25 (citing Ex. 1027, 5).

We conclude that Petitioner has not shown that the parent applications do not provide sufficient support for “a group IV semiconductor.”

The most fundamental problem is that Petitioner fails to delineate the contours of “group IV semiconductor,” which makes it essentially impossible for us to weigh Petitioner’s argument that it is not supported. In addition, while Petitioner asserts that the parent applications lack sufficient support because they do not disclose “carbon by itself and a germanium-carbon alloy,” Petitioner fails to address why the disclosure that *was* made does not provide sufficient support, a problem that is compounded by Petitioners’ failure to define “group IV semiconductor.”

Patent Owner argues that “[t]he chemical elements of group IV (having 4 outer shell electrons and a +4 valence state) are C, Si, Ge, Sn, Pb, Ti, Zr, Hf, and Rf” and that “[o]f those, only the first three are recognized as semiconductors having practical use.” PO Resp. 47. This assertion lacks evidentiary support, but it illustrates the problem. It may be that one of ordinary skill in the art would know that “group IV semiconductor” in this context would be limited to semiconductors composed of or based on C, Si, Ge. In that case, the parent applications’ disclosure of Si and Ge—two out of three—may or may not be sufficient. But Petitioner has not put us in a position to make that judgment.

Petitioner also argues that the bandgaps of the disclosed materials fall into the range 0.1 eV and 4 eV, and that the bandgap of carbon is 5.45 eV. But there is no dispute that carbon is a group IV semiconductor, so this appears to show nothing more than that group IV semiconductors can have bandgaps of at least 0.1 eV and 4 eV or 5.4 eV.

We accordingly conclude that Petitioner has not carried its burden of proving that the pre-2011 priority applications fail to describe the genus of group IV semiconductors.

*B. Anticipation*

Petitioner contends that the challenged claims are anticipated by Grupp '483. *See* Pet 29–57. Patent Owner does not dispute this contention. PO Resp. 49 (“There are no disputes in this IPR regarding whether the prior art reference ([Patent Owner]’s own Grupp '483 patent) teaches any of the claim limitations.”). Patent Owner argues, however, that it would be inconsistent to use Grupp '483 as prior art to anticipate the challenged claims while denying Patent Owner the benefit of priority applications due to a lack of enablement in the priority applications of the recited range of specific contact resistivity.

“The standard for what constitutes proper enablement of a prior art reference for purposes of anticipation under section 102 . . . differs from the enablement standard under section 112.” *Rasmusson v. SmithKline Beecham Corp.*, 413 F.3d 1318, 1325 (Fed. Cir. 2005). Enablement under section 112, which is required for priority under section 120, requires enablement of the full breadth of a claim. *Wyeth and Cordis Corp. v. Abbott Laboratories*, 720 F.3d 1380, 1384 (Fed. Cir. 2013); *MagSil*, 687 F.3d at 1384; 35 U.S.C. § 120. However, enablement for anticipation does not require enablement of

the full breadth of a claim—instead, it requires only enablement of an embodiment or embodiments that fall within the scope of the claim. *See Chester v. Miller*, 906 F.2d 1574, 1577 (Fed. Cir. 1990) (“a CIP’s claim for a genus might not be enabled by a parent’s disclosure, but that parent may enable a species that anticipates the CIP’s claim for a genus . . . . the Court of Custom and Patent Appeals . . . made clear the differences between the requirements for claim-anticipating disclosures and for claim-supporting disclosures”) (citing *In Re Lukach*, 442 F.2d 967, 969–970 (CCPA 1971)).

Here, the enablement challenge for priority is for a lack of enablement of the full breadth of the recited range, and, in particular, a lack of enablement of the lower part of the recited range (that which is at or near zero). No party has argued that the upper part of the recited range is not enabled, by either the priority applications or Grupp ’483. *See, e.g.*, Pet. 20; PO Resp. 1–2; Pet. Reply 22–23; PO Sur-reply 9. And enablement by a prior art patent is presumed. *See In re Antor Media Corp.*, 689 F.3d 1282, 1287 (Fed. Cir. 2012); *Impax Labs., Inc. v. Aventis Pharm., Inc.*, 545 F.3d 1312, 1316 (Fed. Cir. 2008); *Amgen, Inc. v. Hoechst Marion Roussel, Inc.*, 314 F.3d 1313, 1355 (Fed. Cir. 2003). Thus, we find no inconsistency in determining that the priority applications do not enable the full breadth of the recited range while, at the same time, finding that Grupp ’483 enables the upper part of the range for anticipation purposes.

As set forth below, we find that Petitioner has proven that Grupp ’483 anticipates every challenged claim.

*1. Claim 1*

Petitioner first argues that “[t]o the extent the preamble is limiting, Grupp ’483 discloses” an electrical junction. Pet. 30 (citing Ex. 1016 ¶ 120; Ex. 1015, 3:44–47, 3:18–22, 5:49–58, 19:26–27).

Next, Petitioner argues that Grupp ’483 discloses an interface layer disposed between a contact metal and a conductor and that the semiconductor is a group IV semiconductor. Pet. 30–31 (citing Ex. 1016 ¶¶ 112, 121–122; Ex. 1015, 4:20–22; 3:18–28, 3:44–47, 5:49–58, 18:4–17, Fig. 7d).

Petitioner further argues that Grupp ’483 discloses that the semiconductor comprises a source or drain of a transistor. Pet. 31 (citing Ex. 1016 ¶¶ 123–124; Ex. 1015, 18:32–35, 18:19–20, 19:11–15).

Petitioner then argues Grupp ’483 discloses that the “interface layer compris[es] a metal oxide” because “[i]n a discussion of the dielectric tunnel barriers of various interface layer materials, Grupp ’483 discloses that “[s]pacer layers may be used with lower barriers (e.g., TiO<sub>2</sub> has a barrier of less than 1 eV),” that “Grupp ’483 [thus] discloses a TiO<sub>2</sub> (titanium dioxide) interface layer,” and that “[t]itanium dioxide is a metal oxide.” Pet. 32 (citing Ex. 1016 ¶ 125).

Petitioner further argues that “Grupp ’483 discloses reducing the height of the Schottky barrier by providing an interface layer of the appropriate thickness” and that “[a]t this thickness the effect of MIGS has been sufficiently reduced to depin the metal and lower the Schottky barrier, and the layer is still sufficiently thin to allow significant current flow across the interface layer.” Pet. 33 (citing Ex. 1015, 15:34–57; Ex. 1016 ¶ 127.) According to Petitioner, “Grupp ’483 also discloses that its interface layer

reduces the Schottky barrier height from that which would exist at a contact junction between the contact metal and the semiconductor without the interface layer disposed therebetween,” illustrating the difference in Figures 7a and 7b. Pet. 33 (citing Ex. 1016 ¶¶ 128–135).

Finally, Petitioner argues that “Grupp ’483 discloses that “minimum specific contact resistances of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$  or even less than or equal to approximately  $1\ \Omega\text{-}\mu\text{m}^2$  may be achieved for such junctions in accordance with the present invention.” Pet. 34 (citing Ex 1015, 6:1–5; 3:40–43, 5:64–6:1, 8:58–61, 10:44–47, 15:52–57). Petitioner contends that “[b]oth  $1\ \Omega\text{-}\mu\text{m}^2$  and  $10\ \Omega\text{-}\mu\text{m}^2$  are within the range “less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$ ” and therefore satisfy that limitation for purposes of anticipation.” *Id.* As mentioned, no party has argued that the upper part of the recited range is not enabled Grupp ’483, and enablement by a prior art patent is presumed. *Antor*, 689 F.3d at 1287; *Impax Labs.*, 545 F.3d at 1316; *Amgen*, 314 F.3d at 1355.

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claim 1.

2. *Claim 5*

Claim 5 recites “[a]n electrical junction” that comprises “an interface layer disposed between a contact metal and a semiconductor,” where “the semiconductor compris[es] a source or drain of a transistor,” and the interface layer is “a metal oxide and sufficiently thick to depin a Fermi level of the semiconductor, yet sufficiently thin to provide the junction with a specific contact resistance of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$ .”

Petitioner argues that Grupp ’483 discloses the interface layer, contact metal, semiconductor, and interface layer limitations, relying on its analysis

for claim 1. *See* Pet. 38–39. Petitioner also argues that Grupp discloses that “[t]he interface layer is sufficiently thick to depin a Fermi level of the semiconductor.” *Id.* at 39 (citing Ex. 1015, Abstract, 3:18–43, 3:47–52, 18:5–10). Petitioner further argues that “Grupp ’483 provides [a] presumptively enabling disclosure of an electrical junction with a specific contact resistance— $10\ \Omega\text{-}\mu\text{m}^2$  or  $1\ \Omega\text{-}\mu\text{m}^2$ —within the claimed range. *Id.* at 40 (citing Ex. 1015, 5:64–6:5, 15:52–57; Ex. 1016 ¶ 157).

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claim 5.

### 3. *Claim 13*

Claim 13 recites “[a]n electrical junction” comprising “a semiconductor and a conductor separated from the semiconductor by an interface layer comprising a metal oxide,” where the interface layer “ha[s] a thickness sufficient to depin a Fermi level of the conductor in a vicinity of the junction yet thin enough to provide the junction with a specific contact resistance of less than or equal to approximately  $10\ \Omega\text{-}\mu\text{m}^2$ .” The claim further recites that “the semiconductor comprises a source or drain of a transistor.”

Petitioner argues that Grupp ’483 discloses the interface layer, contact metal, semiconductor, and interface layer limitations, relying on its analysis for claim 1. *See* Pet. 43, 45. Petitioner also argues that Grupp discloses a thickness sufficient to depin a Fermi level of the conductor in a vicinity of the junction” because it “[d]iscusses the optimum thickness of an interface layer for depinning a Fermi level of a conductor in a metal-semiconductor junction” and “discloses that ‘[a]t this thickness the effect of MIGS has been sufficiently reduced to depin the metal and lower the Schottky barrier, and

the layer is still sufficiently thin to allow significant current flow across the interface layer.” *Id.* at 42–43 (citing Ex. 1015, 15:50–54). Petitioner relies on its analysis of claim 5 for “thin enough to provide the junction with a specific contact resistance of less than or equal to approximately 10  $\Omega\text{-}\mu\text{m}^2$ .” *See* Pet. 44–45.

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claim 13.

4. *Claim 77*

Claim 77 recites “[a]n electrical junction” comprising “an n-type doped Si semiconductor and a conductor separated from the semiconductor by an interface layer comprising a metal oxide,” where the interface layer “ha[s] a thickness sufficient to depin a Fermi level of the conductor in a vicinity of the junction yet thin enough to provide the junction with a specific contact resistance of less than or equal to approximately 1000  $\Omega\text{-}\mu\text{m}^2$ .”

Petitioner contends that “Grupp ’483 discloses ‘a semiconductor and a conductor separated from the semiconductor by an interface layer’” and that “Grupp ’483’s Fig. 7d depicts a junction between a metal (conductor) and an n-type doped semiconductor separated by an interface layer in accordance with the invention.” Pet. 54 (citing Ex. 1016 ¶ 256; Ex. 1015, Fig. 7d, Fig. 4, Fig. 7a, 5:37–40, 18:4–10). Petitioner further argues that “Grupp ’483 discloses that the semiconductor shown in Fig. 7d can be silicon.” *Id.* (citing Ex. 1015, 18:14–17). Petitioner further contends that Grupp ’483 discloses a metal oxide interface layer with “a thickness sufficient to depin a Fermi level of the conductor in a vicinity of the junction yet thin enough to provide

the junction with a specific contact resistance of less than or equal to approximately  $1000\ \Omega\text{-}\mu\text{m}^2$ .” Pet. 55–56 (citing Ex. 1016 ¶¶ 257–258).

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claim 77.

5. *Dependent Claims*

a. *Claims 2, 6, and 14*

Claims 2, 6, and 14 add to their independent claims that “semiconductor comprises an n-type doped source or drain of a transistor.”

Petitioner argues that “Grupp ’483 discloses that the semiconductor in [an] electrical junction[] according to the invention can be an n-type doped semiconductor” and that “Grupp ’483’s Fig. 7d depicts a junction between a metal and an n-type doped semiconductor with an interface layer in accordance with the invention.” Pet. 35 (citing Ex. 1015 6:5–9; 5:37–40, 18:4–10; Ex. 1016 ¶ 140); *see also id.* (citing Ex. 1016 ¶¶ 141–142).

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claims 2, 6, and 14.

b. *Claims 3, 7, and 15*

Claims 3, 7 and 15 add to their independent claims that “the electrical junction has a specific contact resistance of less than or equal to approximately  $1\ \Omega\text{-}\mu\text{m}^2$ .”

Petitioner argues that “Grupp ’483 provides [a] presumptively enabling disclosure of an electrical junction whose specific contact resistance falls within the range of specific contact resistances specified by this limitation” in that, for example, “Grupp ’483 discloses that ‘minimum specific contact resistances . . . even less than or equal to approximately  $1\ \Omega\text{-}$

$\mu\text{m}^2$  may be achieved for such junctions in accordance with the present invention.” Pet. 37 (citing Ex. 1016 ¶¶ 146–147; Ex. 1015, 6:1–5; 5:64–6:1, 8:58–61, 10:44–47, 15:52–57).

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claims 3, 7, and 15.

*c. Claims 4, 8, and 16*

Claims 4, 8 and 16 add to claims 3, 5 and 15 that “the semiconductor comprises an n-type doped source or drain of a transistor.”

These claims add the same subject matter as claims 2, 6, and 14, and we agree that Grupp ’483 anticipates claims 3, 5, and 15 for the reasons described in connection with those claims.

*d. Claims 78–80*

Claims 78–80 each depend from claim 77 and recite that “the electrical junction . . . has a specific contact resistance of less than or equal to approximately”  $100\ \Omega\text{-}\mu\text{m}^2$ ,  $100\ \Omega\text{-}\mu\text{m}^2$ , and  $100\ \Omega\text{-}\mu\text{m}^2$ , respectively.

Petitioner argues that “Grupp ’483 provides presumptively enabling disclosure of an electrical junction with a specific contact resistance of  $10\ \Omega\text{-}\mu\text{m}^2$ , which falls within the ranges specified in Claims 78 and 79; and  $1\ \Omega\text{-}\mu\text{m}^2$ , which falls within the ranges specified in Claims 78, 79, and 80.” Pet. 56–57 (citing Ex. 1015, 5:64–6:5, 15:52–57; Ex. 1016 ¶¶ 262, 265, 268).

We agree with Petitioner’s analysis and that Grupp ’483 anticipates claims 78–80.

## V. OTHER ISSUES

### A. 35 U.S.C. § 311(b)

Patent Owner argues that “[t]here are no disputes in this IPR regarding whether the ‘prior art’ reference ([Patent Owner]’s own Grupp ’483 patent) teaches any of the claim limitations” and that “[f]or all intents and purposes, this IPR is a § 112 battle, just as if it were a PGR (for which the pre-AIA ’336 Patent is not eligible).” PO Resp. 49.

Patent Owner further argues that “there is no priority dispute here regarding enablement” because “the petition does not assert that any subsequent developments after the filing of the earliest priority/benefit application (resulting in the ’423 Patent) has changed the enablement issue,” meaning that “either all of the specifications are enabling of the specific contact resistance ranges recited in the claims, or none of them are.” *Id.* at 50. Patent Owner concludes that “[e]ntertaining the enablement challenge here would open the door for enablement challenges to a broad class of continuation patents in IPRs that Congress never intended.” *Id.*

We remain unpersuaded by Patent Owner’s argument that an *inter partes* review may not address whether priority applications enable or have written description support for challenged claims. Although the issue of whether challenged claims are enabled or have written description support in the specification of the challenged patent is beyond the scope of an *inter partes* review (see 35 U.S.C. § 311), whether a patent is entitled to the benefit of earlier filed applications under 35 U.S.C. §§ 119 or 120 is properly an issue to be addressed in an *inter partes* review. See *Indivior UK Ltd. v. Dr. Reddy’s Lab ’ys S.A.*, 18 F.4th 1323, 1326–1330 (Fed. Cir. 2021). And the benefit of an earlier filed application requires written description

and support for and enablement of the challenged claims in the earlier filed application. *See* 35 U.S.C. § 120.

*B. Appointments Clause*

Patent Owner argues that “[t]he AIA as written by Congress violates the Appointments Clause.” PO Resp. 51.

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

*C. “Structural Bias”*

Patent Owner argues that “[t]he Board’s handling of this IPR is structurally biased in a way that has violated Acorn’s due-process rights” because the Director’s delegation of the authority to determine whether to institute and try this case “results in an improper structural bias because the Board has a strong financial incentive to institute trials.” PO Resp. 52.

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

*D. Stipulation*

Patent Owner argues that “[t]he Board’s eleventh-hour invitation to the petitioner to revise its stipulation regarding parallel validity challenges in the district court . . . violated *SAS Institute Inc. v. Iancu*, 138 S. Ct. 1348 (2018), due-process, and fundamental notions of fairness.” PO Resp. 55.

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

This argument is unpersuasive. The stipulation did not change the contours of, or “curate,” the Petition; instead, in accordance with our precedential case *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB December 1, 2020), Petitioner simply stipulated to not bring the same arguments in the District Court.<sup>5</sup>

## VI. MOTION TO EXCLUDE

Patent Owner seeks to exclude the following portion of the cross-examination testimony of Dr. Kuhn: page 114, line 10 through page 123, line 14. Mot. Excl. 1, 5. Patent Owner argues that the testimony at issue concerns the scope of claims that recite “an oxide of titanium.” Mot. Excl. 1. According to Patent Owner, however, the oxide-of-titanium limitation was not substantively addressed in the Petition and Dr. Kuhn did not address it in her declaration. *Id.* Further, Patent Owner argues that it timely objected to the testimony at issue and thus the testimony should be excluded for exceeding the scope of Dr. Kuhn’s direct testimony.

Petitioner disagrees, arguing that Dr. Kuhn expressly opined on the “oxide of titanium” limitation. Opp. Mot. Excl. 1. Petitioner asserts:

First, Dr. Kuhn opined that “nothing in the petition or Dr. Schubert’s declaration specifically address[ed] the written-description support of those dependent claims or an oxide of titanium.” Ex. 2070, Kuhn Decl. at ¶114. Second, Dr. Kuhn opined that “the metal oxide comprises an oxide of titanium” claims are “clearly narrower than ‘metal oxide.’” *Id.*

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<sup>5</sup> *Sotera Wireless* issued and was designated precedential (on December 1, 2020 and December 17, 2020, respectively) after the Petition and Petitioner’s Preliminary Reply were filed (on July 18, 2020 and October 16, 2020, respectively).

*Id.* at 1–2 (emphasis omitted). Petitioner argues that it was entitled to explore Dr. Kuhn’s understanding of why she believes those claim limitations are “clearly narrower” and to challenge the assertion that they were not addressed in the petition or in Dr. Shubert’s declaration. *Id.* at 2.

Patent Owner responds that Dr. Kuhn merely stated that the class of oxides of titanium is clearly narrower than the class of metal oxides and did not provide an opinion on that issue. Reply Mot. Excl. 1. Patent Owner further argues that statement did not open the door to Petitioner’s questioning regarding the titanium oxide genus. *Id.* at 2.

We dismiss Patent Owner’s Motion to Exclude as moot because, unlike other cases in this family, this case does not include any claims that recite an “oxide of titanium.”

## VII. CONCLUSION

Claims 1–8, 13–16, and 77–80 of the ’443 have been shown to be unpatentable. The motion to exclude is dismissed.

The results are summarized below.

| Claims                  | 35 U.S.C. § | Reference  | Claims Shown Unpatentable    | Claims Not Shown Unpatentable |
|-------------------------|-------------|------------|------------------------------|-------------------------------|
| 1–8,<br>13–16,<br>77–80 | 102         | Grupp ’483 | 1–8, 13–16,<br>77–80         |                               |
| <b>Overall Outcome</b>  |             |            | <b>1–8, 13–16,<br/>77–80</b> |                               |

## VIII. ORDER

For the reasons given, it is:

ORDERED that claims 1–8, 13–16, and 77–80 of U.S. Patent 8,766,336 B2 have been shown to be unpatentable;

ORDERED Patent Owner’s Motion to Exclude is dismissed as moot; and

FURTHER ORDERED that, because this is a Final Written Decision, the parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.<sup>6</sup>

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<sup>6</sup> Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner’s attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

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