

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LONGI GREEN ENERGY TECHNOLOGY CO., LTD., LONGI SOLAR
TECHNOLOGY CO., LTD., LONGI (H.K.) TRADING LTD., LONGI
(KUCHING) SDN. BHD., LONGI SOLAR TECHNOLOGY (TAIZHOU)
CO., LTD., LONGI SOLAR TECHNOLOGY (ZHEJIANG) CO., LTD.,
LONGI SOLAR TECHNOLOGY (HEFEI) CO., LTD., AND LONGI
SOLAR TECHNOLOGY (US), INC.,
Petitioner,

v.

HANWHA Q CELLS & ADVANCED MATERIALS CORPORATION,
Patent Owner.

IPR2019-01072
Patent 9,893,215 B2

Before CHRISTOPHER L. CRUMBLEY, JEFFREY W. ABRAHAM, and
JULIA HEANEY, *Administrative Patent Judges*.

CRUMBLEY, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
37 C.F.R. § 318(a)

I. INTRODUCTION

In this *inter partes* review, instituted pursuant to 35 U.S.C. § 314, LONGi Green Energy Technology Co., LONGi Solar Technology Co., Ltd., LONGi (H.K.) Trading Ltd., LONGi (Kuching) Sdn. Bhd., LONGi Solar Technology (Taizhou) Co., Ltd., LONGi Solar Technology (Zhejiang) Co., Ltd., LONGi Solar Technology (Hefei), Co., Ltd., and LONGi Solar Technology (US), Inc. (collectively “Petitioner”) challenge the patentability of claims 12–14 of U.S. Patent No. 9,893,215 (Ex. 1001, “the ’215 patent”), owned by Hanwha Q Cells & Advanced Materials Corporation (“Patent Owner”).

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision, issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73, addresses issues and arguments raised during trial. For the reasons discussed below, we determine that Petitioner has shown by a preponderance of the evidence that claims 12–14 of the ’215 patent are unpatentable.

A. *Procedural History*

On May 13, 2019, Petitioner requested an *inter partes* review of claims 12–14 of the ’215 patent. Paper 1 (“Pet.”). Patent Owner filed a Preliminary Response. Paper 7. On December 4, 2019, we instituted an *inter partes* review of the challenged claims. Paper 12 (“Decision on Institution” or “Dec. on Inst.”). Following institution, Patent Owner filed a Patent Owner Response (Paper 18, “PO Resp.”), Petitioner filed a Reply (Paper 26, “Pet. Reply”), and Patent Owner filed a Sur-Reply (Paper 29, “PO Sur-Reply”).

Petitioner relies upon the declaration testimony of Dr. Sanjay Banerjee (Ex. 1003) to support the Petition; Patent Owner took cross-

examination of Dr. Banerjee via deposition and submitted the transcript (Ex. 2007). Patent Owner relies upon the declaration testimony of Dr. Michael S. Lebby (Ex. 2008); Petitioner took cross-examination of Dr. Lebby via deposition and submitted the transcript (Ex. 1053).

Petitioner filed a Motion to Exclude, seeking to exclude certain paragraphs of Dr. Lebby's Declaration. Paper 32, "Mot." Patent Owner filed an Opposition (Paper 34, "Mot. Opp.") and Petitioner filed a Reply (Paper 35, "Mot. Reply").

Oral hearing was requested by both parties. Papers 27, 28. A consolidated oral hearing for this proceeding and Case IPR2019-01145, also involving the '215 patent, was held on September 9, 2020. A transcript of the hearing in this proceeding has been entered into the record. Paper 37 ("Tr.").

B. Related Proceedings

Petitioner and Patent Owner identify the following pending litigation involving the '215 patent: *Certain Photovoltaic Cells and Products Containing Same*, Inv. No. 337-TA-1151 (U.S.I.T.C.) and *Hanwha Q CELLS & Advanced Materials Corp. v. LONGi Green Energy Technology Co., Ltd. et al.*, No. 1:19-cv-00451-MN (D. Del.). Pet. 5–6; Paper 6, 1. Patent Owner also identifies the following pending litigation involving the '215 patent: *Hanwha Q CELLS & Advanced Materials Corp. v. JinkSolar Holding Co. Ltd. et al.*, No. 1:19-cv-00450-MN (D. Del.) and *Hanwha Q CELLS & Advanced Materials Corp. v. REC Solar Holdings AS et al.*, No. 1:19-cv-00452-MN (D. Del.). Paper 6, 1. As noted above, the '215 patent is the subject of another petition for *inter partes* review that was concurrently filed: IPR2019-01145. *Id.*

C. The '215 Patent

The '215 patent, entitled “Method For Manufacturing a Solar Cell With a Surface-Passivating Dielectric Double Layer, And Corresponding Solar Cell,” issued February 13, 2018 and claims priority to a foreign application filed November 14, 2007. Ex. 1001, [30], [45], [54]. According to the '215 patent, “[a] key requirement for achieving high degrees of efficiencies in solar cells is very effective suppression of surface recombination losses.” *Id.* at 1:14–16. The '215 patent explains that, in order to achieve this purpose, the surface of solar cells should be passivated as effectively as possible, so that charge carrier pairs which are generated inside the solar cell by incident light and which diffuse to the surfaces of the solar cell substrate do not recombine at the solar cell surface, where they would no longer be available to improve the efficiency of the solar cell. *Id.* at 1:16–22. Good passivating results can be achieved using aluminum¹ oxide layers which are deposited by means of atomic layer deposition (ALD). *Id.* at 2:19–21. However, in atomic layer deposition, only a single molecular layer of the material to be deposited is generally deposited on the substrate surface within each deposition cycle. *Id.* at 2:23–25. Because a deposition cycle typically lasts about 0.5 to 4 seconds, low deposition rates are generally obtained using atomic layer deposition, where the thickness of the deposition of the aluminum oxide layers may not be suitable for use as an antireflection layer or as a back reflector. *Id.* at 2:25–32.

The '215 patent describes a method for manufacturing silicon solar cells with a dielectric passivating layer for reducing surface recombination

¹ The '215 patent refers to the element as “aluminium.” We substitute the typical American spelling, “aluminum.”

losses in light of the challenges using an ALD process described above. *Id.* at 2:57–60. The dielectric passivating layer is composed of two partial layers: a first dielectric layer (*i.e.*, very thin aluminum oxide containing layer), which is formed by ALD, and a second dielectric layer (*i.e.*, a thicker layer made of silicon oxide, silicon nitride, or silicon carbide, for example), which can be deposited on the first dielectric layer by means of plasma enhanced chemical vapor deposition (“PECVD”), for example. *Id.* at 2:61–67.

According to one embodiment, the first dielectric layer is deposited at a thickness of less than 50 nm, preferably less than 30 nm, and more preferably less than 10 nm. *Id.* at 5:40–43. According to the ’215 patent, even at a very low thickness, the first dielectric layer offers very good surface-passivating properties on account of its high quality which can be achieved as a result of the ALD. *Id.* at 5:43–45. Further, according to the embodiment, the second dielectric layer is deposited at a thickness of more than 50 nm, preferably more than 100 nm, and more preferably more than 200 nm. *Id.* at 5:51–54. As described in the ’215 patent, the thickness of the second dielectric layer can be adapted to its task as an antireflection layer. *Id.* at 5:54–56.

Figure 1 of the ’215 patent is reproduced below:

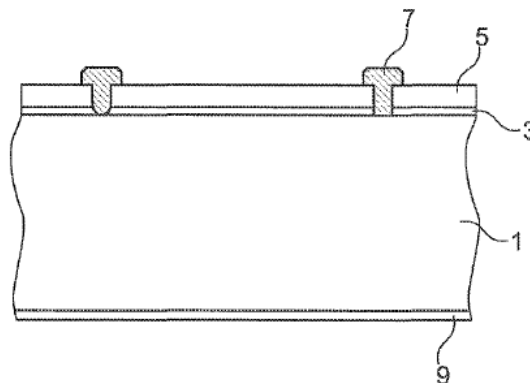


Figure 1 is “a solar cell according to one embodiment of the present invention.” *Id.* at 6:44–45. The ’215 patent describes that the solar cell includes silicon wafer 1. *Id.* at 6:51–57. The solar cell further includes aluminum oxide (Al_2O_3) layer 3 that is deposited onto the silicon wafer via an ALD coating process. *Id.* at 6:63–7:11. The solar cell additionally includes silicon oxide thin layer 5 that is subsequently coated onto the Al_2O_3 layer. *Id.* at 7:30–35. The silicon oxide layer, which is deposited by means of PECVD, has a very high hydrogen content and therefore serves as a source of hydrogen. *Id.* at 7:65–8:3. The hydrogen diffuses through the ultrathin Al_2O_3 layer and passivates unsaturated silicon bonds (“dangling bonds”) at the Si/ Al_2O_3 interface, leading to very good surface passivation. *Id.* at 8:3–7.

D. The Challenged Claims

Petitioner challenges claims 12–14 of the ’215 patent. Pet. 1. Claim 12, reproduced below, is illustrative of the subject matter of the challenged claims:

12. A solar cell comprising:
- a silicon substrate;
 - a first dielectric layer comprising aluminum oxide on a surface of the silicon substrate; and
 - a second dielectric layer directly on a surface of the first dielectric layer, materials of the first dielectric layer and the second dielectric layer differing and hydrogen being embedded into the second dielectric layer;
- wherein the first dielectric layer has a thickness of less than 50 nm and is interposed between the surface of the silicon substrate and the second dielectric layer.

Ex. 1001, 9:35–10:9.

Claims 13 and 14 depend from claim 12. Claim 13 requires that the second dielectric layer comprise silicon nitride, silicon oxide, or silicon carbide, while claim 14 further limits the thickness of the first dielectric layer to less than 30 nm.

E. Instituted Grounds

We instituted an *inter partes* review of all claims challenged in the Petition on the following grounds of unpatentability, each alleging obviousness of the claims under 35 U.S.C. § 103(a)²:

Claims Challenged	Reference(s)
12–14	Bhattacharyya ³
12–14	Bhattacharyya, Duerinckx, ⁴ Hoex 2006 ⁵
12–14	Hagino ⁶
12–14	Hagino, Duerinckx, Hoex 2006

² The Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112-29, 125 Stat. 284 (September 16, 2011), included revisions to 35 U.S.C. § 103 that became effective on March 16, 2013. Because the ’215 patent issued from an application filed before March 16, 2013, we apply the pre-AIA versions of the statutory bases for unpatentability.

³ U.S. Patent Application Publication No. 2006/0102972 to Bhattacharyya (Ex. 1005).

⁴ F. Duerinckx and J. Szlufcik, “Defect passivation of industrial multicrystalline solar cells based on PECVD silicon nitride,” *Solar Energy Materials & Solar Cells* 72 (2002) 231–246 (Ex. 1008).

⁵ B. Hoex, et al. “Ultralow surface recombination of c-SI substrates passivated by plasma-assisted atomic layer deposited Al₂O₃,” *Applied Physics Letters* 89, 042112 (2006) (Ex. 1007). We adopt Petitioner’s convention of referring to the reference as “Hoex 2006,” to differentiate from other articles by Hoex also made of record.

⁶ U.S. Patent Application Publication No. 2004/0112426 A1 to Hagino (Ex. 1006).

Pet. 6. Petitioner alleges that Bhattacharyya and Hagino are prior art to the '215 patent under either 35 U.S.C. § 102(a) or (b), while Duerinckx and Hoex 2006 are prior art under § 102(b). Pet. 19, 23, 27, 29. Patent Owner has not contended that any of the asserted references are not prior art to the '215 patent.

II. MOTION TO EXCLUDE

Petitioner moved to exclude paragraphs 1–24, 27–41, 43–77, 80–82, 85–105, 108, 111–12, 114–15, 119–30, 132–33, 135–43, 145–46, 148–50, 153–72, 175–76, 178–85, and 189–90 of Dr. Lebby's Declaration (Ex.2008) under Federal Rules of Evidence 401–03. Mot. 1. According to Petitioner, these portions of Dr. Lebby's testimony are either irrelevant to the issues involved in the trial, or are unduly prejudicial, because they are "either not cited at all in Patent Owner's Response" or are "cited only as part of a sweeping range of paragraphs." *Id.* In its Reply, Petitioner also alleges that any reliance on these paragraphs amounts to improper incorporation by reference of arguments from one paper into another, in violation of our Rules. Mot. Reply 1 (citing 37 C.F.R. § 42.6(a)(3)).

Patent Owner responds that the Board has never adopted a practice of excluding all portions of a declaration that are "vaguely cited" in a paper, or not cited at all, and that applying such a rule would be unworkable. Mot. Opp. 2–3. In addition, the paragraphs to which Petitioner objects include routine statements such as Dr. Lebby stating his name and retention by Patent Owner (¶ 1) or declaring that his testimony is truthful (¶ 190), or several blank "reserved" paragraphs. *Id.* at 1. Patent Owner argues that these paragraphs, or others that relate to Dr. Lebby's work and experience, compensation, or the documents he reviewed, are not irrelevant or

prejudicial simply because they were not cited directly in a paper. *Id.* at 1–2. According to Patent Owner, Petitioner has failed to establish that the objected-to paragraphs are inadmissible under the Rules of Evidence, or that the proper remedy would be exclusion of the paragraphs from the record. *Id.* at 5–6 (citing *Amerigen Pharm. Ltd. et al v. Janssen Oncology, Inc.*, IPR2016-00286, Paper 86 at 45–46 (PTAB Jan. 17, 2018) (“We are unaware of any legal basis for striking uncited paragraphs of an expert declaration.”)).

Upon review, Petitioner’s Motion to Exclude fails to establish that Petitioner is entitled to the remedy it seeks. To the extent the Motion seeks exclusion of evidence under FRE 403 as overly prejudicial, Petitioner does not adequately explain what prejudice it would suffer if we were to simply disregard or give little weight to the uncited paragraphs of Dr. Lebby’s testimony, rather than excluding them from the record. Indeed, as the Board is not a jury, it would appear that the risk of unfair prejudice against which Rule 403 guards is diminished, if not eliminated entirely. *See, e.g., Schultz v. Butcher*, 24 F.3d 626, 632 (4th Cir. 1994) (“in the context of a bench trial, evidence should not be excluded under 403 on the ground that it is unfairly prejudicial”); *see also Gulf States Utils. Co. v. Ecodyne Corp.*, 635 F.2d 517, 519 (5th Cir. 1981). The Board is capable of hearing relevant evidence and weighing its probative value, including determining the weight to be given Dr. Lebby’s testimony or disregarding it entirely.

Nor is it clear that the objected-to paragraphs are irrelevant to the issues involved in the trial merely because they were uncited or cited as part of a range of paragraphs. Some of the paragraphs provide important context or foundation for the remainder of Dr. Lebby’s testimony, such as his experience or the evidence he reviewed in forming his opinions. That testimony does not become irrelevant simply because it is not cited in a

paper. We also note that some of the paragraphs that Petitioner objects to as being cited in “sweeping range[s] of paragraphs” span three or five paragraphs (Mot. 2), which do not appear to be categorically problematic. Indeed, Petitioner concedes that some paragraphs from these ranges were cited with more specificity in Patent Owner’s Sur-Reply. *Id.* at 5.

Evidence is relevant if it “has any tendency to make a fact more or less probable than it would be without the evidence” and that fact is material to determining the case. FRE 401. We have no reason to conclude the paragraphs of Dr. Lebby’s testimony objected to by Petitioners fail to meet this broad standard. While the Board has, in past cases, excluded exhibits that a party submitted as “background” but never cited to any part of (*see SK Innovation Co., Ltd. v. Celgard, LLC*, IPR2014-00679, Paper 58 at 49 (PTAB Sept. 25, 2015)), Dr. Lebby’s Declaration does not fall into this category. We decline to parse an individual exhibit at the paragraph level to exclude insufficiently cited-to portions from the record, without a clear reason for undertaking such a task.

For these reasons, we *deny* Petitioner’s Motion to Exclude.

III. ANALYSIS OF UNPATENTABILITY

A. Claim Construction

For petitions such as this one, filed after November 13, 2018, claims “shall be construed 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),” which is articulated in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). 37 C.F.R. § 42.100(b) (2019). Under the *Phillips* standard, the “words of a claim ‘are generally given their ordinary and customary meaning,’” which is “the meaning that the term would have to a person of

ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application.” *Phillips*, 415 F.3d at 1312–13 (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). Only those terms in controversy need to be construed and only to the extent necessary to resolve the controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

In our Institution Decision, we determined that no term of the challenged claims required an express construction. Dec. on Inst. 8. During trial, neither party proposed that we adopt any specific construction of a claim term. Upon review of the record and the parties’ positions, we agree that no term appearing in the challenged claims requires express construction.

B. Level of Ordinary Skill in the Art

Factors pertinent to a determination of the level of ordinary skill in the art include “(1) the educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) educational level of workers active in the field.” *Envtl. Designs, Ltd. v. Union Oil Co.*, 713 F.2d 693, 696–697 (Fed. Cir. 1983) (citing *Orthopedic Equip. Co. v. All Orthopedic Appliances, Inc.*, 707 F.2d 1376, 1381–82 (Fed. Cir. 1983)). Not all such factors may be present in every case, and one or more of these or other factors may predominate in a particular case. *Id.* Moreover, “[t]hese factors are not exhaustive but are merely a guide to determining the level of ordinary skill in the art.” *Daiichi Sankyo Co. v.*

Apotex, Inc., 501 F.3d 1254, 1256 (Fed. Cir. 2007). In determining a level of ordinary skill, we also may look to the prior art, which may reflect an appropriate skill level. *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). Additionally, the Supreme Court informs us that “[a] person of ordinary skill is also a person of ordinary creativity, not an automaton.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

Petitioner relies on the Declaration of Sanjay Banerjee, Ph. D. (Ex. 1003). Dr. Banerjee testifies that a person having ordinary skill in the art would have “an advanced degree involving the discipline of electrical engineering, applied physics, chemistry, or materials science, and at least two years of experience designing, developing, or researching in the field,” or alternatively, “a bachelor’s degree in electrical engineering, applied physics, chemistry, or materials science, and at least three years designing, developing, or researching in the field.” Ex. 1003 ¶ 46. We adopted this definition for purposes of deciding whether to institute trial. Dec. on Inst. 9. For purposes of this *inter partes* review, Patent Owner “does not contest this level of skill.” PO Resp. 2. In view of this agreement, we adopt Dr. Banerjee’s definition of the level of ordinary skill in the art.

C. *Principles of Law*

To prevail in challenging Patent Owner’s claims, Petitioner must demonstrate by a preponderance of the evidence that the claims are unpatentable. 35 U.S.C. § 316(e) (2012); 37 C.F.R. § 42.1(d) (2016). A claim is unpatentable under 35 U.S.C. § 103 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.” *KSR*, 550 U.S. at 406. 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) when available, evidence such as commercial success, long felt but unsolved needs, and failure of others. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966); *see also KSR*, 550 U.S. at 407 (“While the sequence of these questions might be reordered in any particular case, the [*Graham*] factors continue to define the inquiry that controls.”).

The Supreme Court made clear that we apply “an expansive and flexible approach” to the question of obviousness. *KSR*, 550 U.S. at 415. Whether a patent claiming the combination of prior art elements would have been obvious is determined by whether the improvement is more than the predictable use of prior art elements according to their established functions. *Id.* at 417. Reaching this conclusion, however, requires more than merely showing that the prior art includes separate references covering each separate limitation in a challenged claim. *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). Rather, obviousness additionally requires that a person of ordinary skill at the time of the invention “would have selected and combined those prior art elements in the normal course of research and development to yield the claimed invention.” *Id.*

D. Obviousness Based on Hagino

Petitioner contends that claims 12–14 would have been obvious over the disclosure of Hagino. Pet. 52–66.

1. Hagino (Ex. 1006)

Hagino, entitled “Solar Cell and Method of Manufacturing the Same,” relates to “a solar cell for photoelectric conversion.” Ex. 1005, at [54]; ¶ 2.

Hagino’s Figure 1 is reproduced below.

FIG.1

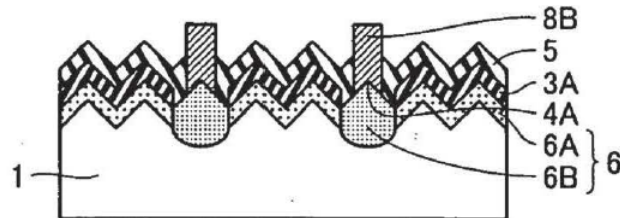
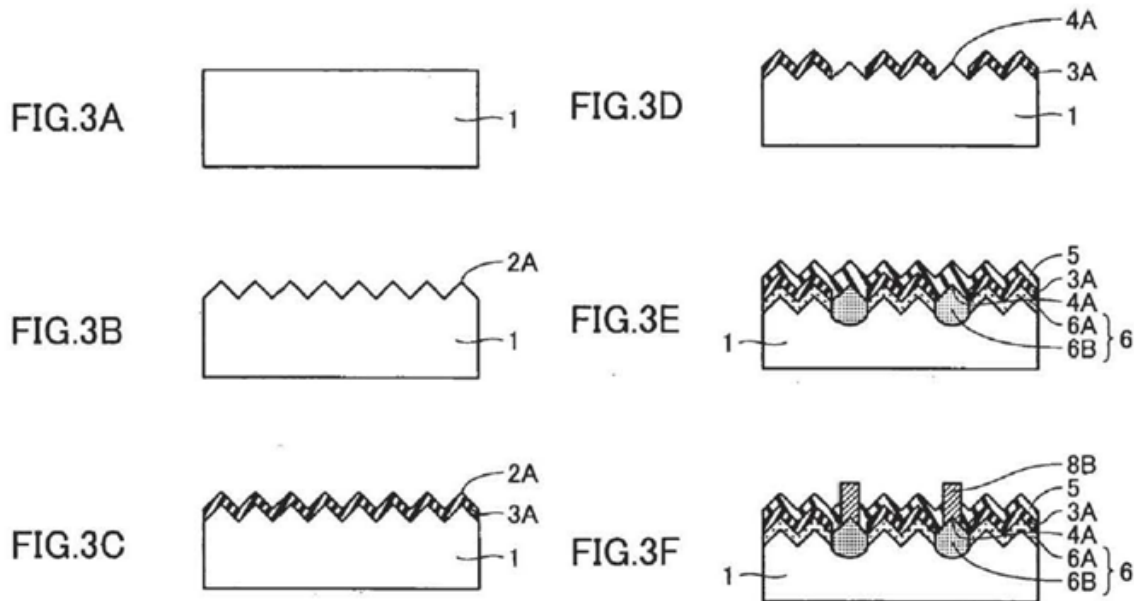


Figure 1 illustrates a schematic cross-sectional view of solar cell 1. *Id.* ¶ 18. Solar cell 1 includes dopant diffusion layer 6 formed on a side of a light-receiving surface of a silicon wafer, and light-receiving surface passivation film 3A formed on dopant diffusion layer 6. *Id.* ¶ 26.

Hagino’s Figures 3A–3F are reproduced below:



Figures 3A–3F of Hagino are schematic cross-section views showing a process of manufacturing a solar cell. *Id.* ¶ 20. As shown in Figure 3C, a

silicon oxide film is formed as light-receiving surface passivation film 3A on texture etching surface 2A that is on a light-receiving surface of silicon wafer 1. *Id.* ¶ 28. Light-receiving surface passivation film 3A can be a silicon film, a silicon nitride film, a titanium oxide film, or an aluminum oxide film. *Id.* ¶¶ 29–30. As shown in Fig. 3E, a low-concentration dopant diffusion layer is formed in first region 6A covered with light-receiving surface passivation film 3A, and a high concentration dopant diffusion layer is formed in second region 6B under the opening portion of light-receiving surface passivation film 3A. *Id.* ¶ 28. As also shown in Fig. 3E, titanium dioxide formed on the top of the wafer forms an antireflection film, where the antireflection film includes, other than titanium dioxide, aluminum oxide, tin oxide, silicon nitride, tantalum oxide, or the like. *Id.* ¶¶ 54–55.

2. Claim 12

Petitioner provides analysis setting forth how the disclosure of Hagino allegedly meets each element of claim 12, and supports its analysis with the testimony of Dr. Banerjee. Pet. 52–65; Ex. 1003. For example, Petitioner asserts that Hagino discloses a solar cell, satisfying the preamble of claim 12.⁷ Pet. 52–53. Petitioner also sets forth how Hagino discloses a silicon substrate, indicating Hagino’s “silicon wafer 1.” *Id.* at 53 (citing Ex. 1006 ¶ 43, Fig.1). Patent Owner does not provide a substantive response on these or several other limitations of the independent claim, or contend that the art does not disclose them. Patent Owner’s response to this ground of

⁷ Petitioner also argues that the preamble of claim 12 is not limiting on the scope of the claim. Pet. 30. Because each ground of unpatentability set forth in the Petition discloses a solar cell, whether or not the preamble of claim 12 is limiting has no effect on our evaluation of the grounds. We will assume, without deciding, that the preamble is limiting.

unpatentability focuses on the question of whether the second dielectric layer is embedded with hydrogen. PO Resp. 12–13.⁸ We have reviewed the Petitioner’s evidence and arguments on the uncontested limitations of claim 12, and find that a preponderance of the evidence supports the conclusion that Hagino teaches these limitations. We, therefore, turn to the disputed limitation of the claim.

Hydrogen being embedded into the second dielectric layer

Petitioner does not contend that Hagino expressly discloses that its second layer contains embedded hydrogen. Instead, Petitioner directs us to Hagino’s disclosure that its silicon nitride layer is formed by “CVD using silane, ammonia, hydrogen and the like as a base material.” Pet. 60 (citing Ex. 1006 ¶ 29). Relying on the testimony of Dr. Banerjee, Petitioner argues that this process would necessarily result in hydrogen being embedded in the silicon nitride film. *Id.* (citing Ex. 1003 ¶¶ 206–210). Dr. Banerjee also cites Hseih, a reference that explains that performing CVD using a reaction “gas mixture of undiluted silane (SiH_4) and pure ammonia (NH_3)” resulted

⁸ Prior to institution, Patent Owner’s Preliminary Response also challenged whether the Petition established that Hagino discloses a first dielectric layer having a thickness of less than 50 nm. Paper 7, 36–45. Patent Owner did not preserve any arguments on this issue by making them following institution, in its Response. See Paper 13 at 7 (cautioning Patent Owner that “any arguments for patentability not raised in the response may be deemed waived.”); see also Tr. 47:11–18 (J. CRUMBLEY: “I didn’t see anything in the post institution briefing as to thickness in the Hagino reference, the thickness of the layer.” MR. GLASS: “We did not argue that point in response.”). Even if these arguments had been preserved, we have reviewed Petitioner’s evidence supporting its contentions (Pet. 61–64) and find that Hagino discloses a first dielectric layer with a thickness of less than 50 nm.

in a silicon nitride layer having embedded hydrogen. Ex. 1003 ¶ 207 (citing Ex. 1021).

In our Institution Decision, we evaluated Petitioner’s evidence based on the partial record available at the time, and in light of the arguments made in Patent Owner’s Preliminary response, and concluded that

On this record, we are not convinced that a person of ordinary skill in the art would have understood the antireflection layer of Hagino to contain embedded hydrogen. Patent Owner is correct that the First Embodiment of Hagino, relied on by Petitioner, does not teach depositing the antireflection layer via CVD, and CVD processing is key to Petitioner’s argument regarding embedded hydrogen. Indeed, Hagino’s First Embodiment does not mention CVD at all, for any of its layers. The only mention of CVD in an embodiment of Hagino is for the passivation layer of the Second Embodiment, on which Petitioner does not rely.

Dec. on Inst. 30.

In reaching these initial determinations, we relied on Patent Owner’s arguments that, at least in the “First Embodiment” of Hagino on which Petitioner primarily relies, the second-layer antireflection film is not formed using CVD. *Id.* at 29. Instead, we concluded that Hagino uses a spin coating and heating process to deposit and form the film in this embodiment. *Id.* We noted that the portion of Hagino Petitioner cites for the disclosure of CVD is in the general description of the preferred embodiments, and relates to using CVD to deposit a silicon nitride passivation film. *Id.* (citing Ex. 1006 ¶ 29).

Despite our doubts, however, we instituted trial on this ground of unpatentability, having found that other grounds in the Petition established a reasonable likelihood that at least one claim was unpatentable. *Id.* at 31 (citing *Guidance on the Impact of SAS on AIA Trial Proceedings* (Apr. 26, 2018), <https://www.uspto.gov/patents-application-process/patent-trial-and->

appeal-board/trials/guidance-impact-sas-aia-trial; *see also SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1359–60 (2018).)

During trial, Petitioner argued that our doubts regarding Hagino were unfounded, and that we were mistaken in concluding that the reference discloses using a spin-coating method for silicon nitride in the First Embodiment. Pet. Reply 21. Rather, Petitioner argues that the spin-coating process of the First Embodiment of Hagino is used only for forming antireflection films of titanium dioxide or other oxides. *Id.* (citing Ex. 1006 ¶¶ 54–55). While silicon nitride is listed as a potential material for an antireflection film, Petitioner contends that the only method Hagino discloses for creating a silicon nitride layer is CVD. *Id.* at 21–22. And, because Hagino discloses performing this CVD in the presence of silane and ammonia, this process would necessarily result in the silicon nitride second layer of Hagino containing hydrogen. *Id.* at 22 (citing Ex. 1003 ¶¶ 206–213).

Patent Owner responds that our Institution Decision was correct, that there is no basis to interpret Hagino’s disclosure of a spin coating method in its First Embodiment to exclude deposition of a silicon nitride layer. PO Sur-Reply 21. Repeating its argument from the Preliminary Response, Patent Owner points out that the only embodiment of Hagino that discloses using CVD is the second, and only in the creation of a “back passivation film.” *Id.* at 21–22.

Having the benefit of a fully developed record before us, and in light of the parties’ expanded arguments regarding the disclosure of Hagino, we find that the preponderance of the evidence supports Petitioner’s interpretation of the reference. Petitioner is correct that the only deposition

process disclosed in Hagino for the deposition of a silicon nitride film is CVD, in the following passage:

[I]n the solar cell in accordance with the present invention, it is also preferable to form an amorphous silicon film or a silicon nitride film as a passivation film. Here, an amorphous silicon film can be formed by CVD (Chemical Vapor Deposition) using silane, hydrogen, and the like as a base material. A silicon nitride film can be formed by CVD using silane, ammonia, hydrogen and the like as a base material.

Ex. 1006 ¶ 29. By contrast, the next paragraph of Hagino discloses a contrasting method for creating a surface passivation film using titanium oxide or aluminum oxide. *Id.* ¶ 30. “These films are formed by a vacuum evaporation process.” *Id.* Thus, the reference generally distinguishes between two deposition methods, depending on the material being deposited.

Turning to the First Embodiment of Hagino on which Petitioner relies, the method recites applying a “Solution A” to the light-receiving surface of the silicon wafer using a spin-coating method. *Id.* ¶ 50. The primary purpose of this step is to diffuse an n-type dopant into the p-type monocrystalline silicon when the wafer is heated to 800-950°C. *Id.* ¶¶ 50, 51. But there can be a secondary purpose to this step: Hagino discloses that Solution A may contain tetraisopropoxytitanium, which becomes a layer of titanium dioxide when the wafer is heated. *Id.* ¶ 54. As a result, “at the same time when the low concentration dopant diffusion layer is formed in first region 6A and the high concentration dopant diffusion layer is formed in second region 6B, *titanium dioxide formed on the top of the wafer forms an antireflection film 5.*” *Id.* (emphasis added).

Hagino also provides alternative materials to titanium dioxide that can be used as the antireflection film of its First Embodiment, including “aluminum oxide, tin oxide, silicon nitride, tantalum oxide, or the like.” *Id.*

¶ 55. Notably, for the *oxides* listed, the metals for those oxides may be mixed into solution A in place of, or together with, tetraisopropoxytitanium. *Id.* (listing “aluminum, tin, tantalum, or the like”). No precursor for silicon nitride is provided in this disclosure, and we find that Hagino did not contemplate creating a silicon nitride layer using the “Solution A” spin-coating method. Instead, we must turn to the only other disclosure for the deposition of a silicon nitride layer contained in Hagino, which, as described above, is a CVD process. *Id.* ¶ 29. Indeed, while Hagino’s First Embodiment discloses the formation of the dopant diffusion layer and the antireflection layer in a single step (involving Solution A), it alternatively provides that “the antireflection film may be formed *after the n-type dopant diffusion.*” *Id.* ¶ 56 (emphasis added). The “Solution A” spin-coating method must not be the exclusive process for forming the antireflection film, and the absence of silicon nitride from the list of materials applied through Solution A is telling.

Dr. Banerjee’s testimony supports the conclusion that a person of ordinary skill in the art would have interpreted Hagino’s disclosure in this manner. Dr. Banerjee states that paragraph 29 of Hagino is “certainly . . . the only described method for forming ‘silicon nitride’ layers” in the reference. Ex. 1003 ¶ 211. We noted in our Institution Decision that this appeared to not be the case, because silicon nitride could also be applied through spin coating Solution A. Dec. on Inst. 30 n.10. But on the full record now before us, we credit Dr. Banerjee’s testimony, because upon further evaluation the Solution A spin-coating method does not pertain to the deposition of a silicon nitride layer.

We have also reviewed Dr. Lebby’s testimony on this issue in evaluating how a person of ordinary skill would have interpreted Hagino.

While Dr. Lebby states that the First Embodiment of Hagino does not disclose using a CVD deposition method (Ex. 2008 ¶ 87), he does not address how a person of ordinary skill in the art would have understood Hagino to deposit a silicon nitride layer in the First Embodiment without using CVD. In particular, Dr. Lebby did not indicate, in Hagino or elsewhere, any disclosure that spin coating was a recognized method for depositing a silicon nitride layer. The only method for depositing silicon nitride recognized by Dr. Lebby was CVD as disclosed by the '215 patent, and he testified that CVD deposition of a silicon nitride layer in the presence of silane leads to the “cracking” of silane and “typically you would . . . see hydrogen as part of a deposited layer.” Ex. 1053, 55:6–57:20.

Based on the foregoing, we find that Hagino discloses deposition of a surface layer of silicon nitride using CVD that corresponds to the second layer of claim 12. We also credit Dr. Banerjee’s uncontradicted testimony that performing CVD deposition of silicon nitride in the presence of silane, as Hagino discloses (Ex. 1006 ¶ 29), would necessarily result in hydrogen being embedded in the layer. Ex. 1003 ¶¶ 206–213.

3. Claims 13 and 14

Dependent claim 13 specifies that the second dielectric layer comprises a material selected from the group consisting of silicon nitride, silicon oxide and silicon carbide. Petitioner notes Hagino’s disclosure that its antireflection film can be titanium dioxide, aluminum oxide, tin oxide, silicon nitride, or tantalum oxide. Pet. 65 (quoting Ex. 1006 ¶ 55). Patent Owner does not separately address this dependent claim. As discussed above, we find that Hagino discloses a second layer comprised of silicon nitride, thus meeting the additional limitation of claim 13.

Dependent claim 14 requires the first dielectric layer of claim 12 to have a thickness of less than 30 nm. Petitioner relies on Hagino's disclosure that its passivation layer of silicon oxide may be from 3 to 30 nm in thickness and Dr. Banerjee's testimony that a person of ordinary skill in the art would have recognized that a similar thickness may be used when aluminum oxide is used as the passivation layer. *Id.* at 66 (citing Ex. 1003 ¶ 242). Patent Owner does not separately address this dependent claim, and we again note that any challenge Patent Owner may have made to this limitation in the Preliminary Response was not preserved during the instituted trial. We find that Hagino discloses a layer having the thickness specified in claim 14.

For these reasons, we find that the preponderance of the evidence supports a conclusion that the subject matter of claims 12–14 would have been obvious to a person of ordinary skill at the time of the invention, in light of the disclosure of Hagino.

E. Obviousness Based on Hagino, Duerinckx, and/or Hoex 2006

Petitioner also argues that claims 12–14 would have been obvious over the combined teachings of Hagino, Duerinckx, and/or Hoex 2006. Pet. 66–71.

1. Duerinckx (Ex. 1008)

Duerinckx, entitled “Defect Passivation of Industrial Multicrystalline Solar Cells Based on PECVD Silicon Nitride,” is an article related to “efficiency improvements of solar cells based on . . . multicrystalline silicon materials.” Ex. 1008, 231. Duerinckx describes that there are several techniques for hydrogen passivation of silicon bulk and surfaces, including “deposition of H-containing silicon nitride layers (SiN_x:H).” *Id.* at 232.

Duerinckx further describes that hydrogen-containing silicon nitride layers were becoming widely introduced in industrial crystalline silicon solar cell processes due to “combining in one processing step an antireflection coating deposition along with surface and bulk passivation.” *Id.* The deposition of SiN_x layers, including direct plasma enhanced chemical vapor deposition (PECVD), effectively passivates the bulk of multicrystalline cells resulting in an important efficiency improvement, according to Duerinckx. *Id.* at 232–35.

2. *Hoex 2006 (Ex. 1007)*

Hoex 2006, entitled “Ultralow Surface Recombination of *c*-Si Substrates Passivated By Plasma-Assisted Atomic Layer Deposited Al_2O_3 ,” relates to “[s]urface passivation of crystalline silicon (*c*-Si)” that improves “performance of high efficiency industrial solar cells.” Ex. 1007, 042112-1. Hoex 2006 describes using a high band-gap dielectric Al_2O_3 as a surface passivation layer. *Id.* More specifically, Hoex 2006 describes preparing ultrathin films of Al_2O_3 via plasma-assisted atomic layer deposition (PA-ALD) with a thickness of 7–30 nm that provide a “good level of surface passivation on *p*-type *c*-Si.” *Id.*

3. *Claim 12*

Petitioner’s analysis of this ground of unpatentability is similar to the ground based solely on Hagino. But, to the extent that Hagino does not teach hydrogen embedded in its antireflective second layer, Petitioner argues that Duerinckx teaches this limitation. Pet. 66–69. And, if we were to conclude that Hagino does not teach that the thickness of its passivation first layer is less than 50 nm, Petitioner contends that Hoex 2006 teaches this limitation. *Id.* at 69–71. As to the latter combination with Hoex 2006,

because Patent Owner has not contested the thickness of the first layer of Hagino, we need not consider whether Hoex 2006 remedies any lack of disclosure in Hagino. And Patent Owner does not dispute the disclosure of Duerinckx, instead focusing primarily on the reason to combine the references in the manner Petitioner proposes. We have reviewed Petitioner's uncontested contentions as to the disclosures of Hagino and Duerinckx, and find that the preponderance of the evidence supports them. We, therefore, focus our discussion on Patent Owner's opposition, and its contention that a person of ordinary skill in the art would not have combined the references. PO Resp. 39–42.

Combination with Duerinckx

To the extent that the silicon nitride layer of Hagino does not inherently contain hydrogen as a result of its deposition process, Petitioner contends that a person of ordinary skill in the art would have applied Duerinckx's disclosure that embedding a silicon nitride layer with hydrogen improves passivation to the second antireflective layer of Hagino. Pet. 67–68. Petitioner observes that Duerinckx explicitly describes the deposition of a silicon nitride insulating layer in a solar cell, and discloses that it is advantageous to embed hydrogen in such a layer. Pet. 29–30, 45–46 (citing Ex. 1008, Abstract, 232). According to Duerinckx, “[d]efects, impurities and segregated impurities on extended defects can be passivated by hydrogen,” and one of the known techniques for hydrogen passivation was “deposition of H-containing silicon nitride layers.” Ex. 1008, 232. Dr. Banerjee testifies that depositing such a layer on top of an aluminum oxide layer, as disclosed in Hagino, would cause the hydrogen to diffuse through the aluminum oxide layer to the surface of the silicon substrate, helping to passivate the silicon. Ex. 1003 ¶¶ 216, 219 (citing Ex. 1023, 3823).

Petitioner contends that a person of ordinary skill in the art would have had reason to combine Hagino with Duerinckx because both disclose layers of silicon nitride in solar cells, and Duerinckx discloses the advantages of a hydrogen-embedded silicon nitride layer in achieving increased passivation. Pet. 67–68.

Patent Owner contends that a person of ordinary skill in the art would not have combined Duerinckx with Hagino in the manner Petitioner asserts because the two references are “fundamentally incompatible.” PO Resp. 39–42. First, Patent Owner argues that Hagino uses a spin-coating method to apply its silicon nitride layer, while Duerinckx teaches a PECVD process for depositing a single layer of silicon nitride. *Id.* at 40–41. In addition, Hagino is a two-layer structure that uses both a passivation layer and an antireflection layer, while Duerinckx discloses a single layer that performs both functions. *Id.* Patent Owner contends that Duerinckx’s one-layer system was “state-of-the-art at the time and would be simpler and presumably less expensive to manufacture,” and there is no reason for a person of ordinary skill in the art to make the combination Petitioner proposes instead of simply replacing Hagino’s two-layer structure with the one layer of Duerinckx. *Id.* at 41–42. Finally, Patent Owner argues that even if Duerinckx provides a reason to improve a layer of Hagino by embedding hydrogen, it would be the first passivation layer of Hagino that would be improved by incorporating hydrogen, not the second antireflection layer. *Id.* at 42. According to Patent Owner, because Hagino already contains a passivation layer, there would be no reason to also modify the antireflection layer to enhance passivation. *Id.*

Petitioner responds that Patent Owner’s argument is premised on the mistaken interpretation that Hagino’s silicon nitride layer is formed by spin

coating. Pet. Reply 24. We agree, for the reasons discussed above in the prior ground. Both references disclose depositing a silicon nitride layer using CVD.

Nor are we persuaded that a person of ordinary skill in the art would have only considered the wholesale substitution of Duerinckx's single silicon nitride layer for the dual-layer structure of Hagino. This is not the combination proposed by Petitioner, which argues that the skilled artisan would have recognized that the technique used in Duerinckx (increased passivation using embedded hydrogen) would similarly improve the second layer of Hagino. While an alternative modification might be the one proposed by Patent Owner, it would more fundamentally reconfigure the structure of Hagino's solar cell. Patent Owner provides insufficient evidence or argument to persuade us that the person of ordinary skill in the art would have only considered a more drastic modification of Hagino, to the exclusion of Petitioner's proposed combination.

Finally, as to Patent Owner's argument that a person of ordinary skill in the art would have seen no passivation advantage in embedding hydrogen in Hagino's second layer because the device already contained a separate passivation layer, Petitioner directs us to evidence that the hydrogen in a second layer can diffuse and pass through a first layer to further passivate a substrate. Pet. Reply 25 (citing Ex. 1003 ¶ 216; Ex. 1023, 3823, Ex. 1053, 23:1–21). Patent Owner does not directly respond to this evidence. We find that, even if Hagino already contained a passivation layer, there would have been reason for a skilled artisan to further improve the overall passivation of the solar cell by implementing Duerinckx's hydrogen embedding method in a second silicon nitride layer.

For these reasons, we find that even if Hagino's silicon nitride layer does not inherently contain embedded hydrogen, a person of ordinary skill in the art at the time of the invention would have combined the disclosures of Hagino and Duerinckx, by modifying Hagino's second silicon nitride layer to embed hydrogen with the goal of further improving the passivation characteristics of the solar cell. The resulting combination would teach or suggest all elements of claim 12. We, therefore, conclude that the subject matter of claim 12 would have been obvious over the combined disclosures of Hagino, Duerinckx, and Hoex 2006.

4. Claims 13 and 14

Petitioner does not rely on the disclosures of Duerinckx or Hoex 2006 for the additional limitations of dependent claims 13 and 14. Rather, Petitioner's analysis as to these claims is the same as for the previous ground based solely on Hagino. We find that the preponderance of the evidence supports a conclusion of obviousness as to these claims for the same reasons as discussed in the prior ground.

F. Obviousness Based on Bhattacharyya

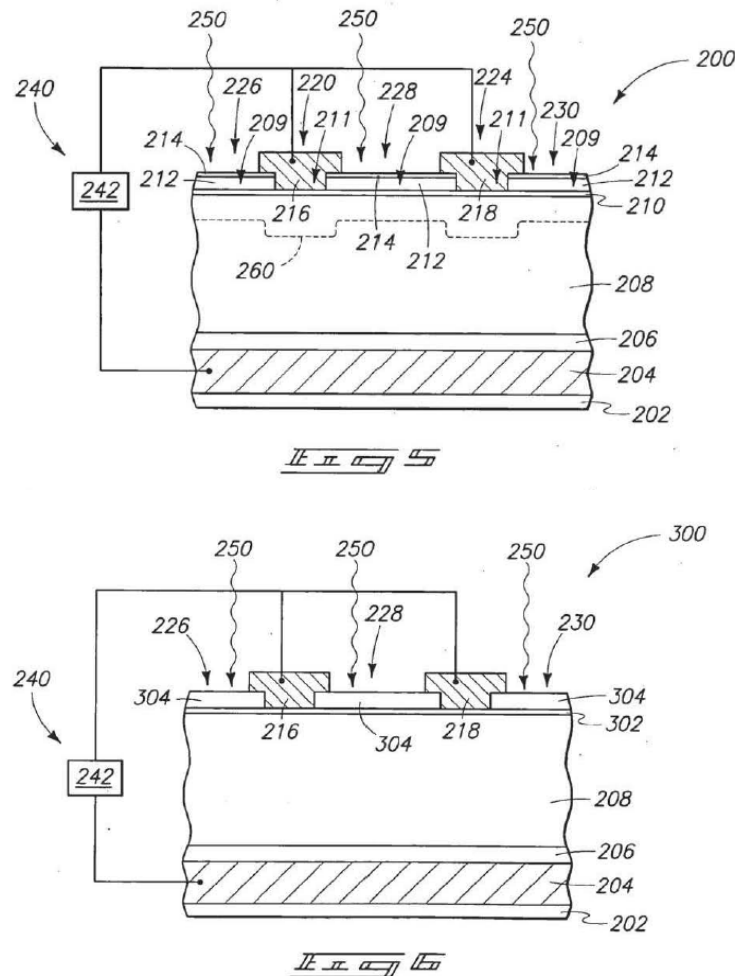
Petitioner contends that claims 12–14 would have been obvious over the disclosure of Bhattacharyya. Pet. 30–45.

1. Bhattacharyya (Ex. 1005)

Bhattacharyya, entitled "Optoelectronic Devices, Solar Cells, Methods of Making Optoelectronic Devices, and Methods of Making Solar Cells," published on May 18, 2006. Ex. 1005, [43], [54]. Bhattacharyya describes a solar cell comprising a first electrode, a first layer of semiconductor material over the first electrode, a second layer of semiconductor material over the first layer of semiconductor material, a

layer of semiconductor-enriched insulator over the second layer of semiconductor material, a second electrode extending over one or more segments of the layer of semiconductor-enriched insulator, and one or more windows over one or more segments of the layer of semiconductor-enriched insulator. *Id.* ¶ 7.

Bhattacharyya's Figures 5 and 6 are reproduced below.



Figures 5 and 6 are diagrammatic, cross-sectional, fragmentary views of a solar cell. *Id.* ¶¶ 15, 16. Bhattacharyya describes that Figure 5 illustrates solar cell 200 supported by base 202. *Id.* ¶ 67. First electrode 204 is over the base, first layer 206 of semiconductor material is over first electrode 204, and second layer 208 of semiconductor material is over first layer 206. *Id.*

¶ 69. Layers 206 and 208 comprise conductive-doped silicon, conductively-doped germanium, or conductively-doped silicon germanium. *Id.* Further, Bhattacharyya describes that Figure 6 illustrates solar cell 300 that also includes base 202, first electrode 204, first layer 206, and second layer 208. *Id.* ¶ 82. Solar cell 300 further includes thin dielectric material 302 in direct physical contact with second layer 208 of semiconductor materials and further comprises semiconductor-enriched insulator 304 over the dielectric material. *Id.* ¶ 83. Dielectric material 302 can be aluminum oxide or silicon dioxide, and the semiconductor-enriched insulator can comprise one or both of silicon-enriched silicon nitride and silicon-enriched silicon oxide. *Id.* ¶¶ 83, 85, 87.

2. Claim 12

Petitioner provides analysis setting forth how the disclosure of Bhattacharyya allegedly meets each element of claim 12, and supports its analysis with the testimony of Dr. Banerjee. Pet. 30–45; Ex. 1003. For example, Petitioner asserts that Bhattacharyya discloses a solar cell, satisfying the preamble of claim 12.⁹ Pet. 30. Petitioner also sets forth how Bhattacharyya discloses a silicon substrate, indicating layers 206 and 208 as shown in Figure 6 of the reference, which are said to comprise “single crystal or polycrystalline silicon.” *Id.* at 31 (citing Ex. 1005 ¶¶ 82, 86, Fig. 6.). On these and several other limitations of the independent claim, Patent Owner does not provide a substantive response or contend that the art does not disclose these limitations. We have reviewed the uncontested assertions of Petitioner on these points and find that a preponderance of the evidence supports the conclusion that the uncontested limitations of claim 12 are

⁹ Again, we assume, without deciding, that the preamble is limiting.

disclosed by Bhattacharyya. We will, therefore, turn to the contested limitations of the independent claim.

Wherein the first dielectric layer has a thickness of less than 50 nm

While Patent Owner does not dispute that Bhattacharyya discloses the first dielectric layer, the parties disagree as to whether that first layer has a thickness of less than 50 nm, as required by claim 12. Bhattacharyya does not directly disclose a value for the thickness of its layer, but Petitioner relies on the disclosure that layer 302 in Figure 6 is said to be “very thin,” not just “thin.” Pet. 39. Petitioner notes that elsewhere in Bhattacharyya, layers of “approximately 10 nanometers” and “from about 1 nanometer to about 100 nanometers” are referred to as simply “thin.” *Id.* at 39–40 (citing Ex. 1005 ¶¶ 47, 71, 80). If Bhattacharyya considers a “thin” layer to be 1–100 nm, Petitioner argues a “very thin” layer must be even thinner than that, or at the very least at the low end of the range. *Id.* at 40.

Petitioner also observes that layer 302 of Bhattacharyya’s Figure 6 embodiment must necessarily rely on quantum tunneling for electrons to pass from the silicon layer below to the electrodes above. Pet. 41. Petitioner also notes that in Figure 5 of Bhattacharyya, the first layer is explicitly said to “function as a tunnel medium.” Ex. 1005 ¶ 71. Relying on the testimony of Dr. Banerjee, Petitioner contends that a person of ordinary skill would have recognized that the tunneling effect is increased the thinner the intervening layer is made, and would have understood that layer 302 should be as thin as possible. Pet. 42–43. Dr. Banerjee testifies that the number of electrons that can tunnel through a layer is inversely proportional to the thickness of that layer, and that a person of ordinary skill in the art would have understood that the layer should be no more than 10 nm thick. Ex. 1003 ¶ 160 (citing Ex. 1019, 275–76 as “showing that electron tunneling

through Al₂O₃ film can occur at thicknesses up to 10 nm”). Dr. Banerjee also testifies that it would have been obvious to keep the thickness of the layer at much less than 50 nm, because the efficiency of the solar cell would be inversely related to the thickness of the layer. *Id.* ¶ 161. He states that this would provide another reason for the first layer of Bhattacharyya to be maintained at a thickness of less than 10 nm. *Id.*

Patent Owner disagrees with Petitioner’s interpretation of Bhattacharyya and the implications of tunneling. Patent Owner contends that Dr. Banerjee has admitted that tunneling can occur through an aluminum oxide layer thicker than 50 nm. PO Resp. 14 (citing Ex. 2005 ¶ 248). In addition, according to Patent Owner, there is no reason to believe that a person of ordinary skill in the art would have interpreted a “thin” layer in a completely different context, such as the embodiments of Figures 2 and 3 of Bhattacharyya, as relevant to the understanding of what a “very thin” dielectric layer means in the context of the Figure 6 embodiment. PO Resp. 15. Notably, the “thin” layer of Figures 2 and 3 is an electrically conductive pure metal such as aluminum or gold that are not a dielectric layer, while layer 302 is a dielectric layer. *Id.*; Ex. 1005 ¶ 47. According to Patent Owner, “a [person of skill in the art] would understand that **each layer** must be considered independently; what is ‘thin’ for one type of layer may actually be ‘thick’ for another layer made from a different material. PO Resp. 16 (citing Ex. 2008 ¶ 110). In addition, Patent Owner also observes that Bhattacharyya does not always refer to layer 302 as “very thin,” describing it as simply “thin” in a subsequent paragraph. *Id.* at 16 (citing Ex. 1005 ¶ 87). As a result, a person of ordinary skill in the art “would never have imparted precise, nanometer-scale measurements to words such as ‘thin’ and ‘very thin.’” *Id.* at 15.

In response, Petitioner argues that it is irrelevant that some tunneling can occur through layers over 50 nm, because in order to achieve the goals of Bhattacharyya and provide an operable solar cell, the thickness of the layer must be less than 10 nm. Pet. Reply 2. Petitioner observes that Dr. Lebbby's testimony supports this conclusion, in that he stated that an insulator 3.5 nm thick would be "greater than the amount that was believed would allow tunneling to yield an operable solar cell." *Id.* (citing Ex. 2008 ¶ 106. "Thus, regardless of whether it is mathematically possible that one single electron could tunnel through a thicker barrier," Petitioner contends that "both parties and their experts agree that the barrier in Bhattacharyya would need to be less than 10 nm to yield an operable solar cell." Pet. Reply 3.

This is a misinterpretation of Dr. Lebbby's testimony, Patent Owner contends. In the passage Petitioner cites, Dr. Lebbby was discussing a layer as described in Hoex 2006, which includes an interfacial silicon oxide layer between the substrate and the aluminum oxide layer. PO Sur-Reply 4 (citing Ex. 2008 ¶ 106). According to Patent Owner, it is the presence of this *interfacial layer* that makes thicknesses over 3.5 nm uncondusive to tunneling. *Id.* By contrast, Bhattacharyya excludes an interfacial layer. Patent Owner also points to Dr. Banerjee's testimony that tunneling effectiveness is not dependent on layer thickness alone, but rather is dependent on "many parameters." *Id.* at 3–4 (citing Ex. 2007, 243:18–244:12).

Upon reviewing the record as a whole, we believe Patent Owner has the better argument on this issue, and find that Bhattacharyya does not disclose that its first layer is necessarily thinner than 50 nm, much less the 10 nm thickness posited by Dr. Banerjee. Turning first to Petitioner's

argument that Bhattacharyya's characterization of a layer of 1–100 nm as “thin” implies that a “very thin” layer must be less than 50 nm, we are not persuaded that Bhattacharyya intended to use these terms with the degree of exactitude Petitioner wishes to impart upon it. As Patent Owner correctly notes, Bhattacharyya describes the same layer as both “thin” and “very thin,” which indicates that the term is not being used with much precision. And Petitioner provides no real explanation why the thickness of a “thin” conductor in Bhattacharyya would have been relevant to the thickness of a “very thin” dielectric layer.

Petitioner's other rationale based on tunneling is more persuasive, to some extent. Dr. Banerjee reasonably testifies why a person of ordinary skill in the art would have recognized that for Bhattacharyya's solar cell to work, quantum tunneling must occur (Ex. 1003 ¶ 159), and Dr. Lebby appears to agree with this assessment and states that the dielectric layer 302 of Bhattacharyya “must be thin enough to allow quantum tunneling.” (Ex. 2008 ¶ 105). And the experts appear to be in agreement that as a layer becomes thinner, the ability for electrons to tunnel through that layer increases. Thus, Dr. Banerjee's conclusion that a person of ordinary skill in the art would have had reason to make the first layer of Bhattacharyya thinner is reasonable. Ex. 1003 ¶ 161.

That said, we cannot conclude based on the evidence before us that a person of ordinary skill in the art would have concluded that a layer thinner than 50 nm is required in Bhattacharyya, much less the 10 nm layer that Dr. Banerjee testifies to. The only support for 10 nm that Dr. Banerjee cites for his conclusion that “a Skilled Artisan would have recognized that the geometry of FIG. 6 confirms that layer 306 would be less than 10 nm” is an

article by Yadavalli. *Id.* ¶ 160.¹⁰ But while Yadavalli describes a “tunnel oxide barrier” of less than 10 nm (Ex. 1009, 275–76), Dr. Banerjee does not explain how a “tunnel oxide barrier” applies to the solar cell of Bhattacharyya, or why Yadavalli leads to a conclusion that a solar cell cannot operate with a layer thicker than 10 nm.¹¹

Nor have we found sufficient evidence in the record that a layer of 50 nm would result in an inoperable solar cell. Indeed, Bhattacharyya itself indicates otherwise: its layer 210 is described as a “tunnel medium” and may have a thickness of up to 100 nm (Ex. 1005 ¶ 71), strongly indicating that in some cases a layer may be thicker than 50 nm while still permitting sufficient tunneling to occur. Although layer 210 is silicon dioxide or silicon nitride, not the aluminum oxide layer 302 of Bhattacharyya’s Figure 6 embodiment, Dr. Banerjee testified that he would expect the materials to have similar tunneling properties. Ex. 2007 364:20–366:8.¹²

¹⁰ Dr. Banerjee also cites Hoex 2006 as supporting his conclusion that a skilled artisan would have selected a 10 nm layer. (Ex. 1003 ¶¶ 164–166). We discuss the disclosure of Hoex 2006 in the ground below, where it is made part of the combination of references.

¹¹ In the Reply, Petitioner cites to additional prior art references that allegedly show layers less than 10 nm in solar cells. Pet. Reply 3. But the fact that *some* solar cells include layers of less than 10 nm does not prove Dr. Banerjee’s proposition that an operable solar cell *must* contain a layer of less than 10 nm. Patent Owner also observes that the cited prior art layers use different materials than the Al₂O₃ of Bhattacharyya, thus diminishing the relevance of their disclosed layer thicknesses. PO Sur-Reply 5.

¹² Q: “So in your opinion the 1 to 100 nanometer thickness of the semiconductor-enriched insulator in Figure 5 of Bhattacharyya is helpful to inform a person of ordinary skill in the art what the thickness of aluminum oxide in Figure 6 of Bhattacharyya would need to be. Right?” A: “Especially the silicon nitride portion. Because its band cap is so close . . . [to] aluminum oxide.” Ex. 2007 365:21–366:8.

We also find that while tunneling efficiency is inversely proportional to layer thickness, thickness is not the only variable that affects efficiency. Dr. Banerjee's testimony does not take into account other factors such as the material of the layer, instead simply stating an absolute threshold of a particular thickness. For this reason, we do not believe Dr. Lebbby's testimony regarding a 3.5 nm layer in Hoex 2006 is the admission that Petitioner asserts, because Petitioner's analysis does not take into account the fact that Hoex 2006 includes an interfacial layer of a different material than Bhattacharyya.

Absent sufficient evidence that an Al_2O_3 layer of the type used in Bhattacharyya would have been inoperable at thicknesses greater than 50 nm, we cannot conclude on the present record that a person of ordinary skill in the art would have found it obvious to make the first layer of Bhattacharyya at a thickness within the range of claim 12, much less the "no more than 10 nm" range that Dr. Banerjee asserts. For these reasons, we do not find that a preponderance of the evidence supports the conclusion that claim 12, or its dependent claims 13 and 14, would have been obvious over Bhattacharyya alone.

G. Alleged Obviousness Based on Bhattacharyya, Duerinckx, and Hoex 2006

Petitioner contends that claims 12–14 would have been obvious over the combined teachings of Bhattacharyya, Duerinckx, and Hoex 2006. Pet. 45–52.

1. Claim 12

Petitioner's analysis of this ground of unpatentability is similar to the ground based solely on Bhattacharyya. But, to the extent that Bhattacharyya does not teach hydrogen embedded in the second layer of its Figure 6 solar

cell, Petitioner argues that Duerinckx teaches this limitation. Pet. 45–48. And, as we have concluded that Bhattacharyya does not teach that the thickness of the first layer of Figure 6 should be less than 50 nm, Petitioner contends that Hoex 2006 teaches this limitation. *Id.* at 48–52. Because the question of the combination with Hoex 2006 resolves this ground of unpatentability, we focus on it here.

Combination with Hoex 2006

According to Petitioner, to the extent that Bhattacharyya does not disclose the thickness of its first layer, the thickness would have been obvious in light of the disclosure of Hoex 2006. Pet. 48–51. As set forth above, Hoex 2006 describes excellent surface passivation using an aluminum oxide layer as thin as 7 nm. Ex. 1007, 042112-1. Petitioner contends that, given that Bhattacharyya also uses aluminum oxide in a solar cell to “reduce surface recombination and to enhance collection and thereby also enhance solar cell efficiency” (Ex. 1005 ¶ 87), a person of ordinary skill in the art would have applied Hoex 2006’s disclosure regarding the thickness of its Al₂O₃ film to Bhattacharyya. Pet. 49.

Patent Owner argues that “Petitioners arbitrarily force Hoex 2006’s thin layer into the system of Bhattacharyya,” where in fact a person of ordinary skill in the art would not have combined the references due to the differences between the structures disclosed. PO Resp. 23–24. In particular, Patent Owner notes that Hoex 2006 discloses that its structure has an interfacial silicon oxide layer between its silicon substrate and the aluminum oxide layer, whereas Bhattacharyya places aluminum oxide directly onto the substrate. *Id.* at 24–25. Dr. Lebby testifies that the absence of an interfacial layer in Bhattacharyya is significant because it contributes to the ability of electrons to tunnel through the aluminum oxide layer, which allows the solar

cell to function. Ex. 2008 ¶¶ 113–115. Hoex 2006’s deposition process, by contrast, necessarily results in the presence of an interfacial layer. *Id.* ¶ 106.

We rejected this argument in our Institution Decision, and find it no more persuasive on the full record. As we said before, we do not understand Petitioner’s proposed ground of unpatentability to rely on Hoex 2006’s deposition method; rather, Petitioner cites Hoex 2006 as providing guidance as to the appropriate thickness of the aluminum oxide layer of Bhattacharyya. Patent Owner’s argument based on Hoex 2006’s deposition method is beside the point.

Patent Owner responds, however, that Hoex 2006’s thickness cannot simply be separated from the presence of its interfacial oxide layer. PO Resp. 26–28. Dr. Lebby testifies that for a layer to be as thin as disclosed in Hoex 2006, the presence of an interfacial layer is required in order to contribute to the aluminum oxide’s high negative charge density and promote field effect passivation. Ex. 2008 ¶ 106. In other words, if the layer of Hoex 2006 were formed without an interfacial layer, as the combination proposed by Petitioner contemplates, then Hoex 2006’s layer would necessarily have to be made thicker to maintain its passivation qualities. *Id.* Patent Owner contends that Petitioner does not attempt to address these modifications, or whether they would take the thickness of Bhattacharyya’s layer outside the range required by claim 12. PO Resp. 28.

Petitioner replies by noting that Hoex 2006 explicitly states that its interfacial oxide layer “does not contribute to passivation.” Pet. Reply 16. But the portion of Hoex 2006 that Petitioner cites is referring to the passivation qualities of the oxide layer *in itself*, not the effect that the oxide layer has on the passivation abilities of the aluminum oxide layer above it. Ex. 1007, 2 (“the oxide layer formed during the O₂ plasma exposure in itself

does not yield any surface passivation, also not after annealing.”). Nor do we find persuasive Petitioner’s argument that because Hoex 2006’s combined layers are 8.5 nm thick—less than the 10 nm cutoff proposed by Dr. Banerjee—both layers can be incorporated into Bhattacharyya without preventing tunneling. Pet. Reply 15. Again, this argument focuses only on the thickness of the layer, to the exclusion of the materials of the layer, an oversight in Dr. Banerjee’s testimony we addressed above.¹³

Finally, to counter Patent Owner’s argument that the layer of Hoex 2006’s Al₂O₃ layer would have to be made thicker if the interfacial layer were removed, Petitioner cites to our Institution Decision, which pointed out that Bhattacharyya uses two layers for passivation while Hoex 2006 discloses only one, so it was reasonable to conclude that Bhattacharyya could achieve passivation with thinner layers. Pet. Reply 17 (citing Dec. on Inst. 25). At the time, however, we had not been presented with Dr. Lebby’s testimony, or Patent Owner’s argument and evidence regarding the effect of Hoex 2006’s interfacial layer on tunneling and passivation characteristics. Based on the fully developed record, we find that a person of ordinary skill in the art would not have assumed that the Al₂O₃ layer of Hoex 2006 could simply be transplanted into Bhattacharyya without making any adjustment to its thickness. As a result, the fact that Hoex 2006 found its layer of 7 nm to have “excellent surface passivation” qualities does not lead us to conclude

¹³ Nor do we find it persuasive that Petitioner cites a reference that shows a barrier comprised of two different materials may actually increase tunneling effectiveness. Pet. Reply 15 (citing Ex. 1044, 1353). Petitioner does not explain why the fact a dual silicon oxide/silicon nitride layer stack may improve tunneling has any bearing on the question of whether the silicon oxide/aluminum oxide layers of Hoex 2006 permit tunneling at a thickness of 8.5 nm.

that the Al₂O₃ layer of Bhattacharyya could simply be modified to a similar thickness with a reasonable expectation of successfully achieving the same results.

For these reasons, we cannot conclude that the preponderance of the evidence establishes that a person of ordinary skill in the art would have combined Bhattacharyya and Hoex 2006 to arrive at the claimed invention, namely a solar cell having a first dielectric layer of less than 50 nm. As Hoex 2006 does not remedy the deficiency found above in the ground based on Bhattacharyya alone, and Petitioner does not contend that Duerinckx remedies this deficiency, we need not address the combination of Bhattacharyya with Duerinckx.

IV. CONCLUSION

Based on the evidence and arguments, Petitioner has demonstrated by a preponderance of the evidence that:

- (1) claims 12–14 are unpatentable under 35 U.S.C. § 103(a), as having been obvious over the disclosure of Hagino;
- (2) claims 12–14 are unpatentable under 35 U.S.C. § 103(a), as having been obvious over the combined disclosures of Hagino, Duerinckx, and Hoex 2006;
- (3) claims 12–14 have not been proven unpatentable under 35 U.S.C. § 103(a) as having been obvious over the disclosure of Bhattacharyya; and
- (4) claims 12–14 have not been proven unpatentable under 35 U.S.C. § 103(a) as having been obvious over the combined disclosures of Bhattacharyya, Duerinckx, and Hoex 2006.

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner's Motion to Exclude is *denied*;

FURTHER ORDERED that claims 12–14 of U.S. Patent No. 9,893,215 B2 are *unpatentable*; and

FURTHER ORDERED that, because this Decision is final, a party to the proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

In summary:

Claims	35 U.S.C.	Reference(s)	Claims Shown Unpatentable	Claims Not shown Unpatentable
12–14	§ 103	Bhattacharyya		12–14
12–14	§ 103	Bhattacharyya, Duerinckx, and Hoex 2006		12–14
12–14	§ 103	Hagino	12–14	
12–14	§ 103	Hagino, Duerinckx, and Hoex 2006	12–14	
Overall Outcome			12–14	

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