

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner,

v.

MAXEON SOLAR PTE. LTD.,
Patent Owner.

IPR2024-01040
Patent 8,878,053 B2

Before JO-ANNE M. KOKOSKI, KRISTINA M. KALAN, and
AVELYN M. ROSS, *Administrative Patent Judges*.

ROSS, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Canadian Solar, Inc. (“Petitioner”) filed a Petition (Paper 1, “Pet.”) requesting an *inter partes* review of claims 9–20 of U.S. Patent No. 8,878,053 B2 (Ex. 1001, “the ’053 patent”). Maxeon Solar Pte. Ltd. (“Patent Owner”) filed a Preliminary Response to the Petition. Paper 9. With Board authorization, Petitioner filed a Preliminary Reply (Paper 10), and Patent Owner filed a Preliminary Sur-reply (Paper 12). Taking account of those papers, we instituted an *inter partes* review. Paper 13 (“DI”)

Thereafter Patent Owner filed a Response (Paper 25, “PO Resp.”), Petitioner filed a Reply (Paper 32, “Pet. Reply”), and Patent Owner filed a Sur-reply (Paper 35, “Sur-reply”). The Final Hearing was held on October 12, 2025, and a transcript of the Final Hearing is in the record. Paper 42 (“Tr.”).

For the reasons set forth below, upon considering the Petition, Patent Owner’s Response, Petitioner’s Reply, Patent Owner’s Sur-reply, and evidence of record, we determine that Petitioner has established by a preponderance of the evidence that claims 9–20 of the ’053 patent are unpatentable.

A. *Real Parties-in-Interest*

Petitioner identifies Canadian Solar Inc. (“CSI”) and Canadian Solar (USA) Inc. as real parties-in-interest. Pet. 3.

Patent Owner identifies itself as the real party-in-interest. Paper 5, 2.

B. *Related Proceedings*

The parties identify the following legal proceedings as involving the ’053 patent:

Maxeon Solar Pte. Ltd. v. Canadian Solar Inc., 2-24-cv-00210
(E. D. Tex.)

Maxeon Solar Pte. Ltd. v. Hanwha Solutions Corp., 2-24-cv-
00262 (E. D. Tex.)

Maxeon Solar Pte. Ltd. v. REC Solar Holdings AS, 2-24-cv-
00260 (E. D. Tex.)

Pet. 3; Paper 5, 2.

Patent Owner further identifies IPR2024-01199 (U.S. Patent
No. 8,878,053) as a related matter. Paper 6, 2.

C. The '053 patent

The '053 patent, titled “Front Contact Solar Cell with Formed Emitter,” issued on November 4, 2018. Ex. 1001, codes (45), (54). The '053 patent discloses “structures for a relatively efficient and cost-effective front contact solar cell and processes for manufacturing [the] same.” Ex. 1001, 1:47–49. The '053 patent explains that a solar cell includes P-type and N-type diffusion regions that form a junction, and metal contacts that allow an external circuit to be coupled to and powered by the solar cell. Ex. 1001, 1:26–29. In a backside solar cell, both the diffusion regions and the metal contacts coupled to them are on the back side of the solar cell. Ex. 1001, 1:32–36. In a front contact solar cell, at least one of the metal contacts is on the front side of the solar cell, which is the side that faces the sun to collect solar radiation. Ex. 1001, 1:37–41. The '053 patent shows one embodiment of its solar cell in Figure 1, reproduced below.

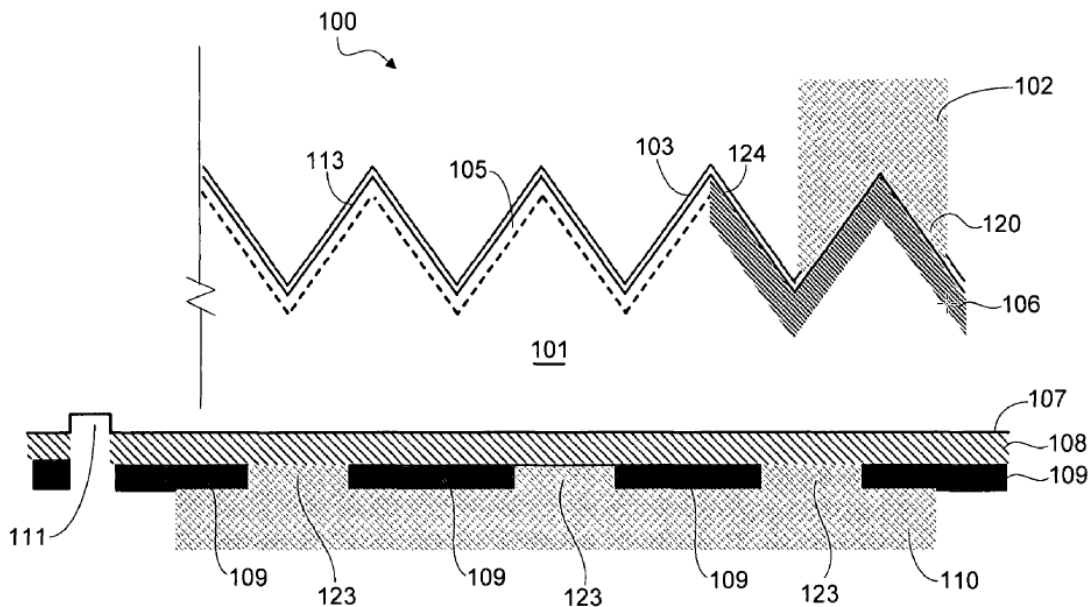


Figure 1 shows a cross-section of front contact solar cell 100 having metal contact 102 on its front side, which faces the sun during normal operation, and metal contact 110 on its backside. Ex. 1001, 2:29–34. Solar cell 100 also includes N-type silicon substrate 101, tunnel oxide layer 107, polysilicon emitter 108, silicon dioxide layer 109, contact holes 123, and edge isolation trench 111. Ex. 1001, 2:35–39, 2:64–65, 3:6–3:9, 3:30–33. The front side of silicon substrate 101 is randomly textured (labeled as 113) and includes N-type doped regions 105 and 106, contact hole 120, and passivating oxide layer 124. Ex. 1001, 2:43–45, 2:59–64.

D. Illustrative Claim

Petitioner challenges claims 9–20 of the '053 patent. Independent claims 9 and 16 are representative of the challenged claims and are reproduced below with Petitioner's annotations¹:

¹ For convenience, we adopt Petitioner's annotated claim format.

- [9.a] A method of fabricating a solar cell comprising:
- [9.b] forming a layer of polysilicon over a back surface of a silicon substrate;
- [9.c] forming a first dopant source layer over the layer of polysilicon;
- [9.d] diffusing dopants from the first dopant source layer to the layer of polysilicon to form a backside junction with the silicon substrate;
- [9.e] diffusing dopants into a front surface of the silicon substrate, the front surface of the silicon substrate facing the sun during normal operation; and
- [9.f] forming a metal contact on the front surface of the silicon substrate, wherein the metal contact is electrically coupled to the silicon substrate.

Ex. 1001, 6:52–67.

- [16.a] A method of fabricating a solar cell comprising:
- [16.b] forming an oxide layer over a back surface of a silicon substrate;
- [16.c] forming a layer of polysilicon over the oxide layer;
- [16.d] diffusing dopants into the layer of polysilicon to form a backside junction with the silicon substrate;
- [16.e] diffusing dopants into a front surface of the silicon substrate, the front surface of the silicon substrate facing the sun during normal operation; and
- [16.f] forming a metal contact on the front surface of the silicon substrate, wherein the metal contact is electrically coupled to the silicon substrate.

Ex. 1001, 7:19–8:6.

E. The Asserted Unpatentability Challenges

Petitioner asserts that claims 9–20 would have been unpatentable based on the following grounds:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
9–11, 14, 16–17, 19–20	103	Froitzheim, ² Gan ³
11–13, 15, 18	103	Froitzheim, Gan, Hartiti, ⁴ Sivoththaman ⁵
9–11, 14, 16–17, 19–20	103	Froitzheim, Kwark ⁶
11–13, 15, 18	103	Froitzheim, Kwark, Hartiti, Sivoththaman

Pet. 4. Petitioner relies on the testimony of Sanjay Banerjee. Ex. 1003 (Declaration); Ex. 1082 (Supplemental Declaration). Patent Owner relies on the testimony of Douglas Ruby. Ex. 2020 (Declaration).

II. ANALYSIS

A. Principles of Law

In an *inter partes* review, “the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.”

² EP 1732142 A1, published Dec. 13, 2006 (Ex. 1006, “Froitzheim”).

³ J.Y. Gan et al., *Polysilicon Emitters for Silicon Concentrator Solar Cells*, The Conference Record of the Twenty First IEEE Photovoltaic Specialists Conference–1990, Vol. 1, pp. 245–250 (Ex. 1007, “Gan”).

⁴ B. Hartiti et al., *Low Temperature Formation of Emitter and BSF by Rapid Thermal Co-Diffusion of P, Al or B*, 1994 IEEE First World Conference on Photovoltaic Energy Conversion, Vol. II, pp. 1519–1522 (Ex. 1012, “Hartiti”).

⁵ S. Sivoththaman et al., *Rapid Thermal Processing of Conventionally and Electromagnetically Cast 100 cm² Multicrystalline Silicon*, The Conference Record of the Twenty Fifth IEEE Photovoltaic Specialists Conference–1996, pp. 621–250 (Ex. 1013, “Sivoththaman”).

⁶ Y.H. Kwark et al., *SIPOS Heterojunction Contacts to Silicon*, 1984 International Electron Devices Meeting TECHNICAL DIGEST, 1984, pp. 742–745 (Ex. 1008, “Kwark”).

Harmonic Inc. v. Avid Tech., Inc., 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (2012) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”)). This burden of persuasion never shifts to the patent owner. See *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (discussing the burden of proof in *inter partes* review).

Obviousness is a question of law based on underlying determinations of fact. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966); *Richardson-Vicks, Inc. v. Upjohn Co.*, 122 F.3d 1476, 1479 (Fed. Cir. 1997). A claim is unpatentable as obvious, under 35 U.S.C. § 103, if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time of the invention to a person having ordinary skill in the art. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of nonobviousness.⁷ *Graham*, 383 U.S. at 17–18. Consideration of the *Graham* factors “helps inform the ultimate obviousness determination.” *Apple Inc. v. Samsung Elecs. Co.*, 839 F.3d 1034, 1048 (Fed. Cir. 2016) (en banc), *cert. denied*, 138 S. Ct. 420 (2017). Subsumed within the *Graham* factors are the requirements that all claim limitations be found in the prior

⁷ Petitioner asserts that the objective factors in the record support a conclusion of obviousness. Pet. 66. Patent Owner does not address objective indicia of nonobviousness. See generally PO Resp.; Tr. 21:7–16.

art references and that the skilled artisan would have had a reasonable expectation of success in combining the prior art references to achieve the claimed invention. *Pfizer, Inc. v. Apotex, Inc.*, 480 F.3d 1348, 1361 (Fed. Cir. 2007). “Obviousness does not require absolute predictability of success . . . all that is required is a reasonable expectation of success.” *In re O’Farrell*, 853 F.2d 894, 903–04 (Fed. Cir. 1988) (citations omitted). But, a petitioner cannot satisfy its burden of proving obviousness by employing “mere conclusory statements.” *In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

We analyze the challenges presented in the Petition in accordance with the above-stated principles.

B. Level of Ordinary Skill in the Art

We review the grounds of unpatentability in view of the understanding of a person of ordinary skill in the art at the time of the invention. *Graham*, 383 U.S. at 17.

Petitioner contends that a person of ordinary skill in the art would have been someone with 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. Alternatively, that person would have had a bachelor’s degree in electrical engineering, applied physics, or materials science, and at least three years of experience designing, developing, or researching in the field.

Pet. 4 (citing Ex. 1003 ¶ 45).

Patent Owner also states that it “applies the level of skill in the art [Petitioner] proposed.” PO Resp. 35.

In light of the complete record before us, we adopt Petitioner’s proposal regarding the level of ordinary skill in the art. Based on our review of the ’053 patent and the prior art of record, we determine that the definition offered by Petitioner comports with the qualifications a person would have needed to understand the ’053 patent and the prior art.

C. Claim Construction

We construe claim terms according to the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–17 (Fed. Cir. 2005) (en banc); 37 C.F.R. § 42.100(b). Under *Phillips*, we give claim terms “their ordinary and customary meaning.” *Phillips*, 415 F.3d at 1312. “[T]he ordinary and customary meaning of a claim term 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.” *Id.* at 1313. “Importantly, the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification.” *Id.*

Petitioner contends that “the term ‘in situ’ in dependent claim 15 is appropriate for construction because it is defined in the 053 Patent.” Pet. 20.

In particular, Petitioner argues that

“in situ” refers to processing that occurs after a single manual loading of the substrate into a furnace or other single chamber or multi-chamber processing tool. EX1003, ¶157. Therefore, in the context of claim 15’s diffusion steps, the single, simultaneous drive-in/diffusion of the front and back dopants would constitute “in situ” steps that satisfy the claim.

Pet. 56–57 (citing Ex. 1003 ¶ 157); see Ex. 1001, 5:9–18.

Patent Owner argues that “in the parallel district court litigation, [Petitioner] advocates for an additional limitation on what constitutes the

claimed ‘in situ.’” PO Resp. 35–36. In particular, Patent Owner asserts that Petitioner urges that “in situ” processing “covers only ‘in situ’ diffusion and not ‘in situ’ doping.” PO Resp. 36. But, Patent Owner states that it applies the construction adopted by Petitioner here. PO Resp. 36

Because the outcome of this Decision does not rest on any particular construction, we need not expressly construe any claim terms. *See Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) (holding that “only those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy”); *see also Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (citing *Vivid Techs.* in the context of an *inter partes* review).

D. Challenges Based on Froitheim and Gan

Petitioner alleges that claims 9–11, 14, 16, 17, 19, and 20 of the ’053 patent would have been obvious over the combination of Froitheim and Gan. Pet. 4, 28–46. In addition, Petitioner contends that claims 11–13, 15, and 18 of the ’053 patent would have been obvious over the combination of Froitheim and Gan in further view of either Hartiti or Sivoththaman. Pet. 4, 47–58.

1. Overview of Froitheim (Ex. 1006)

Froitheim is directed to solar cells and a method of manufacturing solar cells that addresses light induced degradation of boron doped base layers in solar cells. Ex. 1006 ¶¶ 1, 3. Froitheim discloses a solar cell comprising an Si layer of n-type bulk doping having a front side and a rear side, a non-alloyed p-type doped region at the rear side of the body layer and forming a p/n-junction with the rear side, a rear side contact in electrical

connection with the p-type doped region, and a front side contact in electrical connection with the n-type silicon body layer. Ex. 1006 ¶ 10. According to Froitzheim, “the use of n-type Si as [the] body layer overcomes the degradation problem of conventional solar cells with a boron doped body layer.” Ex. 1006 ¶ 13. Froitzheim also teaches that “etching can be used to texture the surface in order to improve the geometry of incidence of light in order to prevent reflection.” Ex. 1006 ¶ 39.

2. *Overview of Gan (Ex. 1007)*

Gan is directed to a study of polysilicon emitters with a thermally grown interfacial oxide layer. Ex. 1007, 245. Gan explains that the oxide is not thermally stable, and “tends to break up during high temperature anneals,” which has a “direct impact on both majority and minority carrier transport in the polysilicon emitter.” Ex. 1007, 245. Gan was interested in the performance of polysilicon emitters “when only a small fraction of the interfacial oxide is broken,” and determined that “the cell performance can be improved” under certain circumstances. Ex. 1007, 245. Gan concluded that polysilicon emitters with improved performance “can be obtained with a very small fraction of interfacial oxide breakup,” and that “polysilicon emitters with these qualities can be quite useful for silicon concentrator solar cells.” Ex. 1007, 249.

3. *Analysis of Claim 9*

Petitioner alleges that the combination of Froitzheim and Gan renders claim 9 of the '053 patent obvious. Pet. 35–42. Petitioner contends that Froitzheim describes each of the limitations of claim 9 except for the polysilicon emitter. According to Petitioner, Froitzheim describes a method of fabricating a solar cell that includes forming a back-side diffused p-type

emitter, forming a front surface field or doped region on the substrate by diffusing phosphorus into the front surface, and screen printing front and rear silver-containing electrical contacts. Pet. 35–40 (citing Ex. 1006 ¶¶ 15, 28, 32, 40, 44, 48–49, 60, 116–120, Fig. 1, Abstr.; Ex. 1003 ¶¶ 106–108, 110–113, 114–115, 117–120). Petitioner acknowledges that Froitzheim does not describe a back surface polysilicon layer, but Petitioner proposes replacing the “backside diffused p-type emitter of Froitzheim . . . with a polysilicon emitter, as taught by Gan.” Pet. 35 (citing Ex. 1007, 245; Ex. 1003 ¶ 107). Petitioner alleges that in the Froitzheim/Gan combination, the replaced polysilicon layer would be doped, as taught by Froitzheim and Gan, “by first forming a diffusion source layer and diffusing the dopant from that layer into the polysilicon layer.” Pet. 36 (citing Ex. 1006 ¶ ¶ 40-41; Ex. 1007, 246). Petitioner, through testimony of Dr. Banerjee, alleges that

the Skilled Artisan would understand that the “doped glass deposition” step in Gan deposits a “*first dopant source layer*” on the backside polysilicon and the “drive in” step would diffuse the dopant from the “doped glass” layer into the polysilicon layer at high temperature in step 10. EX1003, ¶110. It was well known that the term dopant “drive in” is synonymous with dopant diffusion in solar cell manufacturing.

Pet. at 37.

Petitioner explains that “Froitzheim and Gan are analogous art because each is in the same field of endeavor—solar cell design” and “[e]ach is reasonably pertinent to the problems of efficiencies and cost-effectiveness of solar cell designs.” Pet. 29 (citing Ex. 1003 ¶¶94; Ex. 1006, Abstr., ¶¶ 1, 9; Ex. 1007, 245, 249). Petitioner asserts that a person of ordinary skill in the art “would have been motivated to

replace Froitzheim's diffused emitter with a deposited polysilicon emitter along with an oxide layer because Gan taught and suggested that this modification would be an improvement.” Pet. 29 (Ex. 1003 ¶ 95). Gan teaches that “the cell performance can be improved if the diffused-emitter [e.g., of Froitzheim] is replaced with the polysilicon emitter” and that “the J_0 [i.e., measure of surface recombination] of the p-type polysilicon emitter (Fig 5) [beneficially] appears to be much lower than what has been previously reported,” which Gan attributes to the thermal oxide interfacial layer. Pet. 29–30 (quoting Ex. 1007, 245, 248); *see also* Ex. 1007, 249 (“polysilicon emitters with these qualities can be quite useful for silicon concentrator solar cells”). Petitioner also argues that the skilled artisan would have had a reasonable expectation of success because the combination is simply

an arrangement of old elements (and their corresponding fabrication steps) with each performing the same function it had been known to perform (the emitter of Froitzheim continuing to act as an emitter, but modified to be of a polysilicon material with an interfacial oxide layer in between it and the substrate) and yielding no more than what one would expect from such an arrangement.

Pet. 33 (citing Ex. 1003 ¶ 102).

Patent Owner does not substantively challenge Petitioner's allegations regarding the teachings of Froitzheim and Gan with respect to elements of the challenged claims. *See generally* PO Resp.; Tr. 21:3–16 (explaining Patent Owner's position as “we agree that the proposed combinations meet all of the elements except for claim 12 of the '516 patent”). Instead, Patent Owner argues that a person of ordinary skill in the art would not have had a

reasonable expectation of success or a reason to combine Froitzheim and Gan. PO Resp. 43, 50; Tr. 5:4–14, 21:3–16. We address each of Patent Owner’s arguments below.

a) Reasonable Expectation of Success

Patent Owner argues that the combination of Froitzheim and Gan (1) “would have led to high resistivity and high recombination,” (2) lacks “predictable results in reliably growing Gan’s oxide layer,” and (3) produces “annealing temperatures [that] are incompatible and the selection of the temperature according to one reference meant foregoing the alleged benefits of the other reference.” PO Resp. 44.

(1) annealing temperatures

Patent Owner argues that a person of ordinary skill in the art would have avoided the high temperature dopant drive-in described in Froitzheim because Gan prefers a lower dopant drive-in temperature. PO Resp. 45. Patent Owner explains that, according to Gan, “polysilicon emitters with $J_o \leq 5 \times 10^{-14}$ A/cm² and $\rho_c \sim 1 \times 10^{-5}$ Ω/cm² [are] ‘quite useful for silicon for silicon concentrator solar cells.’” PO Resp. 44 (citing Ex. 1007, 249). Patent Owner explains “Gan’s device undergoes two anneals: a first step anneal at 1050°C following polysilicon deposition, and a second-step anneal at 900°C-1000°C to drive-in dopants.” PO Resp. 45 (citing Ex. 1007, 246). And, “Gan shows that while a low J_o is desirable, that parameter increases rapidly as the drive in temperature increases above 900°C” and “the experimental results in these references and the Gan Thesis^[8,9] show a rapid

⁸ Jon-Yiew Gan, Polysilicon Emitters for Silicon Concentrator Solar Cells (July, 1990) (Ph.D. dissertation, Stanford University) (“the Gan Thesis”).

⁹ In our Decision on Institution we expressed some concern because the evidence of record did not support the public availability of the Gan Thesis.

decrease in the efficacy of the systems as the second anneal temperature increase over 900°C.” PO Resp. 44 (citing Ex. 1007, 248). Further, Patent Owner asserts that “even at . . . 900°C, the resulting Froitzheim-Gan combination would yield a value of ρ_c that is higher than what Gan finds useful,” i.e., a ρ_c is above $5 \times 10^{-5} \Omega/\text{cm}^2$. PO Resp. 46–47. Patent Owner argues that at Froitzheim’s preferred temperatures of between 1000 and 1100 °C, the resulting J_o and ρ_c would be unacceptable. PO Resp. 46. As a result, Patent Owner contends a person of ordinary skill in the art would not have had a motivation to combine the teachings of Froitzheim and Gan.

On this record, we are persuaded Petitioner has shown that a person of ordinary skill in the art would have had a reasonable expectation of success in combining the teachings of Froitzheim and Gan. Patent Owner’s arguments to the contrary do not convince us otherwise.

Petitioner explains that the combination of Froitzheim and Gan simply replaces one emitter for another, i.e., the diffused emitter of Froitzheim for the polysilicon emitter of Gan. Pet. 33. Gan explains that “the cell performance can be improved if the diffused-emitter is replaced with the polysilicon emitter.” Ex. 1007, 245. Dr. Banerjee testifies that “substituting Froitzheim’s in-substrate emitter with a deposited polysilicon emitter and

DI 23–25. Over the course of trial, the Patent Owner provided some evidence suggesting the Gan Thesis was publicly available on or about April 10, 1991. *See, e.g.*, Ex. 2022 ¶¶ 18–23 (noting a MARC record creation date of April 10, 1991 and concluding that the Gan Thesis “could have been located by a skilled researcher” as of that date). Patent Owner’s evidence appears to address our initial concern. Because Petitioner does not object and because the outcome of this Final Written Decision does not depend on the resolution of this issue, for purposes of this Decision, we assume that the Gan Thesis would have been known to the skilled artisan at the time of invention.

interfacial oxide layer would be simple substitution of one known element.” Ex. 1003 ¶ 109. Petitioner explains that in its combination, and before introducing the boron dopant by diffusion at the rear side of the substrate (for example, as described in ¶¶ 40–41 of Froitzheim), the person of ordinary skill in the art would have performed Gan’s steps of growing a thin thermal oxide to form the interfacial layer followed by polysilicon deposition to form the polysilicon on the oxide layer on the back side of the wafer, after which the polysilicon would be doped instead of the substrate to form the polysilicon emitter. Pet. 33–34 (citing Ex. 1003 ¶ 103, Ex. 1007, 246). Petitioner, through the testimony of Dr. Banerjee, states that “[c]ombining Froitzheim/Gan as described here would have been well within the level of ordinary skill in the art” (Ex. 1003 ¶ 108) and would “have been the combination of well-known prior art steps in solar cell fabrication to yield predictable results” (*id.* ¶ 109). Patent Owner does not allege that the proposed combination would have been outside the skill level of the ordinarily skilled artisan. *See generally* PO Resp.

Instead, Patent Owner alleges that subjecting Gan’s oxide layer to Froitzheim’s high temperature anneal would have resulted in high recombination, i.e., J_0 . PO Resp. 44. We do not find Patent Owner’s argument and evidence persuasive. Both Froitzheim and Gan describe a range of dopant drive in temperatures ranging from 900–1200 °C and 900–1000 °C, respectively, showing an overlap at 900–1000 °C. Ex. 1006 ¶ 12; Ex. 1007, 246; *see also* PO Resp. 52 (acknowledging that “the temperature ranges taught by Gan and Froitzheim encompass a common temperature of 900 °C”). Gan explains that

the J_0 increases with the temperature and time of the second-step anneal. In the meantime, the ρ_c decreases as the drive-in

temperature increases. Considering the significant increase of J_0 caused by increasing the drive-in temperature from 900 to 1000 °C, it is beneficial to use the two-step-anneal to optimize J_0 .

Ex. 1007, 248; *see also id.* (Table 1). Notably, Gan states only that the J_0 “significantly increase[s]” between 900 and 1000 °C—not where that increase occurs or that the increase, even a “significant” one, would be deemed unacceptable at 1000 °C. Moreover, Petitioner presents evidence that even at 1000 °C, J_0 yields improved results. Pet. Reply 2 (citing Ex. 1007, 248 (Table 1), 249) (stating that Patent Owner “ignores that even at higher temperatures of 1000 °C, the temperature [Patent Owner] argues Froitzheim prefer[s], Gan shows that J_0 under that condition was still lower than the J_0 for diffused emitters.”).

Patent Owner’s arguments rest on Froitzheim’s disclosure that anneal temperatures of 1000–1100 °C are preferred (PO Resp. 46–47; Tr. 24:3–6, 28:14–23, 29:20–30:10) and an understanding that Gan’s second anneal should be at or below 900 °C (PO Resp. 45; Tr. 28:14–23). Patent Owner’s arguments rest on two faulty assumptions. First, disclosures in the prior art are not limited to the preferred embodiment, rather, “all disclosure[s] of the prior art, including unpreferred embodiments, must be considered,” including the lower temperature disclosed in Froitzheim, i.e., 900 °C. *See In re Lamberti*, 545 F.2d 747, 750 (CCPA 1976). Second, Patent Owner fails to direct our attention to any disclosure in Gan that suggests the second anneal should be at 900 °C **or below**. Indeed, each citation referenced by Patent Owner describes an anneal temperature of 900 °C and 1000 °C—**not** at or below 900 °C. PO Resp. 45; Ex. 1007, 246 (describing process sequence 10 as “Drive-in: 900–1000 °C”), 248 (Table 1 illustrating the effect of the second annealing step at temperatures of 900° and 1000 °C),

249 (Figure 6 showing experimental results at 900° and 1000 °C). Nothing we are directed to in Gan states that below 900 °C is desired or suggested. *See generally* Ex. 1007.

Patent Owner further alleges that a person of ordinary skill in the art “would have understood [that annealing at 900 °C] would forsake the junction depth and certain doping concentration of Froitzheim.” PO Resp. 47 (citing Ex. 2023, 85:7–87:1; Ex. 2020 ¶¶ 182–183); Tr. 30:6–10 (arguing that at 900 °C, “[i]t would work, but we know that it would work worse”). Patent Owner does not direct our attention to any disclosure in Froitzheim that states or suggests that a 900 °C anneal temperature would not work or would be considered unacceptable by the skilled artisan. Instead, Patent Owner relies on the testimony of Dr. Banerjee, Petitioner’s declarant, which is not as conclusive as Patent Owner argues. PO Resp. 47; Tr. 30:11–14. In particular, Dr. Banerjee testifies that Froitzheim prefers an anneal temperature of 1000 to 1100 °C because with higher temperature, higher diffusion is achieved.

Q Why would they prefer to use 1000 to 1100 degrees, do you know?

A That's because the higher the temperature, the higher is the diffusion coefficient which has a so-called Arrhenius dependency.

* * *

Q So they're trying to achieve a higher diffusion?

Is that correct?

A So you could -- I mean, these are problems that I give to my undergrad students, this type of problem. So you are trying to achieve a certain junction depth and a certain doping concentration. And the two main parameters, the diffusion temperature and the diffusion time. Longer the diffusion time, higher the temperature. Everything else being the same, you'd

get a deeper junction and the higher concentration of the surface. Shorter the temperature -- or diffusion time and lower the temperature, you get a shallow junction. So those are the norms that a POSITA would use.

Q Why would it be preferable to have a deeper junction?

A It depends on the device design parameters. You'd want a junction of the appropriate depth to achieve the maximum efficiency in your solar cell.

Ex. 2023, 85:7–87:1. Accordingly, Dr. Banerjee does not testify that Froitzheim would not work at anneal temperatures of 900 °C, nor does he testify that 1000 °C is required to achieve a level of doping and junction depth to make Froitzheim functional. Indeed, he explains that a person of ordinary skill in the art would have understood that dopant drive and junction depth is a function of diffusion temperature and diffusion time which could have been adjusted to achieve a desired result. Ex. 2023, 85:7–87:1; Ex. 1082 ¶ 6. Furthermore, Dr. Banerjee testifies that diffusing a dopant into polysilicon—the combination proposed by Petitioner—does not require the higher annealing temperatures required for monocrystalline silicon described in Froitzheim. Ex. 1082 ¶¶ 6–9. We credit Dr. Banerjee's testimony in this regard.

Patent Owner also contends that an anneal temperature of 900 °C results in suboptimal ρ_c , or current density. PO Resp. 45. According to Patent Owner, “at 900 °C, both N and P-type polysilicon emitters have a ρ_c of 18 $\mu\Omega\text{-cm}^2$ (or $1.8 \times 10^{-5} \Omega/\text{cm}^2$), which is 80% higher than the value of $\rho_c \sim 1 \times 10^{-5} \Omega/\text{cm}^2$ that Gan deems ‘useful.’” PO Resp. 45 (citing Ex. 1007, 248 (Table 1)). But, Gan states that

[t]he data shown in Fig. 6 are *quite useful* for silicon solar cells. First, most of J_0 are *below* $5 \times 10^{-14} \text{ A/cm}^2$ which is about one order magnitude lower than that of diffused-emitters. Second,

most of ρ_c are also lower than $5 \times 10^{-5} \Omega/\text{cm}^2$. This means that the potential drop across the contact is negligible as long as the current density is less than $100 \text{ A}/\text{cm}^2$.

Ex. 1007, 249 (emphasis added). Thus, at an annealing temperature of $900 \text{ }^\circ\text{C}$, the J_0 and ρ_c reported by Gan are considered “quite useful.”

Compare Ex. 1007, 248 (Table 1), with *id.*, 249.

Furthermore, and relying on the testimony of Dr. Banerjee, Petitioner aptly states that “[t]he current density of the Froitzheim-Gan combination is well below $100 \text{ A}/\text{cm}^2$, as ‘ $100 \text{ A}/\text{cm}^2$ ’ is at the extreme ‘equivalent to 2500 suns’ corresponding to silicon concentrator solar cells, while the Froitzheim-Gan combination generates a one-sun solar cell.” Pet. Reply 5–6 (citing Ex. 1082 ¶¶ 24–25); Ex. 2020 ¶ 132 (Dr. Ruby confirming that “high current levels in the range of $100 \text{ A}/\text{cm}^2$ ” are “equivalent to 2500 suns”). Dr. Banerjee testifies that “non-concentrator one sun solar cells do not generate that high of a current density because there is less light hitting the solar cell. Thus, for standard operations, a one sun cell does not require as low of specific contact resistivity (ρ_c) as concentrator solar cells.” Ex. 1082 ¶ 26. Therefore, even if an anneal temperature of $900 \text{ }^\circ\text{C}$ results in suboptimal ρ_c as Patent Owner alleges, “non-concentrator cells do not suffer from having values of ρ_c that would otherwise render a concentrator cell not useful” and the person of ordinary skill in the art “would not have been discouraged from combining Froitzheim and Gan based on Gan’s disclosure of a ρ_c of $1.8 \times 10^{-5} \Omega\text{-cm}^2$.” Ex. 1082 ¶ 28. We find Dr. Banerjee’s testimony credible.

(2) *thin-oxide layer growth*

Patent Owner asserts although “Gan proposes taking a tunnel oxide layer and breaking it slightly to achieve acceptable values for J_0 and ρ_c ,” a

separate reference, the Gan Thesis, “explains that this requires a degree of precision in forming and breaking the oxide layer that Gan was unable to achieve and documents consistent failure to do so.” PO Resp. 47–48 (citing Ex. 2020 ¶ 184). Patent Owner alleges that the Gan Thesis describes its thin-oxide growth as unreliable, unpredictable, and difficult to reproduce. PO Resp. 48–49. Thus, Patent Owner reasons that a person of ordinary skill in the art “would have understood Gan with the benefit of the Gan Thesis and determined that the experiments discussed in Gan produced unreliable results, created ‘mishap[s],’ produced reproducibility problems, and the good results were only theoretical.” PO Resp. 50 (citing Ex. 2020 ¶ 188).

Patent Owner’s arguments are based primarily on the Gan Thesis, which according to Patent Owner should be treated as “supplemental” to Gan; Patent Owner argues that a person of ordinary skill in the art “would have understood Gan with the benefit of the Gan Thesis.” Tr. 26:21–27:8; PO Resp. 50; *see also* Tr. 27:6–8 (stating that “it’s the same work. It’s literally the same experiments, just in more detail. So we would ask that you consider it a supplementary reference”). Patent Owner, however, does not direct our attention to any precedent that would require, or even permit, reading Gan together with the Gan Thesis as a unified work. *See generally* PO Resp.; Tr. We reject Patent Owner’s invitation to treat the Gan Thesis as an extension of Gan. In our view, the Gan Thesis has value in that it reflects the contemporaneous state of the art, but the Gan Thesis does not supplant Gan’s teachings.

We acknowledge that the Gan Thesis, by way of example, states that:

[T]he breakup process is difficult to control. On several occasions, we have encountered reproducibility problems. [Ex. 2003, 107].

[S]olar cells that were made in this study all suffered high contact resistance. The problem is primarily due to insufficient oxide breakup, and is caused by the fluctuation of the thickness of the interfacial oxide. [Ex. 2003, 107].

[W]e found that a consistent result of ρ_c is difficult to reproduce for the polysilicon emitter with a thermally grown interfacial oxide. [Ex. 2003, 116].

[O]ur thin-oxide growth recipe is not reliable. . . . In order to have predictable results, it appears that a precise control of the oxide thickness is necessary. [Ex. 2003, 117].

It appears that the oxide breakup depends critically on the interfacial oxide thickness. The thin-oxide growth recipe used in this work was not reliable. [Ex. 2003, 119].

It is clear that a more reliable way of growing the thin oxide is needed. [Ex. 2003, 119].

However, these statements do not suggest, as Patent Owner asserts, that a person of ordinary skill in the art “would have concluded that Gan never achieved that ‘precise control’” over its oxide growth. PO Resp. 48 (citing Ex. 2020 ¶ 185); *but see* Ex. 2003, 108 (stating that even though “the oxide-growth recipe is not reliable, it was ignored because the results are still good enough for emitters to be used in the concentrator solar cells.”).

Moreover, Gan itself suggests a level of success in interfacial oxide growth. For example, Gan states:

Polysilicon emitters with a thermally grown interfacial oxide are examined in great detail. [Ex. 1007, Abstr.].

In this paper, detailed calibrations for the polysilicon emitter with a thermally grown interfacial oxide is presented. Compared with

the chemical oxide, the thermal oxide appears to be more robust to the high temperature anneal. [Ex. 1007, 245].

The process sequence is shown as followings : . . . 3. Thin thermal oxide growth at 800 °C (10-minute oxygen flow). [Ex. 1007, 246].

The growth of thin oxide was carried out with 200 sccm oxygen and 5 slm argon mixture. Typically, oxide thickness less than 20 Å was measured with ellipsometer. [Ex. 1007, 246].

Gan does not complain about oxide growth or identify unreliable oxide growth as a barrier that precludes success. *See generally* Ex. 1007.

Furthermore, that there may be some level of unpredictability, as reflected in the Gan Thesis, does not defeat obviousness because “obviousness cannot be avoided simply by a showing of some degree of unpredictability in the art so long as there was a reasonable probability of success.” *Pfizer, Inc. v. Apotex, Inc.*, 480 F.3d 1348, 1364 (Fed. Cir. 2007); *see also In re Longi*, 759 F.2d 887, 896 (Fed. Cir. 1985) (“Only a reasonable expectation of success, not absolute predictability, is necessary for a conclusion of obviousness.”).

In addition, “[w]hen prior art contains apparently conflicting references, the Board must weigh each reference for its power to suggest solutions to an artisan of ordinary skill” and, in so doing, “consider the degree to which one reference might accurately discredit another.” *In re Young*, 927 F.2d 588, 591 (Fed. Cir. 1991). The Gan Thesis describes known techniques that the skilled artisan could have employed to improve thin oxide growth. The Gan Thesis states that “it appears that the variation of the oxide thickness results mainly from the oxide-growth step. If this is the case, it is possible that the thin-oxide growth can be improved by performing the oxidation at a lower temperature such that the oxidation rate

can be controlled more precisely.” Ex. 2003, 112. Though Patent Owner characterizes this disclosure as “an unproven assumption” or “speculation at best” (Tr. 32:23–26), Drs. Banerjee and Ruby disagree. For example, Dr. Banerjee explains that

[l]owering the temperature slows down the chemical reaction between silicon and oxygen in the formation of silicon oxide and thus allows for greater control on the thickness of the oxide layer. As Gan Thesis shows, the oxide thickness increases with time, and slowing that process down by lowering the temperature allows a Skilled Artisan to optimize the oxygen flow time in order to achieve the desired thickness.

Ex. 1082 ¶ 19 (citing Ex. 2003, 111). Dr. Banerjee further testifies that “since at least the 1990s,” the ordinarily skilled artisan was equipped with methods to reliably grown oxide layers with controlled thicknesses.

Ex. 1082 ¶ 12. “These methods were able to finely tune conditions such as reaction time, temperature, pressure, and oxygen concentration of the oxidation reaction as it occurs to obtain reliable formation of thin oxide layers.” Ex. 1082 ¶ 12; *see id.* ¶ 19; Ex. 1048; Ex. 1078. Dr. Ruby, Patent Owner’s declarant, offers similar testimony explaining that prior to 2008, the purported date of invention, it was known that lowering the temperature at which the oxide is formed will slow the growth rate of that oxide. Ex. 1081, 103:3–18.

Accordingly, the evidence of record suggests that the skilled artisan, at the time of invention, would have had a reasonable expectation of success in the combination of Froitzheim and Gan.

b) Reason to Combine

Patent Owner asserts that “[l]acking a reasonable expectation of success in combining Froitzheim with Gan . . . a [person of ordinary skill in the art] would not have been motivated to combine the references as

proposed by Petitioner.” PO Resp. 50. Specifically, Patent Owner asserts that “because any advantages in J_o and ρ_c proposed by Gan would not be obtained if the temperature range disclosed by Froitzheim is used to drive in the dopants” (PO Resp. 50), because at the lowest anneal temperature Froitzheim discloses “the resulting Froitzheim-Gan combination would yield a value of ρ_c that is higher than what Gan finds useful” (PO Resp. 51–52), and “because the Gan Thesis, which discusses the work reported in Gan in greater detail, tells us that the experimental results testing the oxide/polysilicon combination was a theoretical idea, was unreliable, and frequently failed” (PO Resp. 51), a person of ordinary skill in the art would not have had reason to combine Gan and Froitzheim.

Patent Owner’s arguments above rely on a lack of reasonable expectation of success as the basis for its assertion that the ordinarily skilled artisan would not have had a reason to combine the teachings of Froitzheim and Gan in the manner suggested by Petitioner. PO Resp. 20–52. Because we rejected Patent Owner’s arguments based on reasonable expectation of success above in Section D.3.a, we similarly reject Patent Owner’s arguments here for the same reasons.

Patent Owner, however, additionally contends that because “[c]oncentrator cells generate multiple times more free electrons than one sun solar cells requiring concentrator solar cells to have a much lower resistive path from the substrate to the emitter, through the metal contacts and gridlines, than in a one sun solar cell,” a person of ordinary skill in the art would not have had reason to modify the teachings of Froitzheim (one sun solar cell) with those of Gan (concentrator solar cell). PO Resp. 51.

We are persuaded that Petitioner has shown that a person of ordinary skill in the art would have had a reason to combine the subject matter of Froitzheim and Gan for the reasons expressed by Petitioner (Pet. 29–33) and discussed above (*see supra* pp. 12–13). Patent Owner’s arguments in response are not persuasive.

Though Gan’s teachings are directed to silicon concentrator solar cells, the ordinarily skilled artisan would have understood Gan also refers to silicon solar cells in general. *Compare* Ex. 1007, 249 (stating “[t]he data in Fig. 6 are quite useful for *silicon solar cells*” and “cell efficiency is obtained for *backside contact solar cell*”), *with id.* (explaining that “polysilicon emitters with these qualities can be quite useful for silicon *concentrator solar cells*”). Dr. Banerjee testifies that “the Skilled Artisan would interpret Gan as recommending the feature for solar cells in general” and “that its polysilicon emitter with interfacial oxide feature is beneficial for solar cell efficiency in general.” Ex. 1003 ¶ 101; Ex. 2023, 93:10–15. Furthermore, Dr. Ruby testified that when designing solar cells, he reviews published works in the field and would not necessarily limit his review to the type of solar cell being developed. Ex. 1081, 48:4–51:16.

Q So you would agree that if you're developing a 1-Sun solar cell, it might be worthwhile to look at publications regarding concentrator solar cells?

* * *

THE WITNESS: Well, it would be advisable or suggest -- you know, it would certainly be worth -- worth looking at, although not all of the methods for creating solar cells -- concentrator cells are required for producing 1-Sun cells. So some things would be of use and many things would not.

Ex. 1081, 51:7–16. Dr. Banerjee and Dr. Ruby each testify that a person of ordinary skill in the art would have had reason to consult the teachings of

both concentrator and non-concentrator solar cells—in fact describing such consideration as “advisable,” “suggest[ed],” and “worth looking at”—when designing a solar cell is dispositive of this issue. We acknowledge Dr. Ruby’s testimony that consideration of broader teachings may hinge on a specific application for the solar cells. Ex. 1081, 51:7–16. But the combination proposed here by Petitioner, which substitutes one known emitter for another, that is, a polysilicon emitter for a diffused emitter, to improve efficiency of solar cell performance, has been shown to have general applicability regardless of solar cell type. Ex. 1003 ¶¶ 98–105 (citing Ex. 1006, Abstr., ¶¶ 1, 9; Ex. 1007, 245, 248, 249; Ex. 1014; Ex. 1041); Ex. 1082 ¶¶ 21–28; Ex. 2023, 32:2–11.

Accordingly, we are persuaded that Petitioner has shown that the ordinarily skilled artisan would have had a reason to combine the teachings of Froitzheim and Gan with a reasonable expectation of success.

* * *

We determine Petitioner has demonstrated by a preponderance of the evidence that the combination of Froitzheim and Gan would have rendered claim 9 obvious.

4. *Remaining Claims 10–20*

Petitioner asserts that claims 10, 11, 14, 16–17 and 19–20 would have been obvious over the combination of Froitzheim and Gan and that claims 11–13, 15, and 18 would have been obvious over the combination of Froitzheim and Gan with either of Hartiti or Sivoththaman. Pet. 4, 42–57. Patent Owner does not separately address remaining claims 10–20 beyond what is argued for independent claim 9. *See generally* PO Resp. Upon review of the full trial record, and the arguments and evidence therein, we

determine that Petitioner has demonstrated by a preponderance of the evidence that each of the limitations recited in claims 10–20 are suggested by the above-identified prior art and that the skilled artisan would have had reason to make the combination with a reasonable expectation of success.

E. Challenges Based on Froitzheim and Kwark

Petitioner alleges that claims 9–11, 14, 16–17, and 19–20 of the '053 patent would have been obvious over the combination of Froitzheim and Kwark. Pet. 4, 57–64. In addition, Petitioner contends that claims 11–13, 15, and 18 of the '053 patent would have been obvious over the combination of Froitzheim and Kwark in further view of either Hartiti or Sivoththaman. Pet. 4, 64–65.

1. Overview of Kwark (Ex. 1008)

Kwark describes tests on polysilicon films with and without a chemically grown oxide layer (referred to as “chemox”). Kwark explains that reducing the emitter saturation current (J_{oe}) “translates into potential improvements of energy conversion efficiency for solar cells and enhanced high frequency performance of bipolar structures.” Ex. 1008, 742. Kwark determined, from its tests for polysilicon emitters, that the absence of chemox does not “greatly impact J_{oe} ,” but the addition of the chemox “greatly decreases the J_{oe} .” Ex. 1008, 743, Fig. 4.

2. Analysis of Claim 9

Petitioner alleges that the combination of Froitzheim and Kwark renders claim 9 of the '053 patent obvious. Pet. 61–62. Petitioner contends that Froitzheim describes each of the limitations of claim 9 except for the polysilicon emitter, and relies on the same teachings of Froitzheim detailed

for the grounds based on Froitzheim and Gan, discussed above. Pet. 61–62. According to Petitioner, “in the Froitzheim/Kwark combination, the backside diffused p-type emitter of Froitzheim is replaced with a polysilicon emitter, as taught by Kwark.” Pet. 61 (citing Ex. 1003 ¶ 167).

Petitioner, through testimony of Dr. Banerjee, alleges that

the Skilled Artisan would have been motivated to modify Froitzheim’s emitter to be a polysilicon emitter with an oxide layer because Kwark taught and suggested that this modification would be an improvement transferable to solar cells. EX1003, ¶ [166]. Kwark taught that addition of an interfacial chemically grown oxide (chemox) between polysilicon and the substrate “greatly decreases the J_{oc} ,” which “translates into potential improvements of energy conversion efficiency for solar cells. Pet. 58 (citing Ex. 1003 ¶ 162; Ex. 1008, 742, 745).

Petitioner asserts that Kwark’s “data comparing polysilicon emitters with and without the oxide layer, . . . note[s] ‘the large difference when the interfacial oxide is missing.’ ” Pet. 59 (citing Ex. 1008, 745, Fig. 4).

Petitioner also argues that the skilled artisan would have had a reasonable expectation of success because the combination is

merely an arrangement of old method steps with each performing the same function it had been known to perform (the emitter of Froitzheim continuing to act as an emitter, but modified to be polysilicon with an interfacial oxide) and yielding no more than

what one would expect from such an arrangement (a solar cell with improved performance).

Pet. 60 (citing Ex. 1003 ¶ 164). Petitioner alleges that the combination of Froitzheim and Kwark would have been within the skill set of the ordinarily skilled artisan and “substituting Froitzheim’s in-substrate diffused emitter with a polysilicon emitter and oxide layer would be simple substitution of one known element for another to obtain predictable results” and “use[s] a known technique (polysilicon emitters with an oxide layer) to improve similar devices (Froitzheim’s solar cell) in the same way.” Pet. 60.

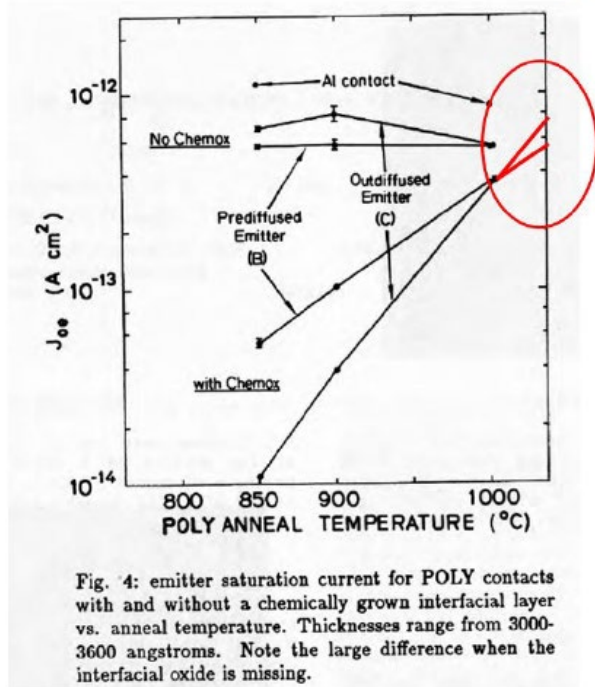
As with the Froitzheim/Gan combination, Patent Owner does not challenge Petitioner’s allegations regarding the teachings of Froitzheim and Kwark with respect to elements of the challenged claims. *See generally* PO Resp. Rather, Patent Owner argues that Petitioner has not shown a person of ordinary skill in the art would have had a reasonable expectation of success or a reason to combine Froitzheim and Kwark in the manner proposed by Petitioner. PO Resp. 52–58. We address Patent Owner’s arguments below.

a) Reasonable Expectation of Success

(1) annealing temperatures

Patent Owner argues that “Kwark is clear that an oxide layer formed as a Chemox layer only works at low temperature anneals.” PO Resp. 53 (citing Ex. 1008, 742). Patent Owner again notes that Froitzheim teaches a range of 900–1200 °C, preferably between 1000–1100 °C. PO Resp. 53–54 (citing Ex. 1006 ¶ 42). “In other words, at the temperatures Froitzheim says should be used to drive in the dopant, the benefits alluded to by Kwark

would be lost.” PO Resp. 54 (citing Ex. 2020 ¶ 195). Patent Owner explains that “[s]imilar to Gan, Kwark discloses a desirable J_{oe} value of $2 \times 10^{-14} \text{ A/cm}^2$ ” and “higher-than-desired J_{oe} values at anneal temperatures above $900 \text{ }^\circ\text{C}$ and above.” PO Resp. 54 (citing Ex. 1008, Abstr., 743). Relying on its annotated Figure 4 of Kwark, reproduced below, Patent Owner argues that “given the rapid breakup of the interfacial oxide layer at temperatures above 850°C , as taught by Kwark, and the much higher temperatures taught as being preferable by Froitzheim, a POSITA would not have a reasonable expectation of success in the combination of Froitzheim and Kwark.” PO Resp. 56 (citing Ex. 2020 ¶¶ 222, 199).



Kwark Figure 4 above, reproduced with annotations by Patent Owner, shows a graph of “emitter saturation current for POLY contacts with and without chemically grown interfacial layer vs. anneal temperature.” Ex. 1008, Fig. 4.

We do not share Patent Owner's concerns. Although Kwark Figure 4 may show that higher annealing temperatures reduce the effects of an oxide layer, it also appears that polysilicon emitters with an oxide layer (i.e., "with Chemox") show improved performance (i.e., lower J_{0e} values) over polysilicon emitters without an oxide layer ("No Chemox"). Ex. 1008, Fig. 4; Pet. Reply 17 (stating "though it is true that Kwark's Figure 4 shows that J_0 increases with anneal temperature, Figure 4 actually shows that a polysilicon emitter 'with Chemox' has a lower J_0 than one with 'no chemox,' even up to 1000°C."); *see also* Ex. 1081, 82:12–19, 84:5–86:3 (explaining that the "with Chemox" emitters have a lower recombination than the "no Chemox" emitters). Kwark expressly states that the "[a]ddition of chemox **greatly reduces** the J_{0e} as has been previously reported." Ex. 1008, 743 (emphasis added); *see also id.* at 745 (noting "the large differences when the interfacial oxide is missing"); *see* Ex. 2023, 67:7–16 (stating that "even up to thousand degrees it's beneficial because you get a lower J nought compared to the no chemox case"). Further, Patent Owner overlooks evidence that shows replacing the diffused emitter with a polysilicon emitter with interfacial oxide further improves cell performance. Ex. 1008, 745 (comparing the A1 contact diffused emitter with the polysilicon emitters B and C and indicating a lower J_{0e} for the polysilicon emitters). Moreover, the record evidence suggests that the skilled artisan would have had a reasonable expectation of success in the combination of Froitzheim and Kwark by selecting an annealing temperature of between 900 and 1000 °C in order to balance a lower J_0 with drive-in dopant. *See* Ex. 1007 ¶ 42 (describing doping at a temperature of between 900 to 1200 °C); Ex. 1008, 743 (describing "severe" outdiffusion at 1000° C);

Ex. 1082 ¶ 33 (stating that “a Skilled Artisan would know that the benefits to J_0 can be achieved by simply annealing the device at 900°C, which is included in Froitzheim’s temperature range, as I discussed above in relation to Gan”).

(2) *thin oxide layer growth*

Patent Owner further argues that Kwark proposes using Chemox, which is “a very crude form of creating silicon dioxide” and that “the Gan Thesis disparages the use of Chemox.” PO Resp. 56 (citing Ex. 2020 ¶ 223; Ex. 2020 ¶ 224). Thus, “a POSITA would not have had a reasonable expectation of success in using this Chemox layer, and . . . [for this reason] would not have had a reasonable expectation of success in using the Chemox layer, and would not have been motivated to combine the Chemox layer and polysilicon layer of Kwark with Froitzheim.” PO Resp. 57–58 (citing Ex. 2020 ¶ 224).

We are convinced by Petitioner’s argument and evidence in this regard. Specifically, Petitioner argues that Patent Owner’s “claim that Kwark’s chemical oxide (‘chemox’) ‘only works’ at low temperature anneals is a mischaracterization of the reference” and rests on “nothing but speculation.” Pet. Reply 15. Petitioner explains that Chemox is a “very standard procedure” and it was “well within the knowledge of a POSITA to reliably grow a thin chemox layer.” Pet. Reply 15 (citing Ex. 2023, 57:3–9, 58:3–59:1; Ex. 1067 ¶¶ 39–40). We also credit Petitioner’s argument regarding the Gan Thesis’s alleged disparagement of Chemox (stating that a particular result obtained using Chemox “would be intolerable”) “was made in the context of concentrator cells.” Pet. Reply 19. Because the requirements for non-concentrator cells “are less stringent than concentrator

cells” we understand that this statement from the Gan Thesis, made in the context of concentrator cells, would not necessarily dissuade one of ordinary skill in the art from using chemox in one sun solar cells. Pet. Reply 19. Furthermore, while the Gan Thesis seems to favor thermal oxide growth, describing it as “more robust during high temperature anneals,” it does not state that chemical oxide layers could not be formed. *See generally* Ex. 2003. And, Kwark details “great[] decreases” in J_{oc} values between 900 and 1000 °C when comparing polysilicon emitters to diffused emitters and with and without Chemox. Ex. 1008, 743, 745 (Fig. 4). On this complete record, we are persuaded by Petitioner’s showing that Chemox would have been a sufficiently standard and reliable procedure to enable one of ordinary skill in the art to “achieve a successful one sun solar cell based on the Froitzheim-Kwark combination.” Pet. Reply 17.

b) Reason to Combine

Patent Owner argues that a person of ordinary skill in the art would not have had a reason to combine the teachings of Froitzheim and Kwark because “Kwark counsels that temperatures above 850°C should be avoided” and Froitzheim prefers a dopant drive-in temperature of 1000 to 1100 °C. PO Resp. 57. According to Patent Owner, a person of ordinary skill in the art “would find it impossible to reconcile these teachings and by choosing one world [sic] forego the alleged benefits of following the other.” PO Resp. 57. Along the same lines, Patent Owner contends that a person of ordinary skill in the art “would not have combined Froitzheim with Kwark because of their incompatible teachings for annealing temperatures to drive in dopants.” PO Resp. 58.

Patent Owner's arguments are similar to those addressed above relating to reasonable expectation of success. PO Resp. 52–56. Patent Owner fails to direct our attention to any teaching in Kwark that requires an anneal temperature of 850 °C or below. Rather, Kwark Figure 4 describes effects of temperature and J_{oc} when diffused emitters versus polysilicon emitters are used and when a chemically grown interfacial oxide layer is included. Ex. 1007, 745 (Fig. 4). To be clear, Patent Owner does not direct our attention to any teaching in Kwark that states temperatures above 850 °C “should be avoided.” PO Resp. 57. Indeed, Kwark, like Gan, suggests temperatures approaching 1000 °C may be undesirable. For example, Kwark states:

In fact for devices annealed at 900°C/13min, there is very little dependence on γ as seen in Fig. 2, although increasing the anneal temperature to 1000°C adversely affected Joe. [Ex. 1008, 742].

To this is added a component due to outdiffusion from the heavily doped POLY which becomes increasingly significant for annealing temperatures above 900°. . . . At 1000° this outdiffusion is severe enough to dominate the Joe which accounted for the lack of difference between emitters and C. [Ex. 1008, 743].

Further, Froitzheim does not state what temperature is needed for doping polysilicon. *See generally* Ex. 1006 (describing doping temperatures of between 900–1200 °C for a diffused emitter). As we explained above, the ordinarily skilled artisan, considering the teachings of Froitzheim and Kwark, would have selected an annealing temperature of between 900 and 1000 °C in order to balance preferences for a lower J_0 with an effective dopant drive-in. *See* Ex. 1007 ¶ 42; Ex. 1008, 743; Ex. 1082 ¶ 33 (stating that “a Skilled Artisan would know that the benefits to J_0 can be achieved by simply annealing the device at 900°C, which is included in Froitzheim's

temperature range, as I discussed above in relation to Gan”). Dr. Banerjee testifies that drive-in depth is a function of diffusion temperature and diffusion time—a concept his undergraduate students are expected to understand. Ex. 2023, 85:7–86:17 (“these are the problems I give to my undergraduate students, this type of problem). As we further discussed above, Dr. Banerjee testifies that diffusing a dopant into polysilicon does not require the higher annealing temperatures required for monocrystalline silicon described in Froitzheim. Ex. 1082 ¶¶ 6–9. Thus, the record evidence supports Petitioner’s position that the skilled artisan would have had a reason to combine the teachings of Froitzheim and Kwark.

Because we rejected Patent Owner’s arguments based on reasonable expectation of success above in Section E.2.a, we similarly reject Patent Owner’s arguments here for the same reasons.

* * *

We determine Petitioner has demonstrated by a preponderance of the evidence that the combination of Froitzheim and Kwark would have rendered claim 9 obvious.

3. *Remaining Claims 10–20*

Petitioner asserts that claims 10, 11, 14, 16, 17, 19, and 20 would have been obvious over the combination of Froitzheim and Kwark and that claims 11–13, 15, and 18 would have been obvious over the combination of Froitzheim and Kwark with either of Hartiti or Sivoththaman. Pet. 4, 61–65. Patent Owner does not separately address remaining claims 10–20 beyond what is argued for independent claim 9. *See generally* PO. Resp. Upon review of the full trial record, and the arguments and evidence therein, we determine that Petitioner has demonstrated by a preponderance of the

evidence that each of the limitations recited in claims 10–20 are suggested by the above-identified prior art and that the skilled artisan would have had reason to make the combination with a reasonable expectation of success.

F. Prior Decisions

Petitioner contends that prior Board decisions involving two continuation applications—App. No. 14/504,771 and 16/460,035, both of which claim priority to the '053 patent—support a finding of obviousness in this *inter partes* review. Pet. 67–70. In particular, Petitioner asserts that Patent Owner's argument "that it would not be obvious to modify a back junction solar cell with a polysilicon emitter with an interfacial oxide layer," "has already been rejected by the PTAB in prior appeal proceedings." Pet. 67.

Patent Owner argues that "[t]he Board's prior findings . . . have no bearing on this proceeding." PO Resp. 36. Specifically, Patent Owner argues that Petitioner does not suggest collateral estoppel applies, that "none of the [prior art] combinations asserted here . . . were at issue in the *ex parte* appeal decisions" identified by Petitioner, and that Petitioner "retains the burden *in this proceeding*, regardless of what the Board found in prior proceedings." PO Resp. 36.

Because we determine that Petitioner has established, by a preponderance of the evidence, that claims 9–20 would have been obvious based on the arguments presented at pages 28–66 of the Petition, a determination of whether prior Board decisions support a finding of obviousness is unnecessary and moot.

III. CONCLUSION

For the foregoing reasons, we determine that Petitioner has demonstrated, by a preponderance of the evidence, that the subject matter of claims 9–20 of the '053 patent is unpatentable.¹⁰

In summary:

Claim(s)	35 U.S.C. §	Reference(s)/ Basis	Claim(s) Shown Unpatentable	Claim(s) Not Shown Unpatentable
9–11, 14, 16–17, 19–20	103	Froitzheim, Gan	9–11, 14, 16–17, 19–20	
11–13, 15, 18	103	Froitzheim, Gan, Hartiti, Sivoththaman	11–13, 15, 18	
9–11, 14, 16–17, 19–20	103	Froitzheim, Kwark	9–11, 14, 16–17, 19–20	
11–13, 15, 18	103	Froitzheim, Kwark, Hartiti, Sivoththaman	11–13, 15, 18	
Overall Outcome			9–20	

¹⁰ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding after this decision issues, we draw Patent Owner's attention to the April 2019 Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding. *See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. §§ 42.8(a)(3), (b)(2).

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has shown by a preponderance of the evidence that claims 9–20 of U.S. Patent No. 8,878,053 B2 are unpatentable; and

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

IPR2024-01040
Patent 8,878,053 B2

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