

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner

v.

MAXEON SOLAR PTE. LTD.,
Patent Owner

Case No. IPR2024-01039
U.S. Patent No. 8,222,516

PATENT OWNER SUR-REPLY

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PATENT OWNER’S EXHIBIT LIST

Exhibit No.	Description
2001	<i>Intentionally Left Blank</i>
2002	Int’l Pub. No. WO 2009/094575 (“Borden-575”)
2003	Gan, Jon-Yiew, Polysilicon emitters for silicon concentrator solar cells, Stanford University (July 1990) (“Gan Thesis”)
2004	Results charted from DocketNavigator.com Document Search, run on October 8, 2024, for Motion to Stay Pending <i>Inter Partes</i> Review Decided by Judge Rodney Gilstrap
2005	Results charted from DocketNavigator.com Document Search, run on October 8, 2024, for Motion to Stay Pending <i>Inter Partes</i> Review Decided by Judge Rodney Gilstrap with “Stipulated/Agreed” Motions Removed
2006	Federal Court Management Statistics (June 30, 2024)
2007	Order Denying Maxeon Partial Motion to Dismiss, <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG, Dkt. No. 26 (E.D. Tex. July 3, 2024)
2008	Docket Control Order, <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG, Dkt. No. 33 (E.D. Tex. Aug. 7, 2024).
2009	Canadian Solar Inc.’s Invalidity Contentions, <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG (E.D. Tex. Sept. 6, 2024).
2010	Feldman, et al., “A Passivated Rear Contact for High-Efficiency n-Type Silicon Solar Cells Enabling High VocS and FF > 82%”

	(28th European PV Solar Energy Conference & Exhibition, Paris, Sept. 30 – Oct. 4, 2013) (“Feldman”)
2011	Chieh-Wa Tsai, et. al, <i>Patent Analysis of High Efficiency Tunneling Oxide Passivated Contact Solar Cells</i> , 13 <i>Energies</i> 3060 (2020)
2012	File History of U.S. Patent No. 8,878,053
2013	File History of U.S. Patent Application No. 17/870,268
2014	Acharyya, S., Sadhukhan, S., Panda, T. et al. Performance analysis of different dielectrics for solar cells with TOPCon structure. <i>J Comput Electron</i> 21, 471–490 (2022) (Abstract) (available at: https://link.springer.com/article/10.1007/s10825-022-01866-0).
2015	<i>Intentionally Left Blank</i>
2016	<i>Intentionally Left Blank</i>
2017	<i>Intentionally Left Blank</i>
2018	<i>Intentionally Left Blank</i>
2019	<i>Intentionally Left Blank</i>
2020	Declaration of Douglas Ruby, Ph.D.
2021	Curriculum Vitae of Douglas Ruby, Ph.D.
2022	Declaration of Mary K. Bolin, Ph.D.
2023	Transcript of Deposition of Petitioner’s Expert Sanjay Banerjee, Ph.D. (March 20, 2025)

I. INTRODUCTION

Patent Owner submits its Patent Owner Sur-Reply to Petitioner's Reply to Patent Owner's Response (Paper 32) ("Reply").

II. PETITIONER'S THEORIES ARE UNSOUND

Petitioner's unpatentability theories are deficient as explained below.

A. Petitioner's Theory Based on Froitzheim and Gan Is Unsound

1. The Record Fails to Support a Diffusion Time-Temperature Combination that Is Compatible with Both Gan and Froitzheim

Petitioner claims to have found all the recited limitations of independent claim 9 of the '516 patent in Froitzheim and Gan, but Petitioner fails to show why a POSITA would have been motivated to combine those aspects. Indeed, Petitioner fails to even show that those aspects could be combined in a manner to yield an operable device. Specifically, Petitioner argues that because the upper extreme of the optimal temperature range disclosed by Gan (900°C and below) and the lower extreme of temperature range (900°C-1200°C) disclosed by Froitzheim meet at precisely one point, a POSITA would have adopted that one specific temperature and ignored teachings to the contrary in both references. Additionally, Petitioner neglects to show that the duration of the annealing process disclosed in Gan would work at the lower extreme disclosed in Froitzheim, a reference that is silent regarding durations for its anneal processes. This failure is fatal.

Petitioner's expert testified that the proposed Froitzheim-Gan combination would apply Froitzheim's annealing steps to diffuse dopants into the polysilicon emitter. EX2023, 85:14-20. Petitioner argues that a POSITA would have been motivated to combine Froitzheim and Gan on the theory that Gan's polysilicon/interfacial oxide structure reduces current density (J_o) to "below 5×10^{-14} A/cm² which is about one order [of] magnitude lower than that of diffused-emitters." Reply, 2 (citing EX1007, 249) (edit in original). Thus, Petitioner's argument assumes that the same J_o value can be achieved with Froitzheim's anneal conditions.

Petitioner supports this assumption with a naked assertion that "a POSITA would have readily reconciled the teachings of Gan and Froitzheim regarding processing temperatures by selecting the lower end of the Froitzheim range." Reply, 3-4. But Petitioner's burden to prove unpatentability is by a preponderance of the evidence, 35 U.S.C. § 316(e), and "rejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness," *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006). Petitioner falls far short of this mark.

Both anneal temperature and anneal time are crucial to achieving Gan's targeted J_o and ρ_c values because the degree of breakup of the interfacial oxide

depends on both variables. *See, e.g.*, EX1007, 245 (“ J_o also depends on the surface dopant concentration and the emitter depth.”); *id.* at 247 (“[M]ore oxide breakup occurs when the anneal time increases.”); *id.* (“[T]he ρ_c decreases as the anneal time increases.”); *id.* at Table 1; *id.* at 248 (“[T]he J_o increases with the temperature and time of the second-step anneal.”); *see also* Reply, 2. The breakup of the interfacial oxide, in turn, affects J_o . EX1007, 245 (citations omitted) (“The breakup of the interfacial oxide has direct impact on both majority and minority carrier transport in the polysilicon emitter. This can be seen from the dependence of the specific contact resistivity (ρ_c) and the emitter saturation current density (J_o) upon either the anneal condition or the oxide integrity.”). Thus, when Gan documents variations in J_o , it specified both the anneal temperatures and anneal time that resulted in the values of J_o and ρ_c .

Further, Petitioner’s expert testified that both anneal temperature and anneal time affect the diffusivity of the dopant. EX2023, 85:17-20 (“[T]he higher the temperature, more will be the diffusivity. And that will determine the junction depth. But it also depends on the diffusion time.”) (emphasis added). Petitioner notes that Gan’s polysilicon emitter has a different diffusion profile (dopant depth based upon anneal conditions) than Froitzheim’s mono-crystalline silicon substrate. Reply, 3-4.

In sum: (1) Petitioner argues that the diffusion profiles of polysilicon and mono-crystalline silicon are different, (2) the record establishes that the diffusion profile depends on anneal temperature and duration, (3) Petitioner's expert testified that the proposed Froitzheim-Gan combination would apply Froitzheim's anneal process, and (4) Froitzheim is silent regarding diffusion times for its anneal process. Thus, Petitioner's proposed combination leaves a POSITA guessing as to one of the two process variables critical to achieving the benefits of Gan's targeted J_o and ρ_c values.

Petitioner asks the Board to ignore this omission because "a POSITA would have readily reconciled the teachings of Gan and Froitzheim regarding processing temperatures by selecting the lower end of the Froitzheim range." Reply, 3-4. This mere conclusory statement lacks "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d at 988. In fact, Petitioner has not shown that the proposed combination would improve J_o because Petitioner has not provided anneal time, and without it, the dopant profile remains unknown.

2. *Merabet Does Not Show that Froitzheim's Diffusion Temperature Would Work on Gan's Polysilicon Emitter*

Petitioner's argument that Froitzheim's preferred temperature range (1,000°C-1100°C) is for diffusion into Froitzheim's mono-crystalline substrate, and

that a POSITA would select the lower (less favored) end of Froitzheim's range (900°C) for diffusion on Gan's polysilicon emitter is unsupported. Reply, 3-4; *see also* EX1067 ¶¶7-11.

In making this argument, Petitioner relies on its expert, who in turn relies on Merabet (EX1062). Merabet applied a higher diffusion temperature for its polysilicon. EX1062, 84 ("To complete this study, we worked with three other temperatures for As and B co-diffusion, i.e. 1150, 1100, and 1000°C, since working at low temperature tends to ultra-large scale integration (ULSI)."); *see also id.* at Fig. 7 (illustrating polysilicon depth after RTA at 1,000, 1,050, 1,100, and 1,150°C). Thus, Merabet shows, if anything, that diffusion of polysilicon emitters should be in, if not higher than, Froitzheim's preferred temperature range. At that temperature range, Gan and Petitioner's additional reference Lemiti agree that the beneficial values of J_o are lost. Patent Owner Response ("POR"), Paper 25 ("POR"), 43-46 (citing EX1007); EX1048, 1378 ("In addition, some attempts on RTA annealed samples (1050 °C/ 20 s) have shown a device structure degradation revealed by a photo-response lowering which might be also linked to the substrate quality (leakage current, minority carrier diffusion length reduction).").

To further confuse a POSITA, Petitioner provides conflicting evidence on the outcome of diffusion at different temperatures. Petitioner's expert testified that dopants would diffuse further in polysilicon with increased temperature. EX2023,

85:17-20. But Merabet suggests that dopant would diffuse less with increased temperature. EX1062, 84 (“For a given depth, diffusivity decreases with temperature, since certain grain size increases versus this parameter.”); *see also id.* at Fig. 7 (illustrating diffusion being the highest at 1,000°C and lowest at 1,150°C for all depth). Gan and the Gan Thesis both teach that the existence of dopant affects J_o . EX1007, 245 (“It has been reported that the interfacial oxide tends to break up more rapidly with the existence of dopant. Moreover, J_o also depends on the surface dopant concentration and the emitter depth.”); EX2003, 100 (“Recalling the critical dependence of J_o on the surface dopant concentration in Figure 4.7, the J_o difference between the sample with a 900 °C-4 hour drive-in and the sample with a 1000 °C-30 min drive-in can be attributed to the difference of the surface [dopant] concentration.”).

In sum, Petitioner has not shown that Froitzheim’s anneal temperatures (which, according to Petitioner, is specific for monocrystalline silicon) would provide a useful doping profile for Gan’s polysilicon emitter. Indeed, Petitioner’s own references suggest otherwise.

3. *Petitioner Has Not Identified a Viable Method to Grow Thin Oxides in Solar Cells*

Petitioner’s claim that Gan or the Gan Thesis shows the successful reduction to practice of a polysilicon emitter and interfacial oxide is unfounded. The Gan

Thesis (EX2003) followed shortly after Gan (EX1007), and by Petitioner's admission, is "broader and more exploratory." Reply, 7; *see also* § II.A.4 below. As discussed in the POR, the Gan Thesis examines the same polysilicon emitter and interfacial oxide as Gan, and, in doing so, makes it clear that Gan's oxide growth recipe was not reliable, and that a more reliable recipe was needed:

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; the oxide thickness between 15 and 20 Å have been found with the same growth condition. As a result, this contributes to the fluctuation of the ρ_c results. It is then clear that a more reliable way of growing the thin oxide is needed.

EX2003, 119 (emphasis added); *see also* POR, 47-49. Thus, the Gan Thesis would have discouraged a POSITA from replacing Froitzheim's diffused emitter with Gan's unreliable polysilicon emitter and interfacial oxide.

Petitioner's claim that the Gan Thesis proposed a solution to its own problem is equally meritless. The Gan Thesis merely considered an unproven assumption: "[I]t 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 . . ." EX2003, 112 (quoted by Petitioner's expert in his supplemental declaration, EX1067, ¶18). Contrary to Petitioner's assertion, a

POSITA would have seen this as speculation at best—not a concrete “solution.”

More importantly, it fails to support motivation to combine.

Nor do Petitioner’s additional references, Lemiti (EX1048) and Kermani (EX1063), teach a POSITA how to grow Gan’s interfacial oxide on a structure like Froitzheim’s. *See, e.g.*, Petition (Paper 2), 42 (illustrating an oxide layer between a silicon substrate and a polysilicon emitter). Lemiti only achieved reproducible results in an “MOS [metal-oxide semiconductor] device,” Reply, 9 (citing EX1048, 1376), but requires changes for its semiconductor device, EX1048, 1376 (“[I]t appears preferable in the future to work at a lower oxidation temperature and/or oxygen process pressure.”). Thus, a POSITA would not have understood Lemiti to be instructive for the proposed Gan-Froitzheim combination forming an oxide layer on a solar cell with different surfaces (polysilicon and silicon).

Kermani is equally uninformative. The only “conditions for formation of a thin interfacial oxide of 10 to 30 Å” that Kermani provides, Reply, 9, are vague suggestions to “reduc[e] the oxidation temperature, pressure” and to “lower[] the partial pressure of oxygen,” with no specific parameters, EX1063, 570. The thin oxide layer is also not exposed to high temperature annealing to demonstrate its functionality in solar cells as Froitzheim and Gan intended. In fact, Kermani specifies that, for interfacial oxide in the thickness range of 10Å to 30Å, “the oxidation kinetics must be greatly reduced.” EX1063, 570; *see also id.* at 569

(only disclosing high temperature annealing for “80 Å thick oxide films.”). In other words, Kermani teaches away from applying high temperature anneals to interfacial oxide in the thickness range of 10Å to 30Å.

Further, as Petitioner admits, Kermani “is about bipolar transistors.” Reply, 9. Kermani does not report on adopting polysilicon emitters in solar cells. Neither Kermani nor Petitioner provides evidence that findings on the use of polysilicon emitters in bipolar transistors are applicable to solar cells.¹ *Id.* Notably, Petitioner has not cited any prior art showing that a thin oxide layer can be reliably grown on a solar cell between the polysilicon emitter and silicon substrate, as proposed in the Froitzheim-Gan combination.

In sum, Petitioner remains silent on why a POSITA would have been motivated to fundamentally modify Froitzheim’s proven technology with Gan’s unreliable polysilicon emitter and interfacial oxide. This modification adds

¹ Gan was also motivated to explore the transferability of the use of polysilicon emitters in bi-polar transistors to solar cells. EX1007, 245 (“Polysilicon emitters, because of their important applications in high speed bipolar transistors, have been widely studied.”). The Gan Thesis showed that Gan could not reliably incorporate Gan’s proposition into actual solar cells. *See, e.g.*, EX2003, 110 (“Later, in the real solar cell runs, the situation got even worse.”) (cited in POR, 15).

components and steps from Gan, only to result in a structure relying upon Gan's unreliable formation of an interfacial oxide which produces unacceptable results.

4. *A POSITA Would Have Given Equal Consideration to The Gan Thesis and Gan*

Petitioner's challenge to the credibility of the Gan Thesis (EX2003)² defies logic. The author of the Gan Thesis, Jon-Yiew Gan, meets Petitioner's definition of a POSITA. At the time of his thesis, Jon-Yiew Gan was a graduate student about to receive his Ph.D in the technical area of concentrator solar cells. EX2023, Title. Thus, Jon-Yiew Gan has "an advanced degree in electrical engineering, applied physics, chemistry, or material science, and at least two years of experience designing, developing, or researching in the field." Petition, 2; *see also* EX1066, 106:15-107:20 (Patent Owner's expert opining that Gan meets Petitioner's definition of a POSITA.).

² Petitioner also misrepresents Patent Owner's expert's testimony as "Dr. Ruby was given only select excerpts of the Gan Thesis by his counsel." Reply, 8, n3 (citing EX1066, 102:19-21) (emphasis added). Dr. Ruby testified that he reviewed excerpts of the Gan Thesis, and that counsel selected those excerpts. EX1066, 101:21-102:21.

A POSITA would have considered the Gan Thesis credible and informative. Three Stanford University professors from the departments of Electrical Engineering and Materials Science and Engineering certified the Gan Thesis as “fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.” EX2003, iii. The Gan Thesis was approved by Stanford’s Committee on Graduate Studies. EX2003, iii.

A POSITA would also have considered Gan and the Gan Thesis as contemporaneous. Gan (EX1007) lists Jon-Yiew Gan as the lead author and Dr. Swanson as a co-author. Gan (EX1007) was presented at a scientific conference between May 21 to 25, 1990:

THE CONFERENCE RECORD OF THE
**TWENTY FIRST IEEE
PHOTOVOLTAIC
SPECIALISTS
CONFERENCE—1990**

VOLUME I



EX1007, cover (partial, annotated).

The Gan Thesis was approved two months later, and lists Dr. Swanson as principal advisor:

POLYSILICON EMITTERS FOR
SILICON CONCENTRATOR SOLAR CELLS

A DISSERTATION
SUBMITTED TO THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
AND THE COMMITTEE ON GRADUATE STUDIES
OF STANFORD UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

By
Jon-Yiew Gan
July 1990

EX2003, dissertation cover page (partial, annotated).

I certify that I have read this thesis and that in my
opinion it is fully adequate, in scope and in quality, as
a dissertation for the degree of Doctor of Philosophy.


R.M. Swanson
(Electrical Engineering)
(Principal Advisor)

EX2003, iii (partial).

A POSITA would have understood that Gan (EX1007) and the Gan Thesis (EX2003) were based on the same research by the same researcher and published contemporaneously. Indeed, by Petitioner's logic, if Gan (EX1007) gains credibility from having "pioneers of the industry such as Richard Swanson" as a co-author, Reply, 7, then the Gan Thesis (EX2003) is equally noteworthy given that Dr. Swanson was the principal thesis advisor.

A POSITA would also have understood that the results reported in Gan (EX1007) were based on the research compiled in the Gan Thesis (EX2003). Indeed, the data shown in Gan can be found in the Gan Thesis, but the latter discusses the data with greater detail and in more context. *Compare* EX1007, 246 (Figure 1 illustrating the test device structure in Gan) *with* EX2003, 93 (Figure 5.14 illustrating an identical test device structure in the Gan Thesis); *compare* EX1007, 247 (Figure 2 in Gan) *with* EX2003, 95 (Figure 5.16 illustrating an identical figure in the Gan Thesis); *compare* EX1007, 247 (Figure 3 in Gan) *with* EX2003, 97 (Figure 5.17 illustrating an identical figure in the Gan Thesis); *compare* EX1007, 248 (Figures 4 and 5 in Gan) *with* EX2003, 98 (Figures 5.18, 5.19 illustrating identical figures in the Gan Thesis); *compare* EX1007, 248 (Table 1 in Gan) *with* EX2003, 100 (Table 5.4 being identical in the Gan Thesis). Thus, any POSITA would have considered Gan within the context provided by, and in view of, the additional information provided in the more detailed Gan Thesis.

5. *Petitioner Has Not Established that Increased Resistivity Would Affect One Sun Cells Less*

Petitioner's claim that "non-concentrator cells can work with a higher series resistance than what is required by a concentrator solar cell" is not relevant. Reply, 6; *see also* EX1067, ¶¶27-28 (emphasis added). The parties' dispute is over Gan's

contact resistivity (ρ_c), not series resistance. As Petitioner's reference Wolf (EX1065) teaches, the two are not the same:

Major contributions to the internal series resistance come from the sheet resistance of the p -layer, the bulk resistance of the n -layer, and the resistance between the semiconducting material and the metallic contacts. While the contact series resistance can properly be represented by a lumped resistance, the sheet resistance and the bulk resistance are distributed throughout the device.

EX1065, 470. Thus, Wolf's discussion on, for example, a linear relationship between short circuit current versus solar irradiance "at different internal series resistance values" is not relevant to the parties' disagreement on the effect of an increase in Gan's contact resistivity. EX1067, ¶27 (citing EX1065, Fig. 3 and 461) (Petitioner's expert discussing the linear relationship in Fig. 3).

Further, Wolf's research focuses on sheet resistance in the magnitude of 0.1 to 5 Ω (100,000 to 5,000,000 $\mu\Omega$). *See, e.g.*, EX1065, Figs. 3, 5. Wolf does not examine the effect of the resistivity in the magnitude of 1 to 2×10^{-5} $\Omega\text{-cm}^2$ (10 to 20 $\mu\Omega\text{-cm}^2$). Thus, Wolf's teachings shed no light on whether Gan's P-type polysilicon emitters having a ρ_c of 18 $\mu\Omega\text{-cm}^2$ (or 1.8×10^{-5} $\Omega\text{-cm}^2$) would have deterred a POSITA from combining it with Froitzheim. POR, 44 (citing EX1007, Table 1).

Thus, Petitioner's claim that "non-concentrator cells can work with a higher series resistance than what is required by a concentrator solar cell," Reply, 6, does not overcome (or even address) Patent Owner's argument that even at 900°C, the proposed Froitzheim-Gan combination would "yield a value of ρ_c [contact resistance] that is higher than what Gan finds useful," POR, 45.

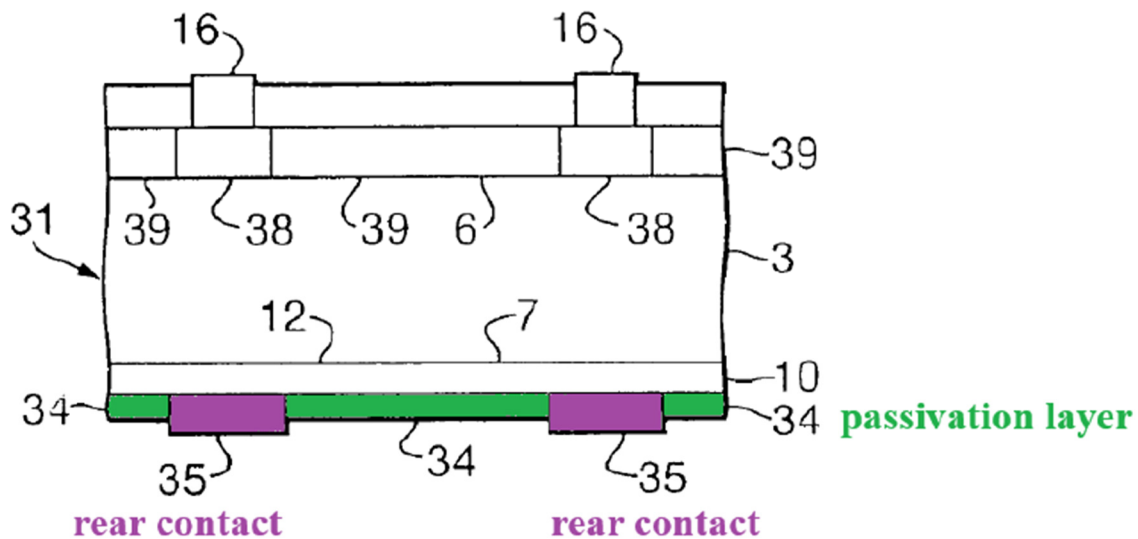
6. *Petitioner's Argument on Claim 12 Misses the Mark*

Petitioner purports to rebut Patent Owner's position that Petitioner failed to establish motivation to combine Froitzheim's alternative embodiment with Gan, POR, 52-53, by pointing to selected paragraphs in Petitioner's expert declaration, Reply, 14 (citing EX1003, ¶¶179-82). But those paragraphs are silent on motivation to combine. Patent Owner's argument stands.

Further, on the merits of claim 12, the parties' disagreement boils down to whether Froitzheim's formation of metal contacts after formation of a passivation layer, Petition, 55-57, is the equivalent of forming metal contacts over a layer of silicon dioxide, as claim 12 recites. To that end, Petitioner's argument that the term forming "over" does not preclude forming "after," Reply, 14-15, misses the issue. The issue is that forming after does not mean forming over. And to date, Petitioner has not pointed to any description in Froitzheim to suggest that its metal contacts are formed over the passivation layer.

Separately, Petitioner’s attempt to include a new unpatentability theory is improper. In its Reply, Petitioner argues, for the first time, that there are “overlapping portions between the metal and the oxide layer.” Reply, 15. This argument is waived and should not be considered. *Corephotonics, Ltd. v. Apple Inc.*, 84 F.4th 990, 1002 (Fed. Cir. 2023) (quotations omitted) (“[T]he Board is not permitted to entertain ‘[s]hifting arguments’ but must, instead, reject any ‘entirely new theory of prima facie obviousness absent from the petition,’ if the petitioner attempts to inject such a theory into the proceeding post-petition.”); *Masimo Corp. v. Apple Inc.*, IPR2023-00745, Paper 44, 40 (PTAB Oct. 15, 2024) (Determining the petitioner’s argument as “waived because it presents an entirely new theory that does not clarify an earlier position, is not responsive to arguments presented in the Patent Owner’s Response, and it raises entirely new issues and evidence.”).

Nor does Froitzheim support Petitioner’s new and improper theory. Froitzheim does not disclose any overlap between its metal contacts and its passivation layer. Indeed, Froitzheim’s illustration of its alternative embodiment make clear that no such overlap exists:



EX1006, Fig. 3 (annotated).

B. Petitioner's Theory Based on Froitzheim and Kwark Is Unsound

1. Petitioner Has Not Established that Kwark's Purported Benefits Apply at Froitzheim's Anneal Temperature Range

Petitioner does not dispute that at Froitzheim's preferred temperature range of 1000°C-1100°C, Kwark's purported benefits would be lost. EX1006, ¶42; POR, 57; Reply, 19. Instead, Petitioner reverts to its conclusory statement that "a POSITA would understand to apply the lower end of the preferred temperatures disclosed in Froitzheim (*i.e.*, 900°C-1000°C)." Paper 32, 19. Not only is 900°C-1000°C outside of Froitzheim's preferred temperature range, but as discussed in §II.A.1, such mere conclusory statements are insufficient.

Even at that lower temperature range of 900°C-1000°C, it is unclear that Kwark's structure would improve Froitzheim's existing structure. First,

Petitioner's claim that "Kwark's polysilicon emitter offers advantages over a diffused emitter (the 'Al contact' control in Kwark Fig. 4)" is incorrect. Reply, 18. Referring to Figure 4, Kwark describes an emitter B that is "diffused prior to the POLY deposition," and showing "[t]he value for emitter B with a conventional aluminum contact" for reference (the "Al contact" control, according to Petitioner). EX1008, 743. Kwark notes that "[a]ddition of POLY without the chemox does not greatly impact J_{oe} as would be expected since the heavily doped POLY acts essentially as an extension of the monocrystalline emitter." *Id.* In other words, Kwark discloses the opposite of what Petitioner claims.

Second, Kwark's control value (the "No Chemox" line in Figure 4) refers to the J_{oe} of Kwark's "[b]ipolar test structures," EX1008, 742, which, as Figure 4 illustrates, is closer to 1×10^{-12} A/cm², *id.* at Fig. 4. Gan discusses a lower J_o value for diffused emitters in concentrator cells, 4.5×10^{-13} A/cm². Reply, 2 (citing EX1007, 245). Thus, it makes sense that the J_o/J_{oe} of the diffused emitter in Froitzheim's one-sun solar cell would differ from that of Kwark (and Gan), and remains an unknown value.

Further, as discussed in §II.A.1 above, without providing specific anneal temperature and anneal time, the dopant profile of Kwark's polysilicon emitter in the proposed Froitzheim-Kwark combination would be unknown. Thus, Petitioner has not shown that modifying Froitzheim with Kwark would have improved J_{oe} .

What is known is that Froitzheim's system works, and many references disparage the use of Kwark's chemox. Thus, a POSITA would not have been motivated to modify Froitzheim's working system with the disparaged technique of chemox. Froitzheim's structure already has "improved stability and good efficiency." EX1006, ¶9. On the other hand, chemox, as used in Kwark, is generally inferior to thermal oxide layers. *See, e.g.*, EX1048, 1357 ("[T]hermally grown oxide is often chosen owing to its thermal stability with respect to native or chemical oxide."); EX1063, 567-68 ("Chemical oxide films are silicon-rich and have a rough surface morphology. Due to the delay between their growth and polysilicon deposition, control of the oxide thickness is poor. Both native and chemical oxide films are thermally and chemically unstable and break down during the polysilicon and emitter drive-in steps."); EX1007, 245 ("Compared with the chemical oxide, the thermal oxide appears to be more robust to the high temperature anneal."); *see also* POR, 59-60 (citing EX2020, ¶223-25; EX2003, 39). Thus, a POSITA would have understood that combining Froitzheim with Kwark would not have achieved Kwark's purported benefit, and Petitioner does not dispute this in its Reply. Reply, 16-22.

2. *Petitioner Failed to Establish that a POSITA Would Have Been Able to Control the Thickness of Kwark's Chemox Layer*

Petitioner's claim that a POSITA would have been able to "modify the thickness of [Kwark's chemox] to reduce its resistivity" is an impermissible new argument. Reply, 21. According to Petitioner's expert, such modification requires adjustment to "reaction variables (such as the treatment solution, time, temperature, and pH)" based on a new reference, Petitdidier (EX1064). EX1067, ¶38. Effectively, Petitioner claims that a POSITA considering the proposed Froitzheim-Kwark combination would have looked to techniques disclosed in Petitdidier to adjust Kwark's chemox layer. This is a new argument, relying on a new reference, which is improper. *Corephotonics*, 84 F.4th at 1002 ("[T]he Board is not permitted to entertain '[s]hifting arguments' but must, instead, reject any 'entirely new theory of prima facie obviousness absent from the petition,' if the petitioner attempts to inject such a theory into the proceeding post-petition."); *Masimo*, IPR2023-00745, Paper 44, 40 (determining the petitioner's argument as "waived because it presents an entirely new theory that does not clarify an earlier position, is not responsive to arguments presented in the Patent Owner's Response, and it raises entirely new issues and evidence."). Thus, neither Petitioner's argument nor Petitdidier (EX1064) should be considered.

Petitioner's argument is also unfounded because Kwark's chemox and Petitdidier's chemox are apples and oranges. First, the two chemox layers have different functions. Kwark's chemox reduces bulk recombination in the monocrystalline emitter region. EX1008, 743. In contrast, Petitdidier examined the use of oxide as a cleaning and protective layer. *See, e.g.*, EX1064, 51 (discussing generating "a thin chemical oxide layer which repels all inorganic particles from the surface by setting the zeta potential of both the surface and the particles.").

Second, the two chemox layers are formed differently. In Kwark, the chemox is formed by dipping a clean wafer in dilute Hydrofluoric Acid. EX1008, 743 ("[D]evices were prepared with and without a chemically grown oxide (chemox) by dipping half of the wafer which underwent a full RCA clean in dilute HF." In Petitdidier, the chemox is formed by treating organic contaminants with "an alkaline ammonia-hydrogen peroxide mixture." EX1064, 51.

Third, the two chemox layers have different properties. Kwark's chemox is a "thin tunnelable interfacial oxide layer." EX1008, 743. The tunneling property implies that the chemox layer must be thin enough to allow the desired carriers to pass through, but thick enough to block the undesired carriers. Petitdidier's chemox, on the other hand, is not formed as a continuous film. EX1064, 53 (recording "a thickness less than one monolayer."); *see also id.* at 55 ("In SC2 at

50 °C. . . when the oxide film is thicker than one monolayer . . . indicating that the oxide cannot be considered as a continuous film.”). Thus, Petitdidier’s chemox does not have tunneling properties because gaps in the chemox monolayer will hinder its ability to block undesired carriers. *See, e.g.*, EX1007, 245 (discussing the impact of an interfacial oxide on majority and minority carrier transport, and the effect of the interfacial oxide losing its integrity); EX1014, ¶¶3-7 (same) (cited in EX2020, ¶¶80-84).

Lastly, even if Petitdidier’s teachings are used to supplement Kwark, Petitdidier would still not have taught a POSITA how to adjust the thickness of Kwark’s chemox to be within the proper thickness range for it to be effective. The ’516 patent, for example, suggests the tunnel oxide layer be between “10 to 50 Angstroms.” EX1001, 2:64-66. Petitioner’s own reference, Kermani, is in accord. EX1063, 570 (“The interfacial oxide must be thicker than 10 Å to be thermally and chemically stable and, thin enough [to] not block dopant atoms, approximately less than 30 Å.”).

In contrast, Petitdidier examines chemox that is less than 10 Å in thickness. *See, e.g.*, EX1064, 56 (Table 3 listing thickness between 2.5 to 7.5 Å). In fact, using Petitdidier’s method of growing oxide, the thickness levels never reach the thickness necessary for stable tunneling (10-50 Å):

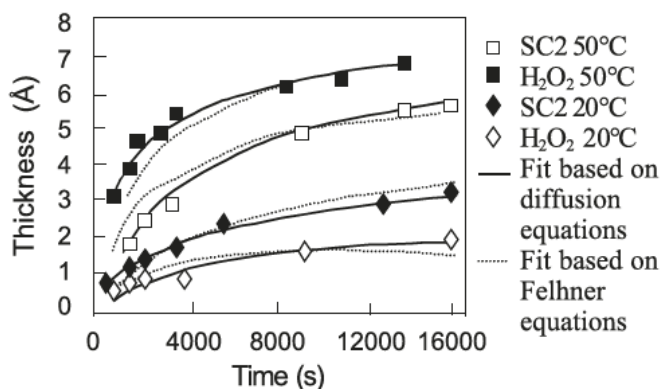


Fig. 7. Comparison of the time dependence between the optical thickness and the fits with the Fehner or diffusion formalisms.

EX1064, Fig. 7; *see also id.* at 56 (“This mechanism leads to a parabolic law during the first stages of growth and tend to plateau corresponding to the steady regime oxidation/dissolution.”). The distinction in thickness is relevant because, as discussed above, an oxide layer that is too thin would not be able to properly block undesired carriers. *See, e.g.*, EX1007, 245; EX1014, ¶¶3-7.

C. Petitioner’s Theory Based on Froitzheim and Borden Is Unsound

1. Borden Expressly Limits the Benefits Relied Upon by Petitioner to HIT Cells and Amorphous Silicon

It is not, as Petitioner claims, Patent Owner’s burden to “explain why Borden would disclose an embodiment forming a polysilicon emitter cell if the benefits would not apply to such a cell, [or] point to any instances where Borden disparages the use of polysilicon.” Reply, 23-24; *but see Apple Inc. v. Masimo Corp.*, IPR2024-00290, Paper 35, 7 (PTAB July 3, 2025) (citing *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016); *Dynamic Drinkware, LLC v.*

Nat'l Graphics, Inc., 800 F.3d 1375, 1378 (Fed. Cir. 2015)) (“In an [inter partes review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable. . . This burden of persuasion never shifts to Patent Owner.”) (emphasis added).

Petitioner fails to carry its burden of persuasion in explaining why a POSITA would have been motivated to modify Froitzheim with Borden’s polysilicon emitter structure because the motivation that Petitioner references is limited only to Borden’s amorphous silicon HIT (heterojunction with intrinsic thin layer) structure, which is a structure not addressed in the contested claims.

The Petition relies on Borden’s Abstract to establish motivation. Petition, 66 (citing EX1009, Abstract, ¶8; EX1003, ¶199). But tellingly, Borden’s Abstract describes “improved HIT type or polysilicon emitter solar cells,” but clearly limits the benefits that Petitioner relied on to only HIT cells and their use of amorphous silicon:

The present invention relates to improved HIT type or polysilicon emitter solar cells. . . Benefits of the invention include that it provides a controlled interface for the HIT cell through insertion of a thin tunnel oxide. Moreover, the tunnel oxide prevents epitaxial growth of amorphous silicon, allowing it to remain amorphous for the optimum band structure. Still further, it provides a layer to protect the surface from plasma damage during deposition of the a-Si layer. Further, it

may be used in conjunction with a point contact structure to further increase efficiency.

EX1009, Abstract (emphasis added); *see also id.* at ¶¶8, 20 (Borden's remaining disclosures are in accord). By specifically limiting certain benefits to HIT cells, Borden's Abstract makes clear that it did not consider these benefits applicable to polysilicon emitter solar cells.

Borden also unfavorably distinguishes a polysilicon emitter with respect to the disclosed HIT cells. For example, after discussing the benefits of HIT cells (and only HIT cells), EX1009, ¶3, Borden then discusses the "considerable complexity" during fabrication of HIT cells (and only HIT cells), *id.* at ¶6. Later, Borden examines the similar band structures of HIT cells and polysilicon emitter solar cells, but emphasizes that the latter "does not provide the heterojunction and its benefit of a higher cell voltage due to the higher bandgap of a-Si." *Id.* at ¶16.

Thus, Petitioner's claim that Borden's purported benefit of preventing epitaxial growth and plasma damage applies to Borden's polysilicon emitter cell is inconsistent with Borden's clear attribution of those benefits only to HIT cells and amorphous silicon.

2. *Petitioner's Argument Involving a Point Contact Structure Is Improper and Incomplete*

In its Reply, Petitioner references, for the first time, Borden's "additional stated benefit of increased efficiency with a point contact structure." Reply, 24 (emphasis added). Arguing a new benefit at this stage is improper and should not be considered. *Corephotonics*, 84 F.4th at 1002; *Masimo*, IPR2023-00745, Paper 44, 40.

Aside from being improper, Petitioner's new argument is meritless. According to Borden, its tunnel oxide "may be used in conjunction with a point contact structure to further increase efficiency." EX1009, Abstract; *see also id.* at ¶¶8, 26. In other words, this benefit (increased efficiency) requires using a tunnel oxide "in conjunction with a point contact structure." *Id.* But nowhere in the Reply (or the Petition) does Petitioner (1) propose a Froitzheim-Borden combination involving a point contact structure, (2) explain how a POSITA could have adopted a point contact structure in the proposed Froitzheim-Borden combination, or (3) explain why a POSITA would have been motivated to do so. In other words, Petitioner proposes a Froitzheim-Borden combination without a point contact structure; thus, Borden's benefit (increased efficiency from using a tunnel oxide in conjunction with a point contact structure) does not apply.

III. PETITIONER FAILS TO SHOW NEW REFERENCES ARE PRIOR ART

With its Reply, Petitioner submitted four new references (Exs. 1062-1065) without a proper showing of public accessibility of those references. *Microsoft Corp. v. Throughputer, Inc.*, IPR2022-01566, Paper 13, 16 (PTAB May 31, 2023) (determining that Petitioner failed to show a reasonable likelihood that reference Tuan “qualifies as a printed publication” because “Petitioner fails to identify, with particularity, evidence sufficient to establish a reasonable likelihood that Tuan was publicly accessible before the critical date.”). Thus, Petitioner failed to properly establish the references as prior art.

Petitioner did not submit a supplemental declaration from the librarian that it retained to authenticate and show availability of the references included with the Petition. Instead, Petitioner submitted a supplemental declaration from its technical expert who relied on the hearsay dates printed on the exhibits themselves to speculate that they would have been publicly accessible. EX1067, ¶43 (“I see nothing in any of those exhibits to suggest that the exhibit is not what it appears to be, or which raises any doubt as to the exhibit’s authenticity or accuracy.”); *id.* at ¶44 (speculating the dates on the exhibits are “reliable and trustworthy” because they were purportedly published in journals that Petitioner’s expert represents as having a “reputational incentive to accurately publish the submissions.”); *id.* at ¶45

(speculating that “it would be very difficult” to alter the dates of the purported publications); *but see* Paper 13, 14 (requiring evidence demonstrating when a reference became available to the public).

Petitioner put forth no admissible evidence that Exhibits 1062 to 1065 were publicly accessible, so they should not be considered prior art, and Petitioner’s arguments relying on those exhibits should be evaluated accordingly.

IV. CONCLUSION

For the foregoing reasons and those in the POR, claims 9-12 in the ’516 patent are patentable.

Respectfully submitted,

Date: August 12, 2025

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that this Patent Owner Sur-Reply, exclusive of the table of contents, table of authorities, certificate of service, certificate of word count, and list of exhibits, includes 5,588 words. Pursuant to 37 C.F.R. § 42.24(d), Patent Owner relied on the word count feature of the word-processing system used to prepare this paper.

Dated: August 12, 2025

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CERTIFICATE OF SERVICE

I certify that the foregoing Patent Owner Sur-Reply was served on
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