

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner,

v.

MAXEON SOLAR PTE. LTD.
Patent Owner

Inter Partes Review No. IPR2024-01039

Patent No. 8,222,516

PETITIONER'S REPLY TO PATENT OWNER RESPONSE

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The Institution Decision (“ID”) correctly found that challenged claims 9-12 are obvious over the prior art. Patent Owner’s (“Maxeon’s”) Response repeats many arguments that the Board rejected. Maxeon generally does not dispute that Canadian Solar Inc.’s (“CSI’s”) prior art combinations meet the claim elements and instead makes unsupported arguments about motivation to combine and reasonable expectation of success. And Maxeon provides no evidence of objective indicia of non-obviousness. Thus, all claims should be found unpatentable.

I. FROITZHEIM AND GAN (GROUND 3)

Maxeon does not dispute that Froitzheim and Gan teach all limitations of claims 9-11. Instead, Maxeon claims that a POSITA would not reasonably expect success or be motivated to combine Froitzheim and Gan. POR at 42. Maxeon is wrong.

A. A POSITA Would Reasonably Expect Success in Applying Gan’s Teachings to Froitzheim

As explained in the ID, “[o]nly a reasonable expectation of success, not absolute predictability, is necessary for a conclusion of obviousness.” *In re Longi*, 759 F.2d 887, 896 (Fed. Cir. 1985). Despite the Board’s statement that Maxeon was applying an incorrect standard in its POPR (ID at 14), Maxeon’s Response continues to improperly impose effectively a requirement of absolute predictability. This ignores abundant evidence confirming Gan’s teachings could be readily and predictably applied to Froitzheim.

1. Froitzheim's Temperatures Would Work to Reduce J_0 (Recombination)

Maxeon provides no evidence that a combined Froitzheim/Gan solar cell would not work. Instead, Maxeon wrongly argues that the combination would not achieve desired properties of Gan at the higher temperatures “preferred” in Froitzheim. POR at 45.

Maxeon's criticism is unfounded. The reasons to combine Froitzheim and Gan rest not only on the benefits of the oxide layer, but also on the advantages provided by using a polysilicon emitter together with the oxide layer as compared to a diffused emitter. *See* EX1007 at 245; EX1003, ¶144. Gan reports that a diffused emitter has a high J_0 of 4.5×10^{-13} A/cm². EX1007 at 245. Using Gan's polysilicon/interfacial oxide structure, “ J_0 [can be reduced] below 5×10^{-14} A/cm² which is about *one order [of] magnitude lower* than that of diffused-emitters.” *Id.* at 249 (emphasis added). Though Gan reports increasing J_0 as anneal temperature increases above 900°C, Maxeon ignores that even at the higher 1000°C temperature that Maxeon argues Froitzheim preferred, Gan shows that the J_0 under that condition was still lower than the J_0 for diffused emitters. *Id.* at 248 (Table 1 showing ranges of 4.5×10^{-14} to 10.5×10^{-14} for polysilicon/interfacial oxide annealed at 1000°C, still lower than the 4.5×10^{-13} J_0 reported for diffused emitters). Thus, the benefits of Gan's interfacial-oxide-with-polysilicon structure to reduce J_0 would have been achieved *regardless* of whether the processing temperature was 900°C

or 1000°C. Accordingly, Maxeon's argument that higher temperatures would not be successful is contrary to Gan's teachings.

Moreover, a POSITA is "a person of ordinary creativity, not an automaton." *KSR Int'l v. Teleflex*, 550 U.S. 398, 421 (2007). Froitzheim discloses that the temperature range for diffusion can be from 900-1200°C. EX1006, ¶42. It would simply be common sense for a POSITA, based on the teaching of Gan, to use an anneal temperature of 900°C as beneficially taught by Gan and within the range disclosed by Froitzheim. EX1066, 76:9-12. Specifically, Gan reports better J_0 of 3.5×10^{-14} A/cm² for p-type polysilicon/interfacial oxide structure that results from annealing at 900°C, with J_0 increasing at higher temperatures. EX1007 at 248, Table 1. Thus, a POSITA considering Froitzheim and Gan together would logically select the lower end of Froitzheim's temperature range to achieve efficiency gains consistent with Gan. This approach is well within the a POSITA's capabilities. EX1067, ¶8.

Further, Froitzheim's preferred temperature of 1000°C to 1100°C was due to its preference for using mono-crystalline substrate. EX 1006, ¶24; EX1067, ¶¶7-8. However, it was well known in the art that dopant diffusion into polysilicon does not require as high of annealing temperatures as monocrystalline silicon; doping polysilicon can be achieved using temperature at 900°C. *Id.*, ¶¶9-10. Thus, a POSITA would have readily reconciled the teachings of Gan and Froitzheim

regarding processing temperatures by selecting the lower end of the Froitzheim range. *Id.*, ¶11.

2. **Gan's Resistivity Would Work For a One-Sun Solar Cell**

The Board should also reject Maxeon's argument that a lower anneal temperature of 900°C leads to "suboptimal ρ_c " for polysilicon emitters. POR at 44. "Suboptimal" does not mean that the solar cell would not work. *Janssen Pharms. v. Teva Pharms. USA*, 97 F.4th 915, 932 (Fed. Cir. 2024) (remanding for reassessment of obviousness because "a teaching that [one value] was optimal is not a criticism of all other [values]").

Specifically, Maxeon argues that optimal ρ_c is $1 \times 10^{-5} \Omega/\text{cm}^2$, and notes that the ρ_c of Gan's p-type polysilicon emitter is slightly higher at $1.8 \times 10^{-5} \Omega/\text{cm}^2$. POR at 44. Maxeon misreads Gan, as Gan did not state that this so-called "optimal" value represents an absolute limit not to be crossed. EX1067, ¶23. Gan merely reported this as a value it had achieved. EX1007 at 245. Maxeon concedes that Gan demonstrates that this resistivity value is still less than $5 \times 10^{-5} \Omega/\text{cm}^2$, which Gan teaches is "quite useful for silicon solar cells." *Id.* at 249; EX1067, ¶24. Maxeon's suggestion that such a value would not be "relevant" to a POSITA (POR at 44) is thus confusing and contradicted by the evidence.

Gan teaches that when resistivity is less than $5 \times 10^{-5} \Omega/\text{cm}^2$, "the potential drop across the contact *is negligible* as long as the current density is less than 100

A/cm².” EX1007 at 249 (emphasis added). The current density of the Froitzheim-Gan combination is well below 100 A/cm², as “100 A/cm²” 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. EX2020, ¶135; POR at 16 (“Froitzheim and the ’516 patent are directed to one sun cells”); EX1067, ¶25. A POSITA thus would reasonably expect success and would not be deterred by the reported small increase in resistivity, especially for a one-sun cell. *Id.*, ¶28.¹

Further, a POSITA would understand that one-sun cells do not require as low resistance as concentrator cells. EX1067, ¶¶26-27; EX1066, 46:10-13. Maxeon admits that “concentrator 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.” POR at 17. In other words, one-sun solar cells do not require the “optimal” ρ_c of $1 \times 10^{-5} \Omega/\text{cm}^2$ that Maxeon urges because less light is hitting the solar cell. EX1067, ¶26. Dr. Banerjee explains that even

¹ Gan does not limit the usefulness of its teachings to concentrator cells. Rather, Gan teaches that its results are “quite useful for silicon solar cells” generally. EX1007 at 249; EX1067, ¶22.

before Gan, it was known for decades that non-concentrator cells can work with a higher series resistance than what is required by a concentrator solar cell. EX1067, ¶¶27-28, citing EX1065 (Wolf). Thus, even assuming annealing at 900°C results in suboptimal ρ_c for concentrator cells, the small increase in ρ_c would be negligible and irrelevant since the polysilicon/oxide structure is applied to Froitzheim's "one-sun solar cell." EX1067, ¶28.

3. **A POSITA Could Reliably Perform Oxide Growth Before 2008**

The Board should reject Maxeon's arguments regarding the purported unpredictability of growing an oxide layer that relies primarily on the work of a graduate student *before 1990* (the Gan Thesis).² See POR at 46. First, Maxeon does not contest CSI's definition of a POSITA, and Maxeon has not shown that this graduate student has the level of skill of a POSITA *in 2008*. EX1066, 107:14-20. Instead, the thesis reports a graduate student's challenges in his experimentation while learning and aspiring to have the skills of a POSITA. EX1067, ¶17. Moreover, a thesis is an academic report reflecting the extended

² While Gan has been referenced in the literature, see EX1048, Maxeon has not shown that the Gan Thesis has been cited in any papers or patents. EX1066, 105:22-25.

experimentation of a graduate student over multiple years, and would be understood by a POSITA to include all experimentation, whether successful or not. *Id.*, ¶16; EX1066, 55:12-18. Thus, a POSITA would read a thesis's teachings in that light. EX1067, ¶17; *see, e.g.*, EX2003 at 111 (referencing "calibration of our oxide-growth recipe").

A POSITA interested in improving the efficiency of a solar cell would look to work reported at an industry conference rather than a graduate student's thesis. EX1067, ¶17. A POSITA would place greater weight on Gan, which contained a curated set of conclusions deemed appropriate for dissemination to the technical community at the IEEE Photovoltaic Specialists Conference, and Gan's authors include pioneers of the industry such as Richard Swanson. *Id.*; EX1066, 79:8-18. The broader and more exploratory nature of the Gan Thesis does not undermine Gan's significance to a POSITA. EX1067, ¶17.

Even if a POSITA considered the Gan Thesis, the POSITA would still reasonably expect success from using a polysilicon emitter with a thermal oxide layer in combination with Froitzheim. The Thesis's abstract explains that "polysilicon emitters . . . can be a very useful substitute for the diffused emitters for high efficiency solar cells," and that "*experimentally*, such polysilicon emitters [with low J_0 and low resistivity] of [n-type and p-type] were *successfully demonstrated*." EX2003 at iv. Thus, the Gan Thesis did not just theorize, it

successfully demonstrated the value of a solar cell with a polysilicon/oxide structure. *See also, id.* at 104.

To argue against reasonable expectation of success, Maxeon relies on the Gan Thesis’s discussion of variability in its results. POR at 25. But this would not negate a reasonable expectation of success because the Gan Thesis explicitly identified the problem of these variable results and proposed solutions. EX1067, ¶¶18-19. The Thesis identified its oxide growth process as resulting in “poor control over the oxide thickness.” EX2003 at 114. As the Board already recognized in the parallel proceeding challenging the related ’053 Patent, the Gan Thesis explicitly teaches that “it is possible that the thin oxide growth can be improved by performing the oxidation at lower temperature such that the oxidation rate can be controlled more precisely.” *Id.* at 112; IPR2024-01040, ID at 26; *see also*, EX1067, ¶¶18-19. Maxeon’s expert also agrees that this was well known prior to 2008.³ EX1066, 103:15-18. Thus, a POSITA would understand that variability could be mitigated with better control of the oxide thickness and could optimize the oxide growth conditions to achieve a thin oxide.

³ Dr. Ruby was given only select excerpts of the Gan Thesis by his counsel, so he did not consider the entirety of the work. EX1066, 102:19-21.

Indeed, it was well known as early as the 1990s, including in work immediately following Gan, that thin thermal oxides can be reliably grown with controllable thicknesses by adjusting conditions such as reaction time, temperature, pressure, and oxygen concentration. EX1067, ¶12. For example, Lemiti, which cites Gan, reports “thin oxide films were achieved...” EX1048 at 1376; *see also*, EX1047 (showing Lemiti's public availability by August 2002). Lemiti further successfully achieved “among others...reproducible in-situ oxide/polysilicon stack with acceptable MOS device performance.” EX1048 at 1376. Such disclosures underscore the maturity of thermal oxidation techniques at that time. EX1067, ¶13.

Likewise, a POSITA would reasonably expect success in reliably growing a very thin oxide layer with a thickness of 1-3nm (10-30Å). For example, the 1991 Kermani paper, which is cited in Lemiti (reference [6]), reports conditions for formation of a thin interfacial oxide of 10 to 30 Å for bipolar transistors by controlling oxidation temperature and pressure, among other parameters. EX1063 at 570; EX1067, ¶14. Although the paper is about bipolar transistors, the findings are applicable in the solar cell context. *See, e.g.*, EX1003, ¶¶59, 127, 132, 148; EX1066, 128:14-17. Thus, growing reliable thin oxides was well within the knowledge and skill of a POSITA before Froitzheim in 2006. *See also* ID at 19 (“Gan states that... ‘polysilicon emitters . . . with a very small fraction of interfacial oxide breakup’ can be obtained.”).

Notably, the '516 Patent does not disclose any specific parameters for the oxide-growth process or provide any guidance as to how to form its oxide layer, except for disclosing that the oxide layer may be “thermally grown” from silicon dioxide to a wide range of thicknesses. EX1001, 2:64-66. This further evinces that by 2008, the process for reliably growing oxide layers was well within the skill of a POSITA. *Lockwood v. American Airlines*, 107 F.3d 1565, 1570 (1997); *Ebay v. Kelora Sys.*, 2012 WL 1835722, at *16 (N.D. Cal. May 21, 2012), *aff'd*, 500 F. App'x 953 (Fed. Cir. 2013).

B. A POSITA Would Be Motivated to Combine Froitzheim and Gan

Contrary to Maxeon's arguments, a POSITA would have been motivated to combine Froitzheim and Gan to develop an improved solar cell. Maxeon's first two arguments simply reiterate its arguments against a reasonable expectation of success and should be rejected for the same reasons as explained above and in the Petition. *See* POR at 49.

Maxeon incorrectly asserts that a POSITA would not look to concentrator solar cells as inspiration to modify Froitzheim. But Maxeon's expert admitted concentrator art is relevant to non-concentrator solar cells. EX1066, 51:7-16. Dr. Banerjee also explained the polysilicon emitter and interfacial oxide taught by Gan is “equally applicable to enhancing efficiency of [non-concentrator] solar cells.” EX1003, ¶¶131, 146; *see also* EX2023, 32:2-11. Thus, a POSITA would be

motivated to apply Gan's teachings to improve the efficiency of non-concentrator solar cells like Froitzheim.

Nothing in Gan limits its findings to concentrator cells. As explained above in §I.A.2, Gan states that its results are "quite useful for silicon solar cells" and that the potential drop in efficiency of non-concentrator cells is negligible with the results obtained by Gan. EX1007 at 249; *see also* EX2023, 93:12-15; 106:8-11. This broader applicability is understood in the industry. For example, Lemiti, a paper discussing polysilicon emitter solar cells generally, cites to Gan as a relevant example of an investigation of polysilicon-emitter solar cells. EX1048 at 1375. Thus, a POSITA would apply Gan's findings to solar cells broadly, including Froitzheim.

As explained above (§I.A.2), because concentrator solar cells require lower resistances, a POSITA would not be discouraged by Gan's findings. On the contrary, a POSITA would instead be *encouraged* that Gan's findings would work more effectively in non-concentrator solar cells because resistance requirements are less stringent. EX1067, ¶36; EX1066, 46:10-13, 51:18-21. Thus, clear motivation exists for a POSITA to apply Gan's teaching to modify Froitzheim's solar cell.

C. Maxeon's Teaching Away Argument Fails

Maxeon's reliance on Froitzheim's identification of a 900°C-1200°C annealing range—with 1000°C-1100°C described as the preferable subrange—does not meet the high threshold required to establish teaching away. A mere indication of what is “optimal or standard does not criticize, discredit, or otherwise discourage investigation into other compositions” and does not constitute teaching away. *Galderma Lab'ys, v. Tolmar*, 737 F.3d 731, 739 (Fed. Cir. 2013); *see also UCB v. Actavis Lab'ys UT*, 65 F.4th 679, 692 (Fed. Cir. 2023) (affirming reference did not teach away where it merely expressed a “preference” for a higher percentage).

Maxeon cites *Urbanski*, which actually supports CSI's position. There the Court affirmed a finding that a reference did not teach away from using a shorter reaction time, even though it disclosed and used a longer reaction time, because the reference did “not criticize or discredit the use of a shorter reaction time.” *In re Urbanski*, 809 F.3d 1237, 1244 (Fed. Cir. 2016). Similarly, here, although Froitzheim prefers drive-in temperatures that are above those tested in Gan and the Gan Thesis, it does not criticize or discredit the use of lower temperatures, and in fact discloses a range of permitted temperatures that includes 900°C as used by Gan. EX1006, ¶42; EX1007 at 248 (Table 1 indicating optimal results at 900°C).

Maxeon also relies on *Mouttet*, in which the Federal Circuit affirmed the Board's finding of obviousness and no teaching away. There, the Court emphasized that "mere disclosure of alternative designs does not teach away" and "just because better alternatives exist in the prior art does not mean that an inferior combination is inapt for obviousness purposes." 686 F.3d 1322, 1334 (Fed. Cir. 2012). Here, Maxeon fails to show that a working solar cell with a polysilicon/oxide structure cannot be formed at the temperatures disclosed in Froitzheim. Instead, Maxeon merely shows that a higher temperature may be more favorable. But, under *Mouttet*, such a preference is not teaching away.

Maxeon's reliance on *Syntex* is similarly misplaced. In *Syntex*, the Federal Circuit found no teaching away where an element was disclosed as optional but not preferred. *Syntex (U.S.A.) v. Apotex*, 407 F.3d 1371, 1380 (Fed. Cir. 2005). Here, as in *Syntex*, it is not the case that the disclosures in Gan suggest it would be "unlikely to produce the objective of the ['516 Patent's] invention." *Id.* On the contrary, Gan affirmatively demonstrates that a polysilicon emitter with an oxide is superior to Froitzheim's diffused emitter because the J_0 of Gan's configuration was an order of magnitude lower, even at 1000°C. EX1007 at 248 (Table 1). Thus, Gan's teachings are fully consistent with the objectives of both Froitzheim and the '516 Patent.

Moreover, Froitzheim cannot possibly teach away from a combination with Gan, as Froitzheim is silent as to the temperature that would be needed for doping polysilicon. EX1066, 77:13-18; 136:1-4. Where a reference is silent regarding a particular feature, it “does not tend to teach away from it, especially if”—as here—“it is disclosed elsewhere in the prior art.” *See, e.g., In re Haase*, 542 F. App'x 962, 967 (Fed. Cir. 2013). As discussed above at §I.A.1, a POSITA would understand that a lower temperature, including 900°C, is appropriate for doping polysilicon and results in beneficial J_0 and ρ_c .

D. The Froitzheim-Gan Combination Satisfies Claim 12

In its response, Maxeon wrongly claims that CSI did not explain how Froitzheim's alternative embodiment of FIG. 3 would be modified with Gan or a POSITA's motivation to do so. POR at 53. But CSI explained the combination in its Petition (at 55-57), citing further explanation from its expert (EX1003, ¶¶179-182). Dr. Banerjee explained that the combination “replaces the diffused emitter in Froitzheim with a polysilicon emitter with interfacial oxide layer, as taught by Gan” and that in the alternative embodiment, the metal rear contacts “may be formed *after* a passivation layer of silicon dioxide is deposited,” *i.e.*, after the formation of the oxide layer. *Id.*, ¶¶180-81. Dr. Banerjee explained that a POSITA was capable of such modifications and it would be advantageous because less metal is required. *Id.*, ¶182.

Unable to overcome Froitzheim's clear disclosure of a metal contact comprising silver formed over a layer of silicon dioxide, Maxeon resorts to construing claim 12 exceedingly narrowly. Although Maxeon stated it was applying "the plain and ordinary meaning of claim terms," POR at 37, its interpretation is inconsistent with that standard. Instead, Maxeon's argument amounts to defining the term "over" to exclude formation of a metal contact on the silicon dioxide layer "after" the passivation layer by reading in several limitations from the specification. POR at 53-54 (citing EX1001, 5:38-50).

Maxeon argues that "in the '516 patent, the rear metal contact is formed *over* a layer of silicon dioxide because there are metal holes ensuring electrical contact," reciting portions of the specification explaining that "the metal contact 110 is formed *on* the silicon dioxide layer" and "parts of the metal contact 110 overlap with the silicon dioxide layer 109." POR at 54-55. However, nothing in the plain meaning of "over" requires the presence of metal holes, contact formation directly *on* the oxide layer, or overlapping portions between the metal and the oxide layer. Nor do the quoted portions of the specification actually purport to describe formation of the metal contact "over" the silicon dioxide or even use the word "over." Instead, the plain meaning clearly includes forming the rear contact over the layer of silicon dioxide after the passivation layer, as in CSI's combination. Maxeon's narrow construction should thus be rejected.

II. FROITZHEIM AND KWARK (GROUND 4)

Maxeon does not dispute that Froitzheim and Kwark teach all limitations of claims 9-11. Instead, Maxeon claims that a POSITA would not reasonably expect success or be motivated to combine Froitzheim and Kwark. POR at 56-61. Maxeon is wrong.

A. A POSITA Would Be Able to Grow a Useful Chemox as Taught in Kwark

Maxeon's claim that Kwark's chemical oxide ("chemox") "only works" at low temperature anneals is a mischaracterization of the reference. POR at 56-59.

Maxeon is wrong to speculate without evidence that Kwark may have failed to create a uniform oxide layer. POR at 60. As Dr. Banerjee explained in his deposition, the RCA clean process is a "very standard procedure to clean silicon wafers . . . which, by the way, I've been using for 30, 40 years. And an outcome of that cleaning process is you will end up growing this chemical oxide on the surface. So that's what they are using in this particular example [in Kwark]." EX2023, 57:3-9. Dr. Banerjee further explained that chemox layers ranging from 10-20 angstroms in thickness could be grown using "a range of temperatures and times and chemical recipes that are used that I teach my undergrad students in my class." EX2023, 58:3-59:1. It was thus well within the knowledge of a POSITA to reliably grow a thin chemox layer, as described by Kwark. EX1067, ¶¶39-40. And,

a POSITA would understand that he or she could achieve a successful one sun solar cell based on the Froitzheim-Kwark combination.

1. A POSITA Would Achieve Improved J_o By Combining Froitzheim and Kwark

As in the Froitzheim/Gan combination, Maxeon incorrectly sets a “desirable” J_o of $2 \times 10^{-14} \text{ A/cm}^2$ as a purported limit for a working solar cell. POR, 57. It is not, as discussed above (§I.A.1). Kwark's abstract only reports this number as a J_o value attained with prior SIPOS films with interfacial oxide layer and makes no mention of any absolute J_o value that shall not be exceeded. EX1008 (Abstract). Maxeon's arguments fail for several reasons.

First, though it is true that Kwark's Figure 4 shows that J_o increases with anneal temperature, Figure 4 actually shows that a polysilicon emitter “with Chemox” has a lower J_o than one with “no chemox,” even up to 1000°C , as Maxeon's expert admitted. EX1066, 82:8-11, 84:18-21. Figure 4's description states: “note the large difference [i.e., higher J_o] when the interfacial oxide is missing.” EX1008 at 745 (Figure 4). As Dr. Banerjee explained, “the key point is, regardless of some degree of breakup, it's still beneficial to have this oxide compared to no oxide at all. . . . even up to thousand degrees it's beneficial because you get a lower [J_o] compared to the no chemox case.” EX2023, 67:7-16, 113:1-4. In the ID, the Board agreed that Figure 4 teaches “improved performance (i.e., lower J_{oc} values) [of ‘with Chemox’] over polysilicon emitters without an oxide

layer ('No Chemox')." ID at 19. Because there remains a significant improvement in the J_0 even at 1000°C, Maxeon's premise that a POSITA would not have a reasonable expectation of success is simply wrong.

Second, Maxeon's criticisms ignore that Kwark's polysilicon emitter offers advantages over a diffused emitter (the "Al contact" control in Kwark Fig. 4).⁴ The relevant comparison is not simply the differing effects of temperature on the chemox, but rather between conventional diffused emitters and polysilicon emitters with an interfacial oxide at a temperature range consistent with Froitzheim. A POSITA would expect successful results and benefits at 900-1000°C because the J_0 remains substantially lower than the J_0 of the "Al contact" control in Fig. 4. EX1008 at 743; EX1066, 84:18-25; *see also* ID at 19 ("despite Gan's data showing the effect of annealing temperature on the oxide layer, Gan states that 'the cell performance can be improved if the diffused-emitter is replaced with the polysilicon emitter'...").

Third, it is wrong to conclude from Kwark that samples with a chemox layer would have higher J_0 than samples without chemox at temperatures above 1000°C.

⁴ The "Al Contact" differs from the "prediffused emitter B" only in the use of a conventional aluminum contact diffused emitter, instead of polysilicon. EX1008 at 743.

POR at 58-59. Dr. Ruby's attempts to extrapolate the results of Kwark should be rejected as unsupported and unreliable. EX2020, ¶221; EX1066, 190:7-9. He fails to explain how a chemox layer broken up at a high temperature could have an even higher J_0 than the reported "no chemox" control, and he did not run experiments or make calculations to corroborate such results. EX1066, 89:13-24. Instead, a POSITA would understand that as temperature increases, the J_0 of the chemox case "asymptotes to the value for [the no chemox case]." EX2023, 113:5-14; EX1067, ¶32.

Maxeon also makes much of Kwark's reference to outdiffusion being "severe [enough]" at 1000°C to account for the differences between emitter B and C. POR at 32; EX1008 at 743. But a POSITA would understand that temperature and time can be adjusted to avoid "severe" outdiffusion, for example, by annealing at a temperature between 900-1000°C, which is consistent with Froitzheim and is where Kwark reported a beneficially lower J_0 . EX1067, ¶¶30-33. Furthermore, for the reasons discussed in §I.A.1, a POSITA would understand to apply the lower end of the preferred temperatures disclosed in Froitzheim (*i.e.*, 900-1000°C). Thus, a POSITA would readily understand that outdiffusion would be less "severe" at the lower temperature.

2. Kwark's Resistivity Would Work for a One-Sun Solar Cell

Maxeon also points to the Gan Thesis's statement that a chemically grown interfacial oxide having a ρ_c resistivity of $4 \times 10^{-4} \Omega\text{-cm}^2$ "would be intolerable." POR at 60. But this statement was made in the context of concentrator cells. EX2003 at 23. As discussed in §I.A.2, a POSITA would know that non-concentrator cells are less stringent than concentrator cells and would be effective even with a higher ρ_c value. EX1067, ¶28. Gan Thesis's purported $4 \times 10^{-4} \Omega\text{-cm}^2$ resistivity is still more than an order of magnitude lower than Dr. Ruby's admitted "less than $1 \times 10^{-2} \text{ ohm-cm}^2$ " requirement for one-sun cells. *Id.*, ¶36; EX2020, ¶64. Thus, a POSITA would not be dissuaded from combining Froitzheim and Kwark, and would reasonably expect success in that combination.

Moreover, a POSITA would understand that the Froitzheim-Kwark combination would have lower contact resistance. When the polysilicon emitter with oxide layer is applied to the one-sun solar cell of Froitzheim, the full back metal contact (15) of Froitzheim (as shown in Figure 1) would reduce the overall contact resistance (and compensate for the higher ρ_c) because contact resistance is dependent on the surface area of the contact between the two conducting materials. EX1067, ¶37; EX1066, 47:17-48:5. Based on simple math, a POSITA would know that the greater the contact area (denominator), the lower the contact resistance would be. EX1067, ¶37; EX1066, 47:23-48:5.

A POSITA would also be capable of using ordinary creativity to modify the thickness of the oxide to reduce resistivity. A POSITA would understand that ρ_c resistivity depends on the thickness of the oxide layer which acts as an insulator, as disclosed by the Gan Thesis. EX2003 at 9 (expressing ρ_c as resistivity multiplied by oxide thickness divided by the broken areal function). Thus, a thinner oxide layer would result in a lower ρ_c . EX1067, ¶38; EX1066, 47:1-22. Even before Froitzheim in 2006, a POSITA would know how to adjust the thickness of a chemox layer by adjusting the growth conditions of the chemox layer. EX1067, ¶39, citing Petitdidier (EX1064 Fig. 2). Thus, a POSITA would reasonably expect to succeed in replacing the diffused emitter in Froitzheim's one-sun, full back metal contact solar cell with a polysilicon emitter/chemox structure as taught by Kwark. EX1067, ¶¶37, 40.

B. A POSITA Would Be Motivated to Combine Froitzheim and Kwark

Most of Maxeon's arguments regarding motivation to combine overlap entirely with its reasonable expectation of success arguments. *See* POR at 60. Thus, as explained above and in the Petition, these arguments should be rejected.

Maxeon's only other argument is a conclusory paragraph alleging purported concerns with long-term performance degradation or reproducibility of chemox. POR at 61. Maxeon provides no support for this speculation. Instead, Maxeon cites to ¶227 of its expert declaration, which essentially regurgitates the same few

sentences, also with no support. Thus, this argument should be disregarded as conclusory.

Even if Maxeon's argument is considered, it is incorrect. Though the Gan Thesis describes the thermal oxide as "more robust" compared to a chemically grown oxide, it would not discourage a POSITA from fabricating a solar cell with an interfacial chemical oxide layer and a polysilicon emitter. Instead, even if chemox is slightly more sensitive as compared to a thermal oxide, a polysilicon emitter with a chemox layer still provided a substantial reduction of J_0 over the range of temperatures from 900°C-1000°C compared to a polysilicon emitter without chemox or a diffused emitter. EX1008 at 745 (Fig. 4). Thus, a POSITA would be motivated to combine Froitzheim and Kwark to reduce J_0 recombination and improve solar cell efficiency.

C. Maxeon's Teaching Away Argument Fails

Maxeon's teaching-away arguments for Froitzheim-Kwark merely incorporate its arguments for Froitzheim-Gan. As discussed above at §I.C, Maxeon's arguments fail.

D. The Froitzheim-Kwark Combination Satisfies Claim 12

Maxeon's arguments regarding Froitzheim-Kwark for claim 12 incorporate its arguments for Froitzheim-Gan. As discussed above at §I.D, Maxeon's arguments fail.

III. FROITZHEIM AND BORDEN (GROUND 5)

Maxeon makes little attempt to respond to the majority of CSI's arguments, and focuses primarily on motivation to combine.⁵ Maxeon's arguments fail.

A. A POSITA Would Be Motivated to Combine Froitzheim and Borden

Maxeon's arguments should be rejected because they are based on an overly narrow read of the benefits of Borden as applying only to amorphous silicon.

As the Board acknowledged in the ID, Borden discloses "that tunnel oxides can be used between a heavily doped or insulating layer of polysilicon and a crystal silicon substrate, forming a polysilicon emitter solar cell." ID at 20.

Maxeon does not dispute that a polysilicon emitter with an interfacial tunnel oxide is disclosed, instead claiming the benefits "are not directed to polysilicon emitter cells." POR at 62. But Maxeon does not explain why Borden would disclose an embodiment forming a polysilicon emitter cell if the benefits would not apply to such a cell, nor does it point to any instance where Borden disparages the use of

⁵ Maxeon's introductory paragraph on Froitzheim-Borden makes a conclusory and unsupported statement that Borden does not disclose an oxide layer between the substrate and the emitter. POR at 62. This is wrong, as explained in the Petition at 67-68.

polysilicon. Instead, polysilicon emitter solar cells are one of two examples of what the invention in Borden encompasses. The first sentence of Borden's summary of invention reads: "the present invention relates to improved HIT type *or polysilicon emitter solar cells.*" EX1009, [0008] (emphasis added).

Borden discloses several benefits of its invention, including that it "prevents epitaxial growth of amorphous silicon" and "protect[s] the surface from plasma damage." *Id.* Both of these benefits apply also to CSI's Froitzheim-Borden combination. As Dr. Banerjee explained in his deposition:

I think the key teaching in Borden is that use of interfacial oxide. If you had put amorphous silicon on top, it would prevent epitaxial regrowth of amorphous silicon. If you didn't have amorphous silicon, instead have polysilicon, you would help minimize the epitaxial growth of the polysilicon. And the presence of the interfacial oxide would help minimize any plasma damage, if you're doing plasma-enhanced deposition.

EX2023, 152:6-15 (emphasis added). Maxeon's misleading characterizations of Dr. Banerjee's testimony ignore this, as well as his testimony that "a lot of the benefits transfer from amorphous silicon to polysilicon." *Id.* 145:1-12; *see also* EX1066, 120:15-121:1. Further, Borden's additional stated benefit of increased efficiency with a point contact structure is not limited to amorphous silicon. EX1009, [0008]; EX1066, 120:23-121:1. Thus, the benefits of Borden would motivate a POSITA to combine it with Froitzheim.

B. The Froitzheim-Borden Combination Satisfies Claim 12

Maxeon's arguments regarding Froitzheim-Borden for claim 12 incorporate its arguments for Froitzheim-Gan. As discussed above at §I.D, Maxeon's arguments fail.

IV. SECONDARY CONSIDERATIONS

Maxeon does not dispute that there is no commercial success or that the '516 Patent achieved no unexpected results with respect to a polysilicon emitter with an interface oxide layer. In fact, the '516 Patent says nothing about how to grow its oxide layer other than to use thermally grown silicon dioxide at varying thicknesses (e.g., EX1001, 2:64-66). This confirms there was nothing unusual or unexpected about generating the oxide layer beyond what was known to a POSITA.

V. COLLATERAL ESTOPPEL

CSI understands that the Board has rejected CSI's collateral estoppel arguments in the ID. Solely for preservation for appeal, CSI incorporates herein the arguments it made in the Petition on collateral estoppel.

VI. CONCLUSION

For the reasons set forth above and in the Petition, CSI respectfully requests that claims 9-12 of the '516 Patent be cancelled as unpatentable.

Dated: July 1, 2025

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE

I hereby certify that this brief complies with the type-volume limitations of 37 C.F.R. § 42.24, because it contains 5,492 words (as determined by the Microsoft Word word-processing system used to prepare the brief), excluding the parts of the brief exempted by 37 C.F.R. § 42.24.

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I hereby certify that on this 1st day of July, 2025, a copy of the foregoing and accompanying exhibits, has been served in its entirety by electronic mail on the following counsel of record for patent owner:

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