

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. IPR2024-01040
U.S. Patent No. 8,878,053

PATENT OWNER RESPONSE

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PATENT OWNER’S EXHIBIT LIST

Exhibit No.	Description
2001	<i>Intentionally Left Blank</i>
2002	<i>Intentionally Left Blank</i>
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 Energies 3060 (2020)
2012	File History of U.S. Patent No. 8,222,516
2013	File History of U.S. Patent Application No. 17/870,268
2014	<i>Intentionally Left Blank</i>
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	U.S. Patent no. 8,222,516 to Cousins
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)
2024	U.S. Patent Pub. No. 2002/0142500 to Foglietti

I. INTRODUCTION

Patent Owner, Maxeon Solar Private Limited, (“Maxeon” or “Patent Owner”) submits its Patent Owner Response to Petitioner, Canadian Solar Inc.’s (“CSI’s” or “Petitioner’s”), Petition for *Inter Partes* Review.

II. OVERVIEW OF THE ’053 PATENT

A. Background Art of the ’053 Patent

Solar cells convert solar radiation to electrical energy. Ex. 1001, 1:25-30. The front side of the solar faces the sun. A solar cell with at least one metal contact on the front side is called a “front contact solar cell.” Ex. 1001, 1:37-41.

B. The ’053 Patent

The ’053 patent discloses and claims a novel front contact solar cell with formed emitter. Ex. 1001, Title.

The patent describes, with reference to Fig. 1, a cross-section of a solar cell in accordance with an embodiment of the present invention. Ex. 1001, 2:6-7.

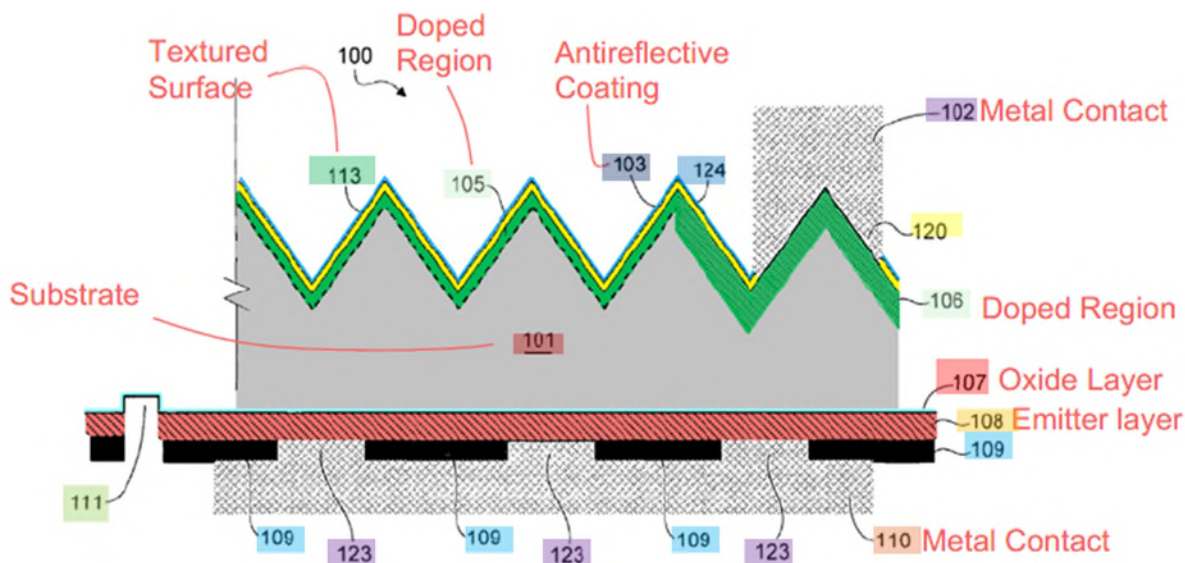


FIG. 1

Ex. 1001, Fig. 1 (annotated).

In this exemplary embodiment, an N-type silicon substrate 101 is formed from a silicon wafer, is etched to remove damaged surfaces. Ex. 1001, 3:59-64. The front side of the substrate is located at the top of Fig. 1 and faces the sun, the back side of the substrate is at the bottom of Fig. 1 and faces away from the sun. *Id.* at 2:33-34. A tunnel oxide 107, which can be silicon dioxide, is provided on the back surface of the substrate 101. *Id.* at 4:4-8.

A layer of polysilicon 108 is deposited on the tunnel oxide layer 107 to form the polysilicon emitter 108 (formed on the back side). Ex. 1001, 4:9-11. A dopant source layer 461 (not shown in Fig. 1) is formed on the polysilicon emitter 108 (i.e., formed on the back side of the polysilicon emitter) and the dopant is later driven into the polysilicon layer during a drive-in step. *Id.* at 4:14-27. A capping

layer 462 (not shown in Fig. 1) is formed over this dopant layer to keep the dopants from escaping during the dopant drive in process. *Id.* at 4:18-21. An edge isolation trench 111 is formed near the edge of the substrate 101 and is cut through the capping layer all the way through to contact a small area of the substrate 101. *Id.* at 4:28-35.

Exposed surfaces of the substrate 101 (on the front side) are etched to form pyramid like structures 113. Ex. 1001, 4:36-41. This etching step removes the previously applied layers 401 and 402, as can be seen in Figs. 4D and 4E. An N-type dopant source 412 is formed on the textured surface of the substrate. *Id.* at 4:42-46. The N-type dopants from dopant layer 412 are then driven-in to the substrate 101 forming N-type doping regions 105 and 106. This drive-in step also drives in the dopants from the doping source layer 461, into the back side of the polysilicon (polysilicon emitter 108), thus forming a **backside junction**. *Id.* at 2:43-45, 4:60-5:1.

The drive in step may be formed in-situ, which the patent explains is “a single manual (i.e., by fabrication personnel) loading of the substrate 101 in a furnace or other single chamber of multi-chamber processing tool.” *Id.* at 5:9-16. After this drive in step, layers 461 and 462 become silicon dioxide layer 109 and the front side of the silicon becomes N-doped region 106. *Id.* at 4:66-67, 2:43-45.

A thin silicon dioxide layer 124 is provided as a passivation layer on the surface of the silicon substrate 101. *Id.* at 5:6-8.

An antireflective (also serving as a dielectric) coating of silicon nitride layer 103 is formed over the textured surface 113 after removal of the N-type dopant source layer 412. Ex. 1001, 5:28-34. A front contact mask is then provided on the silicon nitride layer 103 to create a pattern for forming contact holes 102. *Id.* at 5:36-40. A back contact mask 422 is used on the silicon dioxide layer 109 to create a pattern for the back side contact holes 123. The holes 102 and 123 are then etched away. *Id.* at 5:46-55.

A back side metal contact 110 is formed on the silicon dioxide layer 109 to fill the contact holes 123 and to make electrical connection to the polysilicon emitter 108. Ex. 1001, 5:56-63. Finally, a front side metal contact 120 is formed on the silicon nitride layer 103 to fill contact holes and to make electrical connection to the substrate 101. *Id.* at 5:64-66.

While Fig. 1 illustrates a solar cell with an N-type substrate and a P-type polysilicon emitter forming a backside junction, the patent claims are broader than that and can encompass an N-type substrate and an N-type polysilicon emitter forming a backside junction. Ex. 2020, ¶95. This is shown in the below comparison of the independent claims 1, 9, and 16.

Claim 1	Claim 9	Claim 16
1. A method of fabricating a solar cell having a front side facing the sun to collect solar radiation during normal operation and a backside opposite the front side, the method comprising:	9. A method of fabricating a solar cell comprising:	16. A method of fabricating a solar cell comprising:
		forming an oxide layer over a back surface of a silicon substrate;
forming a layer of polysilicon over a back surface of an N-type silicon substrate on the back side of the solar cell;	forming a layer of polysilicon over a back surface of a silicon substrate;	forming a layer of polysilicon over the oxide layer;
forming a P-type dopant source over the layer of polysilicon;	forming a first dopant source layer over the layer of polysilicon;	
forming a capping layer over the P-type dopant source;		
diffusing P-type dopants from the P-type dopant source to the layer of polysilicon to form a backside junction with the N-type silicon substrate;	diffusing dopants from the first dopant source layer to the layer of polysilicon to form a backside junction with the silicon substrate;	diffusing dopants into the layer of polysilicon to form a backside junction with the silicon substrate;
diffusing N-type dopants into a front surface of the N-type silicon substrate; and	diffusing dopants into a front surface of the silicon substrate, the front surface of the silicon substrate facing the sun during normal operation; and	diffusing dopants into a front surface of the silicon substrate, the front surface of the silicon substrate facing the sun during normal operation; and

Claim 1	Claim 9	Claim 16
forming a metal contact on the front side of the solar cell, wherein the metal contact is electrically coupled to the N-type silicon substrate.	forming a metal contact on the front surface of the silicon substrate, wherein the metal contact is electrically coupled to the silicon substrate.	forming metal contacts on the front surface of the silicon substrate, wherein the metal contact is electrically coupled to the silicon substrate.

Ex. 1001, claims 1 (6:13-29), 9 (6:52-65), and 16 (7:19-8:6) (emphasis added).

As is shown above, claim 1 is directed toward specific N-type and P-type dopants/dopant sources in the silicon and polysilicon layers, respectively. Claims 9 and 16, on the other hand, are silent with respect to the types of dopants/dopant sources used to dope the silicon substrate and the polysilicon layer. Therefore, considering the dopants/dopant sources, claims 9 and 16 are broader in scope than claim 1. Claims 9 and 16 are not limited to N-type silicon and P-type polysilicon layers. Ex. 2020, ¶96.

C. Prosecution History of the '053 Patent

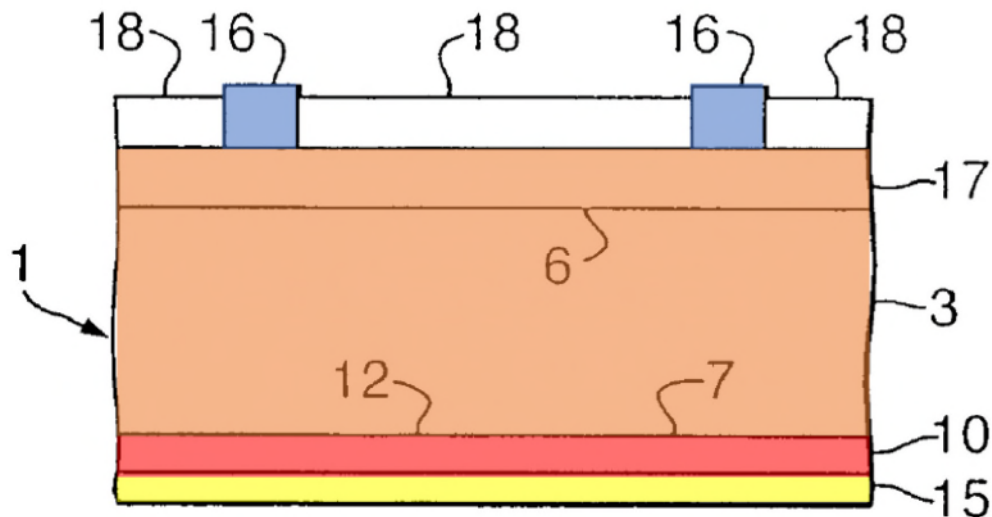
During prosecution of the '053 patent's parent application (*i.e.*, the '516 patent), the Examiner issued a restriction requirement between the claims “drawn to a solar cell” and those “drawn to a method of making a solar cell.” Ex. 2012, 61. The assignee, SunPower Corporation, elected the solar cell claims for the '516 patent and filed a divisional application to pursue the method claims issued in the '053 patent and challenged here. *Id.* at 70. The '053 patent issued after the Examiner determined that “[t]he prior art of record lacks the instantly claimed backside junction formed at the interface of a first material of a silicon substrate

comprising one dopant type and a second material of a polysilicon layer of an opposite dopant type.” Ex. 1002, 250.

III. THE PRIOR ART

A. Froitzheim (Ex. 1006)

EP1732142A1 (“Froitzheim”) explains that in conventional (one sun) solar cells, an N-type emitter is located on the front side of the cell to form a P/N junction with P-type doped substrate. Petition, 21; Ex. 1006, ¶2; Ex 1003, ¶84. In contrast to such conventional cells, Froitzheim proposes to form the emitter at the rear (back) side of a solar cell creating a P/N junction at the rear side of the substrate. Ex. 1006, ¶8.



Petition, 21 (citing Ex. 1006, ¶24) (annotations in Petition).

Specifically, the proposed solar cell includes an N-doped substrate 3 having a front side 6 and a rear side 7. Ex. 1006, ¶24. Froitzheim provides a P-doped

layer 10, *id.* at ¶22, which is actually a region of the substrate 3 doped with boron to form a P/N junction 12, *id.* at ¶25. A contact 15 covers substantially all of the rear side 7 of the cell. *Id.* at ¶27. The front side 6 of the substrate 3 is heavily doped with an N-type dopant, *e.g.*, phosphorous, to provide a heavily N-doped layer 17 formed in the substrate in a region at the front side 6. *Id.* at ¶28. Contacts 16 are fabricated to contact the top side 6 of the underlying substrate 3, *id.*, and passivation layer 18 is formed over the exposed areas of the N-type doped layer 17, *id.* at ¶30.

Froitzheim teaches doping the front side 6 of the substrate 7 with an N-type dopant and doping the back side 7 of the **same silicon substrate 3** with a P-type dopant. Petition, 21; Ex. 1006, Abstract; *id.* at ¶¶10, 11, 40. To drive the dopants into the rear side 7, Froitzheim teaches “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degrees centigrade, preferably between 1000 and 1100 degree C, to generate an oxide layer and to drive in the dopant.” Ex. 1006, ¶ 42. This high temperature processing required by Froitzheim is important because, as explained below, the secondary references Gan and Kwark warn that treatment at such a high temperature must be avoided in order to attain a cell with the alleged benefits of an oxide layer disclosed by Gan and Kwark.

Dr. Banerjee testified as to why Froitzheim preferred a temperature between 1000°C and 1100°C:

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... So higher temperature, more will be the diffusivity. And that will determine the junction depth. But it also depends on diffusion time...

Q: So they're trying to achieve a higher diffusion. Is that correct?

A: . . . 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.

The 1000°C to 1100°C temperature range preferred by Froitzheim maximizes the efficiency of the solar cell. Reducing the dopant drive in temperature to the lower temperatures taught by Gan and Kwark would reduce the efficiency of the solar cell described by Froitzheim. Ex. 2020, ¶113.

Froitzheim does not disclose the use of a polysilicon layer, and instead proposes using a silicon substrate 3 with in-substrate doped regions in its front and back surfaces. Froitzheim does not teach or suggest providing a polysilicon layer on the back surface of the substrate as required by claims 9 and 16 or providing an oxide layer, *e.g.*, a tunnel oxide, between the rear surface of the substrate and a polysilicon layer, as required by claim 16. Consequently, CSI resorts to research papers (Gan and Kwark) and proposes to add to Froitzheim an oxide layer and a polysilicon layer from those papers to meet the limitations of claims 9 and 16. However, as discussed below, an author of one of the papers, in the Gan Thesis, candidly admits that results of the experiments described in both papers were unreliable and frequently failed. For example, the Gan Thesis states “[t]heoretically, a model was proposed to make the polysilicon emitter with both low J_o ($\sim 3 \times 10^{-14}$ A/cm²) and low contact resistance ($\rho_c \leq 1 \times 10^{-5}$ Ω-cm²).” Ex. 2003, 8 (Abstract) (emphasis added). However, the Gan Thesis concluded that the “thin-oxide growth recipe used in this work was not reliable,” that “solar cells that were made in this study all suffered high contact resistance” and that “in the real solar cell runs, the situation grew even worse.” *Id.* at 129, 135-36 (110, 116-17 in original). In view of this pessimistic assessment, a POSITA would have had little motivation to combine the unproven and unreliable technology of Gan or Kwark

with Froitzheim and surely would have had no reasonable expectation of success from doing so. Ex. 2020, ¶¶115-16.

B. Gan (Ex. 1007)

Initially, as noted above, there are two Gan publications relevant to the Petition. One is a publication that CSI uses as the Gan reference in combination with Froitzheim. This is Gan et al., “*Polysilicon Emitters for Silicon Concentrator Solar cells*,” Proceedings of the 21st IEEE-PVSC (“Gan”), which was a paper presented in 1990 (Ex. 1007, face, ii-iii). Petition, 22.

The other is the Gan Thesis (Ex. 2003). The Gan Thesis was published and publicly available on the shelves in the Stanford Library on April 10, 1991, which is prior to the priority date of the ’053 patent. See, Ex. 2022, ¶23. Thus, a POSITA would have had knowledge of both of Gan and the Gan Thesis before that priority date. As explained below, the Gan Thesis is important for several reasons, including telling the complete story of why the technology disclosed in Gan was experimental, could not be reliably reproduced, and was not suitable for use in commercial concentrator cells. *Id.*

CSI and its expert, Dr. Banerjee, have made clear that the proposed Froitzheim-Gan and Froitzheim-Kwark combinations start with the method described in Froitzheim to prepare the silicon substrate and stops prior to diffusing the dopants into the substrate. Petition, 33-34, 60. The combinations switch to

Gan (or Kwark) to “perform Gan’s steps of thin thermal oxide growth to form the interfacial layer and polysilicon deposition to form the polysilicon on the back side of the wafer” after which the polysilicon would be doped using the steps in Froitzheim to form the polysilicon emitter. *Id.* at 33-34 (citing Ex. 1003, ¶102, Ex. 1007, 246); see also Ex. 2023, 85:14-20 (“Q: Then after you add the oxide in [and] the polysilicon layer from Gan, then you would follow Froitzheim steps to add the dopant. Correct? A: Yes. Q: And would that be the same with Kwark and Borden? A: Well, this part essentially, yes.”).

Below are the steps used in Gan to add the oxide and polysilicon layers. Note, the steps with an “*” are the steps where Gan measures the J_o values. Ex. 2020, ¶121.

- | | | |
|-------------------------------------|---|--|
| Start of process used in Gan |  | 1. Field oxidation (2000 Å)*. |
| | | 2. Polysilicon-substrate contact opening*. |
| | | 3. Thin thermal oxide growth at 800 °C*. (10-minute oxygen flow) |
| | | 4. Polysilicon deposition (6000 Å) and first-step anneal (1050 °C)*. |
| | | 5. First-step anneal *. |
| | | 6. Polysilicon finger definition. |
| End of process used in Gan |  | 7. Undoped glass deposition (2000 Å). |
| | | 8. Metal-polysilicon and metal-substrate contact opening. |
| | | 9. Doped glass deposition on both sides of the wafer*. |
| | | 10. Drive-in; 900-1000 °C*. |
| | | 11. Doped glass stripping and Al-1% Si alloy deposition. |
| | | 12. Metal finger definition. |

Ex. 1007, 246 (annotated)

Step 4 (the anneal performed at 1050°C) causes breakup of the oxide layer.

Ex. 2020, ¶122. This step and step 10, the drive-in step, were the subject of Gan's measurements to try to achieve acceptably low J_o values. Ex. 1007, 246. Step 10 is referred to as "the second-step anneal" in Gan's Table 1 below. Ex. 1007, 248.

Table 1: The effect of the second-step anneal on J_o and ρ_c .

	N-type		P-type	
	$J_{o,e} (\times 10^{-14} \text{ A/cm}^2)$	$\rho_c (\mu\Omega\text{-cm}^2)$	$J_{o,e} (\times 10^{-14} \text{ A/cm}^2)$	$\rho_c (\mu\Omega\text{-cm}^2)$
900 °C-4 hour	2.4	18	3.5	18
1000 °C-30 min	4.5	~ 6	8.2	3.8
1000 °C-60 min	7.9		10.5	

Ex. 1007, 248, Table 1

Table 1 shows that as the temperature and time of the second step anneal increase, the value of J_o increases, which is not a desired result. Ex. 2020, ¶123.

The Petition states that "before introducing the boron dopant by diffusion at the rear side of the substrate (for example, as described in ¶40-41 of Froitzheim, the Skilled Artisan would perform Gan's steps" to grow the thin thermal oxide and form the polysilicon layer. Petition, 33. Paragraphs 40-42 of Froitzheim, which CSI used to add the dopant to the proposed combination and then drive in the dopants, states:

[0040] Providing a non-alloyed p-type doped region is done by a process which introduces dopant, preferably boron, only by diffusion into the rear surface of the body layer. . .

[0041] In general terms, a diffusion source layer that contains boron as a dopant is applied, e.g. spun, only onto the back of the n- doped

silicon wafer. The diffusion source layer is one that contains boron and out of which the boron is thermally driven. . . .

[0042] A suitable doping liquid is Siodop (TM) of Merck. Then the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degree centigrade, preferably between 1000 and 1100 degree C, to generate an oxide layer and to drive in the dopant.

Ex. 1006, ¶¶40-42 (emphasis added).

Froitzheim's dopant drive-in steps are performed at preferably between 1000°C and 1100°C. Ex. 1006, ¶42. Froitzheim uses these high temperatures to get the correct dopant concentration and junction depth. Ex. 2023, 81:7-83:10. However, at these dopant drive in temperatures, the value of adding the thin oxide layer of Gan is damaged to the point that Gan did not even test dopant drive in steps at greater than 1000°C. Ex. 2020, ¶125.

Gan (Ex. 1007) and the Gan Thesis (Ex. 2003) both describe experiments that focused on trying to find the optimum temperature to be used in creating an interfacial oxide between a crystalline silicon substrate and a polysilicon layer and, more specifically, on how to break up the interfacial oxide a little, but not too much. Gan tried different anneal temperatures and durations and determined that above 900°C, the oxide breakup becomes too much. Ex. 2020, ¶119; *see also* Ex. 1007, 248 (“Considering the significant increase of J_o caused by increasing the

drive-in temperature from 900 to 1000°C, it is beneficial to use the two-step anneal to optimize J_o .”); *id.* at (Table 1)

Gan examined “polysilicon emitters with a thermally grown interfacial oxide” for solar cells. Petition, 23 (citing Ex. 1007, 245). Gan also taught that “a very thin oxide (interfacial oxide)” “[a]lways exists” between the polysilicon emitter and the substrate.” Ex. 1007, 245. More importantly, Gan Thesis teaches that “solar cells that were modeled or made in this study all suffered high contact resistance” and that “in the real solar cell runs, the situation grew even worse.” *See, e.g.*, Ex. 2003, 129 (110 in original); *see also id.* at 135-136 (116-117 in original). Thus, the Gan Thesis refutes CSI’s narrative that Gan successfully formed an interfacial oxide layer between a silicon substrate and a polysilicon layer. *See* Petition at 23 (citing Ex. 1007, 245); Ex. 1003, ¶88.

Further, CSI ignores teachings in Froitzheim and Gan from which a POISTA would have understood the references to be incompatible. First, based on the title of Gan—“*Polysilicon Emitters for **Silicon Concentrator Solar Cells***”—a POSITA would have known that Gan’s experiments pertained to the specialized field of concentrator cells discussed above. Ex. 2020, ¶127. As Patent Owner’s expert explained, concentrator solar cells and one sun solar cells like Froitzheim are very different. *Id.* at ¶46.

Next, CSI's argument fails to account for the full extent of the failures that Gan encountered, as documented in the Gan Thesis: "[t]he thin-oxide growth recipe used in this work was not reliable . . . It is then clear that a more reliable way of growing the thin oxide is needed." Ex. 2003, 126 (107 in original). For these and other reasons discussed below, CSI does not (1) show a reasonable expectation of success and (2) fails to establish that a POSITA would have been motivated to combine Gan, focused on silicon concentrator solar cells, with the one sun solar cell of Froitzheim. Ex. 2020, ¶128.

CSI asserts that the combination "would have been well within the level of ordinary skill in the art" and involved "simple substitution of one known element and corresponding fabrication steps for another to obtain predictable results." Petition, 34 (citing Ex. 1003, ¶104). The teachings in Gan and the Gan Thesis, as discussed below, prove that CSI's assertion is not true and is inconsistent—even contrary—with the teachings in the applied art. Ex. 2020, ¶130.

The Gan Thesis discusses the work described in Gan and repeatedly characterizes it as "theoretical," and catalogs for a POSITA a variety of failures and unreliable results. *See, e.g.*, Ex. 2003, 8 (Abstract); *id.* at 72 (53 in original). The unreliable results are documented in the Gan Thesis and belie CSI's argument that the combination of Gan and Froitzheim would yield "predictable results." *See* Petition, 34 (citing Ex. 1003, ¶¶154-55). Moreover, the cited paragraphs relate to

the teachings of Hartiti and Sivoththaman, and not to an expectation of success in combining Gan and Froitzheim.

Understanding that both Froitzheim and the '053 patent are directed to one sun cells, CSI runs from the title of Gan, "*Polysilicon Emitters for Silicon **Concentrator** Solar Cells*," by noting that "[w]hile Gan referred in part to silicon concentrator solar cells, it more broadly suggested that a polysilicon emitter with interfacial oxide is 'quite useful for silicon solar cells.'" Petition at 30 (citing Ex 1007, 249); Ex. 1003, ¶100. However, in its Conclusion, the Gan Thesis established its focus on concentrator solar cells, stating "[f]rom the cell modeling, polysilicon emitters with these qualities can be useful for silicon **concentrator** solar cells." Ex 1007, 249 (emphasis added). As Patent Owner's expert explains, 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. Ex. 2020, ¶¶48-50. Tellingly, a review of the experimental and modeling results reported in the Gan Thesis, including mention of high current levels in the range of 100 A/cm² (equivalent to 2500 suns), Ex. 2003, 28 (9 in original), indicate that the "modeling" referred to by Gan (Ex. 1007) were of silicon concentrator solar cells. Ex. 2020, ¶132. Thus, a POSITA would not look

to modifying the one sun solar cell structure of Froitzheim with the teachings of Gan relating to concentrator solar cells. Ex. 2020, ¶133.

Substantively, Gan is specific about the effect of a high temperature anneal on the interfacial oxide layer between the silicon substrate and the polysilicon layer:

In either case, the oxide is not thermally stable; *i.e.*, it tends to break up during high temperature anneals. 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 on the specific contact resistivity (ρ_c) [6] and the emitter saturation current density (J_o) [1,2,3,4,5,6,7] upon either the anneal condition or the oxide integrity.

Ex. 1007, 245.

Gan specifically says that when the anneal temperature is high and the oxide layer loses its integrity, the ρ_c is low and the J_o is high:

With the effect of the interfacial oxide is negligible, such as when the interfacial oxide loses its integrity in high temperature anneals, the ρ_c is low ($\sim 2 \times 10^{-7}$ -cm²) [6] and the J_o is high ($\sim 1 \times 10^{-12}$)[1,3].

Conversely, when both the carriers are mostly blocked by the interfacial oxide, like for an intact chemical oxide (~ 15 Å), the ρ_c is high and the J_o is low.

Ex. 1007, 245.

Gan teaches that it is optimal to have low values for both J_o (emitter saturation current density] and ρ_c (contact resistivity], and this is achieved when “when both carriers are mostly blocked by the interfacial oxide.” Ex. 1007, 245, 249. What Gan is trying to determine are values for “ ρ_c and J_o when only a small fraction of the interfacial oxide is broken.” *Id.* According to Gan “there always exists a very thin oxide (interfacial oxide), which can be the by-product of the cleaning process or is grown intentionally . . . In either case, **the oxide is not thermally stable, i.e., it tends to break up during the high temperature anneals.**” *Id.* at 245 (emphasis added). Gan explains that “[t]he first-step anneal, which serves to break up the oxide, was performed at higher temperature than that for the second-step anneal which aims for the dopant drive-in.” *Id.*

Gan ran multiple experiments for combinations of temperatures for the first anneal (oxide break up) and the second anneal (dopant drive in) and reported the results in Figure 6, which is a plot of ρ_c v. J_o , with a key in the top right that shows “the type of polysilicon emitter, the first-step anneal (temperature/minute), and the second-step anneal (temperature/minute).” Ex. 1007, 249, Fig. 6. The goal was to provide low values for J_o .

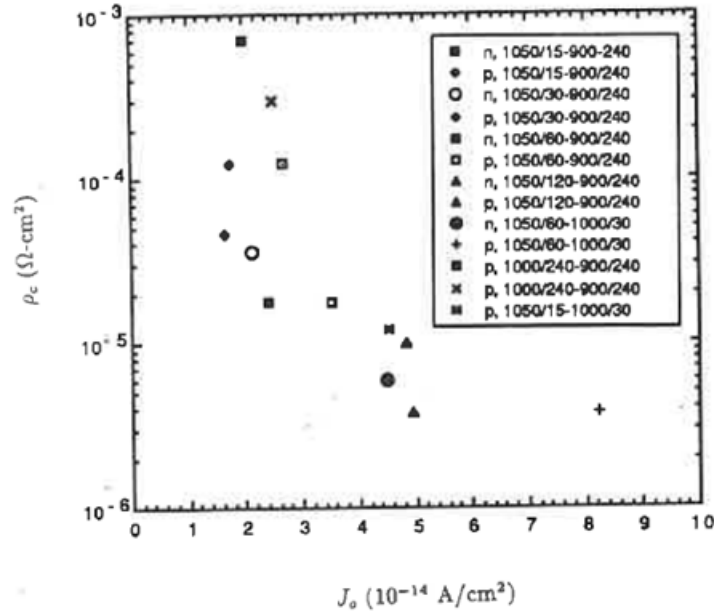


Figure 6: ρ_c - J_o of this work.

Ex. 1007, Fig. 6.

This graph shows that the higher the temperature of the second step anneal (the anneal to drive the dopants into the polysilicon), the higher the J_o . In fact, this figure shows much lower J_o values for the 900 °C second anneal (“regime 1”) than for the 1000°C second anneal (“regime 2”). Ex. 2020, ¶141. Gan then discusses this figure and observes for regimes 1 (900°C) “ J_o is almost constant while ρ_c drops drastically” and for regime 2 (1000°C) “ ρ_c decreases very slowly and J_o increases in much faster pace.” Ex. 1007 at 249.

Gan also explains that the second step anneal is optimal when performed at “900 °C for 4 hours.” Ex. 1007, 247. Gan further says “[considering the

significant increase of J_o caused by increasing the drive-in temperature from 900 to 1000 °C, it is beneficial to use the two-step anneal to optimize J_o .” *Id*

Gan provided further analysis of the experimental results in Table 1, below. These results show that the higher the temperature of the second-step anneal and the longer its duration the worse the device works.

Table 1: The effect of the second-step anneal on J_o and ρ_c .

	N-type		P-type	
	$J_{o,e}$ ($\times 10^{-14}$ A/cm ²)	ρ_c ($\mu\Omega\text{-cm}^2$)	$J_{o,e}$ ($\times 10^{-14}$ A/cm ²)	ρ_c ($\mu\Omega\text{-cm}^2$)
900 °C-4 hour	2.4	18	3.5	18
1000 °C-30 min	4.5	~ 6	8.2	3.8
1000 °C-60 min	7.9		10.5	

Ex. 1007, Table 1

Gan shows that as the temperature increases above 900°C, ρ_c decreases but J_o increases rather than decreases, such that anything above 900°C results in a rapid decrease in the efficacy of the system. Ex. 2020, ¶143. Since Froitzheim teaches that to achieve dopant drive in for the rear surface of the substrate, “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degrees centigrade, preferably between **1000 and 1100** degrees C, to generate an oxide layer and **to drive in the dopant**,” Ex. 1006, ¶42 (emphasis added), combining Froitzheim and Gan either results in annealing at 900°C, which is identified as the lowest limit of Froitzheim’s teachings for the dopant drive in temperature, or performing the second step anneal (dopant drive in) at temperatures above 900°C, and preferably between 1000°C and 1100°C, which

Gan teaches causes “*Jo [to] increase[s] in much faster pace,*” Ex. 1007, 249, which would lead to poor cell efficiency. Ex. 2020, ¶143.

Simply put, while Gan teaches better results are achieved when the second anneal to drive in dopants is at 900°C or below, Froitzheim teaches that the temperature to drive in dopants is preferably at 1000°C to 1100°C. Consequently, following Froitzheim’s teachings nullifies the benefits sought by Gan, and following Gan’s lower annealing temperature prevents realizing the “junction depth” and “doping concentration” achievable when the dopants are driven in at the higher temperatures taught by Froitzheim. Ex. 2023, 85:7-87:1.

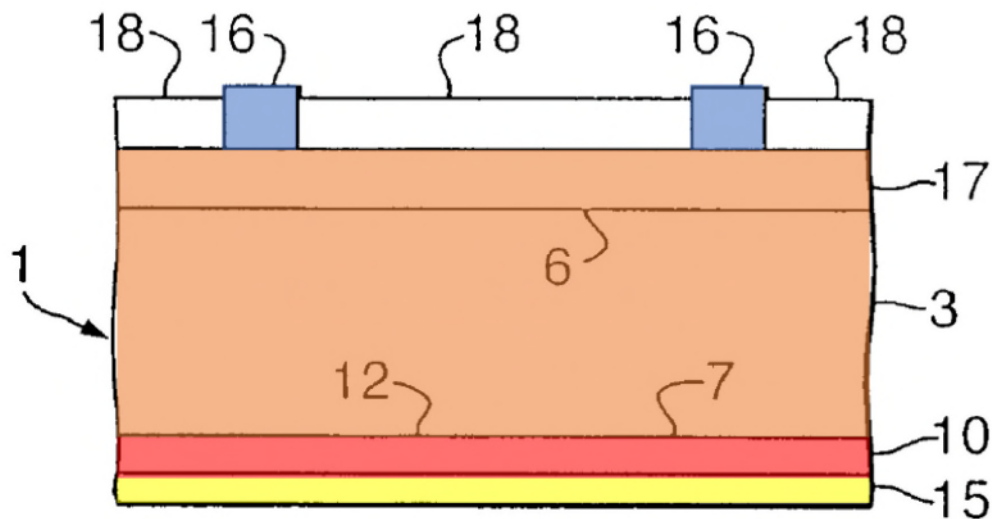
Rather than being motivated to combine Froitzheim and Gan as proposed by CSI, a POSITA would have found the substance of the teachings of the references on the second step anneal temperature to be contradictory and would have rejected the combination. Further, CSI’s reasonable expectation of success arguments fail not only on the merits because they are contradicted by teachings in the relevant art, but also are unsupported by expert testimony. Ex. 2020, ¶¶144-47.

C. Kwark (Ex. 1008)

Kwark et al. “*SIPOS Heterojunction Contacts to Silicon,*” International Electron Devices Meeting, 742-745 (1984) (“Kwark”). Ex. 1008. like Gan, does not concern a commercial embodiment of a solar cell, but focuses on the results of laboratory experiments relating to possible ways to increase the efficiency of a

solar cell. Ex. 2020, ¶148. As discussed below, some of these experiments failed and others identified developments that KwarK considered must be explored further.

Contrary to CSI’s claim, KwarK does not teach or suggest that “modify[ing] Froitzheim’s emitter [(i.e., a diffused in-substrate emitter)] to be a polysilicon emitter with an oxide layer” “would be an improvement.” Petition, 58 (citing Ex. 1003, ¶162); Ex. 2020, ¶149. In Froitzheim, the “in-substrate emitters” are the area 10 in which P-dopants are (boron) diffused into the back side 7 of the substrate 3 and the area 17 at the front side 6 of the substrate 3 in which N-type dopants (phosphorous) are diffused. Ex. 1006, ¶¶25, 41 (disclosing boron diffusion); *id.* at ¶¶24, 44 (disclosing phosphorus diffusion).



Petition, 21 (citing Ex. 1006, ¶24) (annotations in Petition).

Froitzheim makes no reference to polysilicon emitters, and Kwark does not mention in-substrate emitters at all, never mind suggesting improvements thereto. Ex. 2020, ¶150. CSI incorrectly attributes the “potential improvements” and “good results” that Kwark found for SIPOS emitter contacts to a polysilicon emitter. *Compare* Petition, 15 (citing Ex. 1008, 742) (“Incorporation of [SIPOS] films into the emitter structure of an NPE bipolar transistor had been found to reduce the emitter saturation current fifty fold; this translates into potential improvements of energy conversion for solar cells”) *with* Ex. 1008, 742 (“That the γ films [(aka $\gamma=0$ SIPOS contacts)] produced such good results was surprising since POLY films of comparable thickness should yield a J_{oe} an order of magnitude larger.”).

In particular, CSI argues that Kwark showed that in the “SIPOS contact structure[,] . . . the increase in J_{oe} at higher temperature is not as severe as for the devices in Fig. 4,” which shows the polysilicon emitter. Petition, 58; *but see* Ex. 1007, 743; *see also id.* at Figs. 4, 6 (below).

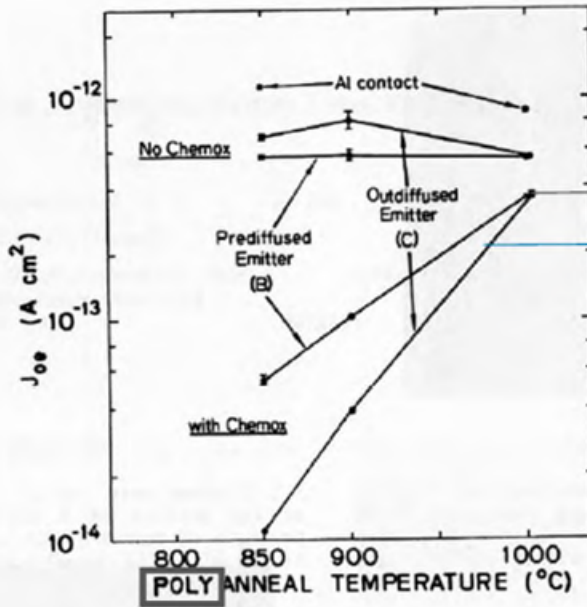


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

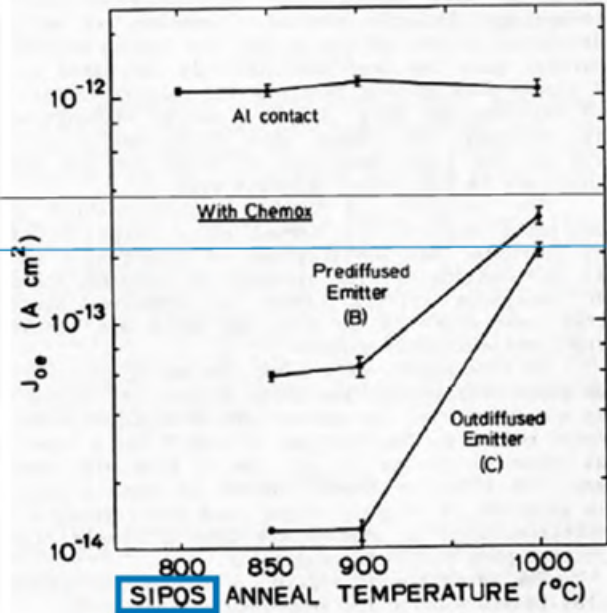


Fig. 6: emitter saturation current vs. anneal temperature for SIPOS contacts with a chemically grown interfacial oxide. The $\gamma = 0$ SIPOS layer is 3300 angstroms thick.

Ex. 1008, Figs. 4, 6 (annotated).

In other words, CSI posits that Kwark recognized that polysilicon emitters with a chemical oxide (“Chemox”) rapidly lose performance in saturation current density (J_o) after high temperature anneal steps whereas the SIPOS emitters are more resilient.

However, a POSITA would have understood from Kwark that the Chemox layer works far better when subject to low temperature anneals. Ex. 2020, ¶153; Ex. 1008, 742 (“In fact for devices annealed at 900°C/13 min, there is very little dependence on γ as seen in Fig. 2, although increasing the anneal temperature to 1000°C adversely affected J_{oe} .”), *id.*, 743 (“Fig. 4 displays the resulting J_{oe} as a

function of annealing temperature for emitter B which has a Gaussian (3×10^{19} surface concentration, 1 micron depth into 5×10^{16} background) emitter diffused prior to the POLY deposition and emitter C which relied solely on outdiffusion from the doped POLY to form the base-emitter junction”), *id.* (“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 J_{oe} which accounted for the lack of difference between emitters B and C.”) (emphasis added).

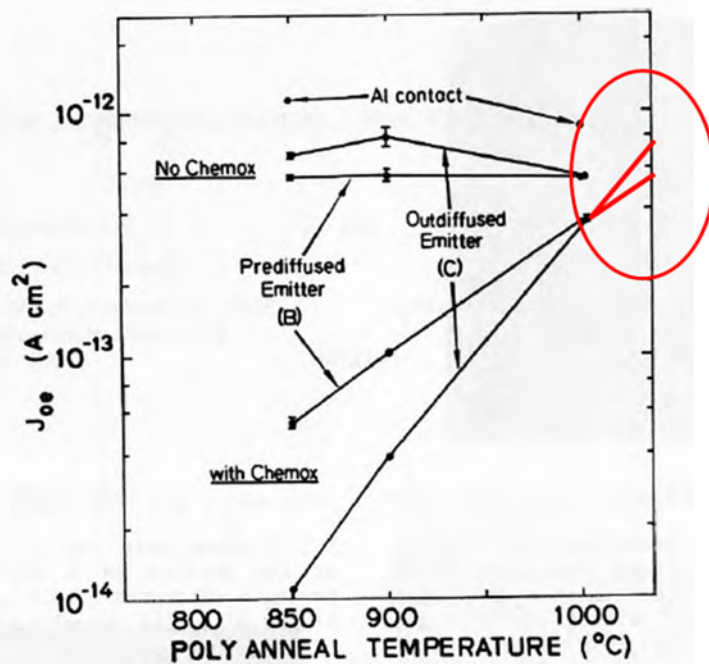


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

Ex. 1008, Fig. 4 (annotated).

A POSITA would also have known that Froitzheim teaches “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degrees centigrade, preferably between 1000 and 1100 degree C, to generate and oxide layer and to drive in the dopant.” Ex. 2020, ¶154; Ex. 1006, ¶42. CSI posits applying the drive in process of Froitzheim, *i.e.*, preferably at 1000°C to 1100°C. But like Gan, Kwark’s data show that such high temperatures would negate the alleged benefits attributed to Kwark’s use of a low temperature for driving in the dopants. Ex. 2020, ¶154. As can be seen above, when the emitter lines are extended (in red) into Froitzheim’s preferred temperature ranges, the alleged benefits from the use of Chemox are lost. *Id.*

Further, the Gan Thesis reports on test results when using Chemox, and specifically considers Kwark’s Fig. 4 analysis. *Compare* Ex. 1008, Fig. 4 with Ex. 2003, Fig. 3.6. As discussed below, the Gan Thesis demonstrates that the results suggested by Kwark are not predictably or consistently reproducible. Ex. 2020, ¶155.

A POSITA would not have chosen to modify Froitzheim by adopting the Chemox layer and polysilicon layer disclosed by Kwark and driving in the dopants at the temperatures suggested by Froitzheim, 900°C to 1200°C with 1000°C to 1100°C being preferred. Ex. 2020, ¶156. Moreover, the POSITA would have been further deterred from that combination by the poor results reported in the Gan

Thesis from annealing within the temperatures taught in Froitzheim for dopant drive in. *Id.*

D. Gan Thesis (Ex. 2003)

Jon-Yiew Gan's thesis entitled "*Polysilicon emitters for silicon concentrator solar cells*," published by the Stanford University in July 1990 ("Gan Thesis"), provides a more comprehensive review of the experiments and methodologies described in Gan (Ex. 1007), *see, e.g.*, Ex2003, 70 106 (Chapter 5), and provides significantly more details about the theory, experimental results, and conclusions set forth in Gan (Ex. 1007). Ex. 2020, ¶157.

The Gan Thesis was published and publicly available on the shelves in the Stanford Library on April 10, 1991, which is prior to the priority date of the '053 patent. *See* Ex. 2022, ¶23. Thus, a POSITA would have had knowledge of the information in Gan, Kwark, and the Gan Thesis before that priority date.

The Gan Thesis also discusses the findings in Kwark. *Compare* Ex. 2003, Fig. 3.6 with Ex. 1008, Fig. 4. These two figures are identical. Ex. 2020, ¶159.

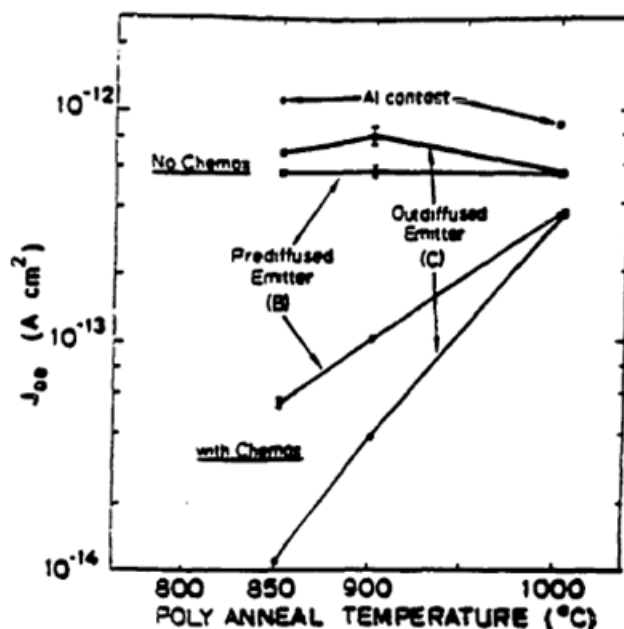


Figure 3.6: $J_{0,e}$ for n-type polysilicon emitters with and without a chemically grown interfacial oxide.

Ex. 2003, Fig 3.6.

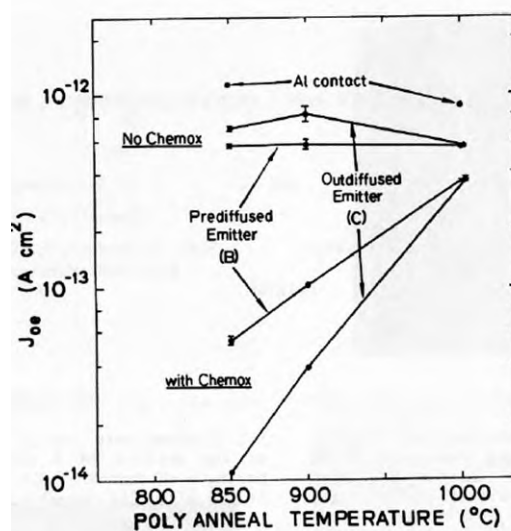


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

Ex. 1008, Fig 4.

The Gan Thesis states:

[T]he very low J_o of the polysilicon SIS emitter has been demonstrated by other authors [7,10]. Figure 3.6 is the J_o of a polysilicon emitter reported by Kwark [7]. **Note that J_o of 1×10^{-14} A/cm² was observed on the device annealed at 850 °C. The rapid increase of J_o upon the anneal temperature is due to breakup of the interfacial oxide which will be discussed later.** A relatively intact interfacial oxide also explains a much lower J_{os} observed on the 900 °C-1 hour curve in Figure 3.3.

Ex. 2003, 53 (34 in original) (emphasis added).

The Gan Thesis recognized the same phenomenon in Kwark as in Gan (Ex. 1007). From this data, a POSITA would understand that the alleged benefits of the interfacial oxide is not achievable at the preferred temperatures described for the anneal step in Froitzheim. Ex. 2020, ¶161. Therefore, there would be no reasonable expectation of success from combining Froitzheim and Kwark, or a motivation for such combination as proposed by CSI. *Id.*

Further, the Gan Thesis acknowledges inconsistent oxide growth during “ramp-up” and “stand-by” periods, and explains that “it is *possible* that the thin-oxide growth can be improved by performing the oxidation at lower temperatures such that the oxide rate can be controlled more precisely.” Ex. 2003, 131 (112 in original). This was referenced by the Board in its Institution Decision. Paper 13, 13.

At best, the Gan Thesis suggested that: “**Theoretically**, it is **possible** to make a polysilicon SIS emitter with an intact inter-facial oxide having low J_o and “acceptable” ρ_c simultaneously.” Ex. 2003, 72 (53 in original)(emphasis added). Gan Thesis also stated “**[t]heoretically**, a model was proposed to make the polysilicon emitter with both low J_o ($\sim 3 \times 10^{-14} \text{ A/cm}^2$) and low contact resistance ($\rho_c \leq 1 \times 10^{-5} \Omega\text{-cm}^2$).” *Id.* at 8 (Abstract) (emphasis added). Also, “[t]he polysilicon emitter with low J_o and ρ_c **can be made** with a very small fraction of interfacial oxide breakup.” *Id.* at 126 (107 in original) (emphasis added). and “[w]ith a few percentages of the interfacial oxide being broken, the ρ_c will be negligible for the application in concentrator solar cells. Under such a condition, there is a regime in which the J_o will not be affected by the oxide breakup because it is dominated by the recombination at the oxide interface. Thus it is **possible** for polysilicon SIS emitter to have both low J_o and ρ_c .” *Id.* at 88 (69 in original) (emphasis added).

Stepping back, however, a POSITA would recognize these musings in the Gan Thesis were theories that fell far short of being reproducible. In context the lack of consistent success in experimental results derived from testing these theories fell far short of supporting a reasonable expectation of success. Ex. 2020, ¶163. This is particularly true in view of experimental data reproduced in both the Gan Thesis and Kwark that show poor results when implementing the theories. *Id.*

Further, the Gan Thesis undermines the motivation to combine Froitzheim and Kwark. *See, e.g.*, the above discussion of Figure 3.6 of the Gan Thesis and the identical Figure 4 from Kwark. To manufacture solar cells, one must have confidence that consistent, predictable, and reproducible results will be attained, not that there is a perceived theoretical possibility that the underlying technology may work occasionally. Ex. 2020, ¶164. There is no evidence in either Kwark or Gan that they could repeatedly achieve the small amount of interfacial oxide breakup that was necessary for solar cells to perform reliably. *Id.*

The Gan Thesis stated “[i]n this chapter, we found that a consistent result of ρ_c is difficult to reproduce for the polysilicon emitter with a thermally grown interfacial oxide. This is mainly attributed to the fact that **our thin-oxide growth recipe is not reliable...**” Ex. 2003, 135-36 (116-17 in original) (emphasis added). The Gan Thesis was trying to obtain a low J_o of around $\sim 1 \times 10^{-14}$ A/cm². *See, e.g.*, Ex. 2003, 8 (Abstract); *id.* at 22 (3 in original); *id.* at 41 (22 in original). This is understandable because Gan, Kwark, and the Gan Thesis are all trying to solve the same problem, namely a very small and consistent breakup of the interfacial oxide to achieve low J_o . In fact, the Gan Thesis showed that there was no known method for getting the oxide thickness reliably to obtain his best results. *Id.* at 138 (119 in original) (“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.”)

(emphasis added); *id.* at 126 (107 in original) (“Although a thermally grown interfacial oxide seems **essential** for a polysilicon emitter to have both low J_o and ρ_c , **the breakup process is still difficult to control**. On several occasions, we have encountered **reproducibility problems**. For example, we find that the ρ_c is quite different between two separate experiments with identical processing conditions. Even worse, **solar 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.”)** (emphasis added); *id.* at 129 (110 in original) (“Later in the real solar cell runs, the **situation grew even worse**...Although the $(J_{on} + J_{op})$ measured from those cells are between 8×10^{-14} and 4×10^{-14} A/cm², **the cell efficiency is greatly degraded by such a high emitter resistance.”)**; *id.* (“As shown in the figure, **the cell is in fact plagued by two things: the high surface recombination velocity ($S = 58$ cm/sec), and high emitter resistance ($\rho_{cm} + \rho_{cp} = 1 \times 10^{-3} \Omega\text{-cm}^2$). . .** From the low emitter recombination and high emitter resistance, **it is clear that the interfacial oxide did not break as expected.”)** (emphasis added); *id.* at 130 (111 in original) (“Although these results can be attributed to many other reasons, the

following experiment shows that **the effect of the oxide thickness cannot be ignored. This, combined with the non-reliable oxide-growth recipe gives rise to the mishap of our solar-cell runs.**)” (emphasis added); *id.* at 133 (114 in original) (“It becomes clear that the wide fluctuation of our results is mainly due to the poor control over the oxide thickness.”); *id.* at 133-136 (114-117 in original) (“[W]e found that a consistent result of ρ_c is difficult to reproduce for the polysilicon emitter with a thermally grown interfacial oxide. This is mainly attributed to the fact that **our thin-oxide recipe is not reliable.**”); *id.* at 75 (56 in original) (“With a window so narrow, it is not possible to have good control over the characteristics of a polysilicon SIS emitter.”). One thing is clear based on a thorough reading of the Gan Thesis. He thought that one day it might be possible to achieve his best results, as well as those in his presentation and in Kwark, such that they could be used in one sun solar cells, but Gan and Kwark were a long way off still. Ex. 2020, ¶165.

Figure 4 of Kwark (figure 3.6 of the Gan Thesis) shows that the results of a polysilicon layer with Chemox rapidly degrades when subject to temperatures over 850°C as shown by the increase in J_o . In contrast, Froitzheim teaches that for dopant drive in “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degree centigrade, preferably between 1000 and 1100 degree C, to generate an oxide layer and to drive in the dopant.” Ex. 1006, ¶42.

The temperature ranges exceed the temperatures Gan and Kwark both recognized as the maximum temperatures possible before a rapid loss of effectiveness occurred. Ex. 2020, ¶166.

Simply, the Gan Thesis established that the processes found in Gan and Kwark would not achieve good results consistently or reliably, especially at the temperatures used by Froitzheim. Consequently, a POSITA would not have had a reasonable expectation of success with the proposed Froitzheim-Gan and Froitzheim-Kwark combinations, and therefore would not have been motivated to combine them. Ex. 2020, ¶167.

IV. THE LEVEL OF ORDINARY SKILL

This Patent Owner Response (“POR”) applies the level of ordinary skill in the art CSI proposed. Paper 2, 4; Ex. 2020, ¶39.

V. CLAIM CONSTRUCTION

CSI contends “the term ‘in situ’ in dependent claim 15 is appropriate for construction because it is defined in the ’053 Patent,” Petition, 20, but CSI then fails to provide an express construction for that term. Rather CSI proffers 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.” Petition, 56.¹ But in the parallel district court litigation, CSI advocates for an additional

¹ Emphasis added throughout unless otherwise indicated.

limitation on what constitutes the claimed “in situ” processing, namely that it covers only “in situ” diffusion and not “in-situ” doping. Ex. 2009, 79.

This POR applies the definition that CSI has applied in its Petition.

VI. THE BOARD’S *EX PARTE* APPEAL DECISIONS IN CONTINUATION APPLICATIONS HAVE NO BEARING ON THIS IPR

CSI alleges that in *ex parte* appeal proceedings for continuation applications of the ’053 patent, the Board already determined that it would have been “obvious to modify a back junction solar cell with a polysilicon emitter with an interfacial oxide layer,” and that the Board should likewise find the same here. Petition, 67-70 (citing Ex. 1005; Ex. 1008).

The Board’s prior findings, however, have no bearing on this proceeding. First, CSI does not allege that Maxeon is collaterally estopped in this IPR. Collateral estoppel does not apply to *ex parte* appeal decisions. Second, none of the combinations asserted here or the claims challenged here were at issue in the *ex parte* appeal decisions discussed by CSI. Third, CSI retains the burden *in this proceeding*, regardless of what the Board found in prior proceedings.

The Board should reject CSI’s attempt to bypass the required showing of obviousness, and instead review CSI’s contentions based on the evidence of record in this proceeding and on CSI’s explanation thereof. *See SAS Inst., Inc. v. Iancu*, 584 U.S. 357, 363 (2018) (petitioner “is master of its complaint”); 37 C.F.R. §

42.22(a)(2) (petitioner “must include . . . [a] full statement of the reasons for the relief requested, including a detailed explanation of the significance of the evidence including material facts, and the governing law, rules, and precedent.”).

A. CSI Does Not Assert that Maxeon Is Collaterally Estopped; And Collateral Estoppel Does Not Apply Here

CSI’s argument that the Board here should follow the Board’s prior *ex parte* appeal decisions is a watered-down version of the collateral estoppel argument that CSI makes in the related ’516 patent IPR. But any collateral estoppel argument, even this flimsy one, fails. At the outset, CSI does not even assert that Maxeon is collaterally estopped in this proceeding. *See generally* Petition. This ends any inquiry related to collateral estoppel.

Also, the Board has rejected estoppel arguments premised on *ex parte* appeal decisions because “[t]he prosecution of [a patent] application is an *ex parte* proceeding, not an adversarial proceeding such as a district court litigation or *inter partes* review.” *Medtronic Vascular, Inc. v. TMT Sys. Inc.*, IPR2021-01532, Paper 56 at 41 (PTAB Mar. 7, 2023). To be clear, there has been no prior *inter partes* challenge to the validity of any claim of the ’053 patent upon which CSI could rely for estoppel here. This Petition and the parallel district court action are the first time the validity of the ’053 patent has been challenged.

Not applying collateral estoppel to PTAB *ex parte* appeals decisions is also consistent with case law. In *B&B Hardware Inc. v. Hargis Indus., Inc.*, the

Supreme Court held that a decision by the TTAB on the issue of likelihood of confusion in an *inter partes* opposition proceeding can have preclusive effect in subsequent federal court litigation, *provided that the ordinary elements of issue preclusion are met*. *B&B Hardware*, 575 U.S. 138, 160 (2015). But the Federal Circuit has also found, while acknowledging *B&B Hardware*'s holding, that "there is *no suggestion* in *B&B Hardware* that an examiner's decision to register a mark or to refuse registration [(i.e., *ex parte* prosecution activities)] satisfies the traditional requirements of issue preclusion." *In re Cordua Restaurants, Inc.*, 823 F.3d 594, 601 (Fed. Cir. 2016).

The Federal Circuit has also distinguished the "nature of *inter partes* reexamination from the initial examination process" in the context of collateral estoppel, because the latter lacks an opposing party. *See SynQor, Inc. v. Vicor Corp.*, 988 F.3d 1341, 1350 (Fed. Cir. 2021); *see also In re Craig*, 411 F.2d 1333, 1335-36 (C.C.P.A. 1969) ("[T]he prosecution of patent applications is not exactly either a dispute or litigation in the usual sense of these terms."). As noted above, consistent with these cases, the Board has previously rejected estoppel arguments premised on *ex parte* prosecution. *See Medtronic Vascular, Inc.*, IPR2021-01532, Paper 56, 39-42.

Likewise, any attempt to transform "an ongoing negotiation between the PTO and the applicant," into an actual, full and fair litigation fails to meet the

requirements of issue preclusion. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1317 (Fed. Cir. 2005) (recognizing, in the context of claim construction, that the “prosecution history represents an ongoing negotiation between the PTO and the applicant, rather than the final product of that negotiation”); see *Medtronic Vascular, Inc.*, IPR2021-01532, Paper 56, at 41 (“The prosecution of [a related] application is an *ex parte* proceeding, not an adversarial proceeding such as a district court litigation or *inter partes* review,” and thus finding that the “same issues were not ‘actually litigated.’”). The same incentives to litigate an issue simply do not exist in *ex parte* prosecution of a patent application and in *inter partes* litigation of an issued patent.

Further, as the Board has previously found, there are “procedural distinctions” between “routine examination of patent applications” and *inter partes* review that “weigh against applying issue preclusion,” namely that, in the latter there is (1) “the availability of cross-examination of witnesses” and (2) “parties may request discovery.” See *BioDelivery Sciences Int’l, Inc. v. MonoSol Rx, LLC*, IPR2015-00168, Paper 88 at 16 (PTAB Feb. 7, 2019).² Accordingly, the

² The *BioDelivery* petitioner sought to estop the patent owner based on a prior *inter partes* reexamination proceeding, but the Board found that such reexamination proceedings “are conducted essentially by the same procedure as routine

“significant safeguard” of having “a full and fair opportunity to litigate” was not afforded to Maxeon through routine examination of the continuation applications. *See Blonder-Tongue Lab’ys, Inc. v. Univ. of Illinois Found.*, 402 U.S. 313, 329 (1971).

For these reasons, collateral estoppel cannot be applied against Maxeon in this proceeding.

B. Neither the Challenged Claims Nor the Asserted Combinations were Involved in the Prior Proceedings

The issues decided in the *ex parte* appeal proceedings were different than the issues to be decided here.

First, the majority of the references asserted here were not at issue in the *ex parte* appeal decisions. *See* Ex. 1005, 506-20; Ex. 1018, 285-93. In particular, CSI’s primary reference, Froitzheim, was not at issue. Neither were any of CSI’s asserted combinations. *Compare, id., with* Petition, 4.

Second, the claims at issue in this proceeding are different than those at issue in both *ex parte* appeal decisions. Where the ’053 patent claims methods of fabricating a solar cell, the claims presented in the ’771 and ’035 applications were directed to solar cells. And CSI does not explain how the claims of the ’053 patent

examination of patent applications.” *BioDelivery*, IPR2015-00168, Paper 88 at 16.

Thus, the distinctions noted apply here as well.

present the same issues as those decided by the Board in the '771 and '035 *ex parte* appeals, including only the conclusory statement that the applications “presented device claims corresponding to the 053 Patent’s method claims.” Petition, 68 (citing Ex. 1003, Appendix A10³).

The chart in Appendix A of Exhibit 1003 is improperly incorporated by reference and should not be considered. *See* 37 C.F.R. § 42.6(a)(3) (“Arguments must not be incorporated by reference from one document into another document.”); *Parus Holdings, Inc. v. Google LLC*, 70 F.4th 1365, 1372 (Fed. Cir. 2023) (citing *General Access Solns Ltd. v. Sprint Spectrum L.P.*, 811 F. App’x 654, 657 (Fed. Cir. 2020)) (holding that “the ‘prohibition against incorporation of arguments from other documents serves various policy goals, including to “minimize the chance that an argument may be overlooked” and to “eliminate[] abuses that arise from incorporation and combination.””); *see also Cisco Sys., Inc. v. C-Cation Techs., LLC*, IPR2014-00454, Paper 12 at 9 (PTAB Aug. 29, 2014) (informative) (declining to consider “conclusory statements [in an expert declaration] for which the Petition does not otherwise provide an argument or

³ Appendix A of EX1003 purportedly compares claims 9-20 of the '053 patent with the claims of the '771 and '035 applications, but only claims 9, 10, 12, and 15-20 of the '053 patent are included in the chart.

explanation”); *Nearmap US, Inc. v. Eagle View Techs., Inc.*, IPR2024-00716, Paper 9 at 14-15 (PTAB Oct. 9, 2024) (“declin[ing] to sift through [expert’s] declaration in order to find the arguments that may support Petitioner’s challenge”); *Berkeley Lights, Inc. v. The Univ. of British Columbia*, IPR2021-01249, Paper 38 at 22 n.7, 45 n.12 (PTAB Jan. 19, 2023) (declining to consider declaration testimony cited “in support of [a] conclusory technical assertion, without additional commentary.”).

In sum, the Board’s *ex parte* appeal decisions, which reviewed different prior art combinations as applied to different claims, should have no persuasive effect in this proceeding.

C. The Board’s Prior Findings Do Not Relieve CSI of Its Burden in this IPR

CSI cannot rely on the Board’s findings for different claims and different prior art to shortcut the requirement that “the initial petition identify ‘with particularity’ the ‘evidence that supports the grounds for the challenge to each claim.’” *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369 (Fed. Cir. 2016) (quoting 35 U.S.C. § 312(a)(3)). This burden remains at all times with the petitioner. 35 U.S.C. §§ 314(a) , 316(e); *In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1375 (Fed. Cir. 2016).

As the petitioner, CSI is “required to identify the particular teachings of each reference that it proposed to combine and *explain how and why a POSA would*

have combined the teachings to produce the claimed invention.” Samsung Elecs.

Co. v. KAIST IP US LLC, IPR2017-01046, Paper 14, 7 (PTAB Jan. 22, 2018)

(citing *TriVascular, Inc. v. Samuels*, 812 F.3d 1056, 1066 (Fed. Cir. 2016))

(emphasis added). Simply pointing to the Board’s *ex parte* appeal decisions, which reviewed different prior art combinations as applied to different claims, does not meet CSI’s burden.

VII. THE PETITION DOES NOT SHOW THAT ANY CHALLENGED CLAIM IS UNPATENTABLE

The Petition fails to show that any of the challenged claims of the ’053 patent is unpatentable.

A. Claims 9-20 of the ’053 Patent Are Patentable Under Froitzheim and Gan (Ground 1) and Froitzheim and Gan in Further View of Hartiti or Sivoththaman (Ground 2)

1. A POSITA Would Not Have Had a Reasonable Expectation of Success in Combining Froitzheim and Gan (Grounds 1 and 2)

Ground 1 of the Petition challenges claims 9-11, 14, 16-17, and 19-20 based on Froitzheim and Gan. Petition, 4. Ground 2 challenges claims 11-13, 15, and 18 based on Froitzheim, Gan, and Hartiti or Sivoththaman. *Id.* at 47. The only independent claims at issue are claims 9 and 16. Therefore, because the proposed Froitzheim-Gan combination of Ground 1 does not invalidate independent claims 9 and 16, then Ground 2 also fails.

A POSITA would not have been motivated to combine Froitzheim and Gan for multiple reasons. Froitzheim's anneal (dopant drive in) temperature when used with the interfacial oxide and polysilicon layer of Gan would have led to high resistivity and high recombination, thereby frustrating Gan's purported benefit. A POSITA would have been discouraged by the lack of predictable results in reliably growing Gan's oxide layer. Ex. 2020, ¶170. Further, Froitzheim and Gan's annealing temperatures are incompatible and the selection of the temperature according to one reference meant foregoing the alleged benefits of the other reference.

a. Exposing Gan's Oxide Layer to Froitzheim's Anneal Temperature Would Have Led to High Recombination

Gan shows that while a low J_o is desirable, that parameter increases rapidly as the drive in temperature increases above 900°C. Consequently, the experimental results in these references and the Gan Thesis show a rapid decrease in the efficacy of the systems as the second anneal temperature increase over 900°C.

Gan identifies polysilicon emitters with $J_o \leq 5 \times 10^{-14}$ A/cm² and $\rho_c \sim 1 \times 10^{-5}$ Ω/cm² to be "quite useful for silicon for silicon concentrator solar cells." Ex. 1007, 249. CSI bases its motivation to combine on Gan's identification of usefulness. Petition, 43 (citing Ex. 1007, 249). But the values of this useful polysilicon emitter "indicate that the interfacial oxide is only broken by a very

small fraction.” Ex. 1007, Abstract; *see also id.* at 248 (“[B]ecause the dominant recombination is likely at the oxide interface, it implies that the oxide must only be broken by very a small [sic] fraction.”).

As explained above, 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. *See, e.g.,* Ex. 1007, 246 (steps 4, 10). However, the temperature range extending up to 1000°C is because to maintain a “useful” value of J_o the experimental data in Gan shows that the second step anneal should be performed at or below 900°C. *See, § III.B* (citing Ex. 1007, 246; *id.* at 249; *id.* at Table 1). Gan focused on the lower temperature for the drive in anneal because Gan observed that “ J_o increases with the temperature and time of the second-step anneal.” Ex. 1007, 248.

Gan’s experimental data for the second step anneal show that P-type polysilicon emitters incur suboptimal ρ_c and J_o values when that anneal is performed at a high temperature. For example, 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.” Ex. 1007, 248 (Table 1).

To the extent CSI argues that Gan discloses its findings to be “useful for silicon solar cells” when ρ_c is lower than $5 \times 10^{-5} \Omega/\text{cm}^2$, Ex. 1007 at 249, Gan

specifies at that ρ_c (current density), “the potential drop across the contact is negligible as long as the current density (ρ_c) is less than 100 A/cm²,” *id.* CSI does not support or even allege that its proposed Froitzheim-Gan combination would feature Gan’s specified current density. Thus, a POSITA would not have found that ρ_c value to be relevant. Ex. 2020, ¶175.

Table 1 shows that dopant drive in at 1000°C, even for 30 minutes, provides a ρ_c that is higher than the value of $J_o \leq 5 \times 10^{-14}$ A/cm² which is what Gan deems “useful.”

Table 1: The effect of the second-step anneal on J_o and ρ_c .

	N-type		P-type	
	$J_{o,e}$ ($\times 10^{-14}$ A/cm ²)	ρ_c ($\mu\Omega$ -cm ²)	$J_{o,e}$ ($\times 10^{-14}$ A/cm ²)	ρ_c ($\mu\Omega$ -cm ²)
900 °C-4 hour	2.4	18	3.5	18
1000 °C-30 min	4.5	~ 6	8.2	3.8
1000 °C-60 min	7.9		10.5	

Ex. 1007, 248 (Table 1) (annotated); Ex. 2020, ¶170. The values of Gan’s P-type polysilicon emitter are relevant because CSI proposes replacing “Froitzheim’s rear P-type diffused *in-substrate* emitter with a rear P-type deposited *polysilicon* emitter plus the beneficial interfacial oxide layer.” Petition, 31 (emphasis in original).

CSI’s proposed Froitzheim-Gan combination would undergo a second-step (dopant drive in). Ex. 2020, ¶178. According to Froitzheim: “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degrees centigrade, preferably between **1000 and 1100** degree C, to generate an oxide layer and to drive in the dopant.” Ex. 1006, ¶42 (emphasis added). Thus, even at the

lowest anneal temperature Froitzheim discloses, 900°C, the resulting Froitzheim-Gan combination would yield a value of ρ_c that is higher than what Gan finds useful. If a POSITA used a temperature within Froitzheim's preferred temperature range of 1000°C to 1100 °C, the resulting Froitzheim-Gan combination would yield a value of J_o that Gan finds unacceptable. Ex. 2020, ¶180.

Further, the Gan Thesis discloses that a desirable value for J_o should be even lower: "cell efficiency . . . is hardly affected by the emitter recombination when J_o is below 1×10^{-14} A/cm²; however, it falls off rapidly as the J_o increases over 1×10^{-14} A/cm²." Ex. 2003, 3.

At a minimum, to attain the alleged benefits of the combined oxide and polysilicon emitter of Gan, a POSITA would have avoided the high temperature dopant drive anneal of Froitzheim. However, to adopt Gan's lower temperature second step anneal a POSITA would have understood would forsake the junction depth and certain doping concentration of Froitzheim. Ex. 2023, 85:7-87:1. Thus, there would have been no motivation to combine. Ex. 2020, ¶¶182-83.

b. A POSITA Would Not Have Been Able to Consistently Grow Gan's Oxide Layer

A POSITA would also not have a reasonable expectation of success in modifying the structure of Froitzheim to include the oxide and polysilicon emitter of Gan. Gan proposes taking a tunnel oxide layer and breaking it slightly to achieve acceptable values for J_o and ρ_c . However, 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. Ex. 2020, ¶184.

The Gan Thesis stated “[i]n this chapter, we found that a consistent result of ρ_c is difficult to reproduce for the polysilicon emitter with a thermally grown interfacial oxide. This is mainly attributed to the fact that **our 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, 135-36 (116-17 in original) (emphasis added). A POSITA would have concluded that Gan never achieved that “precise control.” Ex. 2020, ¶185.

Gan Thesis was trying to get a low J_o of around $\sim 1 \times 10^{-14}$ A/cm². *See, e.g.*, Ex. 2003, 8 (Abstract); *id.* at 22 (3 in original); *id.* at 41 (22 in original). This is understandable because Gan, Kwark, and the Gan Thesis are all trying to solve the same problem, namely a very small and consistent breakup of the interfacial oxide to achieve low J_o . Ex. 2020, ¶186. In fact, the Gan Thesis showed that there was no known method for getting the oxide thickness sufficiently reliable to obtain acceptable results. *Id.* at 138 (119 in original) (“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.”) (emphasis added); *id.* at 126 (107 in original)

(“Although a thermally grown interfacial oxide seems **essential** for a polysilicon

emitter to have both low J_o and ρ_c , **the breakup process is still difficult to**

control. On several occasions, we have encountered **reproducibility problems.**

For example, we find that the ρ_c is quite different between two separate

experiments with identical processing conditions. Even worse, **solar 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.”) (emphasis added); *id.* at 129 (110 in

original) (“Later in the real solar cell runs, the **situation grew even**

worse...Although the $(J_{on} + J_{op})$ measured from those cells are between 8×10^{-14}

and 4×10^{-14} A/cm², **the cell efficiency is greatly degraded by such a high**

emitter resistance.”); *id.* (“As shown in the figure, **the cell is in fact plagued by**

two things: the high surface recombination velocity ($S = 58$ cm/sec), and high

emitter resistance ($\rho_{cm} + \rho_{cp} = 1 \times 10^{-3} \Omega\text{-cm}^2$). . . From the low emitter

recombination and high emitter resistance, **it is clear that the interfacial oxide**

did not break as expected.”) (emphasis added); *id.* at 130 (111 in original)

(“Although these results can be attributed to many other reasons, the following

experiment shows that **the effect of the oxide thickness cannot be ignored. This,**

combined with the non-reliable oxide-growth recipe gives rise to the mishap of

our solar-cell runs.”) (emphasis added); *id.* at 133 (114 in original) (“It becomes clear that the wide fluctuation of our results is mainly due to the poor control over the oxide thickness.”); *id.* at 133-36 (114-17 in original) (“[W]e found that a consistent result of ρ_c is difficult to reproduce for the polysilicon emitter with a thermally grown interfacial oxide. This is mainly attributed to the fact that **our thin-oxide recipe is not reliable.**”); *id.* at 75 (56 in original) (“With a window so narrow, it is not possible to have good control over the characteristics of a polysilicon SIS emitter.”).

A POSITA 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. Ex. 2020, ¶188.

2. *A POSITA Would Not Have Been Motivated to Combine Froitzheim and Gan (Grounds 1 and 2)*

Lacking a reasonable expectation of success in combining Froitzheim with Gan to produce the solar cell of claims 9 and 16, a POSITA would not have been motivated to combine the references as proposed by Petitioner. Ex. 2020, ¶189.

A POSITA would not have had such motivation to combine 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. Ex. 2020, ¶190.

A POSITA would not be motivated to combine Gan with Froitzheim 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. Ex. 2020, ¶191.

Finally, a POSITA would also not be motivated to combine Gan with Froitzheim because Gan is directed to concentrator solar devices. 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. Ex. 2020, ¶¶48-50. But the Gan Thesis's mention of high current levels in the range of 100 A/cm² (equivalent to 2500 suns), Ex. 2003, 28 (9 in original), indicate that the "modeling" referred to by Gan was of silicon concentrator solar cells. Ex. 2020, ¶ 132. Thus, a POSITA would not look to modifying the one sun solar cell manufacturing method of Froitzheim with the teachings of Gan relating to concentrator solar cells. *Id.* at 192.

3. *The Temperatures Preferred by Froitzheim and Gan for Dopant Drive in Are Incompatible and Selection of One Precludes Obtaining the Alleged Advantages of the Other*

Here, as discussed in § VII.A.1.a, at the lowest anneal temperature Froitzheim discloses, 900 °C, the resulting Froitzheim-Gan combination would yield a value of ρ_c that is higher than what Gan finds useful. Further, at

Froitzheim’s preferred temperature of 1000 °C to 1100 °C, the resulting Froitzheim-Gan combination would yield a value of J_0 that greatly exceeds what Gan finds “useful.” Ex. 2020, ¶178. A POSITA would have understood that the respective teachings of preferred temperatures of Froitzheim and Gan for dopant drive are incompatible. Even though the temperature ranges taught by Gan and Froitzheim theoretically encompass a common temperature of 900°C, the references when considered as a whole cannot be reconciled for this issue. The clear teaching of Froitzheim is that temperatures much higher 900°C are preferred and the teachings of Gan and Kwark are that the dopant drive in temperature should be below 900°C, e.g., 850°C for Kwark. Moreover, as noted in Section VII.A.1.a, Gan’s experimental data showed that even 900°C provided unacceptable results.

B. Claims 9-20 of the ’053 Patent Are Patentable Under Froitzheim and Kwark (Ground 3) and Froitzheim and Kwark in Further View of Hartiti or Sivoththaman (Ground 4)

1. *A POSITA Would Not Have Had a Reasonable Expectation of Success in the Combination of Froitzheim and Kwark (Grounds 3 and 4)*

Ground 3 of the Petition challenges claims 9-11, 14, 16-17, and 19-20 based on Froitzheim and Kwark. Petition, 57. Ground 4 challenges claims 11-13, 15, and 18 based on Froitzheim, Kwark, and Hartiti or Sivoththaman. *Id.* at 64. The only independent claims at issue in this matter are claims 9 and 16. Therefore, if

the proposed Froitzheim-Kwark combination does not invalidate claims 9 and 16, then Ground 4 also fails.

Kwark is clear that an oxide layer formed as a Chemox layer only works at low temperature anneals. Ex. 1008, 742 (“In fact for devices annealed at 900°C/13 min, there is very little dependence on γ as seen in Fig. 2, although increasing the anneal temperature to 1000°C adversely affected J_{oe} .”), *id.* at 743 (“Fig. 4 displays the resulting J_{oe} as a function of annealing temperature for emitter B which has a Gaussian (3×10^{19} surface concentration, 1 micron depth into 5×10^{16} background) emitter diffused prior to the POLY deposition and emitter C which relied solely on outdiffusion from the doped POLY to form the base-emitter junction”), *id.* (“To this is added a component due to outdiffusion from the heavily doped POLY which becomes increasingly significant for annealing temperatures above 900°. This is apparent if one notes that the increase in J_{oe} for emitter B can be accounted for by the J_{oe} of emitter C at the same temperature. At 1000° this outdiffusion is **severe** enough to dominate the J_{oe} which accounted for the lack of difference between emitters and C.”) (emphasis added). The annealing process referenced above is the step to drive in the dopants into the polysilicon layer. Ex. 2023, 110:8-111:7.

However, Froitzheim teaches “the wafer is treated in an atmosphere that contains oxygen at a temperature of 900 to 1200 degrees centigrade, preferably between 1000 and 1100 degree C, to generate an oxide layer and to drive in the

dopant.” Ex. 1006, ¶42. In other words, at the temperatures Froitzheim says should be used to drive in the dopant, all of the benefits touted by Kwark would be lost. Ex. 2020, ¶195.

Like Gan, Kwark examined emitter saturation current, J_{oe} , as a function of annealing temperature. Kwark’s J_{oe} and Gan’s J_o are the same; they both use the unit of current density Amperes per square centimeter. *See, e.g.*, Ex. 1007, Abstract (Gan disclosing “ $J_o \leq 5 \times 10^{-14}$ A/cm²”); Ex. 1008, Abstract (Kwark disclosing “ J_{oe} , values of 2×10^{-14} A/cm²”); Ex. 2020, ¶196; Ex. 2028, 107:17-108:3.

Similar to Gan, Kwark disclosed a desirable J_{oe} , value of 2×10^{-14} A/cm². Ex. 1008, Abstract; *see also id.* at 743 (discussing attaining “[e]mitter saturation currents of $1\text{-}2 \times 10^{-14}$ A/cm²” for “POLY with Chemox and for both SIPOS contact structures.”). Kwark also discloses “a baseline J_{oe} of 5×10^{-14} A/cm²” for “[p]rediffused’ emitter B.” *Id.*

Like Gan, Kwark identified higher-than-desired J_{oe} values at anneal temperature of 900 °C and above. and provided relevant analysis in the following chart.

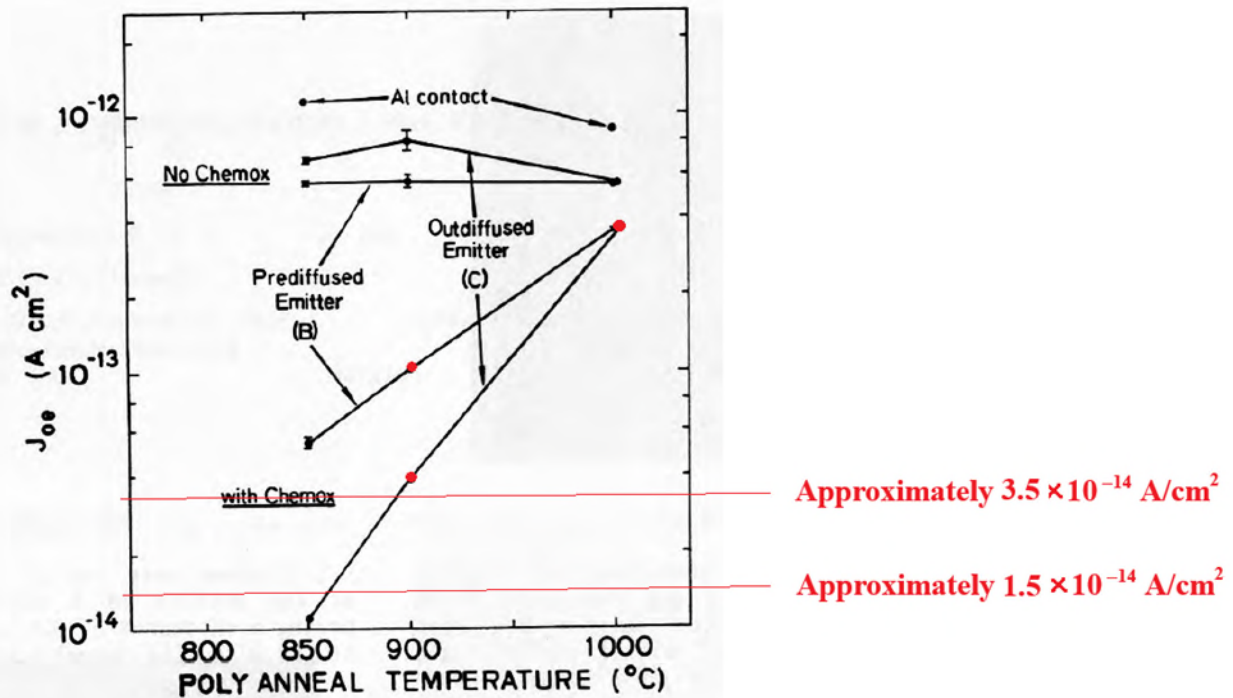
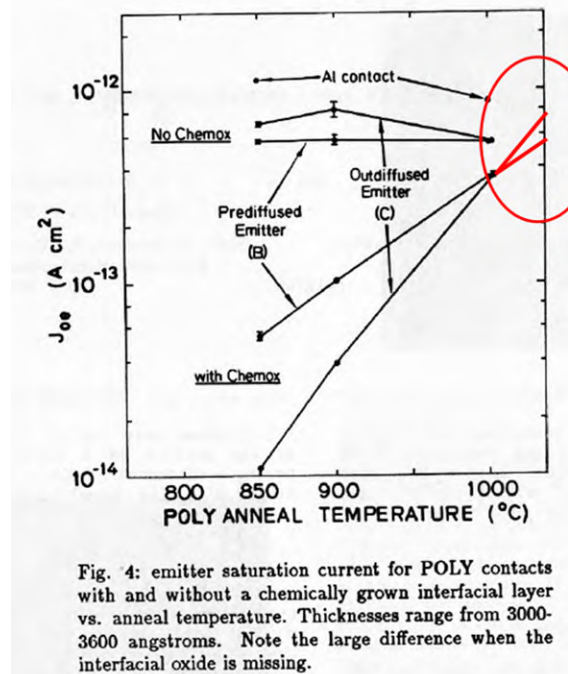


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

Ex. 1008, Fig. 4 (annotated).

Specifically, Kwark explains that “Fig. 4 displays the resulting J_{oe} as a function of annealing temperature for emitter B.” Ex. 1008, 743. Figure 4 of Kwark is relevant because CSI relies on it to argue motivation to combine Froitzheim with both Gan and Kwark. *See e.g.*, Petition, 59.

Further, as can be seen below in red, if the emitter lines are extended into the process temperature ranges disclosed as preferable in Froitzheim, all benefits arising from the use of Chemox are lost. Ex. 2020, ¶199.



Ex. 1008, Fig. 4 (annotated).

Therefore, given the rapid breakup of the oxide at temperatures above 850°C as taught by Kwark, and the much higher temperatures taught by Froitzheim as being preferable, a POSITA would not have a reasonable expectation of success in the combination of Froitzheim and Kwark. Ex. 2020, ¶200.

Moreover, Chemox is a very crude form of creating silicon dioxide and this may be the reason Kwark was not able to reliably form a uniform oxide and had stability problems when exposed to temperatures above 850 °C. Ex. 2020, ¶201. In fact, the Gan Thesis disparages the use of Chemox. The Gan Thesis explains “[a]s mentioned previously, a very low J_o can be obtained (see Figure 3.6) for the N-type polysilicon SIS emitter with a chemically grown interfacial oxide.

However, the corresponding ρ_c of such a device can be as high as $4 \times 10^{-4} \Omega\text{-cm}^2$ at

the doping concentration of $1 \times 10^{20} \text{ cm}^{-3}$, which is the typical doping concentration of the emitter. This is four times higher than the value mentioned in the previous chapter as our goal, and the potential drop across the polysilicon emitter would be **intolerable.**” Ex. 2003, 58 (39 in original) (emphasis added). Therefore, a POSITA would not have had a reasonable expectation of success in using this Chemox layer, and would not have been motivated to combine the Chemox layer and polysilicon layer of Kwark with Froitzheim. Ex. 2020, ¶202. Additionally, the Gan Thesis remarks that the results obtained by Kwark are not reproducible in a consistent manner. Ex. 2020, ¶203.

2. *A POSITA Would Not Have Been Motivated to Combine Froitzheim and Kwark (Grounds 3 and 4)*

Kwark counsels that temperatures above 850°C should be avoided because of deteriorating performance of a solar cell. See § III.C (discussing Fig. 4 of Kwark showing rapid degrading of oxide layer at temperatures over 850 degrees); Ex. 2020, ¶198-200. As explained in § III.A, Froitzheim teaches that dopant drive in processing should be done at 900 °C to 1200 °C, and preferably 1000°C to 1100°C. A POSITA would find it impossible to reconcile these teachings and by choosing one world forego the alleged benefits of following the other. In such a situation, a POSITA would not have considered Froitzheim and Kwark to be compatible and combinable. Ex. 2020, ¶¶194-95.

3. *The Teachings of Froitzheim and Kwark Are Incompatible*

A POSITA would not have combined Froitzheim with Kwark because of their incompatible teachings for the annealing temperatures to drive in dopants. The relevant analysis of this incomparability is discussed with respect to the combination of Froitzheim and Gan in § VII.A.3. with the additional data that Kwark teaches that annealing should be conducted at 850°C while Gan teaches a temperature of 900°C or below.

VIII. CONCLUSION

For the foregoing reasons, claims 9-20 in the '053 patent are patentable.

Respectfully submitted,

Date: April 8, 2025

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that this Patent Owner Response, exclusive of the table of contents, table of authorities, certificate of service, certificate of word count, and list of exhibits, includes 12,151 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: April 8, 2025

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CERTIFICATE OF SERVICE

I certify that the foregoing Patent Owner Response was served on
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