UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

RUNERGY USA INC. ET AL.,

Petitioners,

v.

TRINA SOLAR CO., LTD.,

Patent Owner.

Case No. IPR2025-00006
U.S. Patent No. 10,230,009

PATENT OWNER'S RESPONSE

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LISTING OF EXHIBITS

Exhibit	Description
2001	Expert Declaration of Dr. Martin Peckerar
2002	Transcript from the June 20, 2025 Deposition of Dr. Sanjay Banerjee
2003	U.S. Patent No. 5,989,718 to Smith et al.
2004	Yousuf et al., "A Review on TOPCon Solar Cell Technology," Current Photovoltaic Research 9(3) 75-83 (2021)
2005	Yousuf et al., "Tunnel Oxide Deposition Techniques and Their Parametric Influence on Nano-Scaled SiO_x Layer of TOPCOn Solar Cell: A Review," Energies 2022
2006	Glunz et al., "Silicon-based passivating contacts: The TOPCon route," Prog Photovolt Res Appl. 2021: 1-19 (2021)
2007	Kreig et al., "Wet Chemical Poly-Si(n) Wrap-Around Removal for TOPCon Solar Cells," EPJ Photovoltaics 15, 9 (2024).
2008	Yamaguchi et al., "Characterization of Tunnel Oxide Passivated Contact Fabricated by Sputtering and Ion Implantation Technique," Japanese Journal of Applied Physics 62 SK1024 (2023)
2009	Christiansen, "Thermal Oxidation of structured Silicon Dioxide," ECS Journal of Solid State Science and Technology, 3 (5) N63-N68 (2014)

I. INTRODUCTION

Patent Owner Trina Solar Co., Ltd. submits this response to the Petition for *inter partes* review (Paper 1, "Petition") filed in this proceeding to challenge the claims of U.S. Patent No. 10,230,009 ("the '009 patent").

The Petition does not show unpatentability. The '009 patent discloses—and all the claims require—a tunnel oxide passivated contact (or "TOPCon") solar cell with an ***"isolation portion"*** that separates the cell's emitter and back side conductive layers. This ***"isolation portion"*** must ***"exclude[]"*** not only the backside ***"polysilicon layer,"*** but also the tunnel ***"oxide layer."*** Only two of the Petition's Grounds—1 and 3—address independent claim 1 of the '009 patent. None of the identified prior art teaches a TOPCon solar cell with the claimed type of ***"isolation portion."***

Ground 1 argues that a person having ordinary skill in the art (a "POSITA") would have applied the backside tunnel oxide and polysilicon layers from Feldmann's TOPCon solar cell to Jin's old-fashioned solar cell. According to the Petition, Jin's "gap (or distance) T" separating its doped layers would purportedly be applied to both the newly added backside layers. This amounts to nothing more than improper hindsight. A POSITA would not have been so motivated. Jin explains that its "gap (or distance) T" prevents shorting between its frontside emitter layer 120 and back surface field layer 150, both of which are formed in the same substrate

via doping. In the Petitioner's proposed combination, Jin's substrate backside doped layer 150 is eliminated and replaced with a doped polysilicon layer formed on top of the substrate. Feldmann's tunnel oxide layer is interposed between the substrate and the new polysilicon layer. Thus, Jin's "gap (or distance) T" is no longer required in its present form. And even if a POSITA did remove the new polysilicon layer from the "gap (or distance) T" discussed in Jin, there is absolutely no reason—besides an improper hindsight-driven desire to obtain the '009 patent's subject matter—to do the same with the tunnel oxide layer. Instead, allowing this layer to extend over the entirety of the substrate backside would have furthered Jin's goals by better ensuring that the new doped polysilicon layer does not contact the frontside emitter or diffuse into the substrate. Moreover, Feldmann and the other prior art of record explain that the added tunnel oxide layer operates as a passivating layer. Thus, a POSITA would plainly have wanted this layer to cover the ***entire*** substrate backside to increase solar cell efficiency. It follows that the prior art fails to teach a solar cell that ***"excludes"*** the tunnel ***"oxide layer"*** from its ***"isolation portion"*** as the claims all require.

If this were not enough, in an improper attempt to arrive at the claimed subject matter, the Petition proposes forming the combined structure of Jin and Feldmann using a technique not employed in the TOPCon art (deposition through metal shadow masks). Tunnel oxide layers were grown on the substrate, not deposited

through a mask. This process, however, would have resulted in tunnel oxide covering the ***entire*** backside of the substrate. It would not be ***"exclude[d]"*** from the ***"isolation portion"*** as required. Even if a POSITA did attempt to employ the process discussed in the Petition, this would have been very unlikely to be successful (the thicker polysilicon layer could extend over the thinner oxide increasing the risk of short circuit). Instead, a POSITA would have formed Feldmann's tunnel oxide using the approach actually taught in the prior art (growth over the entire substrate backside) to minimize any risk of shorting and simplify manufacturing.

Ground 3 points to the combination of Chang and Jin. The Petition begins by arguing that Chang itself teaches a solar cell with the claimed isolation portion. It does not: Chang repeatedly states that its tunnel oxide and polysilicon layers are to cover the "entire" substrate surface. Chang also repeatedly teaches that its solar cell does not require any isolation. While Chang does reference that its front and backside layers could potentially be omitted from an "inevitably" formed "isolation region or the like," there is no such isolation region in any of its Figures, which shows that it is not inevitably formed. Moreover, the prior art on which the Petition itself relies establishes that an "isolation region" is not necessary at the substrate edge as the claims here all require. And if Chang's front and backside layers are both omitted from whatever Chang calls its "isolation region or the like," there will not be any contact between the layers. Thus, Chang would still not include the

claimed ***"isolation portion" "for preventing contact"*** required by the '009 patent. Finally, a POSITA would also have had no reason to apply Jin's "gap (or distance) T" to Chang. Chang—like Feldmann—does not form its back surface field layers by doping its substrate.

So, in sum, the Petition repeatedly ignores the express teachings of the prior art and the technical realities encountered when manufacturing a solar cell. Instead, the Petition repeatedly engages in hindsight to cobble together a combination that might meet the claim limitations. Because Petitioners cannot meet their burden to prove that the Jin/Feldmann or Chang/Jin combinations render obvious claim 1 of the '009 patent, none of the claims have been shown to be unpatentable.

II. ARGUMENT

Again, the Petition has not met its burden to show that the challenged claims are obvious over the prior art.

A. <u>The '009 Patent</u>

The '009 patent relates to "a solar cell and a method for manufacturing the same." (Ex. 1001, 1:22-23.) Solar cells "generates electric power from solar energy…." (*Id.* 1:29-30.) According to the '009 patent, prior art solar cells "include[] substrates made of semiconductors having different conductive types, such as a p type and an n type, a second conductive type semiconductor region (or emitter layer), and electrodes respectively connected to the substrates and the second

conductive type semiconductor region." (*Id.*, 1:33-38.) This forms a "p-n junction" at the interface of the substrate and the second conductive type semiconductor region." (*Id.* 1:38-40.) When light strikes the solar cell, "a plurality of electron-hole pairs are generated from the semiconductors." (*Id.*, 1:41-42.) The electrons and holes move toward the n type and p type semiconductor regions, respectively, and are collected by electrodes electrically connected to the substrates and the second conductive type semiconductor region. (*Id.* 1:42-50.) "The electrodes are connected by lines, thereby obtaining power." (*Id.* 1:50-51.)

The solar cell of the '009 patent also include a tunnel layer—formed from silicon dioxide—between the first surface of the semiconductor substrate and the first conductive type semiconductor region. (*Id.* 1:55-60.) "Such a tunnel layer **160** may generate a tunneling effect. More specifically, the tunnel layer **160** may function as a kind of barrier for electrons and holes." (*Id.* 7:62-64.) "That is, the tunnel layer **160** may not transmit minority carriers. After the minority carriers are accumulated in a portion neighboring the tunnel layer **160**, only majority carriers having energy of a specific level or higher may pass through the tunnel layer **160**. The majority carriers having energy of a specific level or higher may easily pass through the tunnel layer **160** by a tunneling effect." (*Id.* 7:65-8:4.) The tunnel layer increases efficiency by preventing recombination of the electron and holes within

semiconductor region and solar cells with such a tunnel layer can be referred to as "TOPCon" or "Tunnel Oxide Passivated Contact."

While TOPCon solar cells were known in the art before the '009 patent was filed, the patent discloses an improved TOPCon structure and method of manufacture. Specifically, the patent describes a process where "tunnel layer **160** can be easily formed because a separate patterning process is not required." (*Id.* 7:59-60). In the method of the '009 patent, "the first conductive type semiconductor region **170** may be formed on the back surface of the tunnel layer **160**…." (*Id.* 8:50-53). As a result of this manufacturing process, the patent explains that the first conductive type semiconductor region **170** might contact second conductive type semiconductor region **120**, which can create a short-circuit where the electrons and holes recombine (rather than be collected) and, thus, reduce the efficiency of the solar cell:

> That is, when the second conductive type semiconductor region **120** is formed, the impurities of the second conductive type may be diffused into the side of or the edge of the back surface of the semiconductor substrate **100**, and thus the first conductive type semiconductor region **170** and the second conductive type semiconductor region **120** may be unwantedly short-circuited in the side of or the edge of the back surface of the semiconductor substrate **100**.

(*Id.* 13:28-35.)

To avoid this, the patent goes on to describe—and then claim—a solution to prevent this unwanted short-circuit: an "isolation portion" that prevents contact between the opposite conductive type semiconductor regions. "In the present embodiment, such a problem can be fundamentally prevented by removing the first conductive type semiconductor region **170** from the edge of the back surface of the semiconductor substrate **100**." (*Id.* 13:35-39.) A key part of this is that the tunnel oxide is also excluded from this isolation portion. (*Id.*, 7:54-56 ("Such a tunnel layer **160** may be generally formed in portions other than an isolation portion I in the back surface of the semiconductor substrate **100**.")))

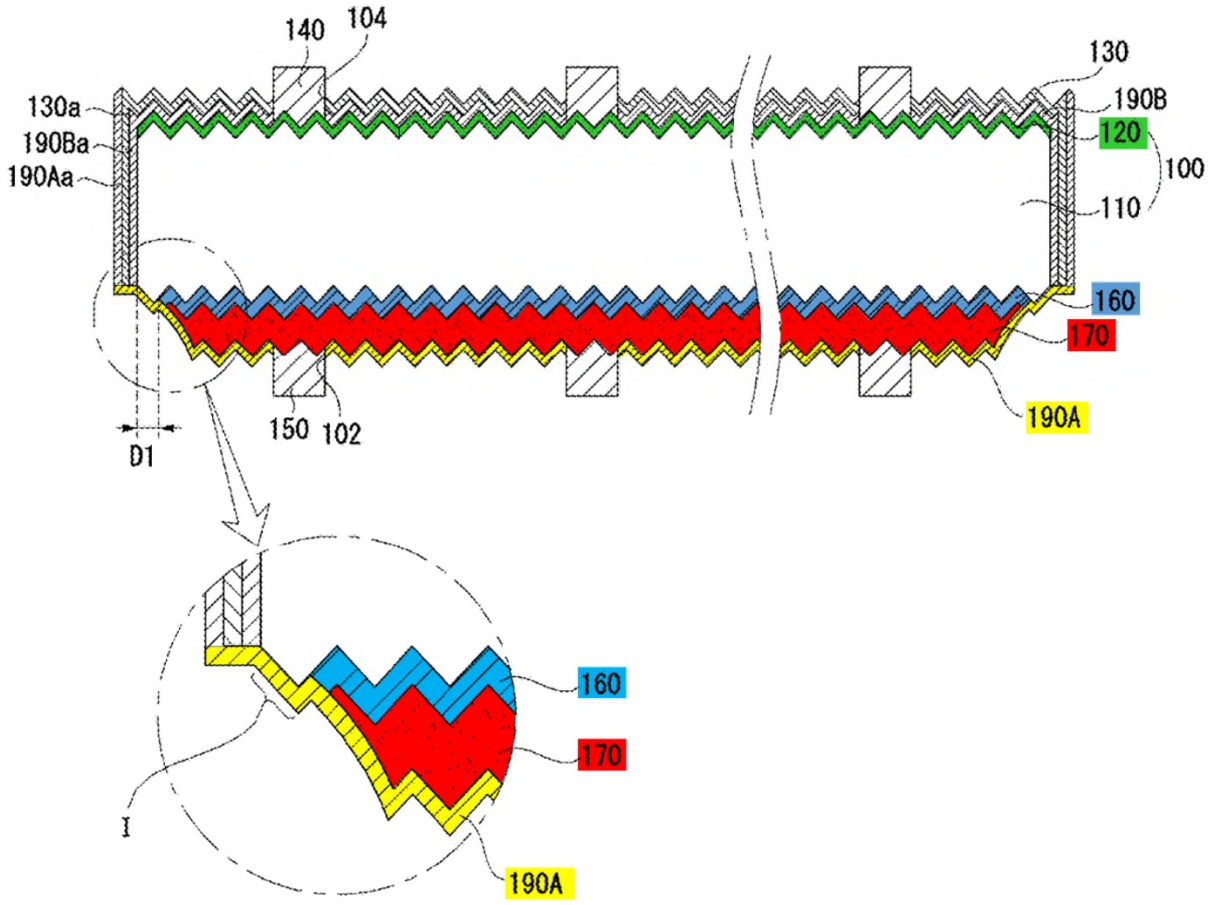
The '009 patent illustrates an example of this inventive TOPCon solar cell in FIG. 2, which is reproduced in annotated form below. The solar cell may include base region **110** and emitter region **120** [shown in green]. In the claims of the '009 patent, silicon substrate **100** and emitter region **120** are of opposite conductive types (*e.g.*, if base region **110** is n-type then emitter region **120** is p-type). "The second conductive type semiconductor region **120** having the second conductive type has a conductive type different from that of the base region **110** and may form an emitter region forming a pn junction along with the base region **110**." (*Id.* 10:18-22.) First conductive n-type semiconductor region **170** [shown in red] is at the opposite side of the solar cell. Tunnel layer **160** [shown in blue] separates first conductive type semiconductor region **170** from base region **110**.

Because, as explained above, the manufacturing process of the ’009 patent can result in second conductive type semiconductor region **120** extending along the sides of the solar cell (described in the specification but not shown in FIG. 2), the inventors included an isolation portion **I** (shown in the magnified portion of FIG. 2) that prevents contact by excluding both tunnel layer **160** and first conductive type semiconductor region **170**:

> That is, when the second conductive type semiconductor region **120** is formed, the impurities of the second conductive type may be diffused into the side of or the edge of the back surface of the semiconductor substrate **100**, and thus the first conductive type semiconductor region **170** and the second conductive type semiconductor region **120** may be unwantedly short-circuited in the side of or the edge of the back surface of the semiconductor substrate **100**. In the present embodiment, such a problem can be fundamentally prevented by removing the first conductive type semiconductor region **170** from the edge of the back surface of the semiconductor substrate **100**.

(*Id.* 13:28-39). Importantly, “tunnel layer **160** may be generally formed in portions other than an isolation portion I in the back surface of the semiconductor substrate **100**” and, thus, is also excluded in this isolation portion. (*Id.*, 7:54-56; *see also* 13:3-16.) A first passivation film **190A** [shown in yellow] covers at least the isolation portion.

FIG. 2



(*Id.*, Fig. 2 (annotated).)

Relevant to this response, all ’009 patent claims require an “isolation portion [that] excludes the oxide layer and the polysilicon layer….” (Ex. 1001, 38:19-20.)

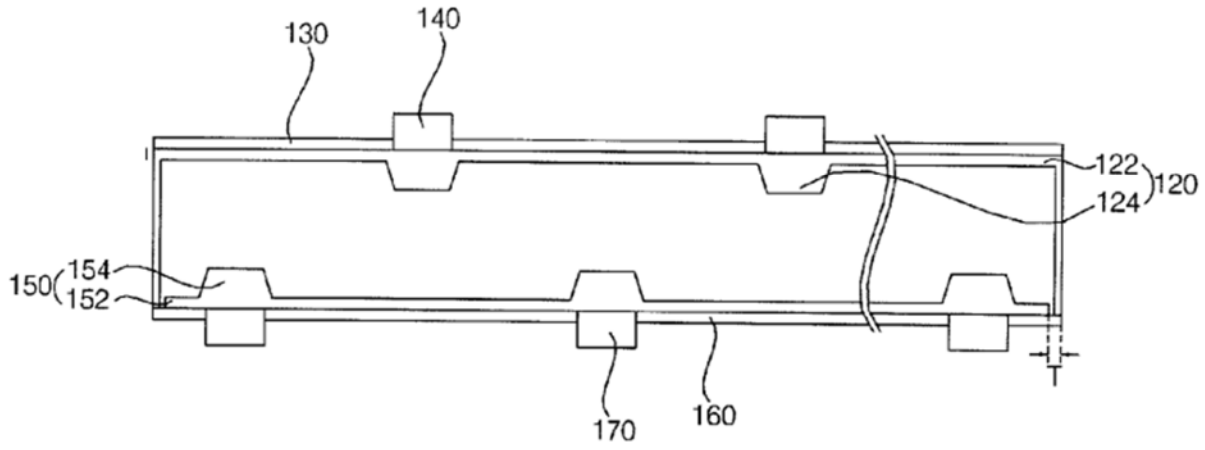
B. <u>Overview of Asserted Prior Art</u>

1. *Jin*

Jin (Ex. 1009) does not disclose a TOPCon solar cell or include a TOPCon tunnel oxide layer or polysilicon layer on the substrate. Instead, Jin describes an

old-fashioned solar cell where regions on the front and back-side of a semiconductor substrate (110) are doped with different impurities to create "an emitter layer **120** disposed on one surface of the substrate **110**… [and] a back surface field layer **150** on the other surface of the substrate **110**…." Emitter **120** and back surface field layer **150** are of opposite conductive types. (*Id.*, [0026].) Figure 3 below provides an example of this:

FIG. 3



(*Id.*, Fig. 3.)

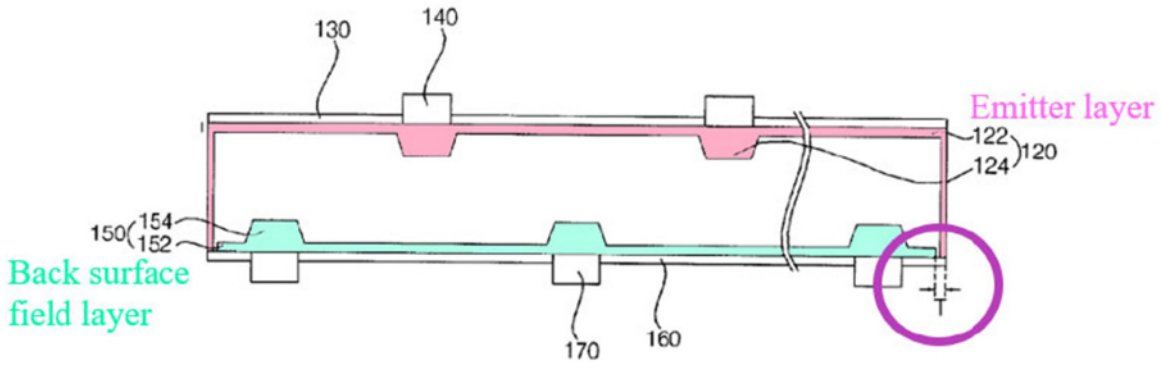
Because it forms the front emitter and back field layer by directly doping the substrate, Jin is also able to include shallow doping areas in the emitter and back surface filed layers. As Jin teaches, "it is very important to improve the efficiency" of solar cells (*id.* [0006]) and "[t]o achieve this and other objectives… the emitter [region] includes at least a first shallow doping area and the back surface field layer includes at least a second shallow doping area…." (*Id.*, [0008].)

Jin also recognized a tradeoff between the amount of impurities in the doped regions and the efficiency of the solar cell. As Jin explained, "where photons are converted to electron-hole pairs, it is advantageous to have a relatively low impurity density" but "where separated electrons or holes move toward the… finger lines…, it is more desirable to have a relatively high impurity density to reduce contact resistance." (*Id.*, [0031].) To account for this, Jin included a shallow doped region where the photons are converted into electron-hole pairs (most of the solar cell surface) and a deeper doped region below the contacts to reduce contact resistance:

> [S]ince the doping density of the third area **154** of the back surface field layer **150** is larger than that of the fourth area **152**, contact resistance between the third area **154** and the rear finger lines **170** is reduced, and since the fourth area **152** is formed throughout the rear surface of the substrate **110**, recombination of electrons and holes may be effectively prevented or reduced. Therefore, since loss due to recombination of electrons and holes is reduced and at the same time, transfer of electrons and holes generated by the photovoltaic effect to the rear finger lines **170** is further expedited, photovoltaic conversion efficiency of the solar cell **100** may be greatly improved.

(*Id.* [0043]). All of Jin's claims require that "the back surface field layer includes at least a second shallow doping area…." (*Id*., claims 1, 12.) Figure 3 of Jin, which Petitioners annotated and relied upon, shows the shallow doping areas (**152)** and thicker doping areas (**154**) in the back surface layer:

FIG. 3

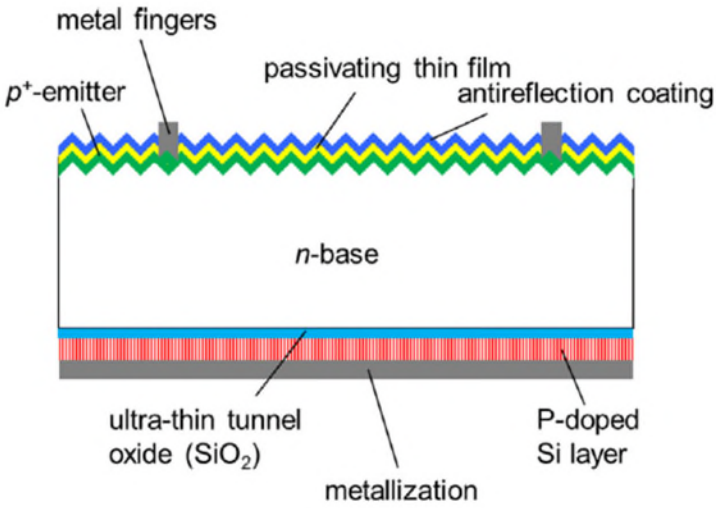


Petition at 13 (reproducing and annotating Jin, Fig. 3).

Jin also uses masks to form the doped regions within its solar cell substrate. (Jin, [0077-0090].) Use of a mask when doping the substrate allows Jin to form a gap T—circled in purple above—between back surface field (**150**) and the edge of substrate (**110**). (*Id.*, [0057]). This gap is formed within the substrate. (*See id.*, Fig. 3.) Jin does not disclose or suggest that its masks could be used to shape regions grown or deposited onto (not within) the substrate.

2. *Feldmann*

In contrast to Jin, Feldmann (Ex. 1012) relates to an entirely different type of solar cell that "is based on an ultra-thin tunnel oxide (SiO_2) and a phosphorus-doped silicon layer." (Feldmann, Abstract). According to Feldmann, this "significantly reduce the surface recombination at the metal-semiconductor interface." (*Id.*) Feldmann depicts this cell in the figure below:



(*Id.* at 272.) As depicted, Feldmann's "p^+-emitter" is completely separated from the "P-doped Si layer" and, consequently, these doped layers are not short-circuited and there is no need for an additional isolation portion.

Feldmann named this depicted solar cell "TOPCon (Tunnel Oxide Passivated Contact)" and identified three prerequisites that "are to be met: (i) excellent interact passivation, (ii) efficiently doped layers to maintain the quasi-Fermi level separation in c-Si (high V_{oc}), and (iii) an efficient majority carrier transport (high FFs)." (*Id.* at 270.)

Feldmann explains that the "tunnel oxide is a vital part" of the cell "that it is required to achieve excellent interface passivation for both open-circuit and maximum power point (MPP) conditions…." (*Id.*, Abstract). "Notably, the tunnel oxide is crucial to obtain very high passivation quality, since lifetime samples solely passivated by an as-deposited Si layer or an annealed Si layer (red circles in Fig. 1) yield very low iV_{oc} values." (*Id.* at 271.) In contrast, "[t]he reduced passivation

quality of the unpassivated lifetime samples (without tunnel oxide) leads thus not only to a lower iV_{oc} but also to a reduced iFF of about 83%." (*Id.*) "As expected, the V_{oc} of the solar cells with an unpassivated contact (without tunnel oxide layer) is drastically decreased to 638 mV due to a high J_{ob}=593 fA/cm^2." (*Id.* at 272).

As shown, Feldmann's TOPCon solar cell has metal finger contacts on its front (sun) facing surface but does not have point contacts on the backside. Instead, Feldmann has a "metallization" layer across that surface. Feldmann explains that using such a metallization layer rather than point contacts increases the cell's efficiency. (*Id.* at 272 ("While the passivated contact's specific contact resistance takes a value of about 10 mΩ cm^2, its contribution to RS can be neglected since the rear is fully metallized. Thus, the relatively small loss in FF due to series resistance can be solely attributed to the solar cell's front side.")

Feldmann further explains that its metallization layer is important to the third "prerequisite" of high FFs: "Contrary to point contact rear side passivation schemes… its one-dimensional design facilitates processing (no structuring and alignment) and enables high FFs above 82% while maintaining a high V_{oc}." (*Id.* at 274.) To make the point clear, Feldmann explicitly criticizes earlier approaches such as PERL cells "which feature a thick dielectric layer with a low index of refraction" with openings through which metal contacts connect to the doped region. As Feldmann explains, "the application of any insulating dielectric layer [between the

metal and P-doped Si layer] would contradict the idea of our TOPCon structure and, thus, it would lose the inherent FF advantage of the one-dimensional junction design." (*Id.* at 273.)

3. *Chang*

Chang (Ex. 1013) relates to a "solar cell including a semiconductor substrate." (Chang, [0003].) Like Feldmann, Chang's solar cell includes "conductive type areas **20** and **30**" at opposite sides of the solar cell. (*Id.*, [0036].) The cell also includes a "tunneling layer **40**" that is "interposed between the semiconductor substrate **10** and at least one of the conductive type areas **20** and **30**." (*Id.*) This is shown in, for instance, Figures 1 and 8:

FIG. 1

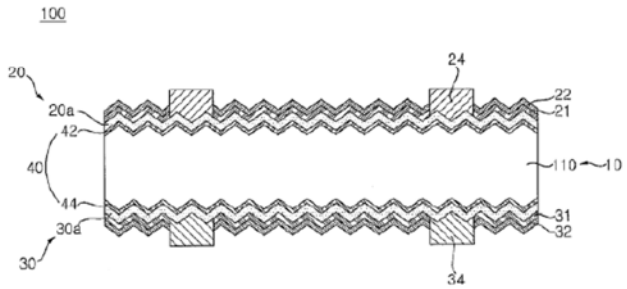
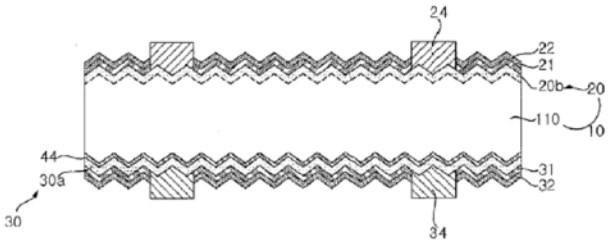


FIG. 8



(*Id.*, Figs. 1, 8.) Chang also specifically teaches that "[b]ecause the emitter area **20** and the back surface field area **30** are not adjacent to each other, the necessity of performing an isolation process when the emitter area **20** and the back surface field area **30** are formed to be adjacent to each other is eliminated." (*Id.*, [0076].) Chang

recites the advantages of this: because no isolation process is required, the solar cell "manufacturing process is simplified and cost is thus reduced." (*Id.*)

C. ***Ground 1*: Jin and Feldmann Fail to Teach What the Claims Require**

All the claims of the '009 patent require ***"an isolation portion"*** that ***"excludes the oxide layer and the polysilicon layer"*** located on the backside of the claimed solar cell. The claims also require ***"a first electrode connected to the polysilicon layer through an opening formed in the first passivation film."*** None of this would have been obvious in view of Jin (Ex. 1009) and Feldmann (Ex. 1012).

Because Jin is related to a standard, old-fashioned solar cell (and not a TOPCon cell), it lacks the claimed ***"oxide layer"*** and ***"polysilicon layer."*** To account for this disclosure deficiency, the Petition argues that it would have been obvious to replace Jin's (Ex. 1009) existing back surface field layer—which is formed by doping its substrate—with Feldmann's (Ex. 1012) tunnel oxide and doped polysilicon layers. The Petition also applies Jin's backside "gap (or distance) T" to both of these new layers from Feldmann. *See* Petition at 24-25.

This is nothing more than an exercise in impermissible hindsight. Because it eliminated Jin's back surface field layer, Petitioner ***also*** eliminated the need to include Jin's gap (or distance) T in its current form. As the back side of the substrate is no longer doped via an ion implantation process, a POSITA would have formed the two new layers discussed in Feldmann differently. And when doing so, a

POSITA would have no reason to exclude Feldmann's tunnel oxide from the gap (or distance) T. Indeed, doing so would likely worsen the very problems Jin is attempting to avoid. Rather than implementing Jin and Feldmann in the way the Petition proposes, a POSITA would have instead allowed the tunnel oxide to cover the entire backside of the substrate. This is not what the claims require: the tunnel ***"oxide layer"*** must be ***"exclude[d]"*** from the ***"isolation portion."***

Moreover, the manufacturing method Petitioner proposes to make a device that excludes both Feldmann's tunnel oxide and polysilicon layers from the gap or distance T (use of a metal mask) ***is not one employed in the TOPCon art***. A POSITA would not have been motivated to use this method and would not have had a reasonable expectation of success when doing so. Using the manufacturing methods actually available in the TOPCon field ***would not have*** resulted in the type of ***"isolation portion"*** the claims here require. Instead, tunnel oxide would be present in the ***"isolation portion."***

Next, the combined device of Jin and Feldman would have lacked the claimed backside ***"opening[s]"*** for finger-like electrodes. Jin does include this structure. But it accommodates it—despite the efficiency loss it produces—only by increasing the backside doping density and doped layer thickness in the area of the electrodes. Once Feldmann's teachings are applied, Jin's substrate is no longer doped. Because it is impossible to vary doping density and thickness in the way Jin does, Feldmann

instead applies a metal layer over the ***entire backside*** of its substrate to achieve the required cell efficiency. This is not what the claims require.

It is not enough for a petitioner to simply point to the "mere fact that … possible arrangements" meeting the claims "existed in the prior art." *Virtek Vision Int'l ULC v. Assembly Guidance Sys., Inc.*, 97 F.4th 882, 886-887 (Fed. Cir. 2024). Instead, claims are obvious only if a POSITA ***had a reason to*** and ***would*** have combined the art in the manner set forth in the petition. *See id.*; *see also Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) (explaining that it is not enough to simply show that a POSITA "could have made" the claimed subject matter). Petitioner made no such showing.

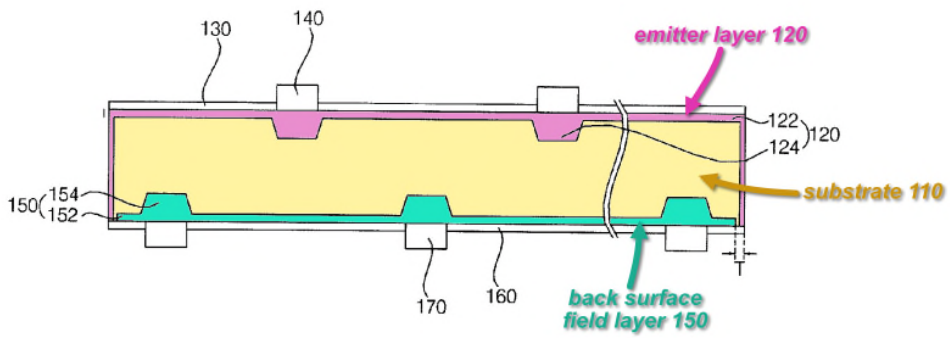
1. *Jin and Feldmann Do Not Teach a Solar Cell with the Claimed "Isolation Portion"*

Jin (Ex. 1009)—the primary reference at issue in this ground—teaches a "solar cell and a manufacturing method for a solar cell" where "a thickness of an emitter layer and a thickness of a back surface field layer are different from each other." Jin, [0003]. Jin's emitter layer and back surface field layers are formed directly in the solar cell's silicon substrate by doping.

The below annotated version of Figure 3 provides examples of this. "FIG. 3 is a cross-sectional view … along line B-B'" of Jin's solar cell. (*Id.*, [0025].) As shown, the solar cell **100** includes "a silicon semiconductor substrate **110** of a first conductive type" (yellow annotation). (*Id.*, [0026].) An "emitter layer **120**" is

"formed" by "dop[ing]" the top surface of the "substrate **110**" "with a first impurity of a second conductive type opposite to that of the substrate **110**" (pink annotation). (*Id.*, [0029].) In one example, the "substrate **110** is a P-type" and "the emitter layer **120** is doped with an N-type impurity…." (*Id.*) "The back surface field layer **150** is a high density doping area" (cyan annotation) formed in the substrate back "using a second impurity of the first conductive type which is the same type as the substrate **110**." (*Id.*, [0041].)

FIG. 3



(*Id.*, Fig. 3 (annotated).)

Jin also discusses the process of manufacturing this solar cell. Once again, both the emitter layer and back surface field layer are formed by doping substrate **110** itself via "a heat diffusion method, a laser doping method, or an ion implantation method." (*Id.*, [0078], [0083]-[0084]; *see also id.*, Figs. 7-11.) Moreover, because back surface field layer **150** is formed by doping the same substrate that already includes the emitter layer, Jin explains that it uses a "mask 410" when forming the back surface field layer to "cover[] or overlap[] a distance T measured from the edge

part of the rear surface of the substrate 110." (*Id.*, [0083]-[0085].) This distance T facilitates Jin's substrate doping by both (1) "prevent[ing] contact" between the back surface field layer 150 and emitter layer 120 (*see id.*, [0090]), and (2) inhibiting the impurities used during doping from "diffus[ing]" into the portion of the substrate between the layers (*id.*, [0058]-[0059]). This in turn allows the "the back surface field layer 150 and the emitter layer 120" to "be kept from being shorted." (*Id.*, [0058].) Jin explains that the "gap (or distance T)" should be in "the range from 2 to 300 μm." (*Id.*, [0060].)

Petitioner's proposed modified version of Jin eliminates Jin's existing back surface field layer **150**. Rather than performing a doping process on the back side of the substrate, Petitioner argues that a POSITA would follow Feldmann's teachings and successively deposit a tunnel oxide layer and then a polysilicon layer on top of the substrate. *See* Petition at 24-25 (noting that a "tunnel oxide layer" and "polysilicon layer" have been applied to the "backside of Jin's solar cell substrate"); 27 (noting that both the "tunnel oxide layer" and "polysilicon layer" are "form[ed]" using a deposition process like "PECVD"). Petitioner also argues that—despite the process differences between Jin and Feldmann—a "metal shadow mask" would still be employed during this process, causing the tunnel oxide and polysilicon layers to not be deposited in Jin's existing "gap-T isolation region." *Id.* at 27.

Feldmann's tunnel oxide is formed from silicon oxide (SiO_2). (Feldmann at Abstract.) This tunnel oxide layer is "grown" on the rear surface of the substrate using a "wet chemical" process. (*Id.* at 271.) It is not deposited via PECVD. The polysilicon—or "phosphorus-doped Si layer"—is then "deposited" on top of the already grown oxide. (*Id.*) Feldmann does not discuss masks. (*See generally* Ex. 2002, 44:16-45:10 (Petitioner's expert agreeing that Feldman is "not using a mask for forming the tunnel oxide").)

The Petition's proposed modification fails to account for what the prior art actually discloses. Jin explains that its gap (or distance) T is intended to prevent layer **150** (which is created by doping the backside of the substrate) from contacting layer **120** (which is also created by doping the frontside of the substrate). The gap is also meant to accommodate impurities from layer **150** that are diffusing into the portion of the substrate located between layer **150** and layer **120** (which again are formed in and by doping opposing sides of the same substrate).

Now, however, because Feldmann's teachings have been applied, there is no longer a doped layer in the backside of the substrate. Rather than being formed by doping the substrate, the backside doped polysilicon layer is located on top of the substrate backside. There is also a layer of tunnel oxide interposed between Jin's substrate and the doped polysilicon layer. Because of this, there is ***no longer contact*** between a doped layer on the back of Jin's substrate and the frontside emitter layer

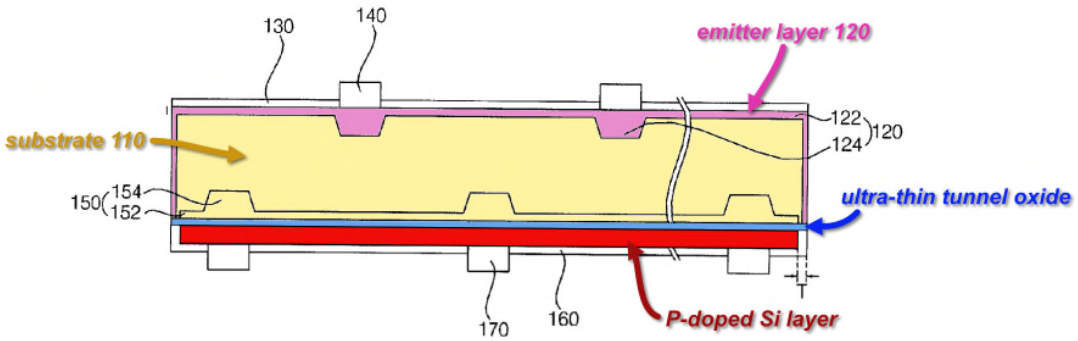
120. (*See* Ex. 2001, ¶¶ 118-131.) The tunnel oxide physically separates the two layers. Moreover, silicon dioxide—the material used to form the tunnel oxide layer—operates as a diffusion barrier. (*See id.*, ¶ 132; *see also* Ex. 2003, 2:41-46 (noting that an "oxide layer substantially prevents diffusion of dopants out of" one layer into another layer).) Thus, the presence of the tunnel oxide limits the ability of impurities in the polysilicon layer to diffuse into Jin's substrate. Put another way, because the back side of the substrate is no longer doped via ion implantation, the modified version of Jin proposed by Petitioner is ***no longer in need*** of the same type of gap (or distance) T shown in Jin's figures.

Both Jin and Feldmann ***also*** teach that it is important to maximize the size of the solar cell's backside layer for efficiency purposes. Jin explains that if the "size of the back surface field layer" is "reduced," the "efficiency of the solar cell" is "degrade[d.]" (*See* Jin, [0060].) According to Jin, doing this would be problematic as "it is very important" to design solar cells in a way that "improve[s] the efficiency." (*Id.*, [0006].) Feldmann likewise explains that a solar cell must be designed to employ "highly efficient passivated contacts." (Feldmann at 270.) Thus, Feldmann employs a "tunnel oxide" and "P-doped Si layer" that covers the entire rear surface of its "solar cell structure." (Feldmann at 272; *see also* Ex. 2001, ¶¶ 133-135.)

Next, it was also known in the art that tunnel oxides operate to "passivate[]" the rear surface to prevent unwanted combination. (*E.g.*, Chang, [0010], [0057].) Indeed, this is one of Feldmann's goals: to "obtain highly efficient passivated contacts." (Feldmann, p. 270.) The Petition identified this as the ***principal*** reason for applying Feldmann to Jin. *See* Petition at 25 (explaining that applying Feldmann "would reduce surface recombination and improve solar cell efficiency"); Ex. 2002, 13:19-14:7 (Petitioner's expert similarly agreeing that one of the purposes of a tunnel oxide layer is to "passivate" the silicon substrate by "eliminat[ing]" "defects" that would otherwise be unwanted "recombination sites"); Ex. 2001, ¶¶ 136-137.

Given all this, a POSITA would not have been motivated to combine Jin and Feldmann in the way discussed in the Petition. Rather than applying Jin's gap (or distance) T to both the polysilicon and tunnel oxide layers, a POSITA would have instead ***maximized*** the size of at least the tunnel oxide layer such that it covers the ***entire rear surface*** of Jin's substrate. This would have furthered Jin's goals. The new doped polysilicon layer would still have the same physical extent as Jin's existing layer 150. The more extensive tunnel oxide would have operated to better ensure both (1) that the new polysilicon backside layer does not contact the emitter layer 120 and (2) that dopant from the polysilicon does not diffuse into the substrate. (*See* Ex. 2001, ¶¶ 138-139.) Moreover, forming the tunnel oxide over the entire substrate backside would have increased the efficiency of the combined solar cell by

allowing for more complete substrate surface passivation. (*See id.*, ¶¶ 140-142.) An example of this is shown below:



(*Id.*, ¶¶ 143-144.) This structure—which again is the most natural result of Jin and Feldmann's teachings—does not satisfy the claims. The ***"oxide layer"*** is not ***"exclude[d]"*** from the ***"isolation portion"*** at the ***"edge"*** of the substrate.

The Petition ignores all of this. It appears to simply assume that Jin's gap (or distance) T would be applied to both Feldman's polysilicon and tunnel oxide layers. It fails to account for the fact that its proposed implementation would not further Jin's goals or maximized the combined solar cell's efficiency. Indeed, the Petition ***offers no explanation at all*** of why a POSITA would have applied Jin's gap (or distance) T to Feldmann's tunnel oxide layer. *See generally* Petition at 25-26. The Petition's brief motivation to combine section merely discusses why Feldmann's layers would be used in the first place. It does not address—let alone explain—why Jin's gap (or distance) T would be applied to both layers. *See id.* This alone should be fatal. *See Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359,

1367 (Fed. Cir. 2016) (noting that the "initial petition" must "identify 'with particularity' the 'evidence that supports the grounds for the challenge to each claim'" (quoting 35 U.S.C. § 312(a)(3)).

Petitioner's expert Dr. Banerjee similarly spends the bulk of his declaration explaining why, in his view, it would have been obvious to implement Jin as a TOPCon solar cell. (*See, e.g.*, Ex. 1003, ¶¶ 109-115.) Dr. Banerjee does state, without citation or further explanation, that "Feldmann's solar cell, like Jin's is susceptible to shorting between the emitter and back surface field." (*Id.*, ¶ 116.) According to Dr. Banerjee, because of this "the modified Jin/Feldmann solar cell would benefit from Jin's gap-T isolation region to prevent shorting." (*Id.*)

Dr. Banerjee points to nothing explaining why (or even how) any purported shorting would occur. These type of bald, conclusory assertions are entitled to no weight. *See, e.g., Coalition for Affordable Drugs VII LLC v. Pozen Inc.*, Case IPR2015-01680, Paper 18 at 15 (Feb. 11, 2016) ("[c]onclusory assertions … are not persuasive"). Even if there were such a "shorting" concern, a POSITA would have reduced the size of ***only*** Feldman's polysilicon layer while maintaining the tunnel oxide across the entire backside surface of the substrate. (*See* Ex. 2001, ¶¶ 145-154 .) Again, maintaining the tunnel oxide (which is an insulator and diffusion barrier) across the entire substrate backside would have (1) better ensured that there is no contact between the polysilicon layer and the emitter layer 120 by interposing an

oxide layer in-between and (2) limited diffusion of the impurities in the polysilicon layer into the substrate via inclusion of an oxide diffusion barrier. (*See id.*, ¶ 139.) And no current can possibly flow from the doped polysilicon, through the tunnel oxide in the gap (or distance) T, and on to the frontside emitter. Jin's gap (or distance) T is "from 2 to 300 µm" (or 2000 to 300,000 nm). (Jin, [0060]; Ex. 2001, ¶¶ 153-154.) According to Feldmann, "tunnelling becomes inefficient" when the distance to be tunneled exceeds 20 Å (or 2 nm). (Feldmann, p, 271.)

Dr. Banerjee also opines—again without any citation—that "[i]f the tunnel oxide layer were to extend to the edge, the exposed portions of the oxide could trap impurities and create negative fixed oxide charges, which could then create a p-type inversion in the n-type based substrate, leading to a leakage path to the p-type emitter on the front of the solar cell." (Ex. 1003, ¶ 116.) None of the prior art or other references cited in the Petition say anything at all about "trap[ping] impurities," "negative fixed oxide charges," or "p-type inversion" associated with tunnel oxide layers. So, this appears to be a theory that Dr. Banerjee manufactured out of thin air and without any apparent factual support. This type of conclusory opinion does not show obviousness. *See Xerox Corp. v. Bytemark, Inc.*, IPR2022-00623, Paper 9 at 15 (Aug. 24, 2022) (precedential) (rejecting expert testimony as "conclusory and unsupported" because it "does not disclose the underlying facts or data on which" it "is based"). There is also no such issue. (*See* Ex. 2001, ¶ 155-162.) And, even if

there were, the mere fact that there "could" be theorical issues with a slightly more extensive tunnel oxide layer does not provide a motivation to combine. *See Belden*, 805 F.3d at 1073 ("obviousness concerns whether a skilled artisan not only could have made but would have been motivated to make the combinations or modifications of prior art to arrive at the claimed invention.")

In any event, even if there were some sort of impurity trapping issue in the device of Jin and Feldmann, this would be ***equally present*** in the Petition's proposed combination. Dr. Banerjee admitted that this issue is not unique to tunnel oxides at his deposition. (*See* Ex. 2002, 32:18-33:22.) The same issue—according to Dr. Banerjee—also applies to "other types of thicker oxides." (*Id.*) According to the Petition, the entire rear surface of the combined device is covered by "Jin's antireflection/passivation layer 160." Petition at 38. Jin explains that this layer can be formed from, among other things, a "silicon oxide." (Jin, [0050]; *see also* Ex. 2002, 31:8-32:14 (Petitioner's expert similarly admitting that layer 160 can be made from silicon oxide).) Thus, removing Feldmann's tunnel oxide from the periphery of the combined device would not resolve the hypothetical problem identified by Dr. Banerjee: oxide would ***still*** be present in the same area and ***would still*** trap impurities resulting in the very same problems. (*See* Ex. 2001, ¶¶ 163-168.) So, in sum, the Petition—and Dr. Banerjee—propose to remove one layer (the tunnel oxide) from a portion of the backside of Jin's substrate only to replace it with another layer (the

antireflection/passivation layer 160) that exhibits the same problems and gives rise to the same concern. This is not only contradictory, but it serves to further confirm the Petition's improper, hindsight driven analysis. Its combination does nothing to improve the combined device. It merely stitches together various, disparate prior art features in an effort to improperly achieve the claimed subject matter.

2. *The Petition Proposes Use of a Technologically Infeasible Manufacturing Method*

Next, according to the Petition, a POSITA would have purportedly formed the combined structure of Jin and Feldmann by using a "metal shadow mask, in the shape of Jin's Fig. 9 mask, on the substrate to cover the periphery before forming the tunnel oxide and phosphorous-doped polysilicon layers using PECVD." Petition at 27. It is use of ***this*** specific process—in particular the same metal shadow mask during both the tunnel oxide and polysilicon layer depositions—that Petitioner argues would have resulted in "oxide and polysilicon layers" covering the entire substrate backside "with the exception of the gap-T isolation region." *Id.* Dr. Banerjee does discuss a series of different manufacturing methods in his declaration. But none of these are referenced anywhere in the petition. This was improper. *See Cisco Sys., Inc. v. C-Cation Techs., LLC, Case IPR2014-00454,* Paper 12 at 9-10 (August 29, 2014) (informative) (noting that it is improper to incorporate arguments from an expert declaration into a petition by reference); *see also* Ex. 2001, ¶¶ 223-236.

A POSITA would not have employed a "metal shadow mask" at all when forming Feldmann's tunnel oxide and polysilicon layers. A POSITA most certainly would not have used the same mask during both deposition steps as Petitioner argues. Feldmann itself does not employ such a process: Feldmann's tunnel oxide is "grown" on the rear surface of the substrate using a "wet chemical" process. (Feldmann at 271.) The polysilicon—or "phosphorus-doped Si layer"—is then "deposited" on top of the already grown oxide. (*Id.*) No mask is employed. While Jin does employ a metal mask, its mask is meant to facilitate "ion implantation" of an "impurity doped region" in a silicon substrate, not a CVD deposition process. (*E.g.*, Jin, [0009], [0079], [0083]-[0084]; *see also* Ex. 2001, ¶¶ 174-178.)

Masks were also not routinely employed in the art during the formation of TOPCon solar cells. "TOPCon solar cells mainly employ[ed] … PECVD oxidation, chemical oxidation, and ozone oxidation processes" to "deposit the thin layer of SiO_x" that forms the tunneling layer. (Ex. 2004 at 4.) The "polysilicon layer" was deposited over the entire substrate via "low-pressure chemical vapor deposition (LPCVD) … plasma-enhanced CVD (PECVD) … inline atmospheric pressure CVD (APCVD) … and sputtering…." (*Id.*; *see also* Ex. 2004 at 76 (similarly explaining that a TOPCon cell's "tunneling SiO_x" layer was typically "thermally developed" and the "poly silicon layer" was "accumulated in a LPCVD system."); Ex. 2006 at 3 (explaining that "[t]he n-TOPCon structure … was realized by growing a thin

interfacial oxide in HNO3" and then "depositing a phosphorus-doped Si Rick SiCx layer by plasma-enhanced chemical vapor deposition (PECVD)").) There is ***no mention of any masking steps***. (*See* Ex. 2005 at 8 (showing the "TOPCon solar cell fabricating process" without any masking step); Ex. 2004 at 76 (similarly showing a TOPCon "[p]rocess diagram" without any masking steps); Ex. 2006 at 12 (same); Ex. 2008 at 4 (same); *see also* Ex. 2001, ¶¶ 179-183.)

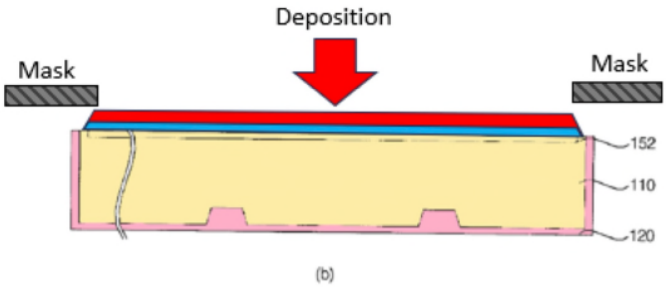
Indeed, as of 2024, the use of masks during deposition of a TOPCon cell's thicker polysilicon layer was still considered to be in the "idea" phase. (*See, e.g.*, Ex. 2007 at 1.) And use of a mask to form a TOPCon cell tunnel oxide layer like that taught by Feldmann would have been virtually impossible. Masks can be used to form, for instance, "~10 µm thick … layers" on solar cells. (*E.g.*, Ex. 1031 at 2126; *see also* Ex. 2009 at N63 (referencing the formation of "205 ± 12 nm thick oxide in [an] etched mask window[]").) The tunnel oxide layer is "an extremely thin coating of approximately 2 nm." (Ex. 2005 at 9.) Feldmann explains that its layer is 14 Å (or 1.4 nm) thick. (Feldmann, p. 271.) This is orders of magnitude smaller than that achievable with masks like those referenced by Petitioner and Dr. Banerjee. Use of a mask when forming the tunnel oxide layer would likely result in significant layer variation around the mask edges, worsening device uniformity and performance. (*See* Ex. 2001, ¶¶ 192-196.)

No TOPCon cell manufacturer or researcher had—or even could have—employed a masking process that even remotely resembles that proposed by Petitioner and Dr. Banerjee. (*See id.*, ¶ 197-.) Because it proposed use of a process that was atypical, not used in the industry, and presented significant technological hurdles, Petitioner has failed to show that a POSITA would have had a reasonable expectation of success. (*See id.*, ¶ 198.) Rather than employing the convoluted process Petitioner proposes, a POSITA would have instead manufactured the combined TOPCon cell of Jin and Feldmann using the processes actually taught in the art. First, a tunnel oxide would be formed over the entire backside of the substrate in a ***separate, maskless*** processing step (such as thermal oxidation). (*See id.*, ¶¶ 199-200.) This process would be carefully controlled to ensure uniformity and proper layer thickness. Then, the polysilicon layer would have been formed over the entire substrate backside in another ***maskless*** processing step (such as CVD deposition). (*See id.*, ¶¶ 201-202.) While a POSITA may have etched away excess polysilicon from the top and sides of the solar cell after deposition, this etching process would have left the tunnel oxide behind. (*See, e.g.*, Ex. 2007 at 3 (noting that only "the poly-Si layer" is removed from unwanted areas of the solar cell).) Indeed, the silicon oxide layer acts as an etching mask during this process. (*See id.* at 2.) The resultant device would lack the claimed ***"isolation portion"*** that

"excludes" the "***oxide layer."*** (*See* Ex. 2001, ¶¶ 202-204.) Instead, there would be tunnel oxide located within the edge region of the substrate. (*See id.*)

Even if it were for some reason employed despite all this, the Petition's proposed manufacturing method would be unlikely to result in the type of structure depicted in the Petition. To begin, use of a shadow mask would have had little impact on the extent of the silicon oxide layer when Feldmann's teachings are followed. Because Feldmann teaches that the layer is grown from the silicon substrate's surface rather than being deposited on it, it will form underneath the mask across the entire exposed surface of the substrate despite the presence of the mask. (*See id.*, ¶¶ 185-192.) Thus, there would be ***"oxide layer"*** in the ***"isolation portion."***

Using an atypical deposition and masking process to form the tunnel oxide (assuming this is even possible) would also not result in the claimed subject matter. As the Petition recognizes, when depositing layers through a mask, "overspray" occurs at the mask boundary. *See* Petition at 71-72. This "overspray" results in deposited layers accumulating "beneath the edge of the mask." *Id.* Petitioner's expert Dr. Banerjee included the following figure in his declaration which attempts to show this "overspray" when Feldmann's layers are applied to Jin:

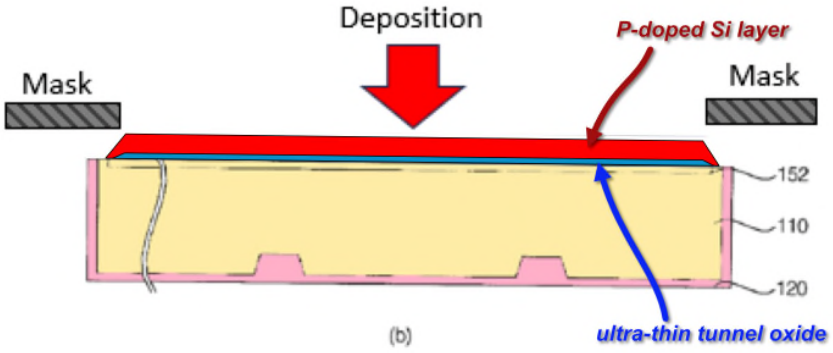


(Ex. 1003, ¶ 165.)

When depositing a layer using a deposition techniques like CVD or sputtering, layer thickness is controlled primarily via deposition time. (*See* Ex. 2001, ¶¶ 207-211; *see also* Ex. 2002, 17:10-18:22 ("we can control the thickness" of a CVD layer "by the deposition time").) While Feldmann's tunnel oxide layer is grown, if one instead attempted to deposit this type of ultra-thin layer despite the technical hurdles encountered when doing so, only a very short deposition time would be required. (*See* Ex. 2001, ¶ 210.) Thicker layers—like Feldmann's polysilicon layer—require longer deposition times. (*See id.*, ¶ 211.) Further, Dr. Banerjee testified that the "overspray" that occurs under mask edges will continue to increase until the mask aperture (*i.e.*, the opening into which material is being deposited) is filled. (*See* Ex. 2002, 59:10-60:16.)

Because the amount of "overspray" can increase with deposition time, attempting to use of the same shadow mask to deposit Feldmann's ultra-thin tunnel oxide and much thicker doped polysilicon layer as the Petition proposes (*see* Petition, 27) would likely have resulted in a polysilicon layer extending ***over*** the

tunnel oxide layer. This would in turn result in the very problem the Petition attempted to avoid: diffusion of impurities into the substrate and potential shorting between the polysilicon layer and Jin's emitter layer 120. (*See* Ex. 2001, ¶¶ 212-219.) Feldmann's tunnel oxide is very thin (14 Å or 1.4 nm). (Feldmann at 271.) The polysilicon layer is much thicker (20 nm). (*See id.*) The ultra-thin tunnel oxide will fill only a portion of the mask's aperture. There will be little overspray due to the layer's thinness and shorter deposition time. The thicker polysilicon layer requires a longer deposition time and will fill the mask's aperture. This will result in more overspray. Thus, rather than producing the layered structure referenced in the Petition and by Dr. Banerjee, the following would be more likely result:



(Ex. 2001, ¶¶ 218-219.)

As shown, the thicker polysilicon layer with increased overspray results in polysilicon on the substrate in close proximity to Jin's emitter layer 120. Forming the tunnel oxide without a mask and across the entire substrate surface—as was routinely done in the prior art—would have eliminated this risk of polysilicon-to-

emitter 120 contact. (*See id.*, ¶¶ 220-221.) But again, Petitioner did not do so because it would have resulted in a structure that lacked the claimed ***"isolation portion"*** that ***"excludes"*** the "***oxide layer."*** (*See id.*.) Again and again the Petition ignores the practical realities of solar cell manufacturing, and instead proposes an impractical, unlikely to work, and non-obvious product combination.

3. *The Petition Improperly Eliminates the Efficiency Benefits of Both Jin's and Feldmann's Solar Cells*

There are still further reasons why a POSITA would not have been motivated to combine Jin and Feldmann in the manner discussed in the Petition. In particular: the combination eliminates nearly all the solar cell efficiency benefits these two references identify. This is yet another example of the Petition's hindsight-based analysis: it discards all of what the prior art identifies as important and keeps only what is needed to achieve the claimed subject matter.

According to Jin, "it is very important to improve the efficiency" of a solar cell." (Jin, [0006].) One of the ways that Jin accomplishes this is "by reduc[ing] surface resistance" between its electrode "finger lines" and the underlying emitter and back surface field layers. (*Id.*, [0032].) To do so, Jin both increases "doping density" and the "doping thickness" of its layers **120** and **150** in the area of the finger electrodes. (*Id.*, [0032], [0042].) So, by forming shallow areas **152** and thicker, more highly doped areas **154** on its back surface, Jin explains that "recombination of electrons and holes may be effectively prevented or reduced." (*Id.*, [0043].)

Feldmann similarly explains that its solar cell is designed to employ "highly efficient passivated contacts." (Feldmann at 270.) One of the efficiency gains Feldmann proposes results from the use of "an appropriate rear metallization." (*Id.*) According to Feldmann, in its solar cell "the requirement for the rear contact in terms of internal reflection is quite high." (*Id.* at 273.) Thus, Feldmann employs an "ITO/Ag stack and AG single layer respectively" to "significantly increase" the "rear side reflection[.]" (*Id.*) This metallization layer covers the entire rear surface of Feldmann's solar cell. (*See id.* at 272.) Feldmann also specifically criticizes solar cells employing point contacts: "[c]ontrary to point contact rear side passivation schemes… [Feldmann's] one-dimensional design facilitates processing (no structuring and alignment) and enables high FFs above 82% while maintaining a high V_{oc}." (*Id.* at 274.) This rear metallization is part of an integrated structure proposed by Feldmann: its tunnel oxide, polysilicon layer, and metallization layer all work together to improve its solar cell's performance. (*See id.*)

The Petition's proposed combination of Jin and Feldmann eliminates all these efficiency benefits. The Petition's proposed combination includes a P-doped Si layer with a uniform thickness on the rear-side of the substrate. Thus, the efficiency benefit identified in Jin is no longer present: the combined structure does not reduce surface resistance between the finger electrodes and the back-side layer and does not prevent recombination of electrons and holes in the same way discussed in Jin. (*See*

Ex. 2001, ¶¶ 237-246, 248.) The efficiency benefits identified in Feldmann have also been lost: because it employs finger electrodes on its backside surface, the combined structure no longer significantly increases rear side reflection. (*See id.*, ¶ 247.) Moreover, the proposed combination uses the very type of rear side contact Feldmann criticizes: a point contact. (*See id.*, ¶¶ 249-256.)

Neither the Petition nor Dr. Banerjee even attempt to explain why a POSITA would modify Jin in a way that eliminates its primary efficiency benefit: the use of increased doping density and thickness in the area of the electrodes. The Petition and Dr. Banerjee also do not explain why a POSITA would allegedly have abandoned Feldmann's teachings regarding the importance of more extensive backside metallization. The Petition also fails to explain why a POSITA would not have simply employed the beneficial, integrated back-side structure Feldmann proposes and identifies as important to solar cell efficiency. Instead, the Petition relies on hindsight to pick and choose what elements of each reference to include and which to ignore. This violates the Federal Circuit's instruction that the question of obviousness must be determined "from a fair reading of the prior art reference as a whole…." *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984) (rejecting Patent Office determination that claim was obvious); *see also In re Enhanced Sec. Research, LLC*, 739 F.3d 1347, 1355 (Fed. Cir. 2014) (improper to "stitch together an obviousness finding from discrete portions of prior art references without

considering the reference as a whole."); *In re Suong-Hyu Hyon*, 679 F.3d 1363, 1367 (Fed. Cir. 2012) ("It is impermissible within the framework of section 103 to pick and choose from any one reference only as much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art." (quoting *In re Wesslau*, 353 F.2d 238, 241 (C.C.P.A. 1965)).

Considering Jin and Feldmann as a whole, a POSITA attempting to combine these references would have been motivated to ***include*** Feldmann's entire rear-metallization layer. Jin references the use of point contacts (170) but attributes no significance to them. (*See, e.g.*, Jin, [0026], [0041]-[0043], [0052]-[0055].) It also does not criticize the use of a rear-side metallization layer like that employed by Feldmann. Feldmann, however, teaches that use of rear metallization is a necessary "prerequisite" for "high FFs." (Ex. 1012 at 270.) Given this, a POSITA would have been particularly motivated to use Feldmann's rear metallization when applying Feldmann's teachings to Jin. Indeed, elimination of Jin's back surface field layer with its efficiency boosting highly doped areas **154** would have provided a strong motivation to employ Feldmann's rear metallization to make up for at least some of the lost efficiency. (*See* Ex. 2001, ¶¶ 251-257.) This structure lacks the claimed ***"first electrode connected to the polysilicon through an opening formed in the first passivation film."***

Rather than seeking to maximize the efficiency of the combined structure, the Petition and Dr. Banerjee ignore Jin's and Feldmann's clear teachings regarding importance of efficiency—and how this is to be achieved—and instead choose a ***less efficient*** design option. This was wrong. "It is impermissible … to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art." *In re Hedges*, 783 F.2d 1038, 1041 (Fed. Cir 1986).

4. *Jin and Feldmann Do Not Teach What Claim 8 Requires*

Dependent claim 8 of the '009 patent requires that ***"a thickness of the edge portion in the polysilicon layer progressively decreases toward the isolation portion."*** According to the Petition, when "Feldmann's polysilicon layer" is formed using "a metal 'shadow' mask configured like Jin's Fig. 9," "small amounts of polysilicon" will "deposit beneath the edge of the mask … resulting in a taper of the polysilicon" in this area. Petition at 43.

This is not what this limitation requires. Jin explains that the mask shown in Figure 9 "covers or overlaps a distance T measured from the edge part of the rear surface of the substrate 110." (Jin, [0085].) Because the mask "covers" Jin's gap (or distance) T, to the extent there is any tapering of polysilicon as alleged by the Petition, the tapered polysilicon will be present ***within*** the gap T. Tapered

polysilicon within Jin's gap (or distance) T does not ***"progressively decrease toward the isolation portion."*** Nor does such a structure satisfy claim 1's requirement that the ***"polysilicon layer"*** be ***"exclude[d]"*** from the ***"isolation portion."*** This claim requires that there be ***no*** polysilicon within the ***"isolation portion"*** at all. The claim also requires that the polysilicon thickness ***"progressively decrease"*** as it gets closer to the bounds of the ***"isolation portion."*** By extending polysilicon into the ***"isolation portion,"*** Jin and Feldmann fail to teach what is required. (*See* Ex. 2001, ¶¶ 258-264.)

D. *Ground 3*: Chang and Jin Fail to Teach What the Claims Require

Ground 3 argues that the combination of Chang (Ex. 1013) and Jin (Ex. 1009) also purportedly renders the claims obvious. This combination of art does not result in the claimed subject matter. Chang fails to teach the claimed ***"isolation portion" "in an edge portion"*** of the ***"substrate" "for preventing a contact between the polysilicon layer and the emitter region."*** And a POSITA would have had no reason to apply Jin's gap (or distance) T to Chang: this gap is meant to address issues arising when doping the backside of a solar cell substrate. Chang does not dope the backside of its substrate.

The Petition begins by pointing to Chang alone. Here, Petitioner admits that "Chang's Figures 1 and 8" does "not show an isolation portion" as required by

challenged claim 1. Petition at 53. This is exactly what the Examiner held during prosecution of the parent application. (Ex. 1006 at 254.)

Figures 1 and 8 of Chang are reproduced below:

FIG. 1

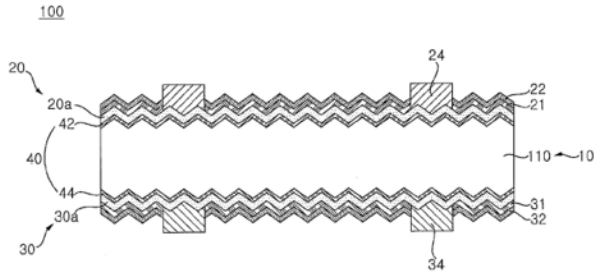
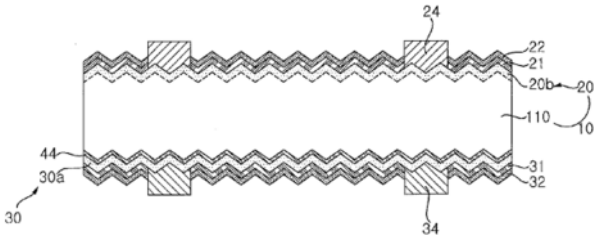


FIG. 8



(Chang, Figs. 1, 8.) Both figures show similar solar cells with a conductive "emitter area **20** and a back surface field area **30**…." (Chang, [0036].) These areas are of opposite conductivity types. "One of the emitter area 20 and the back surface field area 30 is referred to as a 'first conductive type area' and the other is referred to as a 'second conductive type area'." (*Id.*, [0037].) Chang teaches that, as illustrated in the figures, "the emitter area **20** and the back surface field area **30** may be disposed at different sides of the semiconductor substrate **10** to form a double-surface light-receiving type structure." (*Id.*, [0076].) Because these conductive regions are "disposed at different sides" of the substrate, they cannot form a short-circuit and, thus, Chang has no need for an isolation portion, as required by claim 1 "***for***

preventing a contact between the polysilicon layer and the emitter region." (*See* Ex. 2001, ¶¶ 265-271.)

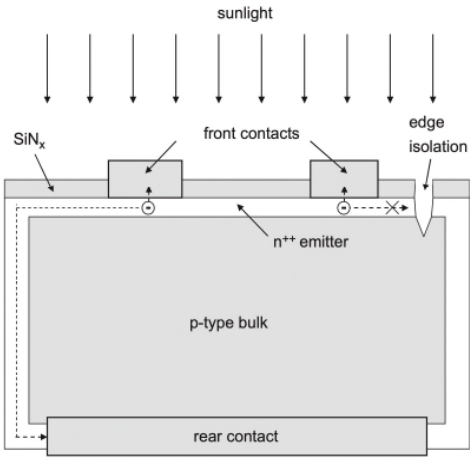
Despite admitting that "Chang's Figures 1 and 8 did not show an isolation portion," the Petition nonetheless contends "the specification describes it." Petition at 53. That is not correct. Nowhere in its specification does Chang describe use of an isolation portion like that required by claim 1 of the '009 patent. Instead, Chang says the opposite: no such isolation portion is required in its solar cell. More particularly, per Chang, "[b]ecause the emitter area 20 and the back surface field area 30 are not adjacent to each other, the necessity of performing an isolation process when the emitter area 20 and the back surface field area 30 are formed to be adjacent to each other ***is eliminated***." (Chang, [0076]. (emphasis added).) This according to Chang, is beneficial because the "manufacturing process is simplified and cost is thus reduced." (*Id.*)

Petitioner and Dr. Bannerjee ignore all this. Instead, they fixate on Chang's statement that tunneling layer **44** is "entirely formed" over the back surface of substrate **10** (*id.*, [0056]), while its back surface field area **30** is "entirely formed" over the second tunneling layer **44** (*id.*, [0062]). The Petition points out a statement in Chang to the effect that "[a]s used herein, the expression 'entirely formed' means that an element such as a layer is formed over an entire surface without an empty area or a non-coverage area, or is formed in an entire area excluding pre-designated

or inevitably formed regions such as periphery region, isolation region or the like." (*Id.*, [0056], [0062].). Petitioners argue that this reference to an "isolation region" means that Chang teaches the specific isolation portion required by claim 1 of the '009 patent.

This fails to account for Chang's actual disclosure. Again, Chang specifically describes that one benefit of its structure is that ***no*** such isolation portion is required. (*Id.*, [0076].) Moreover, while Chang's "entirely formed" language could potentially exclude "pre-designated or inevitably formed regions," Chang does not "pre-designate" the isolation portion claimed by the '009 patent and such an isolation portion is not "inevitably formed." Indeed, Petitioners admit that Chang's Figures 1 and 8 do not show such an isolation portion. (*See* Ex. 2001, ¶¶ 272-280.)

Next, Chang's "isolation region or the like" is not even necessarily located at the substrate edge. Indeed, Petitioner itself cites and points to prior art "edge isolation" is formed within the boundaries of the substrate surface:



(Ex. 1026 at 1639.) There is nothing in Chang that precludes this type of structure. This, however, is not what the claims require: such an ***"isolation portion"*** is not ***"in an edge portion"*** of the ***"substrate."*** (*See* Ex. 2001, ¶¶ 281-283.)

If this were not enough, Chang ***also*** states that the layers formed on its ***front surface*** can be "exclude[ed]" from "pre-designated or inevitably formed regions such as periphery region, isolation region or the like." (Chang, [0045], [0051].) So, even if Petitioner is correct, and Chang's reference to "inevitably formed regions" means that no layers are located in a region around the edge of the substrate, ***none*** of Chang's layers will be located in the substrate's edge regions. It follows that Chang lacks the claimed "isolation portion" ***"for preventing a contact between the polysilicon layer and the emitter region."*** Because both the front and backside layers are not present in the edge regions of the substrate (at least under Petitioner's interpretation of Chang), there can be no contact between the layers. (*See* Ex. 2001, ¶¶ 284-286.)

A POSITA also would have had no reason to apply Jin's gap (or distance) T to Chang. As explained, Jin employs this gap because it forms both its emitter layer 120 and back surface field layer 150 by doping the front and backside of the same substrate. *See supra* Section II.C.1. The gap (or distance) T prevents the layers from contacting each other, and also addresses the diffusion of impurities through the portion of the substrate located between the layers. *See id.*

Chang, however, does not employ a back surface field layer 150 that is formed by doping the substrate. Instead, Petitioner points to tunnel oxide and polysilicon layers that are deposited ***on top*** of the substrate's back surface. Moreover, according to Chang, (i) its emitter and BSF regions are "not adjacent to each other" (and, thus, cannot short), (ii) the need for "performing an isolation process is eliminated," and (iii) not performing an (unnecessary) isolation process results in a "simplified" manufacturing process and "reduced" cost. (Chang, [0076].) Given all this, a POSITA would not have been motivated to modify Chang and add an unnecessary, complicated, and expensive isolation step. Chang explains again and again that it does not have the problems the gap (or distance) T is meant to address. (*See* Ex. 2001, ¶¶ 287-294.) Moreover, even if a POSITA were to try to exclude Chang'e polysilicon layer from the gap (or distance) T, there is absolutely no reason to also exclude the tunnel oxide from this area. Doing so would be entirely unnecessary (as the tunnel oxide is passivating and acts as a diffusion barrier), non-sensical (as the space occupied this layer would later be filled with an oxide in any event), and give rise to the very same manufacturing difficulties and device performance issues discussed in connection with Ground 1. *See supra* Sections II.C.1-3; *see also* Ex. 2001, ¶¶ 295-299.

Thus, Petitioners have not met their burden to prove a reasonable likelihood that the combination of Chang and Jin render obvious claim 1 of the '009 patent.

There is no motivation for a POSITA to make that combination, Chang specifically criticized it, and, at a minimum, the combination does not disclose (i) "***an isolation portion for preventing a contact between the polysilicon layer and the emitter region***" and (ii) "***wherein the isolation portion excludes the oxide layer and the polysilicon layer, and is in an edge portion of the first surface of the silicon semiconductor substrate."***

This combination of prior art also fails to teach claim 8's ***"thickness of the edge portion in the polysilicon layer"*** that ***"progressively decreases toward the isolation portion."*** The Petition once again points to "small amounts of polysilicon" extending into Jin's gap (or distance) T. *See* Petition at 71-72. This is not what this limitation requires. *See supra* Section II.C.4.

III. CONCLUSION

For the reasons explained above, Petitioner has not met its burden to show obviousness. The patentability of all of the challenged claims should be confirmed.

Respectfully submitted,

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Dated: July 28, 2025

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CERTIFICATE OF WORD COUNT

The undersigned certifies that the foregoing reply complies with the type-volume limitation in 37 C.F.R. § 42.24. According to the utilized word-processing system's word count, the reply contains 10,400 words.

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