

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MUNDRA SOLAR PV LIMITED,
Petitioner,

v.

FIRST SOLAR, INC.,
Patent Owner

Case IPR2025-01411
Patent No. 9,666,732

PATENT OWNER PRELIMINARY RESPONSE

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LIST OF EXHIBITS

Exhibit	Description
2001	Keith R. Hummel Biography
2002	Declaration of Keith R. Hummel in Support of PHV Motion
2003	Chunduri, S.K., et al., “PERC Solar Cell Technology 2016: Background, Status and Outlook”, <i>TaiyangNews</i> (2016)
2004	Gupta, M., “Adani targets 10 GW of polysilicon-to-solar module capacity by 2025”, <i>PV Magazine</i> (Sept. 29, 2022)
2005	Fuhs, M., “TOPCon: The next big thing after PERC”, <i>PV Magazine</i> (Oct. 8, 2018)
2006	Press release, “Adani Enterprises Ltd FY23 Results” (May 4, 2023)
2007	“Adani Solar launches 575 W TOPCon bifacial PV module”, <i>Renewable Watch</i> (Apr. 1, 2024)
2008	Adanisolar.com, “Manufacturing Technologies” (accessed Oct. 13, 2025)
2009	Zacks Equity Research, “FirstSolar to Buy TetraSun, Gives View”, <i>Yahoo! Finance</i> (Apr. 10, 2013)
2010	“First Solar to Acquire TetraSun to Expand Addressable Market Opportunity”, <i>Business Wire</i> (Apr. 9, 2013)
2011	Shepard, J., “First Solar to Acquire TetraSun to Expand Addressable Market Opportunity”, <i>EEPower</i> (Apr. 11, 2013)
2012	Glunz, S.W., et al., “Silicon-based passivating contacts: The TOPCon route”, <i>Progress in Photovoltaics</i> (Dec. 20, 2021)
2013	Office of the United States Trade Representative, 2025 Special 301 Report (Apr. 2025)
2014	Gupta, K., et al., “Protecting Intellectual Property for National Security”, <i>Center for Strategic and International Studies</i> (Mar. 2025)
2015	<i>Crystalline Silicon Photovoltaic Cells, Whether or Not Assembled Into Modules from India, Indonesia, and Laos</i> , Investigation Nos. 701-TA-772–774 and 731-TA-1756–1758 (Preliminary), Pub. 5665 (U.S. I.T.C. Sept. 2025)
2016	Scheduling Order, <i>Mundra Solar PV Limited v. First Solar, Inc.</i> , C.A. No. 25-462 (JLH) (D. Del. Oct. 2, 2025), ECF No. 24
2017	Ltr. from S. Etienne-Cummings to Counsel for First Solar (Sept. 19, 2025)
2018	Declaration of Dr. Michael Dudley, Ph.D., in Support of Patent Owner Preliminary Response

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1. INTRODUCTION

Mundra Solar P.V. Limited (“MSPVL”) challenges the claims of the ’732 Patent on two obviousness grounds. But neither supports institution for a simple reason: Mundra’s proposed combinations of references do not contain all of the elements of the challenged claims. And while MSPVL tries to use its expert declaration and attorney argument to fill in the gaps of the missing elements, these arguments are unsupported by the prior art and, in some instances, are contrary to basic scientific principles. *See, e.g.*, Pet. 27-29, 31-33, 54, 56, 57, 93-96.

MSPVL contends in Ground 1 that claims 1–4 and 6–9 are obvious over Yablonovitch in view of Kwark. But MSPVL effectively admits that Yablonovitch does not disclose claim element [1d.2], which recites a process step in which the thermal treatment of a solar cell assembly causes an oxygen dopant to diffuse from an amorphous silicon-containing compound into a substrate and thereby form an oxide layer at the substrate surface. MSPVL attempts to plug this gap by contending that another reference, Kwark, recognizes that the claimed diffusion step would occur under the conditions disclosed in Yablonovitch. Not so. Specifically, MSPVL contends that, upon thermal treatment, oxygen would diffuse *from* a layer of relatively low oxygen content *through* a layer of high oxygen content to diffuse into the silicon substrate. But that is simply not how

diffusion works. Indeed, Kwark discloses an entirely different physical phenomenon – the formation of microscopic crystalline silicon/silicon oxide shells within SIPOS. Thus, Kwark does, and *cannot*, support the conclusion that the challenged process steps would occur under the conditions disclosed in Yablonovitch, because that would defy the laws of physics.

In Ground 2, MSPVL contends that dependent claim 5 is obvious over Yablonovitch in view of Kwark and Batra. Ground 2 relies on the arguments set forth in Ground 1 for the elements of claims 1 and 2, from which claim 5 depends, and therefore is deficient for at least the same reasons.

Thus, the Board should deny institution because MSPVL has not shown a reasonable likelihood of success as to *any* challenged claim.

2. THE CHALLENGED PATENT

A. The Invention

Solar technologies convert sunlight into electrical energy. An emerging solar technology is known as TOPCon, which stands for “tunnel oxide passivated contact”. TOPCon solar cells have reduced recombination (*i.e.*, when excited electrons combine with atoms in the solar cell rather than generating electricity) and higher bifaciality (*i.e.*, the ability to generate electricity from both

sides of a solar panel), which gives those cells higher operational efficiency as compared to other solar cell technologies.

Here, the claimed methods of the '732 Patent improve upon the manufacturing efficiency and performance of solar cells, particularly TOPCon solar cells.

The claimed methods of the '732 Patent were developed by inventors, Oliver Schultz-Wittmann and Denis DeCeuster, who also co-founded TetraSun, which is now a fully owned subsidiary of First Solar.

B. The Claims

The '732 Patent has nine claims. The sole independent claim, Claim 1, recites:

1. [1Pre] A method of fabricating a solar cell,
comprising:

[1a] providing a substrate;

[1b] providing an interface passivation layer over the
substrate;

[1c] providing a passivating film over the interface
passivation layer, the passivating film comprising a
passivating material and a conductive dopant;

[1d] wherein providing the interface passivation layer and providing the passivating film comprise:

[1d.1] providing an amorphous silicon-containing compound over an upper surface of the substrate, the compound comprising oxygen dopant and the conductive dopant;

[1d.2] thermally treating the amorphous silicon-containing compound to diffuse the oxygen dopant, at least in part, into the upper surface of the substrate to form an oxide layer over the substrate, the oxide layer defining the interface passivation layer; and

[1d.3] wherein remaining amorphous silicon-containing compound above the oxide layer defines the passivating film; and

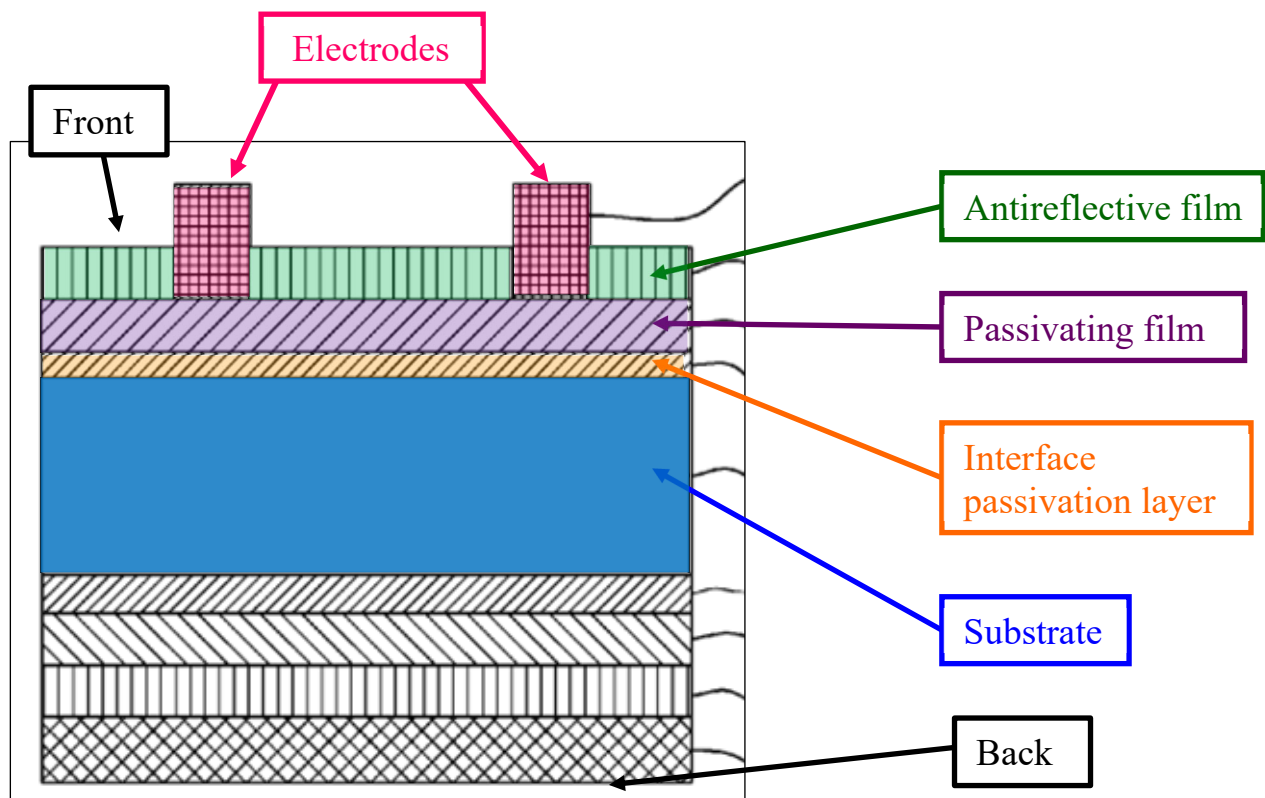
[1d.4] wherein the thermally treating also diffuses at least a portion of the conductive dopant throughout the interface passivation layer to facilitate electrical connection to the substrate; and

[1e] providing at least one electrode over the passivating film, wherein the conductive dopant within the passivating film and throughout the interface passivation

layer provides direct electrical connection between the at least one electrode and the substrate.

Ex. 1001, 19:39–20:20.

A non-limiting illustration of the structure resulting from the inventive method of claim 1 is reproduced in the diagram below.



(Ex. 1001 ('732 Patent), Figure 8 (annotated).)

In this assembly, when electrons are “excited” by sunlight, they move from the substrate and to the electrodes through both the interface passivation layer and the passivating film. The claimed thermal treatment facilitates diffusion of the

conductive dopant through the interface passivation layer and, in some embodiments, into the silicon substrate. That diffusion of dopant creates charge carrier flow paths from the central substrate to the front electrodes.

3. LEVEL OF ORDINARY SKILL IN THE ART

For the purposes of this Response, First Solar accepts MSPVL’s definition of a POSA: “someone with a bachelor’s degree involving the disciplines of electrical engineering, applied physics, chemistry, or materials science, and at least two years of experience designing, developing, or researching in the field. Alternatively, a person with less formal education but additional relevant practical experience, or vice versa, would also qualify as a person of ordinary skill in the art. EX1003, ¶67.” Pet. 20–21.

First Solar reserves the right to present issues relating to the level of ordinary skill should the Board institute this IPR and in other proceedings involving the ’732 Patent.

4. PETITIONER’S BURDEN

An IPR may be instituted only when “the *information presented in the petition* . . . shows that there is a *reasonable likelihood* that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition”. 35 U.S.C. § 314(a) (emphases added). Any IPR petition must “identif[y] . . . with

particularity . . . the grounds on which the challenge to each claim is based . . . ”.

35 U.S.C. § 312(a)(3). As such, it is MSPVL’s burden to “specify where each element of the claim is found in the prior art Patents or printed publications relied upon”. 3 C.F.R. § 42.104(b)(4).

The Board “will not take on the role of advocate for a party, trying to make out a case the party has not adequately stated”. Standing Order ¶ 121.5.2 (B.P.A.I. Mar. 8, 2011). Rather, it is Petitioner’s duty to provide sufficient grounds for the institution of a review “focus[ing] on concise, well organized, easy-to-follow arguments supported by readily identifiable evidence of record”. *Cisco Sys., Inc. v. C-Cation Tech, LLC*, IPR2014-00454, Paper No. 12, at 11 (P.T.A.B. Aug. 29, 2014).

As explained below, the Petition fails to demonstrate a reasonable likelihood that any claim of the ’732 Patent is unpatentable. The Petition should therefore be denied. The Petition should additionally be denied for the reasons described in First Solar’s Request for Discretionary Denial. Dkt. 7.

5. THE PETITION FAILS TO ESTABLISH A REASONABLE LIKELIHOOD OF SUCCESS IN SHOWING THAT ANY CHALLENGED CLAIM IS UNPATENTABLE.

MSPVL has failed to establish a reasonable likelihood of success in showing that any of its two asserted combinations of references renders obvious any of the claims of the '732 Patent.

- A. **Ground 1:** MSPVL has not demonstrated a reasonable likelihood of success in showing that Yablonovitch in view of Kwark renders any challenged claim obvious.

MSPVL fails to show that the combination of Yablonovitch and Kwark would render any of the challenged claims obvious. Specifically, as discussed below, the combination does not disclose at least limitation [1d.2], which recites *thermally treating the amorphous silicon-containing compound to diffuse the oxygen dopant, at least in part, into the upper surface of the substrate to form an oxide layer over the substrate.*

- i. Yablonovitch does not disclose diffusing oxygen dopant into the substrate.

Yablonovitch (Ex. 1005) discloses a process for making a type of solar cell in which oxidized silicon substrates are sandwiched between layers of semi-insulating polycrystalline silicon (known as "SIPOS"). This type of solar cell

is referred to as a “SIPOS-crystalline silicon-SIPOS double heterostructure solar cell”. (Ex. 1005, 1211.)

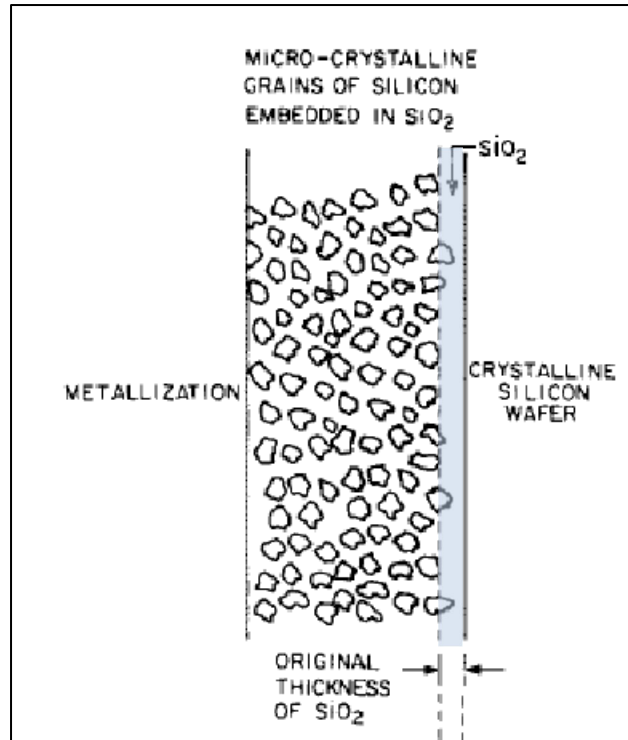
Element [1d.2] requires “*thermally treating the amorphous silicon-containing compound to diffuse the oxygen dopant, at least in part, into the upper surface of the substrate to form an oxide layer over the substrate*”. As noted in the immediately preceding claim limitation (1d.1), the amorphous silicon-containing compound contains both oxygen dopant and conductive dopant. Through the claimed thermal treatment, the oxygen dopant diffuses from the amorphous silicon-containing compound into the substrate, oxidizing the substrate. Yablonovitch does not disclose these process steps.

Instead, it discloses something entirely different. Table II of Yablonovitch, reproduced below, describes the steps for making the SIPOS solar cells.

TABLE II. Processing sequence.

1. Thin silicon wafers to 50 μm in aqueous KOH.
2. Getter in an oxidation furnace containing substantial chlorine.
3. Strip gettering oxide in HF acid.
4. Immediately load into cold APCVD furnace while purging with N_2 .
5. Ramp up to 650 $^{\circ}\text{C}$ while maintaining N_2 purge.
6. Oxidize for 5 min with 100 ppm O_2 .
7. Deposit SIPOS from 1000 ppm SiH_4 , 50 ppm PH_3 , and 10 ppm O_2 .
8. Ramp furnace to 900 $^{\circ}\text{C}$.
9. Anneal for 15 min.
10. Ramp furnace down to 450 $^{\circ}\text{C}$.
11. Anneal in forming gas for 2 h.
12. Pull wafers from cold furnace.

(Ex. 1005, Table II.) In the Yablonovitch process, the silicon wafer is heated to 650 $^{\circ}\text{C}$ (*step 5*) and exposed to oxygen gas for five minutes to form an oxide layer on the surface of the wafer (*step 6*). Ex. 1005, 1212. After the oxide layer is formed, SIPOS is deposited (*step 7*) on top of the silicon oxide. The SIPOS layer is deposited on opposite faces of the device. *Id.* at 1211-12. The solar cell assembly is then annealed at 900 $^{\circ}\text{C}$ (*steps 8 and 9*), causing silicon crystals to form, as shown in Figure 3 of Yablonovitch, reproduced below. *Id.*



(Ex. 1005, Figure 3 (annotated).) Critically, and as the figure makes clear (*see* annotation “ORIGINAL THICKNESS OF SiO₂”), the oxide layer (highlighted in blue) remains the same thickness before and after the annealing step (*step 9*). *Id.*

Thus, in Yablonovitch, the substrate (that is, the crystalline silicon wafer) is already oxidized (in *step 6*) **before** the silicon-based SIPOS layer (which contains the oxygen dopant) has been added in *step 7*. Thus, the oxide layer in Yablonovitch is not formed as a result of the diffusion of the oxygen dopant from the thermal treatment, which would be required to disclose Element [1d.2].

Nor does the annealing step in Yablonovitch result in the claimed diffusion. The oxide layer formed between the SIPOS and the substrate surface in *step 6* is 25-40 Angstroms thick. Ex. 1005, 1212. As Figure 3 of Yablonovitch shows, that oxide layer remains the same thickness (the “original thickness”) *after* the annealing step (*step 9*), which means that no additional oxygen dopant diffuses into the substrate as a result of the annealing step. If the oxygen dopant in Yablonovitch *had* diffused into the substrate as a result of the thermal treatment, as required by element [1d.2], the oxide layer would have become thicker, which would have been depicted in Figure 3. But that is not the case. The consistent thickness of the oxide layer before and after annealing confirms that the thermal treatment in Yablonovitch does not result in diffusion of the oxygen dopant to form an oxide layer. Yablonovitch thus does not disclose element [1d.2].

ii. Kwark fails to cure the deficiency of Yablonovitch.

The Petition does not propose modifying Yablonovitch in view of Kwark. Pet. 22. Instead, the Petition states that “[t]he combination of Yablonovitch and Kwark requires no modification to Yablonovitch – Kwark’s teachings supply details about the physical phenomenon occurring during Yablonovitch’s process that, while understood by a POSITA, Yablonovitch

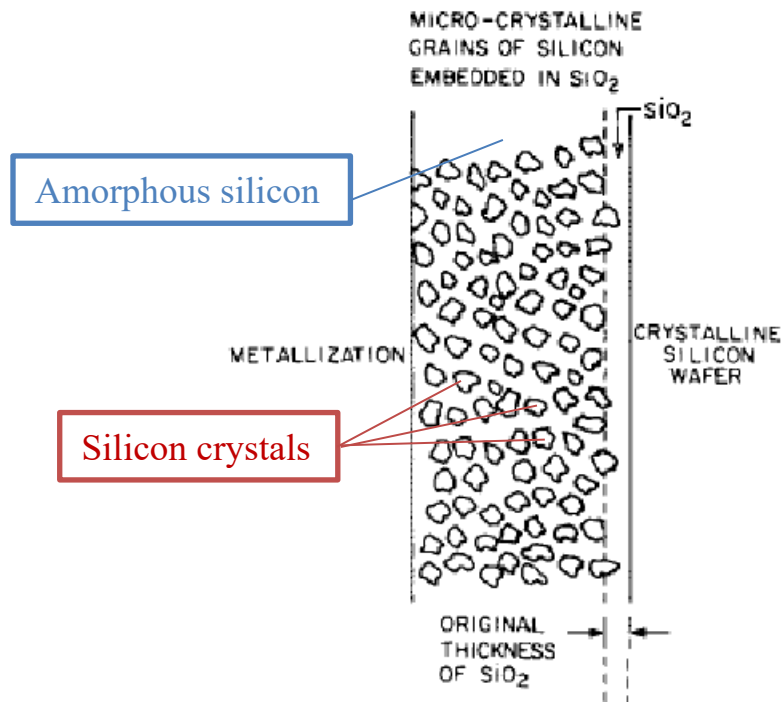
omitted.” *Id.* But MSPVL’s discussion of Kwark fails to fill the gap with respect to element [1d.2] left by Yablonovitch.

Kwark is a doctoral dissertation studying the use of SIPOS in semiconductor devices. Ex. 1017, 1. Kwark discusses the unique “shell morphology” or “shell model” of SIPOS. Ex. 1017, 111–17. This “shell morphology” refers to the structural change undergone by SIPOS when it is thermally treated. *Id.* As disclosed in Kwark, SIPOS is amorphous before thermal treatment is performed. *Id.* When heated, however, isolated grains of silicon within the SIPOS crystallize. *Id.* As Kwark describes, this heating process causes oxygen to be expelled from these crystalline silicon grains, and the expelled oxygen forms a thin silicon oxide layer (or “shell”) on the surface of the silicon grain crystals. *Id.* As Kwark describes it, the silicon grain crystals with silicon oxide “shells” form “microscopic islands” throughout *the amorphous SIPOS*. *Id.*

The Petition asserts that “Kwark recognizes that while ‘SIPOS in the as deposited form consists of amorphous silicon islands embedded in a silicon rich matrix,’ (corresponding to the amorphous silicon-containing compound), annealing (thermally treating) causes ‘rejection of oxygen from the crystals to the surrounding matrix’ (*i.e., to diffuse the oxygen dopant*).” Pet. 51–52 (emphasis added). But contrary to MSPVL’s assertion, Kwark never discloses “diffus[ing]

the oxygen dopant” into the substrate. In Kwark, the silicon “islands” with oxide “shells” are explicitly embedded in a SIPOS matrix. Thus, the thermal treatment step would result in thin silicon oxide shells forming on the surface of the silicon crystals, *not* oxygen dopant flowing into the silicon substrate, which is what is required by element [1d.2] of the '732 Patent.

The same is true in Yablonovitch. Figure 3 of Yablonovitch, as annotated below, shows silicon crystals (the “amorphous silicon islands” in Kwark and as described in the Petition) embedded in amorphous silicon.



(Ex. 1005, Figure 3 (annotated).)

MSPVL contends that, according to the teachings of Kwark, the annealing step (*step 9*) of Yablonovitch would cause the silicon crystals in Yablonovitch to expel oxygen into the “surrounding matrix”, which MSPVL contends is the silicon wafer layer. Pet. 52. This, MSPVL argues, is the diffusion of the oxygen dopant into the silicon substrate. *Id.* But MSPVL misapprehends the structure of Yablonovitch: the “surrounding matrix” into which oxygen would purportedly be expelled *is part of the SIPOS layer* in Yablonovitch. Accordingly, expulsion of oxygen into this “surrounding matrix” results in the oxygen dopant *remaining* in the amorphous silicon-containing compound (here, the SIPOS layer), *not* diffusing into the substrate (here, the silicon wafer) as required by claim 1.

Undeterred, MSPVL contends that “[t]he expulsion of oxygen outside the grains also causes the formation of an oxide layer at the Si-SIPOS interface”, attempting to use Kwark to support an argument about the oxide layer at the interface between the silicon wafer substrate and the amorphous silicon (here, SIPOS). Pet. 51–52 (quoting Ex. 1017, 178). But that is not the Silicon/SIPOS interface to which the quoted portion of Kwark refers; instead, Kwark is referring to the interface between the silicon *crystals* and the *SIPOS* matrix, where the expelled oxygen forms an oxide shell. Ex. 1017, 178. As is clear from reading the full sentence, the quotation from Kwark that is cited by

MSPVL has nothing to do with the interface between the silicon and the substrate, but instead relates to this interface between the crystalline silicon grains and the surrounding SIPOS matrix: “*Annealing promotes crystallization of the α -Si islands with accompanying* rejection of oxygen from the crystals to the surrounding matrix, *thereby forming a multiphase structure of the shell morphology proposed by Ni.*” *Id.* (emphasis added indicating portion of sentence omitted by MSPVL).

Mundra briefly mentions a “composite oxide” purportedly made of the SIPOS-formed oxide and a thermally grown oxide in an attempt to conflate the oxide shells described in Kwark with the silicon oxide layer in Yablonovitch. Pet. 52. However, as shown in Figure 7.19 of Kwark, the SIPOS-formed –oxide layer (the “shell”) is embedded in the SIPOS matrix, and never forms a “composite” oxide layer with the pre-existing chemical oxide (chemox) layer (*i.e.*, what Mundra calls the thermally grown oxide layer). *Id.*; Ex. 2018 ¶¶ 36–37.

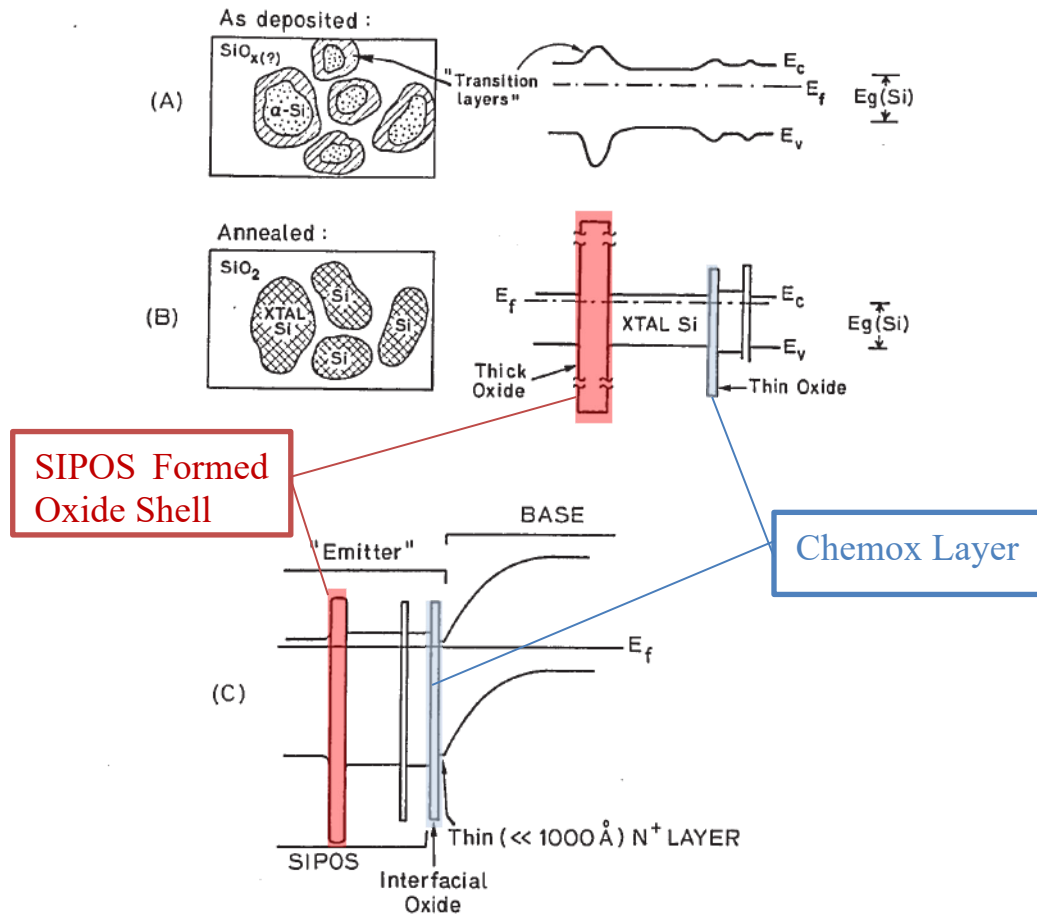


Figure 7.19: influence of annealing on SIPOS microstructure

(Ex. 1017, 179 (annotated).)

Kwark never discloses the diffusion of oxygen from the SIPOS layer (the *amorphous silicon* layer) into the silicon wafer substrate. Ex. 2018 ¶ 37. As such, Kwark cannot be used to overcome Yablonovitch's express teaching that the silicon oxide layer remains the same thickness after the annealing (thermal

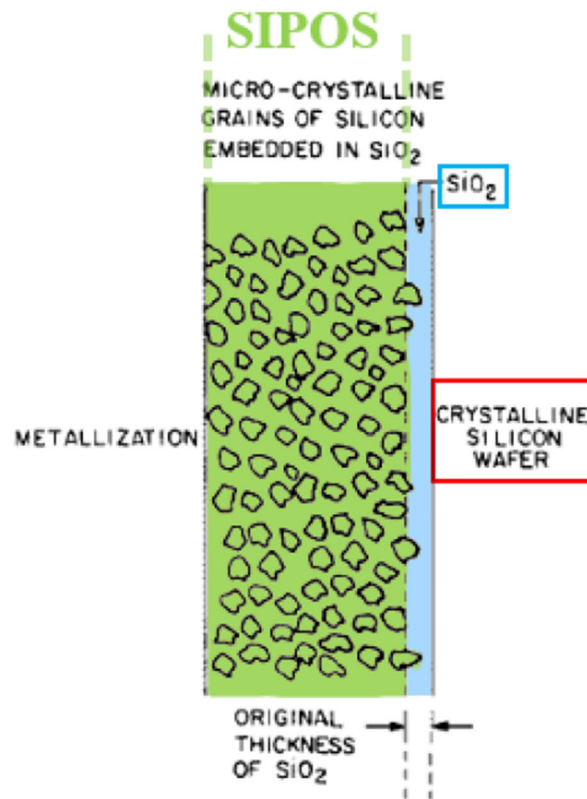
treatment step). Ex. 1005, Figure 3. Indeed, the Petition essentially admits that there is no supporting disclosure: MSPVL never states where the prior art discloses this claim element and instead merely asserts, without support, that “the anneal[ing] causes the SIPOS layer to diffuse the oxygen dopant, at least in part, into the upper surface of the substrate to form an oxide layer over the substrate”, parroting the claim language. Pet. 52.

iii. MSPVL’s application of Yablonovitch defies basic physics.

Not only is MSPVL’s theory devoid of any support in the prior art, it runs contrary to basic physics. As a general rule, atoms (such as an oxygen dopant) diffuse from high concentration areas to low concentration areas. Ex. 2018 ¶ 37. Generally, diffusion forces do not transport atoms into *higher* concentration areas. *Id.* Kwark recognizes this. As Kwark explains, the growth of the silicon crystals is limited by the ability of the oxygen to diffuse into the SIPOS. Ex. 1017, 113. As the grains of microcrystalline silicon form, the oxygen therein is expelled and gathers at the crystal surface. *Id.*; Ex. 2018 ¶ 34. When the oxygen collected at the crystal’s surface reaches a certain threshold, it reacts with the silicon at the interface to form the silicon oxide shell. Ex. 1017, 112-115. Accordingly, as Kwark explains, higher-oxygen SIPOS (*i.e.*, SIPOS with higher oxygen concentrations) grows smaller crystals than lower-oxygen SIPOS, because

oxygen cannot be expelled from the crystallizing silicon into the surrounding SIPOS matrix if the baseline oxygen concentration of the SIPOS is high and thus it more rapidly reaches the threshold to form silicon oxide. Ex. 1017, 113. (stating that high oxygen levels “retard further diffusion and grain growth ceases”).

Yablonovitch discloses that the SIPOS layer contains 5% oxygen and the disclosed oxide layer (SiO_2) contains 53.3% oxygen. Ex. 1005, 1213. The Petition’s reading of Yablonovitch would require oxygen to diffuse from the relatively low-oxygen SIPOS layer (annotated in green below) ***through*** an oxide layer with a high oxygen concentration (annotated in blue). But a POSA would understand that such diffusion could not happen, because the oxide layer has a higher oxygen concentration than the SIPOS layer. Ex. 2018 ¶ 40.



(Pet. 50, Annotated Figure 3.)

Claims 2–4 and 6–9 of the '732 Patent depend from claim 1.

Accordingly, claims 2–4 and 6–9 are patentable over Yablonovitch in view of Kwark for at least the reasons given above with respect to claim 1.

- B. **Ground 2:** MSPVL has not demonstrated a reasonable likelihood of success in showing that claim 5 is rendered obvious by Yablonovitch in view of Kwark and Batra.

Ground 2 of the Petition relies on Ground 1 for all of the elements of claim 1. Pet. 77. As discussed above, Ground 1 fails to render obvious claim 1 of

the '732 Patent. *See supra* section 5.A. Claim 5 depends from claim 1.

Accordingly, MSPVL has not demonstrated a reasonable likelihood of success on Ground 2 for the reasons in section 5.A.

6. CONCLUSION

For the reasons set forth above, MSPVL has not met its burden of establishing a reasonable likelihood of success in arguing that any of the challenged claims of the '732 Patent are obvious under asserted grounds. First Solar respectfully requests that the Board deny institution of *inter partes* review.

Dated: November 19, 2025

Respectfully submitted,



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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that First Solar's Patent Owner Preliminary Response contains 3163 words as counted by the word processing program used to generate this document. The figures in this response contain approximately an additional 196 words. This brings the total number of words to 3359. This total does not include the table of contents, table of authorities, appendix of exhibits, certificate of service, signature or certificate of word count.

Dated: November 19, 2025

Respectfully submitted,



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CERTIFICATE OF SERVICE

The undersigned certifies that a copy of the attached Response and supporting materials were served on November 19, 2025, by electronic mail, as authorized by Petitioner's Mandatory Notices:

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