Paper No. 1

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR (USA) INC.
Petitioner,

v.

TRINA SOLAR CO., LTD.
Patent Owner.

Patent No. 9,722,104
Issued: August 1, 2017
Filed: November 27, 2015
Inventor: Jungmin Ha, *et al*.
Title: Solar Cell and Method for Manufacturing the Same
Inter Partes Review No. 2025-00918

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 9,722,104

TABLE OF CONTENTS

Page

I. INTRODUCTION 1

II. COMPLIANCE WITH REQUIREMENTS FOR A PETITION FOR INTER PARTES REVIEW 2

A. Petitioner Can Contest The 104 Patent 2

B. IPR Fee (37 CFR §42.15(a) 2

C. Mandatory Notices (37 CFR § 42.8(b)) 2

III. IDENTIFICATION OF CHALLENGED CLAIMS 4

IV. PERSON OF ORDINARY SKILL IN THE ART 5

V. CONTESTED PATENT OVERVIEW 5

A. Effective Filing Date 5

B. 104 Patent Overview 6

C. The Prosecution History 9

VI. TECHNOLOGY OVERVIEW 10

VII. THE PRIOR ART 17

A. Jin (EX1009) 17

B. Feldmann (EX1012) 20

C. Chang (EX1013) 22

VIII. CLAIM CONSTRUCTION 24

IX. GROUND 1: CLAIMS 1-6 & 9-10 ARE UNPATENTABLE OVER JIN AND FELDMANN 24

A. Motivation to Modify Jin with Feldmann 25

B. Reasonable Expectation of Success 27

C. Jin and Feldmann Disclose All Claimed Limitations 28

1. Claim 1 28
2. Claim 2 – Finger Electrodes....41
3. Claim 3 – Bus Bars 42
4. Claim 4 –Polycrystalline and Single Crystal 42
5. Claim 5 – Isolation Width....44
6. Claim 6 – Decreasing Polysilicon Thickness....44
7. Claim 9 – Electrodes Connected to the First Conductive Type Semiconductor Region....46
8. Claim 10 – Single Layer Electrodes 48

X. GROUND 2: CLAIMS 1-6 & 9-10 ARE UNPATENTABLE OVER CHANG AND JIN....49

A. Motivation to "Modify" Chang with Jin 52
B. Reasonable Expectation of Success 52
C. Chang and Jin Disclosed All Claimed Limitations....53
1. Claim 1 53
2. Claim 2 – Finger Electrodes....66
3. Claim 3 – Bus Bars 67
4. Claim 4 – Polycrystalline and Single-Crystal Silicon 67
5. Claim 5 – Isolation Width....68
6. Claim 6 – Decreasing Polysilicon....68
7. Claim 9 – Electrodes Connected to the First Conductive Type Semiconductor Region....70
8. Claim 10 – Single Layer Electrodes 70

XI. GROUNDS 3 & 4: CLAIMS 7 & 8 ARE UNPATENTABLE OVER THE COMBINATION OF EITHER JIN/FELDMAN OR CHANG/JIN IN FURTHER VIEW OF SEO....71

A. Overview of Seo....71
B. Ground 3: Jin, Feldmann, and Seo 74
1. Motivation to "Modify" Jin/Feldmann with Seo 74
2. Reasonable Expectation of Success 75

3. Claim 7 – First Passivation on Substrate Sides.....77
4. Claim 8 – Second Passivation on Substrate Sides 78
C. Ground 4: Chang, Jin, and Seo.....80
1. Claim 7 – First Passivation on Substrate Sides.....82
2. Claim 8 – Second Passivation on Substrate Sides 83

XII. GROUNDS 5 & 6: CLAIM 11 IS UNPATENTABLE OVER THE COMBINATION OF EITHER JIN/FELDMAN OR CHANG/JIN IN FURTHER VIEW OF WATABE.....85

A. Overview of Watabe.....85
B. Motivation to Modify Jin/Feldmann and Chang/Jin with Watabe.....88
C. Reasonable Expectation of Success 89
D. Ground 5: Jin, Feldmann, and Watabe (Claim 11) 90
E. Ground 6: Chang, Jin, and Watabe (Claim 11).....90

XIII. OBJECTIVE FACTORS SUPPORT OBVIOUSNESS.....91

XIV. DISCRETIONARY DENIAL IS INAPPLICABLE 92

XV. CONCLUSION 93

Attachment A. Proof of Service of the Petition

Attachment B. List of Evidence and Exhibits Relied Upon in Petition

Attachment C. Table of Claims and Elements

I. INTRODUCTION

This Petition is substantively identical to the petition filed by Runergy USA Inc. *et al*. ("Runergy IPR") (*see* IPR2025-00007, Paper 1), for which review was instituted (*id.*, Paper 11). A request for joinder is being submitted concurrently herewith.

Canadian Solar (USA) Inc. ("Petitioner") requests that claims 1-11 of U.S. Patent 9,722,104 (the "104 Patent") be cancelled as unpatentable. These claims are directed to well-known solar cell features, and the prior art relied in this Petition was not considered or before the Examiner during the 104 Patent's prosecution.

More than two years before August 31, 2015, the 104 Patent's effective filing date, a patent publication by Jin disclosed the alleged novel feature of a solar cell with an isolation region at the periphery of the back surface, between the back surface field (BSF) and the substrate's edge, to prevent to short-circuiting. The 104 Patent simply extended Jin's solar cell by replacing Jin's BSF formed by diffusion with a deposited polysilicon BSF along with an oxide layer in between. However, two years before the 104 Patent, a paper by Feldmann taught this very replacement of the BSF, which Feldmann termed as "TOPCon," or "tunnel-oxide passivated contact." A few months after Feldmann, Chang disclosed a solar cell with this same TOPCon structure implemented with an isolation region, just like the 104 Patent. The 104 Patent claims were neither novel nor non-obvious.

II. COMPLIANCE WITH REQUIREMENTS FOR A PETITION FOR INTER PARTES REVIEW

A. Petitioner Can Contest The 104 Patent

Petitioner certifies it is not barred or estopped from requesting *inter partes* review ("IPR") of the 104 Patent. Neither Petitioner, nor any party in privity with Petitioner, has filed a civil action challenging the 104 Patent's validity. Petitioner or any party in privity with Petitioner also has not previously filed an IPR against the 104 Patent. This IPR is filed within one year of the date of service of a complaint against Petitioner alleging infringement of the patent (October 8, 2024). The 104 Patent issued on August 1, 2017 and is thus available for IPR.

B. IPR Fee (37 CFR §42.15(a)

The Director is authorized to charge the fee specified by 37 CFR §42.15(a) to Deposit Account No. 50-1597.

C. Mandatory Notices (37 CFR § 42.8(b))

Petitioner, Canadian Solar Inc., CSI Solar Co., Ltd., Canadian Solar Manufacturing (Thailand) Co., Ltd., Canadian Solar US Module Manufacturing Corporation, and Recurrent Energy Development Holdings, LLC are the real parties in interest. The 104 Patent is involved in the following legal proceedings:

- *Runergy USA Inc.*, *et al. v. Trina Solar Co., Ltd.,* IPR No. 2025-00007 (trial instituted April 21, 2025).

- *Adani Solar USA Inc. et al. v. Trina Solar Co., Ltd.*, IPR No. 2025-00186.
- *Trina Solar Co., Ltd. v. Canadian Solar (USA) Inc., et al.*, Case No. 1-24-cv-01115 (D. Del.) (currently stayed).
- *Trina Solar Co., Ltd. v. Runergy USA Inc. and Runergy Alabama Inc.,* 24-cv-557-JCG (D. Del.) (currently stayed).
- *Trina Solar Co., Ltd. v. Jiangsu Runergy New Energy Technology Co., Ltd.*, 2-24-cv-07694-MCS (C.D. Cal.) (currently stayed).
- *Certain TOPCon Solar Cells, Modules, Panels, Components Thereof, and Products Containing Same,* Inv. No. 337-TA-1422 (U.S.I.T.C.) (Respondents are Adani Green Energy Ltd., Adani Solar USA Inc., and Mundra Solar PV Ltd.).

The 104 Patent was also involved in *Certain TOPCon Solar Cells, Modules, Panels, Components Thereof, and Products Containing Same,* Inv. No. 337-TA-1425, naming Petitioner and the Real Parties in Interest listed above as Respondents. But on March 21, 2025, Patent Owner filed motions to terminate the investigation against Petitioner and the Real Parties in Interest listed above, which the Administrative Law Judge granted and issued initial determinations on April 3, 2025. The Commission decided not to review the initial determination on April 21, 2025.

In addition, Petitioner is concurrently filing an IPR petition challenging claims 1-17 of related U.S. Patent No. 10,230,009 (the "009 Patent"). The 009 Patent is also being challenged in:

- *Runergy Alabama Inc. et al. v. Trina Solar Co., Ltd.*, IPR No. 2025-00006 (trial instituted April 21, 2025).
- *Adani Solar USA Inc. et al. v. Trina Solar Co., Ltd.,* IPR No. 2025-00187.

Lead Counsel is Samuel N. Tiu (Reg. No. 47,997), stiu@sidley.com, 213-896-6095. Backup Counsel are Brooke S. Boll (Reg. No. 76,268) brooke.boll@sidley.com, 213-896-6633, Tung Nguyen (Reg. No. 42,935) tnguyen@sidley.com, 214-981-3478, and Michael Roberts (Reg. No. 82,131) mlroberts@sidley.com, 214-981-3472.

Service on Petitioner may be made by email on counsel, and mail or hand delivery to: Sidley Austin LLP, 350 South Grand Avenue, Los Angeles, CA 90071. The fax number for lead and backup counsel is 213-896-6600.

Proof of service of this petition is provided in **Attachment A**.

III. IDENTIFICATION OF CHALLENGED CLAIMS

Ground	Claims	35 U.S.C. §	Prior Art Combination
1	1-6, 9-10	103	Jin and Feldmann
2	1-6, 9-10	103	Chang and Jin

3	7-8	103	Jin, Feldmann, and Seo
4	7-8	103	Chang, Jin, and Seo
5	11	103	Jin, Feldmann, and Watabe
6	11	103	Chang, Jin, and Watabe

Attachment B lists the evidence relied upon in this petition. **Attachment C** includes a listing of claims 1-11.

IV. PERSON OF ORDINARY SKILL IN THE ART

The person of ordinary skill in the art in the 104 Patent's field of solar cell design or manufacture in 2014-2015 ("Skilled Artisan") would have been someone with an advanced 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, that person would have had a bachelor's degree in electrical engineering, applied physics, or materials science, and at least three years of experience designing, developing, or researching in the field. EX1003-Decl., ¶49 (*see also* EX1037).

V. CONTESTED PATENT OVERVIEW

A. <u>Effective Filing Date</u>

The 104 Patent was filed on June 1, 2018, claiming priority to Korean Patent App. No. 10-2014-0168624, filed November 28, 2014, and Korean Patent App. No. 10-2015-0122846, filed August 31, 2015. However, the "isolation portion"

feature in every claim was not disclosed in the former priority document. EX1007; EX1003, ¶¶46-47. This feature was first introduced in the August 31, 2015 priority document. EX1008; EX1003, ¶48. Thus, the effective filing date is August 31, 2015.

B. <u>104 Patent Overview</u>

The 104 Patent discloses a solar cell. Figure 2 shows the solar cell's cross-section, while Figure 3 shows a backside plan view of the same solar cell.

FIG. 2

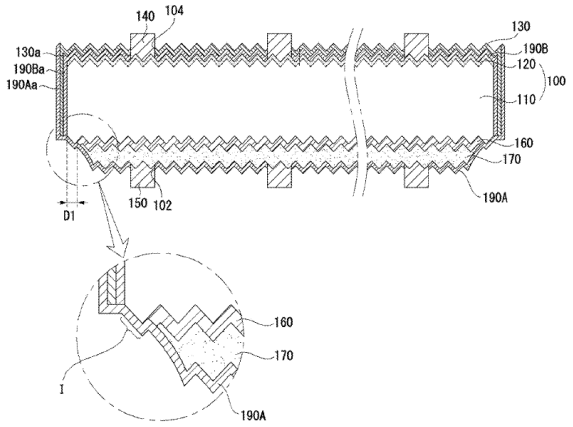
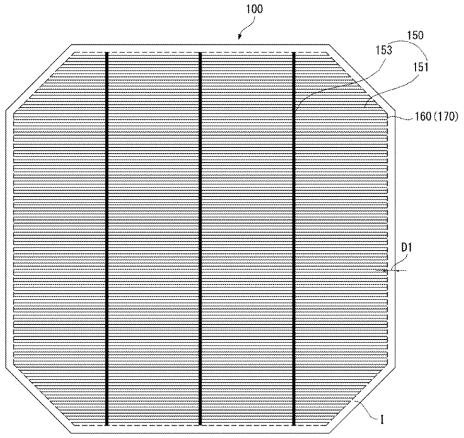


FIG. 3



The solar cell comprises a substrate 100 that includes a base region 110 doped with impurities (also called "dopants") of a first conductive type. EX1001, 7:31-35. On the substrate's back surface (Figure 2, bottom side), a "first conductive type semiconductor region 170" is formed having the same conductive type as the substrate. EX1001, 7:41-43, 8:41-46. This "first conductive type semiconductor region 170" may be made of "polycrystalline silicon material," and is also referred to as a "polysilicon layer." EX1001, 2:15-18; 8:41-46, Abstract;

EX1003-Decl., ¶51. By having the same dopant type as the substrate, the polysilicon, first conductive type semiconductor region forms a "back surface field (BSF) region which has a higher doping concentration than the semiconductor substrate 100" and is referred to as a polysilicon BSF layer. EX1001, 10:10-16.

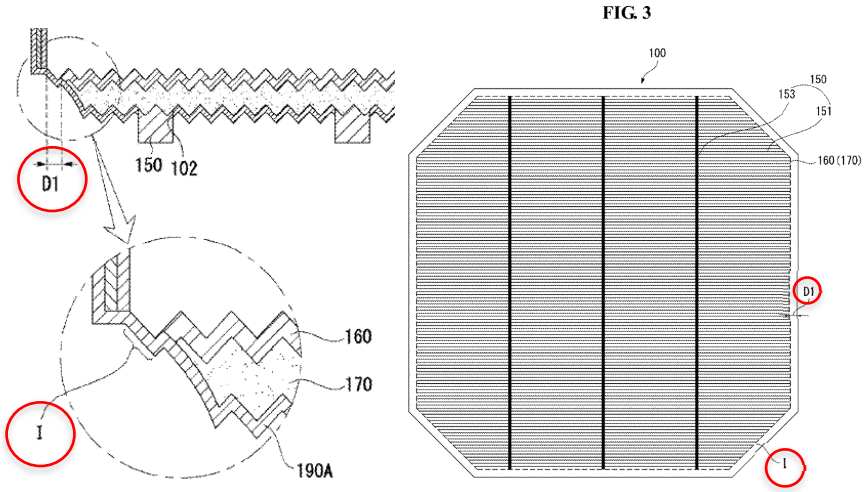
Between the polysilicon BSF 170 and the substrate's base region 110 is a tunnel layer 160. EX1001, 7:45-51. The tunnel layer 160 may include oxides. *Id*., 8:8-12.

On the solar cell's front sun-facing side, (Figure 2, top side), is a "second conductive type semiconductor region 120" that includes dopants of a different conductive type and forms an emitter region and a pn junction with the base region 110. EX1001, 10:16-25. The "second conductive type semiconductor region" is also referred to as the emitter region. EX1001, 10:21-20.

Passivation films 190A and 190B are formed on the polysilicon BSF layer 170 and the emitter region 120, respectively. EX1001, 10:61-11:8. First (back) and second (front) electrodes 150 and 140 respectively contact the polysilicon BSF layer 170 and the emitter region 120, through holes in the passivation films 190A and 190B. EX1001, 12:1-23.

The solar cell also has an "isolation portion I" shown magnified in Figure 2's inset and also as the white space along the solar cell's periphery in Figure 3.

The "isolation portion I" has a width of "D1" measured from the substrate's outer physical boundary.



The 104 Patent explains that the tunnel layer 160 and polysilicon BSF 170 "may be spaced apart from the edge of the back surface of the semiconductor substrate 100 (or the side of the semiconductor substrate 100) at a first distance D1." EX1001, 12:60-65. "That is, the isolation portion I in which the tunnel layer 160 and the first conductive type semiconductor region 170 … are not formed may be placed at the edge of the back surface of the semiconductor substrate 100." *Id.*, 13:6-12. By not forming (i.e., excluding) the tunnel layer 160 and the polysilicon BSF 170 at the edge of the substrate's back surface, the "isolation portion I" blocks contact between the polysilicon BSF 170 and emitter region 120. This contact would have otherwise resulted when "impurities of the second conductive type may be diffused into the side or the edge of the back surface of the semiconductor substrate 100" during formation of the emitter region 120. EX1001, 13:16-35.

This unwanted contact between the polysilicon BSF 170 and emitter 120 would have resulted in short-circuit if not prevented. *Id*.

C. **The Prosecution History**

The 104 Patent was filed with 38 claims. Application Claim 1 of the 104 Patent initially did not contain the "isolation portion" and its related limitations. EX1005, 56. After the election of species to the isolation portion feature, and without a subsequent Office Action, the Examiner initiated an interview "propos[ing] to incorporate the claim limitations from [application] claims 5 and 6 into claim 1 to put the application in condition for allowance," which the applicants accepted. *Id*., 380, 607, 705.

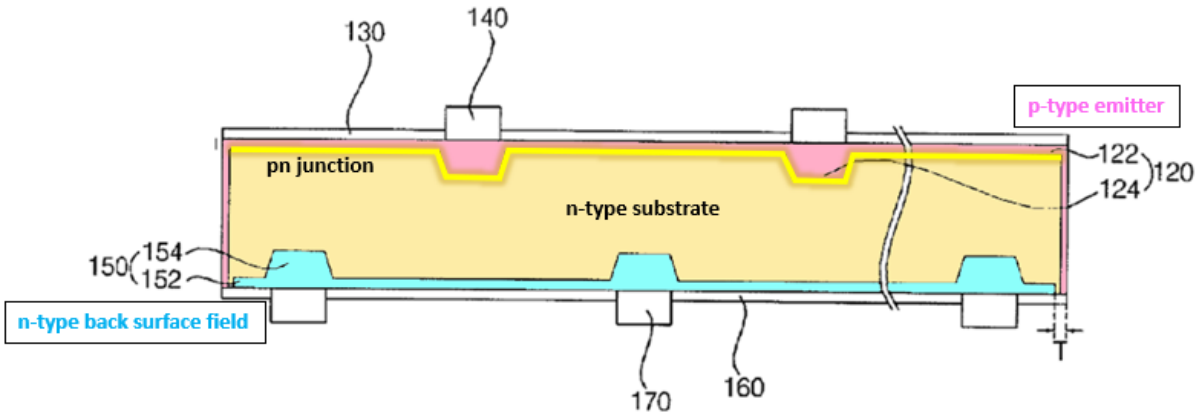
Application claims 5 and 6 were directed to the "isolation portion" and related limitations. EX1005, 57. In the reasons for allowance, the Examiner stated that the closest prior art, Yoon and Gortzen, did not disclose that "the isolation portion excludes the tunnel layer," and "an isolation portion for preventing a contact between the first conductive type semiconductor region and the second conductive type semiconductor region is in an edge portion of the first surface of the semiconductor substrate, and wherein the first passivation film covers the first surface of the semiconductor substrate and the isolation portion together." *Id*., 703.

U.S. Patent No. 10,014,419 (the "419 Patent") was filed as a continuation of the 104 Patent with 20 *method* claims. The applicants authorized an Examiner's amendment to add to claim 1, specific method steps for forming the "isolation portion" by removing the tunnel layer and the "first conductive semiconductor region" layer already on the substrate, to obtain allowance. EX1006, 254, 264. The Examiner stated that the closest prior art, Heng and Chang, did not disclose "the claimed features of the removing step as recited and the first passivation film covering the first surface of the semiconductor substrate along with the isolation portion." *Id*., 254.

VI. TECHNOLOGY OVERVIEW

A solar cell converts sunlight into electricity. EX1003-Decl., ¶66. A cell typically has multiple layers of silicon and other materials, including a base silicon substrate. *Id.* In a standard solar cell, impurities, typically boron or phosphorus, are introduced into the silicon layers to alter the layers' conductive properties in a process known as "doping." EX1021-Quirk, 34-38. Silicon doped with boron has an absence of electrons (i.e., "holes") compared to pure silicon, and is known as a "p-type" material. *Id*., 36-37. Conversely, silicon doped with phosphorous has an excess of electrons, and is known as an "n-type" material. *Id*., 36. Techniques for doping silicon and polysilicon layers were well established by 2015. EX1003-Decl., ¶66.

To generate electrical current, an interface between the n-type and p-type layers must be formed, which is known as the "pn" junction. The layer that is oppositely doped from the substrate is known as the "emitter." Figure 3 of Jin (EX1009) below shows a basic example of a solar cell including an n-type substrate 110 (yellow) and a p-type silicon emitter layer 120 (pink), and an n-type BSF layer (teal). EX1009-Jin, ¶¶29, 47; EX1003-Decl., ¶67.



To form an emitter or BSF region, dopants may be introduced into silicon via thermal diffusion. EX1003-Decl., ¶68. In thermal diffusion, the cell is exposed to a dopant gas at a high temperature, and individual dopants penetrate a small distance into exposed silicon and become embedded. *See, e.g.*, EX1021-Quirk, 478, Fig. 17.3 (reproduced below); EX1003-Decl., ¶68.

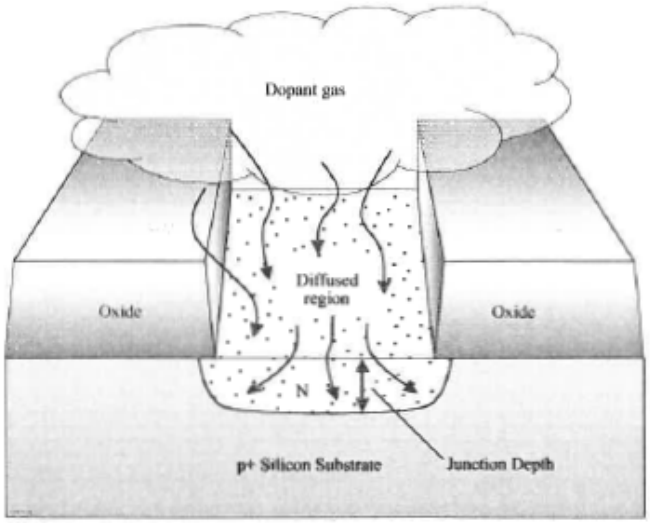
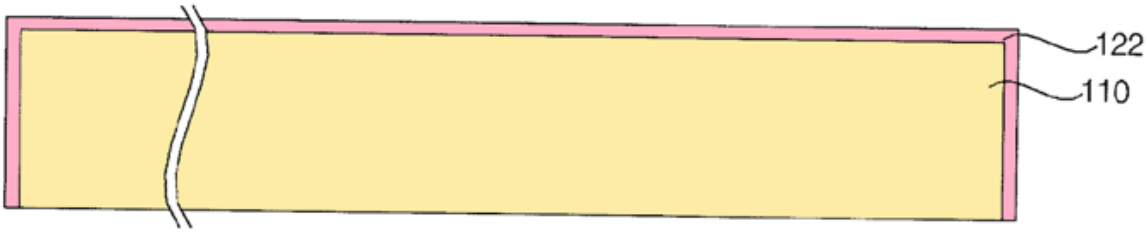


FIGURE 17.3 Doped Region in a Silicon Wafer

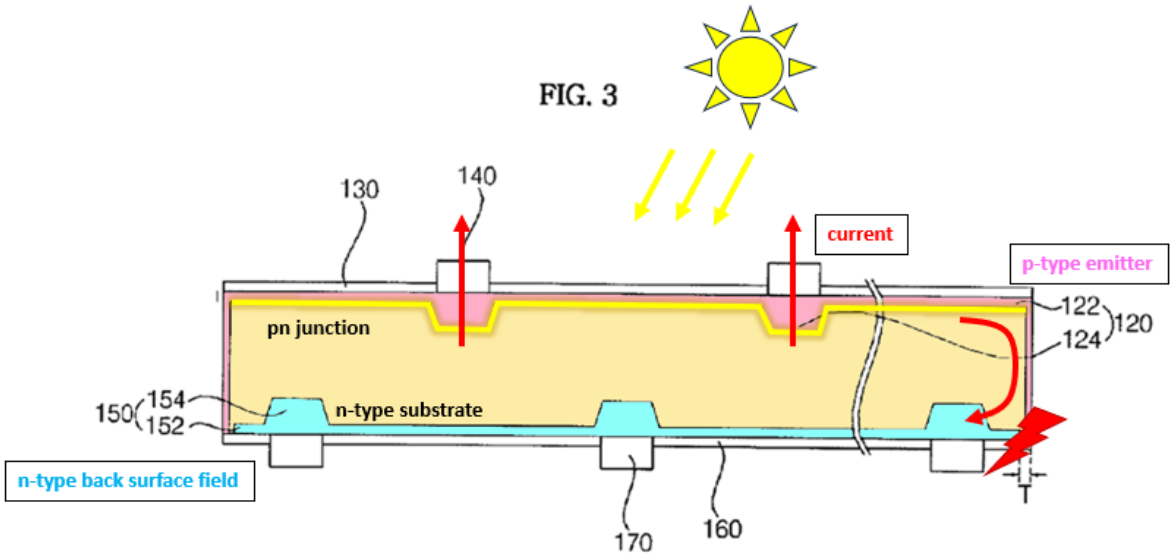
As a result, a flat-lying substrate exposed to dopant gas during thermal diffusion will have dopants diffused into not only the top surface of the substrate, but also the exposed lateral side surfaces. EX1003-Decl., ¶68. This phenomenon is evident in Jin's Figure 7(b), in which the yellow n-type substrate 110 is doped with p-type dopants to form the pink emitter layer 120 ("second area 122"), resulting in p-type doping along both the substrate's top and the lateral sides. *Id.*.



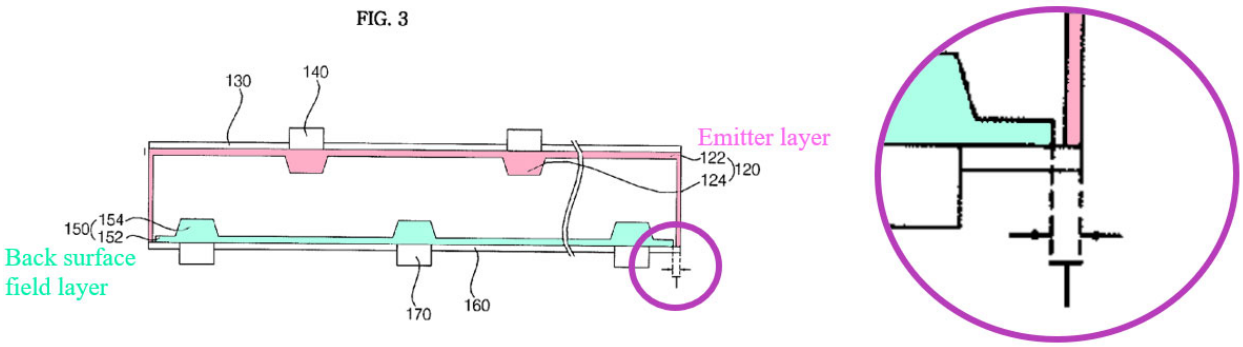
(b)

Because solar cells generate electricity through creation and movement of electron-hole pairs, it was well known that maximizing the number of electrons

and holes exiting a cell via electrodes improves efficiency. EX1003-Decl., ¶70. However, because of the dopants present on the substrate's lateral sides, the p- and n-type dopant regions may come into contact when the BSF layer is subsequently formed on the remaining surface. When this happens, the electrical pathway for the electrons and holes can become shorted between the emitter and the BSF, reducing current output to the electrodes. *Id*. Accordingly, the need to electrically isolate the emitter from the BSF was well known. *Id. citing*, EX1026-Kray, §1.



Jin recognized and solved this problem by using a mask during formation of the BSF layer 150 to leave a "gap T" between the BSF and the edge of the substrate 110, noting that if there is not enough separation, "the back surface field layer 150 and the emitter layer 120 may be shorted due to diffusion of impurities, which may be a cause for degrading the efficiency of the solar cell 100." EX1009-Jin, ¶60.



Chang likewise observed that the BSF may be formed over the entire substrate "excluding pre-designated or inevitably formed regions such as periphery region, isolation region or the like." EX1013-Chang, ¶62. Ensuring that the emitter and BSF layers remain isolated and do not short was thus well known before 2015. EX1003-Decl. ¶71

Another known way to increase solar cell efficiency is to increase the number of electrons and holes exiting through the electrodes by preventing them from "recombining" before exiting. "Recombination" happens when an electron freed by a photon collides with (and fills) a hole before reaching an electrode, preventing both the electron and hole from contributing to the output current and reducing efficiency. EX1003-Decl., ¶72. One well-known recombination mechanism is "surface recombination," whereby electrons or holes recombine at surfaces or interfaces between different materials. *Id*.

For years before 2015, different techniques were known to reduce surface recombination at the solar cell's back surface and thus improve efficiency. For

example, decades earlier, Lindholm replaced the then-"conventional" BSF (formed by diffusing the silicon substrate directly) with a doped polysilicon layer deposited on the substrate's back surface, which Lindholm described as "a new class of designs for high efficiency solar cells" that "show[ed] improvements" over conventional solar cells. EX1010-Lindholm, Abstract. Lindholm credited the improvements to "a decrease in effective surface recombination velocity." *Id*. Lindholm reported that compared conventional cells, "**the polysilicon-back solar cells show improvements** in red spectral response (RSR) and open-circuit voltage." *Id*., Abstract, §I; EX1003-Decl., ¶73.

As another example, Kwark reported that "incorporating a thin, tunnelable interfacial oxide" on polysilicon layers "impedes the flow of holes" and "achieve[d] J_{oe}[1] of less than $2x10^{-14}$ A/cm^2, an improvement of several decades over shallow diffused emitters." EX1011-Kwark, Abstract, §5. Another contemporaneous paper by the same authors, "Kwark II," also taught that addition of an "intentionally grown chemical oxide ['chemox']" between polysilicon and the substrate "greatly decreases the J_{oe}," which "translates into potential improvements of energy conversion efficiency for solar cells." EX1024-Kwark II,

---

[1] J_{oe} or J_0 refers to saturation current density, which is a measure of recombination. EX1003-Decl., ¶74.

742, 745; EX1003-Decl., ¶86. Kwark II provided data comparing polysilicon emitters with and without the oxide layer, and noted "the large difference [i.e., decrease in performance] when the interfacial oxide is missing." EX1024-Kwark II, 745, Fig. 4.

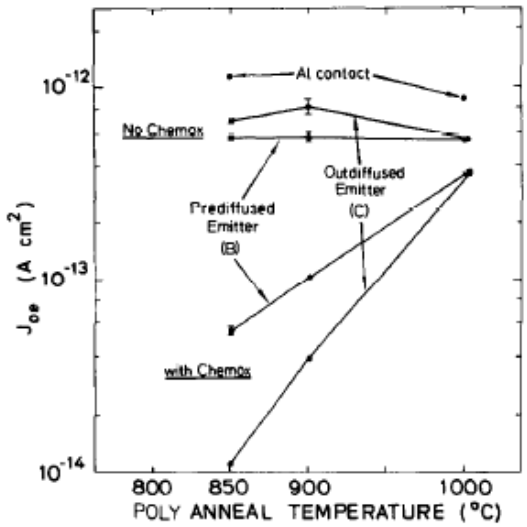


Fig. 9. Experimental J_{oe} vs anneal temperature for polysilicon contacted emitters.

Applying the teachings of Lindholm and Kwark, Feldmann disclosed a solar cell made using a "TOPCon" (tunnel oxide passivated contact) structure "based on an ultra-thin tunnel oxide (SiO2) and a phosphorus-doped silicon layer, which significantly reduce the surface recombination" where the electrodes contact the rear surface of the cell, and which resulted in "conversion efficiency of 23.0% for n-type cells". EX1012-Feldmann, Abstract. Chang (in addition to having a peripheral isolation region) implemented Feldmann's TOPCon structure in bifacial cells, such that "recombination sites on the back surface of the semiconductor

substrate are thus efficiently removed." EX1013-Chang, ¶¶10. As a result, "carriers causing photoelectric conversion are efficiently transferred" and "efficiency of the solar cells can be further improved." *Id*.; EX1003-Decl., ¶74.

VII. THE PRIOR ART

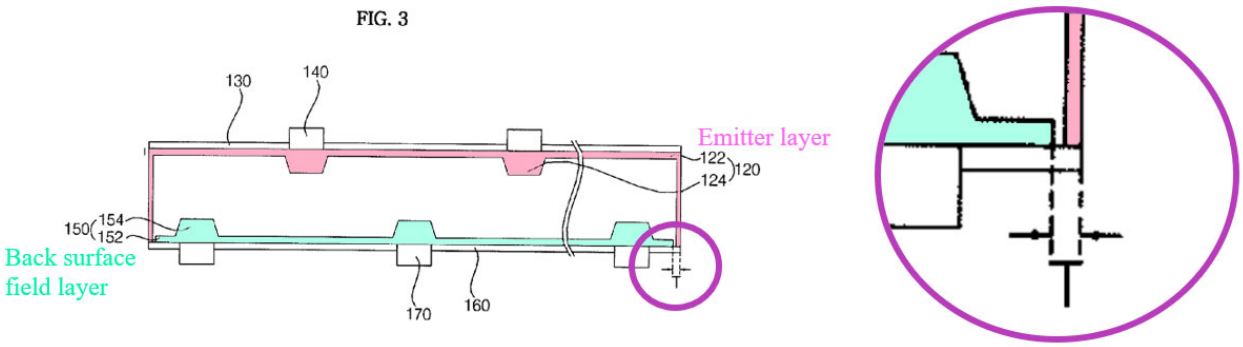
A. Jin (EX1009)

U.S. Patent App. Publication No. 2013/0056051 to Y. Jin, *et al*. ("Jin") was published on March 7, 2013. EX1009-Jin, face. Jin is prior art under 35 U.S.C. §102(a)(1).[2] The Examiner did not consider Jin during the 104 Patent's prosecution. The only difference between Jin and Claim 1 of the 104 Patent is the inclusion of a tunnel layer in between the substrate and the BSF layer of the solar cell. EX1003-Decl., ¶81.

Jin discloses a bifacial solar cell having a "silicon semiconductor substrate of a first conductive type," an emitter layer 120 formed on the front (sun-facing) side, and a BSF layer 150 formed on the opposite/back side. EX1009-Jin, Abstract, Fig. 3. The emitter layer 120 (pink) has a different conductive type than the substrate, while the BSF layer 150 (teal) has the same conductive type as the substrate. *Id*., Abstract. Both the emitter layer 120 and the BSF layer 150 can be formed in the substrate by a "heat diffusion method." *Id*., ¶¶78, 84.

---

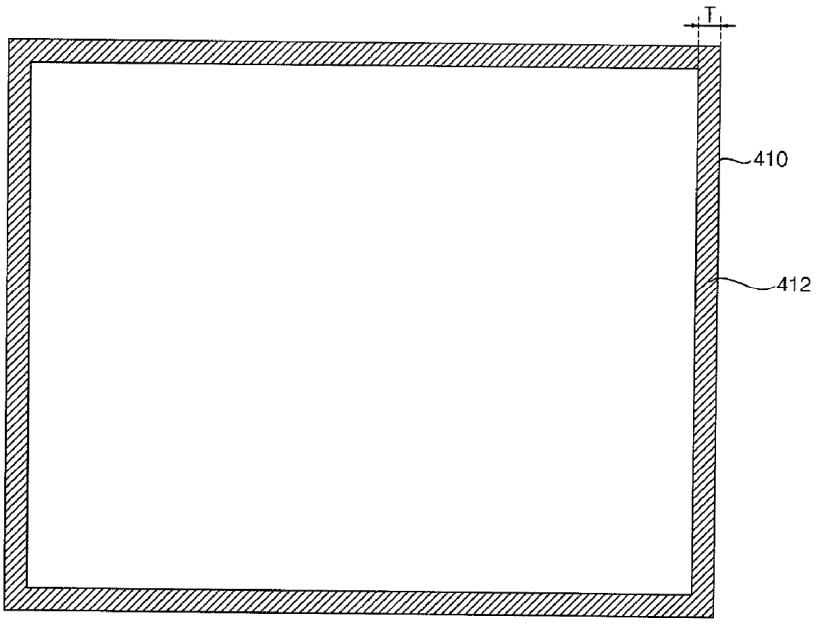
[2] Each citation to 35 U.S.C. §102 refers to the AIA version of that statute.



As shown in Figure 3, the emitter layer 120 is formed not just on the front surface of the substrate; but it also extends vertically down on both lateral surfaces of the substrate. And the BSF layer 150 is formed on the back surface of the substrate but short of the edge of the substrate by a gap "T." Jin explained that by forming the BSF 150 "separated from the edge of the substrate 110," the BSF would be electrically isolated from the emitter layer 120, thus preventing short-circuiting the emitter and BSF regions and degrading the solar cell efficiency. EX1009-Jin, ¶¶57-60, 85-86.

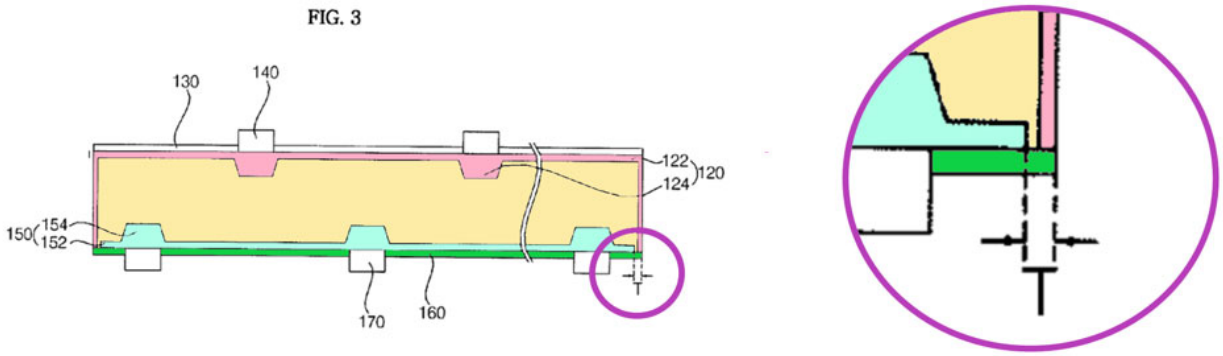
This isolation gap T is created using a mask to shield the perimeter of the substrate's rear surface when doping to form the BSF 150. EX1009-Jin, ¶¶83-86, Fig. 9. Jin explains that by using the mask 410 with "a part 412 to cover or overlap the edge part of the rear surface of the substrate 110, the fourth area 152 of the [BSF] layer 150 is formed." *Id.*, ¶83.

FIG. 9



(a)

Further, on the front and back sides of the solar cell, front and back passivation films 130 and 160 are formed on the emitter layer 120 and BSF layer 150, respectively. EX1009-Jin, ¶¶37, 50, Fig. 3. If the substrate is N-type, Jin explains that backside film 160 performs both anti-reflection and passivation functions. *Id.*, ¶50. As seen from Figure 3, the passivation layer 160 extends to the edge of the substrate and covers both the substrate and isolation gap "T" at the substrate's edge portion.



B. <u>Feldmann (EX1012)</u>

Substituting a diffused BSF with a polysilicon BSF layer and an interfacial tunnel oxide layer would have been obvious to the Skilled Artisan before August 31, 2015. EX1003-Decl., ¶¶105-114. Following the Lindholm (EX1010) and Kwark (EX1011) teachings in the 1980s, Feldmann did just that.

Feldmann published a paper, "Passivated rear contacts for high-efficiency n-type Si solar cells providing high interface passivation quality and excellent characteristics," in Solar Energy Materials & Solar Cells ("Feldmann"). Feldmann was published and made available online on October 11, 2013 and was publicly accessible at least by May 2014. EX1012-Feldmann, 270; EX1035-Mullins, ¶¶40-56 (*see also* EX1038). Feldmann is prior art under 35 U.S.C. §102(a)(1). The Examiner did not consider Feldmann during the 104 Patent's prosecution.

Feldmann demonstrated that a solar cell combining the polysilicon BSF layer of Lindholm with the interfacial oxide layer of Kwark would significantly

improve its efficiency. EX1003-Decl., ¶88. Citing to both Lindholm's and Kwark's studies (EX1010 and EX1011), Feldmann explained that "[o]ur approach, which we have called TOPCon (Tunnel Oxide Passivated Contact) is based on these prior approaches and consists of an ultra-thin tunnel oxide and a phosphorus-doped silicon layer." EX1012-Feldmann, §1. In particular, Feldmann reported that "solar cells with the TOPCon structure have shown excellent performance" and that "the best cell has an independently confirmed efficiency of 23.0%." *Id*., §3. According to Feldmann, the TOPCon structure "significantly reduce[s] the surface recombination at the metal-semiconductor interface." *Id*., Abstract. Feldmann also explained that "the tunnel oxide is a vital part of this passivated contact and that it is required to achieve excellent interface passivation." *Id*.

Feldmann's TOPCon solar cell, shown in Figure 3 below, has an n-type substrate with a "p^+-emitter" (green), a passivation film (yellow), and an anti-reflection coating (blue) on the front sun-facing side of the substrate. EX1012-Feldmann, Fig. 3, §2.1. On the substrate's backside is the TOPCon structure consisting of the tunnel oxide (SiO_2) (light blue) and the phosphorus-doped polysilicon layer (red). *Id*. (Coloring in original); EX1003-Decl., ¶89.

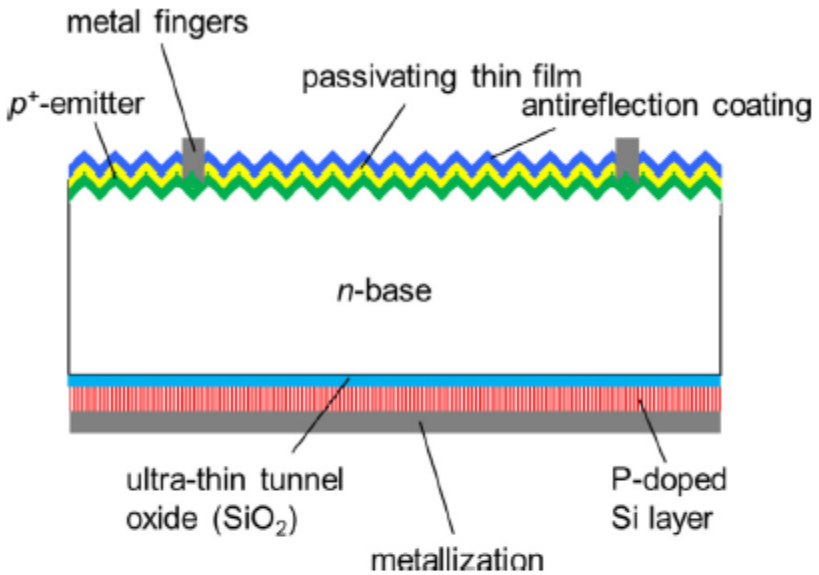


Fig. 3. Schematic of the solar cell structure with the passivated rear contact. The solar cells feature a diffused boron-doped emitter at the front side which is passivated by atomic layer deposited (ALD) aluminum oxide Al_2O_3 and a plasma-enhanced chemical vapor deposited (PECVD) silicon nitride SiN_x.

Applying Feldmann's teaching and replacing the TOPCon structure for the diffused BSF layer in Jin would have resulted in a solar cell that met all of the limitations of Claim 1 and most dependent claims of the 104 Patent. EX1003-Decl., ¶90.

C. <u>Chang (EX1013)</u>

Following Feldmann, U.S. Patent App. Publication No. 2014/0299187 to Chang, *et al.* ("<u>Chang</u>") further demonstrates the obviousness of the 104 Patent claims. Chang was filed on April 2, 2014 and published on October 9, 2014. EX1013-Chang, face. Chang is prior art under 35 U.S.C. §102(a)(1). Although Chang was published less than one year before August 2015, the one-year exception under 35 U.S.C. 102(b)(1) does not apply because there are no common

inventors between Chang and the 104 Patent, though they both were originally assigned to LG Electronics.

Combining the teachings of Jin and Feldmann, Chang disclosed a bifacial solar cell having a frontside emitter 20, a backside polysilicon BSF 30, and a tunnel oxide layer 44 in between the substrate 10 and the BSF 30, as depicted in Figures 1 and 8. EX1013-Chang, ¶¶36, 61, Figs. 1, 8. Figures 1 and 8 are alternative embodiments that differ only in the frontside layers. The backside layers of both Figures 1 and 8 are the same. *Id.*, ¶101. EX1003-Decl., ¶92.

FIG. 1

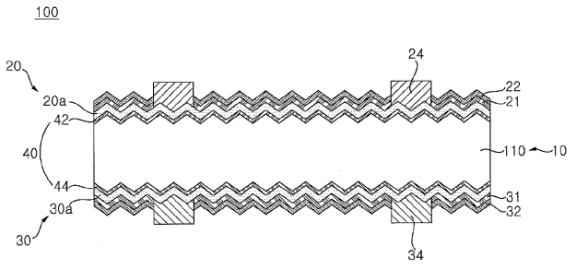


FIG. 8

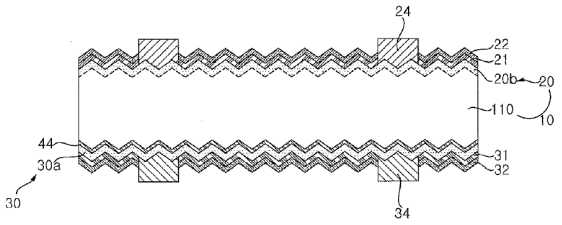


Figure 8 is akin to a solar cell resulting from the combination of Jin and Feldmann that replaces the diffused BSF of Jin with a TOPCon structure, as taught by Feldmann. EX1003-Decl. ¶92. Figure 1 extends Feldmann's approach to likewise include a tunnel oxide 42 and polysilicon layer 20 on the front side to form the emitter region. EX1013-Chang, ¶¶36, 45.

Regardless, with respect to the backside, Chang further taught an embodiment where the tunnel and BSF layers ***are not formed*** all the way to the

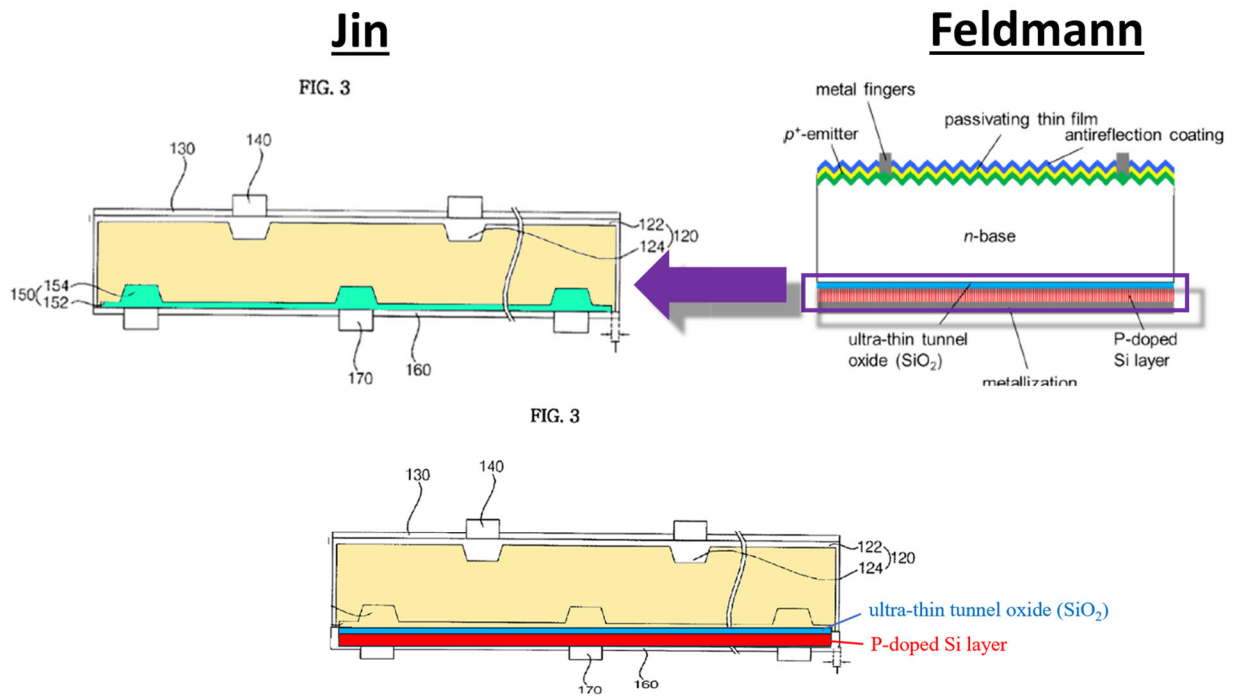
edge of the substrate, and thus forming an "isolation region" at the periphery (EX1013-Chang, ¶¶36, 56, 62), as discussed in more detail in §X.C.1.j below.

VIII. CLAIM CONSTRUCTION

No claim construction is believed to be necessary to resolve this Petition.

IX. GROUND 1: CLAIMS 1-6 & 9-10 ARE UNPATENTABLE OVER JIN AND FELDMANN

The combination of Jin and Feldmann would have rendered Claims 1-6 and 9-10 obvious. The combination would have been nothing more than substituting the diffused BSF layer 150 (green) of Jin with the phosphorous-doped polysilicon layer (red) of Feldmann along with the beneficial tunnel oxide layer (blue) on the backside of Jin's solar cell substrate. EX1003-Decl., ¶105. The resulting solar cell would meet all limitations of Claim 1, as illustrated below using a modified Jin Figure 3. *Id*.



Proposed Combination

A. Motivation to Modify Jin with Feldmann

Jin and Feldmann are analogous art because each is in the same field of endeavor—solar cell design—and pertinent to the problems of solar cell efficiencies. EX1003-Decl., ¶106.

The Skilled Artisan would have been motivated to replace Jin's BSF layer 150 with a tunnel oxide layer and polysilicon BSF because Feldmann and others taught that making this substitution would reduce surface recombination and improve solar cell efficiency. EX1003-Decl., ¶107. As discussed in §VI above, it was known and suggested for decades that heavily-doped polysilicon, like that disclosed in Feldmann, could be used to beneficially replace a BSF layer, like that

used by Jin, as demonstrated by Lindholm in 1985. EX1003-Decl., ¶108. Likewise, it has also been known for decades that tunnel oxides in between a polysilicon layer and substrate could be used to improve solar cells by reducing recombination. EX1003-Decl., ¶109.

Following Lindholm and Kwark's studies, Feldmann did combine the polysilicon BSF of Lindholm and the interfacial oxide layer of Kwark and demonstrated significant improvement in solar cell efficiency. EX1012-Feldmann, §1; EX1003-Decl., ¶110.

The Skilled Artisan would thus have been motivated to follow Feldmann and specifically replace Jin's BSF 150 with a polysilicon BSF layer and an intervening oxide layer to reduce surface recombination and improve solar cell efficiency. EX1003-Decl., ¶111. Indeed, Feldmann itself provides motivation to incorporate the disclosed TOPCon structure in Jin's isolated n-type solar cell by reporting that the TOPCon structure "significantly reduce[s] the surface recombination at the metal–semiconductor interface," making the tunnel oxide "a vital part of this passivated contact and that it is required to achieve excellent interface passivation." EX1012-Feldmann, Abstract. And because Feldmann's emitter, like Jin's, is formed by diffusion, it is susceptible to shorting and would benefit from Jin's gap-T isolation region. EX1003-Decl., ¶113. Indeed, following Feldmann,

Chang disclosed a bifacial solar cell with Feldmann's TOPCon structure and Jin's isolation region. *Id*.

B. Reasonable Expectation of Success

The Skilled Artisan would have considered the Jin/Feldmann combination to be merely an arrangement of old elements with each performing the same function it had been known to perform and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance). EX1003-Decl., ¶115. The Skilled Artisan would have been aware of numerous techniques for making the Jin/Feldmann solar cell, all of which would also have been well within the level of ordinary skill in the art. *Id*.

As an example, the Skilled Artisan could have placed 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. EX1003-Decl., ¶117. The metal mask could then be lifted off the substrate, leaving the oxide and polysilicon layers only in the areas not covered by the mask—the entire surface of the substrate with the exception of the gap-T isolation region. *Id.* (Dr. Banerjee's declaration provides other well-known techniques as well. EX1003-Decl., ¶¶118-121.)

Combining Jin and Feldmann would not have resulted in any unexpected results and could have been readily accomplished with a reasonable expectation of

success. EX1003-Decl., ¶123. The combination would simply have been the combination of well-known prior art elements and processes to yield predictable results. *Id*. It would have further constituted use of a known technique (growing an oxide layer and depositing doped polysilicon) to improve similar devices (Jin's solar cell) in the same way. *Id*. It is nothing more than applying known elements and technique to a known device ready for improvement to yield predictable results. *Id*.

C. Jin and Feldmann Disclose All Claimed Limitations

1. Claim 1

a) [1.a] Preamble

Jin and Feldmann both disclose "*a solar cell*." EX1003-Decl., ¶124.

b) [1.b] Semiconductor Substrate

Jin and Feldmann disclose "*a semiconductor substrate*."

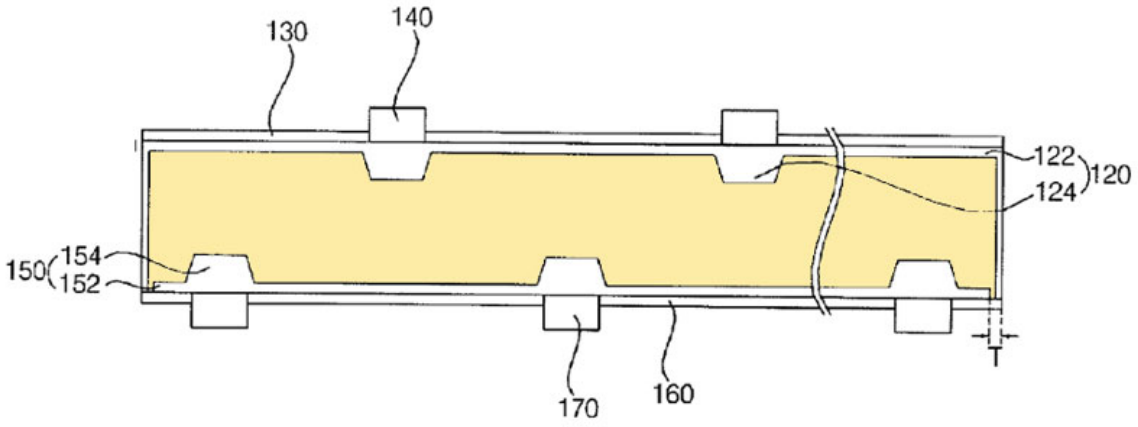
Jin discloses that its solar cell 100 (Figure 3), has a "silicon semiconductor substrate 110 [yellow] of a first conductive type." EX1009-Jin, ¶26, Fig. 3[3]. In the Jin/Feldmann combination, substrate 110 is doped with phosphorous (P) "and [is]

---

[3] Jin Figure 2 identifies the silicon substrate 110. Figure 3 shows a cross-section of the same solar cell as Figure 1 but from a wider perspective. EX1009-Jin, ¶¶11-13; EX1003-Decl., ¶126.

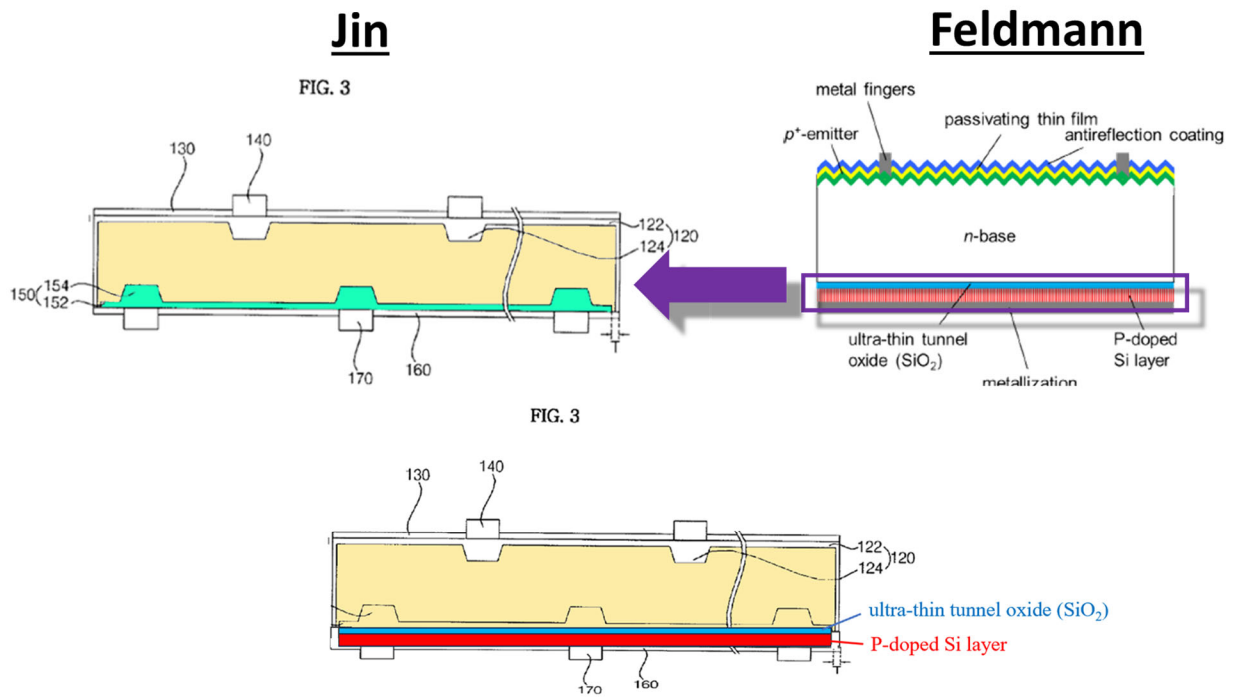
implemented as an N-type" semiconductor. EX1009-Jin, ¶¶26-27. Feldmann likewise discloses using an "n-type" silicon wafer, which is a silicon semiconductor substrate. EX1012-Feldmann, 271.

FIG. 3



c) [1.c] Tunnel Layer

Feldmann discloses "*a tunnel layer on a first surface of the semiconductor substrate.*" In the Jin/Feldmann combination, Jin's diffused BSF layer 150 is replaced with the TOPCon structure of Feldmann, i.e., the tunnel oxide (blue) and phosphorus-doped polysilicon (red) layers. EX1003-Decl., ¶128. Feldmann's tunnel oxide layer is formed on the rear surface (*first surface*) of the silicon substrate 110. *Id.*; EX1009-Jin, Fig. 3.

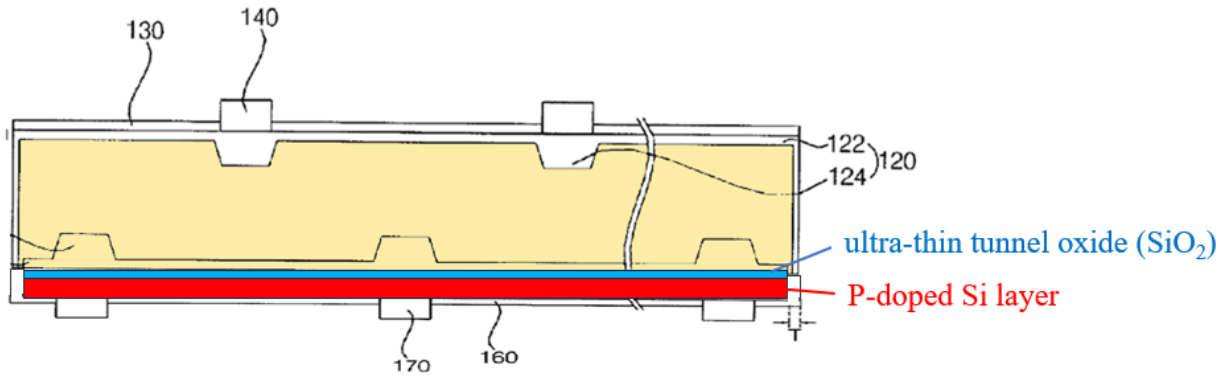


Proposed Combination

d) [1.d] First Conductive Type Semiconductor Region

Feldmann discloses "*a first conductive type semiconductor region on the tunnel layer and containing impurities of a first conductive type.*" In the Jin/Feldmann combination, Jin's diffused phosphorous-doped BSF 150 is replaced with Feldmann's TOPCon structure, which also has a phosphorus-doped polysilicon BSF (red) formed on the tunnel oxide layer. EX1003-Decl., ¶¶129-131. Phosphorous is an n-type dopant ("*impurities of a first conductive type*"). EX1009-Jin, ¶47. Phosphorous-doped silicon is a well-known n-type semiconductor, as observed by the 104 Patent. EX1003-Decl., ¶131; EX1001, 10:38-41.

Combination of Jin and Feldmann

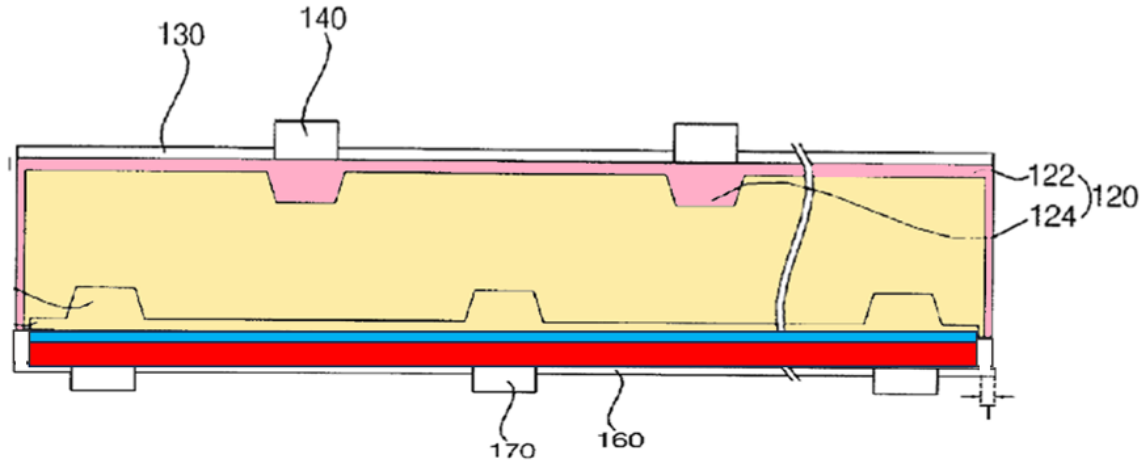


e) [1.e] Second Conductive Type Semiconductor Region

Both Jin and Feldmann disclose "*a second conductive type semiconductor region on a second surface opposite to the first surface of the semiconductor substrate and containing impurities of a second conductive type opposite to the first conductive type*." In Jin, the emitter layer 120 (pink) is on the front "*second surface*" of the silicon substrate 110, opposite to the rear "*first surface*" where the tunnel oxide layer (blue) would be located. EX1009-Jin, ¶29, Fig. 3. Jin teaches that "if the substrate 110 is an N-type, the emitter layer 120 is doped with a P-type impurity" ("*impurities of a second conductive type opposite to the first conductive type*"), and that by doping the substrate 110 and emitter layer 120 with "opposite types of impurities," a P-N junction is formed. *Id*. Jin also discloses that the substrate 110 is a "semiconductor substrate," and that the emitter layer 120 is formed by doping the substrate 110, such that the emitter layer 120 is "*a second*

conductive type semiconductor region" as claimed. EX1009-Jin ¶¶26, 29. In Feldmann, the front side similarly has a boron-doped "p+ emitter" layer on an n-type substrate/base. EX1012-Feldmann, §2.2, Fig. 3.

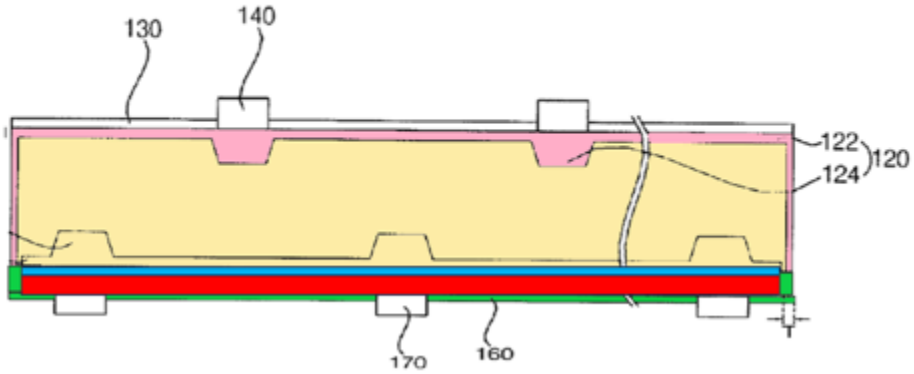
Combination of Jin and Feldmann



f) [1.f] First Passivation Film

Jin discloses "*a first passivation film on the first conductive type semiconductor region*." In the Jin/Feldmann combination shown below, an anti-reflection film 160 (green) would be placed on the phosphorous-doped polysilicon layer (red). EX1003-Decl., ¶134; EX1009-Jin, ¶50 ("a second anti-reflection film 160 is disposed on the back surface field layer 150"). Jin teaches that when the substrate 110 is n-type (as it is here), the anti-reflection film 160 (green) "performs the function of a passivation layer." *Id*.

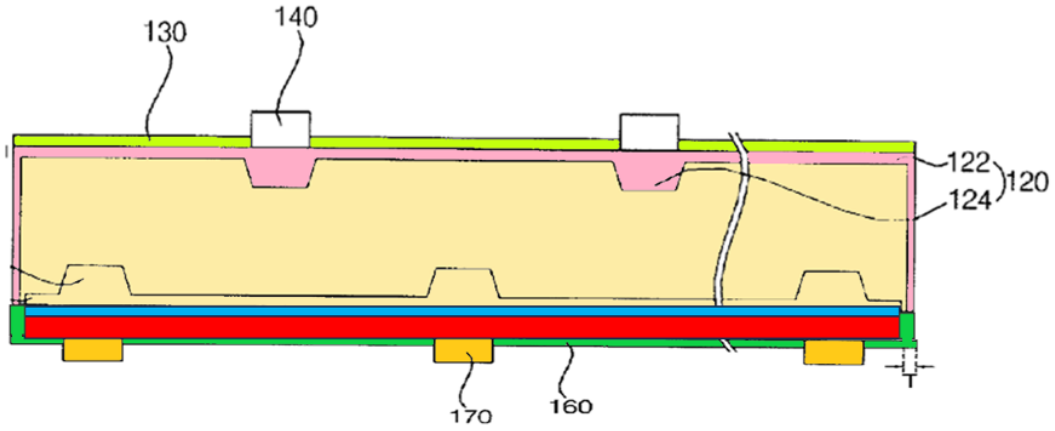
Combination of Jin and Feldmann



g) [1.g] First Electrode

Jin discloses "*a first electrode formed on the first passivation film and connected to the first conductive type semiconductor region through an opening formed in the first passivation film*." In the Jin/Feldmann combination, the rear finger electrodes 170 (orange) would be formed on the anti-reflection film 160 (green) and connected to the polysilicon layer (red) through gaps in the anti-reflection film, for example, by screen printing on the second anti-reflection film. EX1009-Jin, ¶¶26, 52-53, 99, 101; EX1003-Decl., ¶¶136-138. During screen printing of the front electrodes, silver paste is deposited on the anti-reflection film and heated to "penetrate[] the first anti-reflection film" and "make[] contact with the first area 124 of the emitter layer 120." EX1009-Jin, ¶¶52, 99; EX1003-Decl., ¶136. According to Jin, "the rear finger lines 170 may be formed in a similar way as the front finger lines 140" such that they connect to the polysilicon layer (red) through the anti-reflection film 160 (green) acting as a passivation layer. EX1009-Jin, ¶101. EX1003-Decl., ¶138.

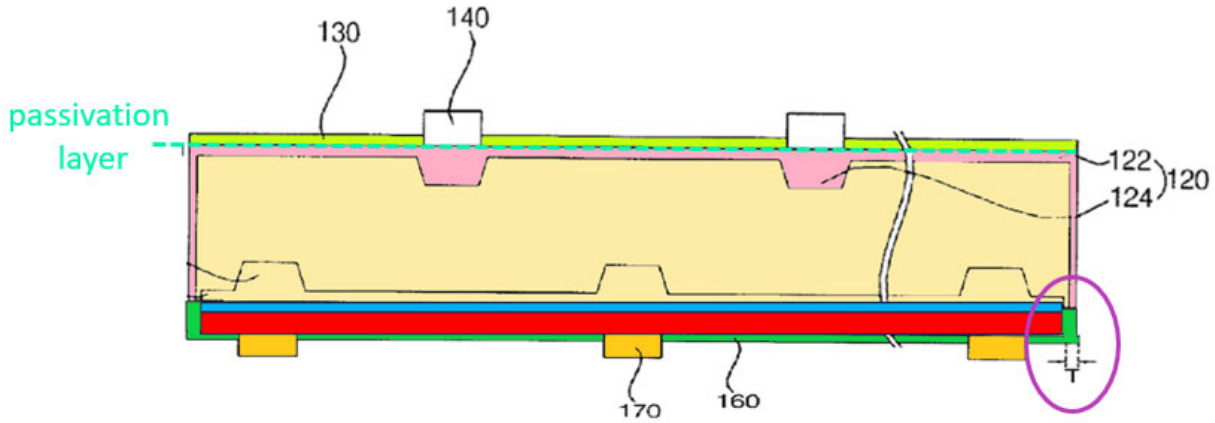
Combination of Jin and Feldmann



h) [1.h] Second Passivation Film

Both Jin and Feldmann disclose "*a second passivation film on the second conductive type semiconductor region.*" Jin discloses that "if the substrate 110 is an N-type [as it is here], a passivation layer may be further included between the emitter layer 120 and the first anti-reflection film 130" on the front side. EX1009-Jin, ¶37, Fig. 3. For Jin's passivation layer (not shown) to be between the emitter layer 120 (pink) and the first anti-reflection film 130 (light green), it must be on the emitter layer 120. EX1003-Decl., 139.

Combination of Jin and Feldmann



Feldmann also discloses a "passivating thin film" (yellow) on the emitter (green) and between the emitter (green) and the front side antireflection coating (blue). EX1012-Feldmann, Fig. 3.

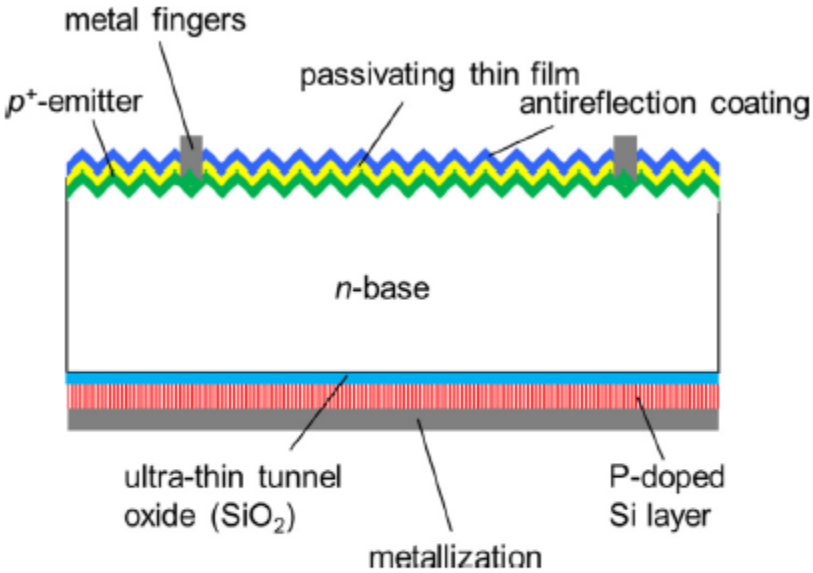


Fig. 3. Schematic of the solar cell structure with the passivated rear contact. The solar cells feature a diffused boron-doped emitter at the front side which is passivated by atomic layer deposited (ALD) aluminum oxide Al_2O_3 and a plasma-enhanced chemical vapor deposited (PECVD) silicon nitride SiN_x.

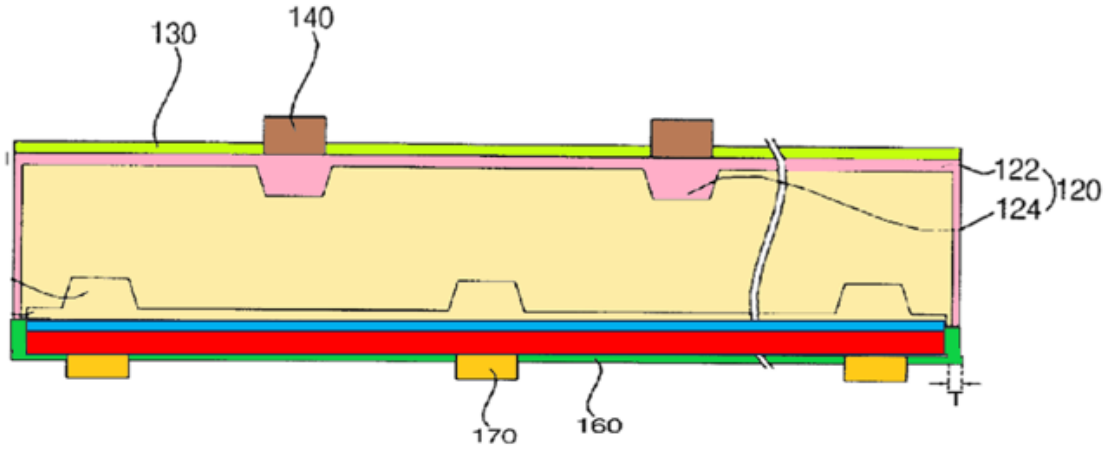
i) [1.i] Second Electrode

Jin and Feldmann both disclose "*a second electrode formed on the second passivation film and connected to the second conductive type semiconductor region through an opening formed in the second passivation film*." In Jin, the front finger electrodes 140 (brown) are formed on the passivation film (not shown) and connect to the emitter layer 120 (pink) (*second conductive type semiconductor region*) through gaps in the passivation film, for example, by screen printing on the passivation film. EX1009-Jin, ¶¶26, 38-40, 99, Figs. 3, 11; EX1003-Decl. ¶141-144. During the screen printing process, silver paste is deposited on the antireflection film and heated to "penetrate[] the first anti-reflection film" and "make[] contact with the first area 124 of the emitter layer 120." EX1009-Jin, ¶99; EX1003-Decl., ¶¶136, 142. Because the passivation film is between the antireflection film 130 and the emitter layer 120 (*see supra* §IX.C.1.h), the finger electrodes 140 must therefore also be formed on[4] the passivation film and connected to the emitter layer 120 through the passivation film.

---

[4] The 104 Patent explains that "on" does not mean a layer must be "directly on" another layer. EX1001, 5:58-63.

Combination of Jin and Feldmann



Feldmann likewise shows front electrodes connecting to the p+ emitter (green) through openings in the passivation film (yellow). EX1012-Feldmann, Fig. 3.

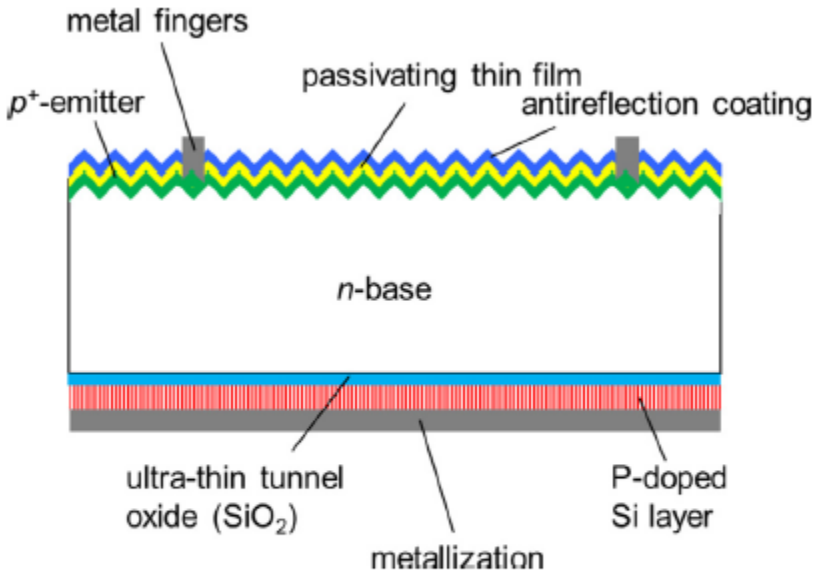
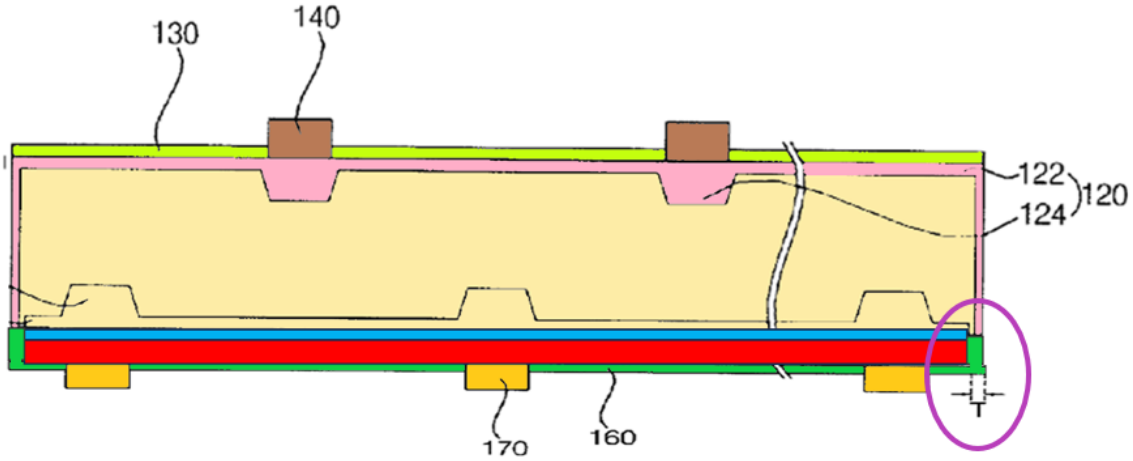


Fig. 3. Schematic of the solar cell structure with the passivated rear contact. The solar cells feature a diffused boron-doped emitter at the front side which is passivated by atomic layer deposited (ALD) aluminum oxide Al_2O_3 and a plasma-enhanced chemical vapor deposited (PECVD) silicon nitride SiN_x.

j) [1.j] Isolation Portion

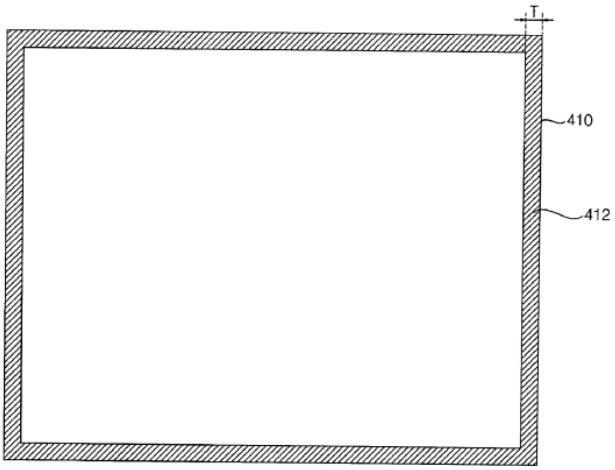
Jin discloses "*an isolation portion for preventing a contact between the first conductive type semiconductor region and the second conductive type semiconductor region, wherein the isolation portion excludes the tunnel layer and the first conductive type semiconductor region, and is in an edge portion of the first surface of the semiconductor substrate*." Jin's gap T separates the BSF 150 from the edge of the silicon substrate 110, and thus isolates and inhibits electrical shorting between the BSF 150 and the emitter 120 (pink) caused by diffusion of dopants along the edge of the substrate 110 when forming BSF 150. *Id.*, ¶¶57-60, Fig. 3. In the Jin/Feldmann combination, the gap T would separate the edge of the polysilicon BSF (red) and tunnel oxide layer (blue) from the edge of the silicon substrate 110, "*preventing contact*" with the emitter layer 120 (pink). EX1003-Decl., ¶148.

Combination of Jin and Feldmann



In the Jin/Feldmann combination, the mask configuration of Jin's Fig. 9 would be used to exclude the tunnel oxide (blue) and polysilicon (red) from being formed around the edge portion or periphery of the substrate. EX1003-Decl., ¶149; EX1009-Jin, ¶¶83-85, Fig. 9. *See* §IX.B.

FIG. 9



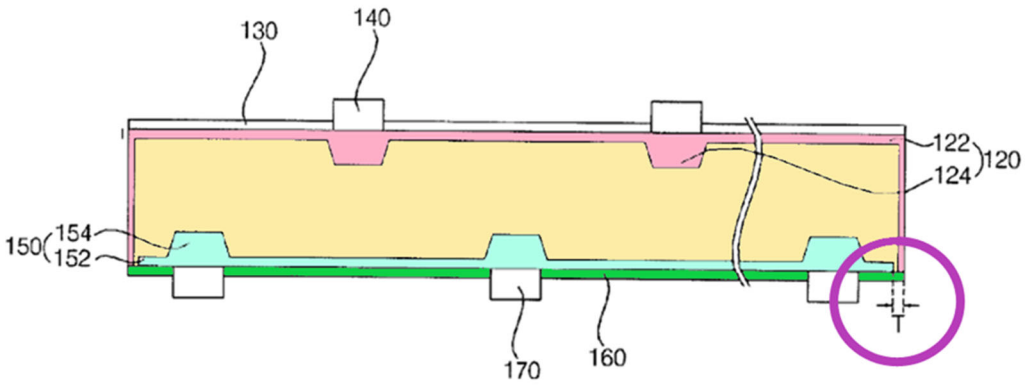
(a)

Finally, gap T is "measured from the edge part of the rear surface of the substrate 110." EX1009-Jin, ¶¶57-60 ,85-86, Figs. 3, 9.

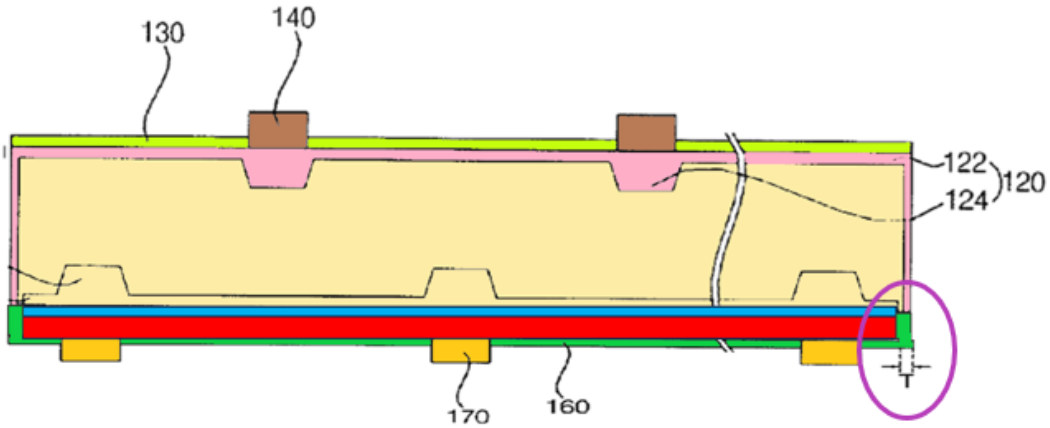
k) [1.k] First Passivation Film Covering Isolation Portion

Jin discloses "*wherein the first passivation film covers the first surface of the semiconductor substrate and the isolation portion together*." Jin's antireflection/passivation layer 160 corresponds to the "*first passivation film*." *See* §IX.C.1.f. Jin's antireflection/passivation film 160 covers the rear ("*first surface*") of the substrate 110 and the gap T ("*isolation portion*"). EX1009-Jin, ¶¶50-51, 57, Fig. 3. In the Jin/Feldmann combination, this same film would also cover the rear of the substrate and gap T isolation portion. EX1003-Decl., ¶151.

FIG. 3



Combination of Jin and Feldmann



2. Claim 2 – Finger Electrodes

Jin discloses "*a plurality of first [second] finger electrodes spaced apart from each other and extended in parallel in a [the] first direction*." In Jin, the front and backside electrodes comprise "front **finger** electrodes" 140 (brown) and "rear **finger** electrodes" 170 (orange), respectively. EX1009-Jin, ¶26, 38-40, 52-54, Fig. 3. They are shown as thin parallel lines extending into the page in Figs 1, 3. By being parallel to each other, the finger electrodes naturally extend in the same "*first direction.*" EX1003-Decl., ¶152.

FIG. 1

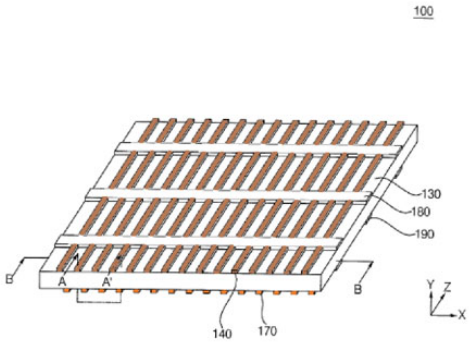
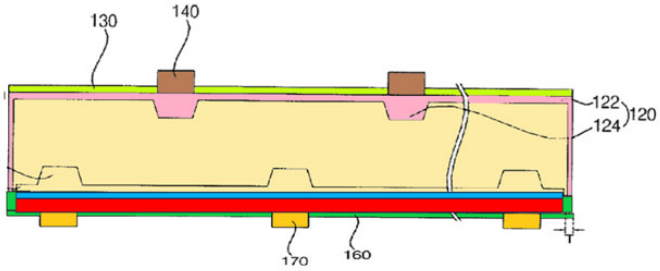


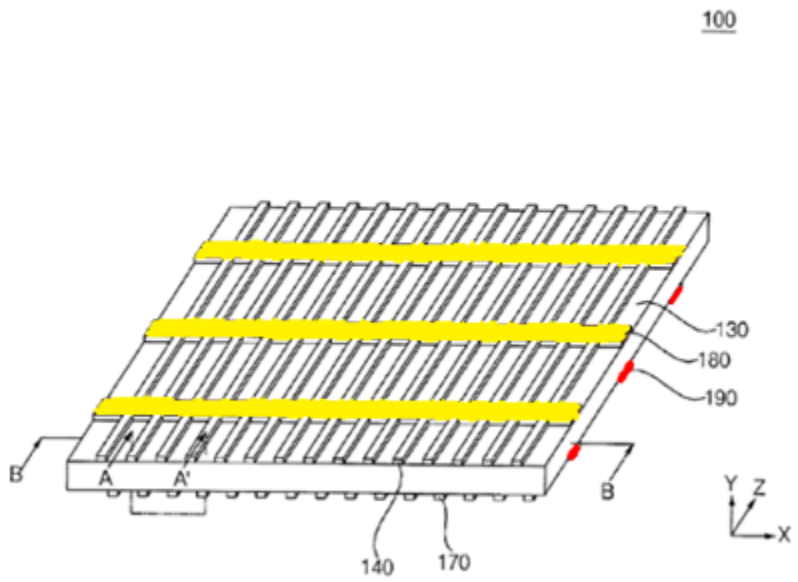
FIG. 3



3. Claim 3 – Bus Bars

Jin also discloses "*a first [second] bus bar connected to the plurality of first [second] finger electrodes.*" In Jin, the front finger electrodes 140 "adjoin front surface bus electrode 180" (yellow) and the rear finger electrodes 170 "adjoin[] to a rear surface bus electrode 190" (red). EX1009-Jin, ¶¶38, 54, Fig. 1.

FIG. 1



4. Claim 4 –Polycrystalline and Single Crystal

Feldmann discloses that "*the first conductive type semiconductor region includes a polycrystalline silicon material, and the second conductive type semiconductor region includes a single crystal silicon material*." As described above in §§IX-IX.A, in this Ground Jin's diffused phosphorous-doped BSF layer 150 is replaced with the Feldmann's ultra-thin tunnel oxide (SiO_2) (blue) and

phosphorus-doped polysilicon layer (red) ("*the first conductive type semiconductor region*"). EX1009-Jin, ¶78; EX1012-Feldmann, §2.1, Fig. 3. Feldmann's "P-doped Si layer" is a polysilicon (i.e., "*polycrystalline silicon*") because Feldmann anneals the phosphorus-doped Si layer after depositing the silicon on the wafer. EX1012-Feldmann, §2.1; EX1003-Decl. ¶155. Annealing was a well-known method for converting deposited silicon to polysilicon. EX1021-Quirk, 499-501; EX1030-Streetman, 159-61; EX1003-Decl., ¶155. The same annealing step is described in the 009 Patent to form the polysilicon layer 170. EX1001, 29:15-19.

Feldmann disclosed that the wafers used to form Feldmann's TOPCon solar cells were "(100)-oriented floating zone (FZ) silicon wafers," which are single-crystalline. EX1003-Decl., ¶156. Jin is silent on the crystalline type of substrate, from which the emitter layer 120 is formed. *See* EX1009-Jin, ¶29. It would have been obvious to a Skilled Artisan to use a monocrystalline silicon substrate to build the Jin/Feldmann combination because monocrystalline silicon was one of the two most prevalent options used in the industry and was used by Feldmann. EX1003-Decl., ¶156. It was also well known that single-crystalline silicon was more efficient than multicrystalline. EX1034-Saga, 5; EX1003-Decl., ¶157.

5. Claim 5 – Isolation Width

Jin discloses that "*a width of the isolation portion is 1 nm to 1 mm*." In Jin, the width of gap T "may range from 2 to 300 μm," which is between 1 nm and 1 millimeter. EX1009-Jin, ¶¶60, 86; EX1003-Decl., ¶158.

6. Claim 6 – Decreasing Polysilicon Thickness

In the Jin/Feldmann combination, "*a thickness of an edge region in the first conductive type semiconductor region progressively decreases towards the isolation portion.*" A common way to form Feldmann's polysilicon layer with Jin's gap T in the Jin/Feldmann combination would be to use a metal "shadow" mask configured like Jin's Fig. 9, to cover the periphery of the substrate before depositing the polysilicon. EX1003-Decl., ¶159 (citing EX1031-Scherff, §§1-2); *see also* §IX.B. This process would result in "overspray"—small amounts of polysilicon that deposit beneath the edge of the mask—resulting in a taper of the polysilicon as depicted below. EX1032-Decker, 97, Fig. 4; EX1033-Okuyama, 2890, Fig. 4; EX1003-Decl., ¶¶159-163. This phenomenon was well known before 2015. EX1003-Decl., ¶162.

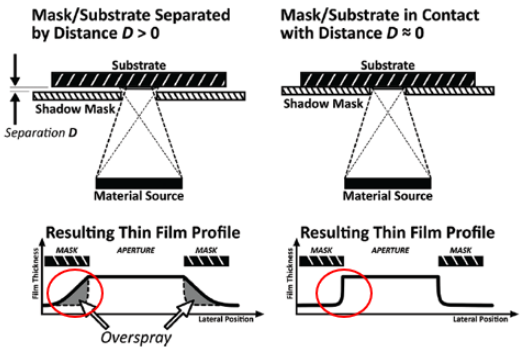


Figure 4. Thin film height profile for deposition with shadow mask separated by distance *D* from substrate (left) and shadow mask in close contact with substrate (right).

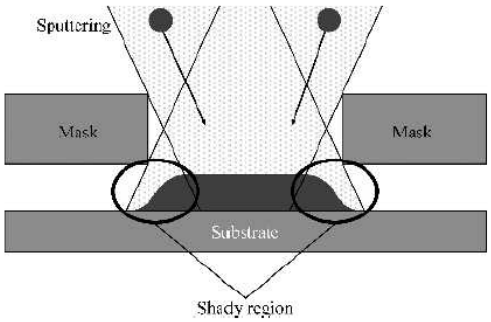


FIG. 4. Schematic of the "shadow effect" that appeared through the mask pattern. The pattern edges thin down because of deposition of shaded sputtered atoms under the mask edges (indicated by the oval).

A Skilled Artisan would find it obvious that the polysilicon layer in the Jin/Feldmann combination would decrease in thickness toward the gap T "isolation region" depicted in modified Jin Fig. 3, 9. EX1003-Decl., ¶163.

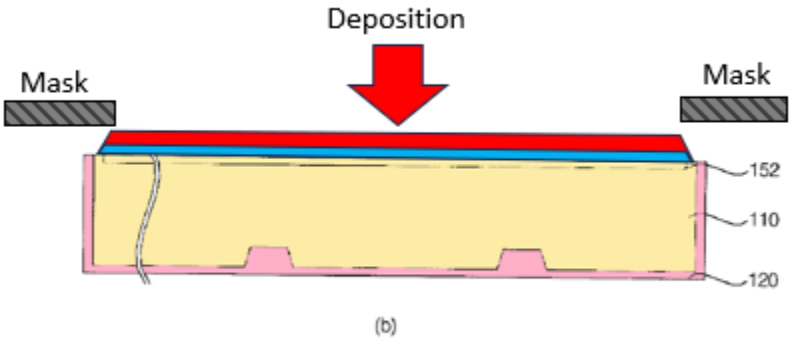
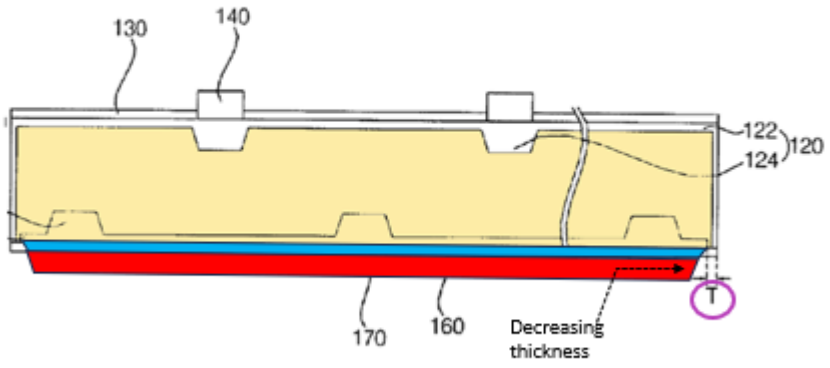


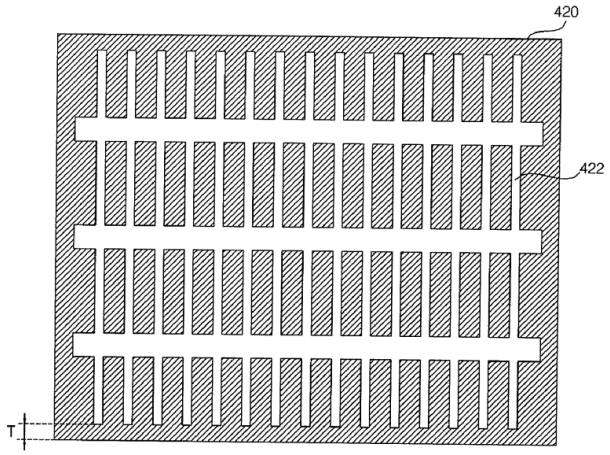
FIG. 3



7. Claim 9 – Electrodes Connected to the First Conductive Type Semiconductor Region

In the Jin/Feldmann combination "*all of the plurality of first finger electrodes and the first bus bar are connected to the first conductive type semiconductor region through the first passivation film*." To form the rear finger electrodes 170 ("*first finger electrodes*") and rear surface bus electrode 190 ("*first bus bar*"), Jin discloses mask 420 with openings 422 "formed to have a grid shape to correspond to the back surface finger lines 170 and the back surface bus electrodes 190." EX1009-Jin, ¶¶88-89, Fig. 10.

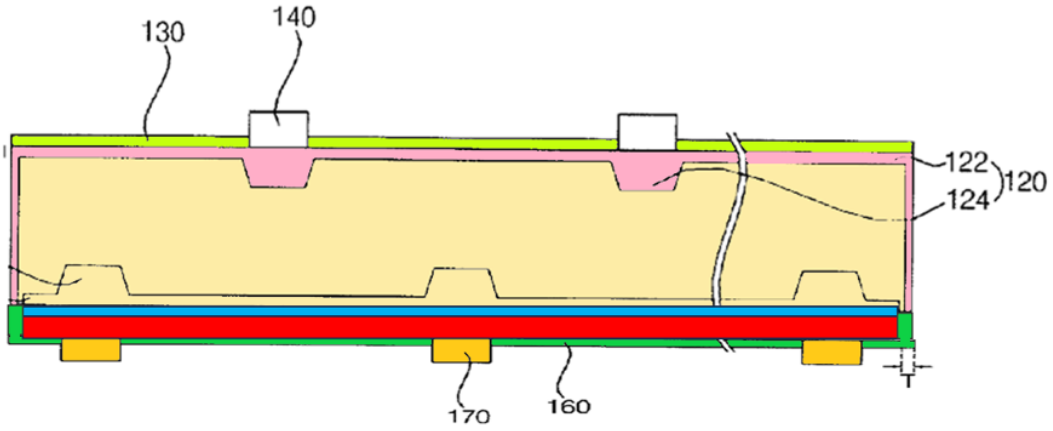
FIG. 10



(a)

As discussed in §IX.C.1.g, the rear finger electrodes 170 (orange) connect to the phosphorous-doped polysilicon layer (red) ("*first conductive type semiconductor region*") through gaps in the second anti-reflection film 160 (green) formed, for example, by screen printing or laser ablation of the second anti-reflection film. By using the same mask 420 to form the back surface finger lines 170 and the back surface bus electrodes 190, all the back surface finger lines 170 and the back surface bus electrodes 190 would connect through the anti-reflection film 160 (green) to connect to the "P-doped Si layer" (red). EX1003-Decl., ¶¶164-166.

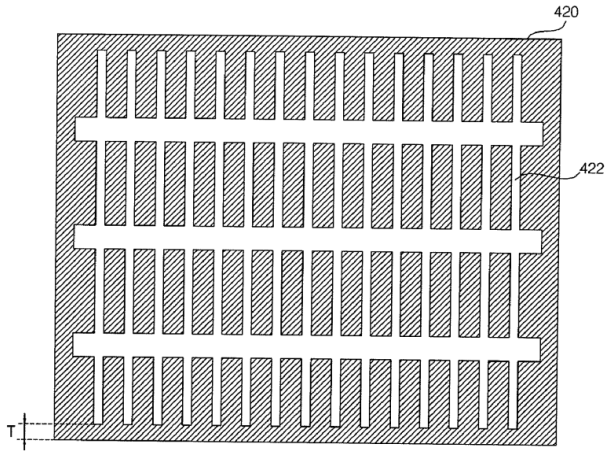
Combination of Jin and Feldmann



8. Claim 10 – Single Layer Electrodes

Jin discloses that "*all of the plurality of first finger electrodes and the first bus bar have a single layer or double layer structure*." As discussed in §IX.C.1.g, Jin's mask 420 is used to form both the rear finger electrodes 170 and rear surface bus electrode 190. EX1009-Jin, ¶¶88-89, Fig. 10. Jin explains that the rear finger electrodes 170 can be screen printed using silver paste, resulting in a single layer of silver. EX1009-Jin, ¶52; EX1022-Luque, 277-78 ("The oxides forming the glass frit melt, enabling silver grains to sinter and form a continuous conductor so that the layer can present low sheet resistance."). Screen printing using the mask 420 would result in both the rear finger electrodes 170 and rear surface bus electrode 190 having a single layer structure of silver. EX1003-Decl., ¶¶167-168.

FIG. 10



(a)

X. GROUND 2: CLAIMS 1-6 & 9-10 ARE UNPATENTABLE OVER CHANG AND JIN

The Chang/Jin combination would have rendered Claims 1-6 and 9-10 obvious.

Chang implemented Feldmann's TOPCon structure into a bifacial solar cell and further disclosed an isolation region on the substrate's backside where the oxide "tunneling layer 44" and polysilicon BSF 30 are not formed at the periphery or edge of the substrate. EX1013-Chang, ¶¶56, 62; EX1003-Decl., ¶191. Chang mentions the "isolation region" four times, explaining that the tunneling layer, emitter, and back side field are **not** formed in the "isolation region" or "periphery region." EX1013-Chang, ¶¶45, 51, 56, 62.

During prosecution of the child 419 Patent, which recites method claims, the Examiner noted that Chang did not disclose "the removing step as recited and the first passivation film covering the first surface of the semiconductor substrate

along with the isolation portion." EX1006, 254. However, the claims of the challenged 104 Patent are device claims and do not include any such step of "removing" deposited tunnel or polysilicon layers to form the isolation portion. Rather, the challenged claims only require the existence of the isolation portion.

As to the Examiner's assertion that Chang did not disclose "the first passivation film covering the first surface of the semiconductor substrate along with the isolation portion," the Examiner was only partially correct. Although Chang's Figures 1 and 8 did not show an isolation portion, the specification describes it. EX1003-Decl., ¶193.

FIG. 1

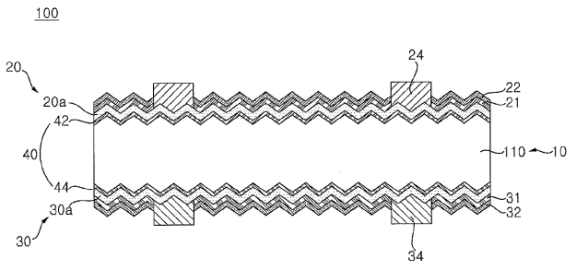
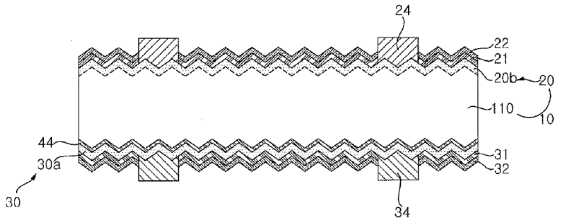


FIG. 8



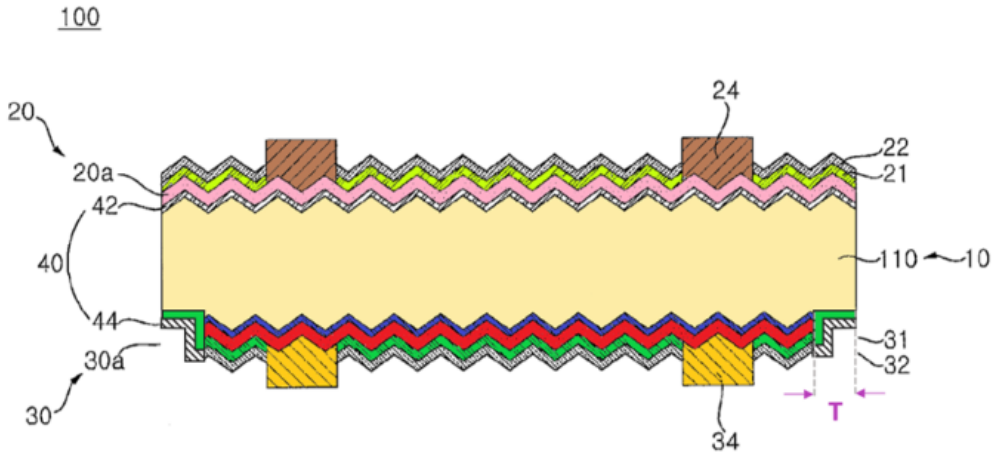
Chang states that the "tunneling layer 44" and the "back surface field area 30" (both formed on the back surface of the substrate) may be "entirely formed" over the substrate's back surface. EX1013-Chang, ¶¶56, 62. Chang specially defined the phrase "entirely formed" to mean "that an element such as a layer is formed over an entire surface without an empty area or a non-coverage area, ***or is***

formed in an entire area <u>excluding</u> pre-designated or inevitably formed regions such as <u>periphery region, isolation region</u>, or the like." *Id*.

Nevertheless, to the extent not expressly disclosed in Chang, the Skilled Artisan would have looked to Jin to understand details of Chang's isolation region, including the formation of the passivation layer over the isolation region, to improve upon the bifacial solar cell of Chang. EX1003-Decl. ¶¶194-95.

In the Chang/Jin combination, Chang's isolation portion would be implemented using Jin's teaching to separate Chang's tunneling layer 44 (blue) and BSF 30 (red) from the edge of the substrate by a gap T and the gap T would then be covered by the rear passivation film as taught by Jin and depicted in the modified Chang Figure 1 below. EX1003-Decl. ¶¶195-96.

<u>Combination of Chang and Jin</u>



A. Motivation to "Modify" Chang with Jin

Chang and Jin are analogous art because each is in the same field of solar cell design and is pertinent to the problems of solar cell efficiencies. EX1003-Decl., ¶197. The Chang/Jin combination requires no modification to Chang's device; Jin supplies details about Chang's isolation region and its covering by the rear passivation film that Chang presumed was already known. A Skilled Artisan would have been motivated to look to Jin to understand the details missing from Chang regarding Chang's isolation region, because others taught and understood that the isolation region was an important tool for preventing the emitter and BSF from being shorted. EX1003-Decl., ¶198. Indeed, Chang and Jin were both filed by LG Electronics, the original assignee of the two patents, further providing close association to the Skilled Artisan of their teachings. EX1003-Decl., ¶197. The Skilled Artisan would have looked to similar references, especially from the same assignee, to ascertain more information regarding Chang's isolation region and its covering by the passivation layer. *Id*., ¶199-201.

B. Reasonable Expectation of Success

The Skilled Artisan would have considered the Chang/Jin combination to be merely an arrangement of old elements with each performing the same function it had been known to perform (the solar cell of Chang having an isolation region at the periphery, made using the details of the isolation and "gap T" spacing disclosed

by Jin) and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance). EX1003-Decl., ¶202. Specifically, the Skilled Artisan would use the mask shown in Fig. 9 of Jin to form the tunneling layer 44 and BSF 30 of Chang, creating the isolated gap T at the periphery between the BSF 30 and the edge of the substrate. *Id.* The Skilled Artisan would have been aware of numerous techniques for making the Chang/Jin solar cell, such as using a metal "shadow" mask. EX1003-Decl., ¶¶203-208.

Combining Chang and Jin would not have resulted in any unpredictable results and could have been readily accomplished with a reasonable expectation of success. EX1003-Decl., ¶210. The combination would employ well-known prior art steps in solar cell and semiconductor fabrication to yield predictable results. *Id*. Implementing Chang's isolation region as taught by Jin would have been a simple use of a known technique to improve similar devices (Chang's solar cell) in the same way. *Id.* It is nothing more than applying known techniques to a known device ready for improvement to yield predictable results. *Id*.

C. <u>Chang and Jin Disclosed All Claimed Limitations</u>

1. Claim 1

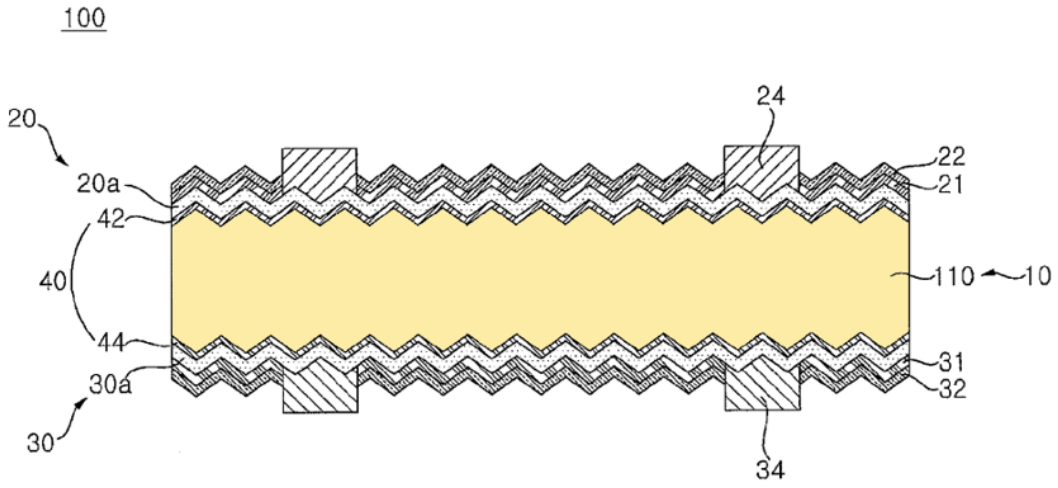
a) [1.a] Preamble

Chang and Jin both disclose "*a solar cell.*" EX1003-Decl., ¶211.

b) [1.b] Semiconductor Substrate

Chang discloses "*a semiconductor substrate*," shown as "semiconductor substrate 10" including base area 110 (yellow) doped with "a first conductive type dopant" such as "an n-type impurity." EX1013-Chang, ¶¶38-40, Fig. 1. The base area 110 is made from "a semiconductor silicon wafer." *Id.*; EX1003-Decl., ¶212.

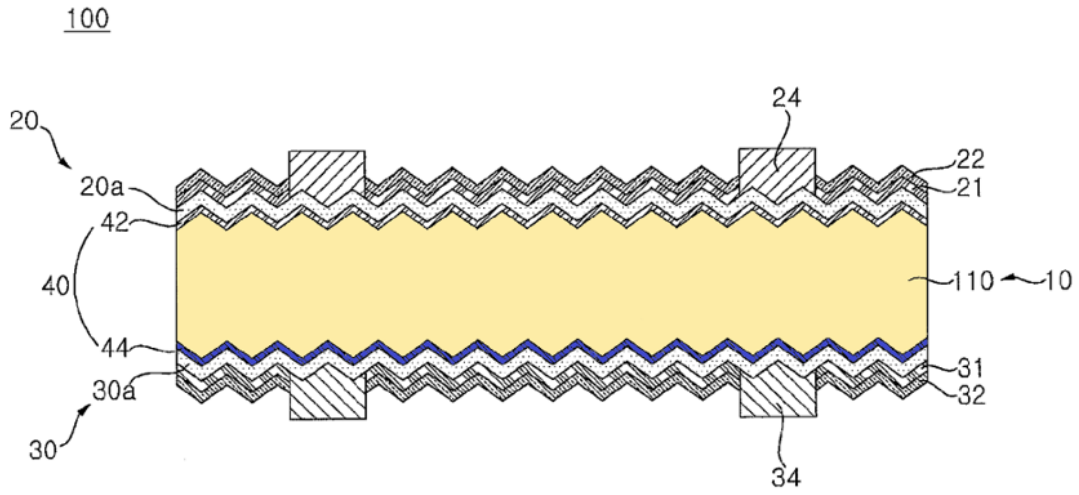
FIG. 1



c) [1.c] Tunnel Layer

Chang discloses "*a tunnel layer on a first surface of the semiconductor substrate,*" shown as "tunneling layer 44" (blue) on the back surface (*first surface*) of the substrate 10. EX1013-Chang, ¶¶56, 60, Fig. 1. This "tunneling layer 44" may be an oxide such as silicon oxide. *Id.*, ¶58; EX1003-Decl., ¶213.

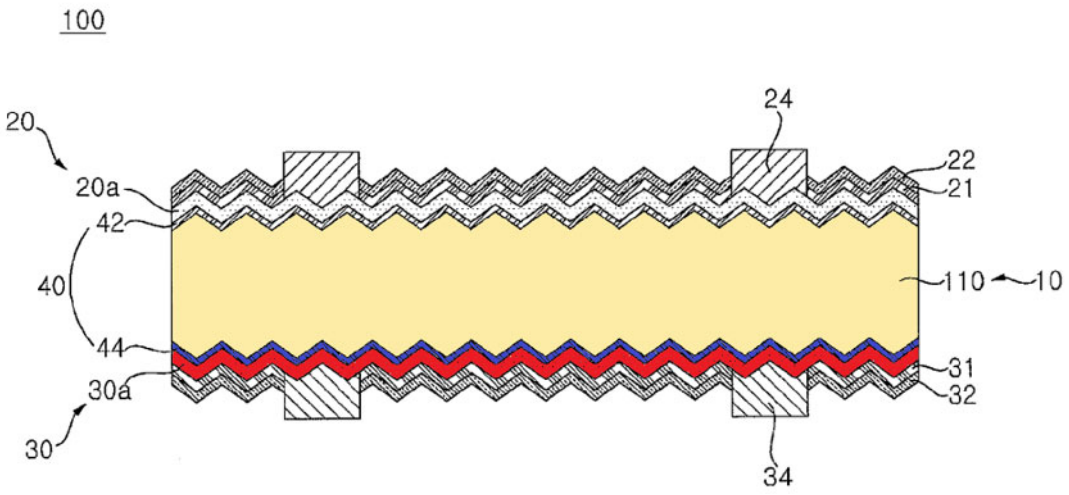
FIG. 1



d) [1.d] First Conductive Type Semiconductor Region

Chang discloses "*a first conductive type semiconductor region on the tunnel layer and containing impurities of a first conductive type,*" shown as the "back surface field area 30" (red) on the "tunneling layer 44" (blue). EX1013-Chang, ¶¶61-62, Fig. 1. Chang discloses that "the back surface field area 30 may include a polycrystalline silicon," which is polysilicon. *Id.*, ¶61; EX1003-Decl., ¶214. Chang also discloses that the back surface field area is a polycrystalline "semiconductor." EX1013-Chang, ¶61.

FIG. 1



BSF 30 "ha[s] the same conductive type (for example, p-type or n-type) as the semiconductor substrate 10" and thus has "*impurities of a first conductive type*," e.g., n-type impurities. EX1013-Chang, ¶61; EX1003-Decl., ¶215.

e) [1.e] Second Conductive Type Semiconductor Region

Chang discloses "*a second conductive type semiconductor region on a second surface opposite to the first surface of the semiconductor substrate and containing impurities of a second conductive type opposite to the first conductive type*," shown as the "emitter area 20" (pink) on the front surface (*second surface*) of the substrate 10. EX1013-Chang, ¶¶36-37, Figs. 1, 8. Fig. 8 is an alternative embodiment of Fig. 1 and has the exact same back side layers. *Id.* ¶101; EX1003-

Decl., ¶217. The only difference is that the "emitter area 20" in Figure 8 is formed by thermal diffusion of dopants into the substrate 10. EX1013-Chang, ¶98.

FIG. 1

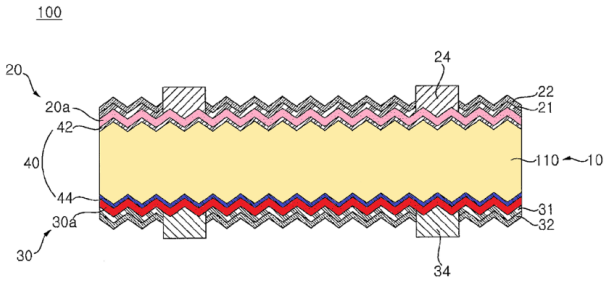
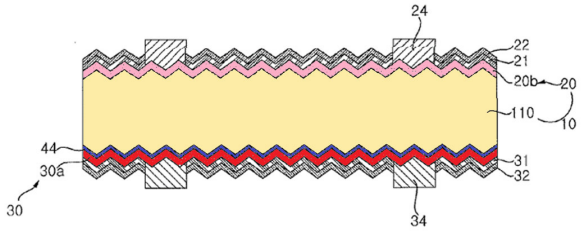


FIG. 8



When the base area 110 or substrate 10 is an n-type semiconductor, "the emitter area 20 forming a pn junction with the base area 110 is p-type." EX1013-Chang, ¶¶40, 50, 98. Thus, Chang doped the "emitter area 20" with "*impurities of a second conductive type [p-type] opposite to the first conductive type,*" n-type. EX1003-Decl., ¶¶216-18.

f) [1.f] First Passivation Film

Chang discloses "*a first passivation film on the first conductive type semiconductor region*," shown as a passivation film 31 (green), on the polysilicon BSF layer 30 (red), and which "passivates defects present in the back surface field area 30." EX1013-Chang, ¶¶63-65, Fig. 1.

FIG. 1

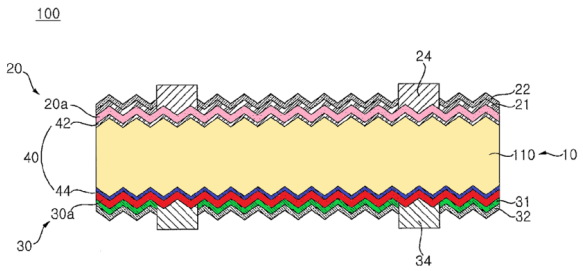
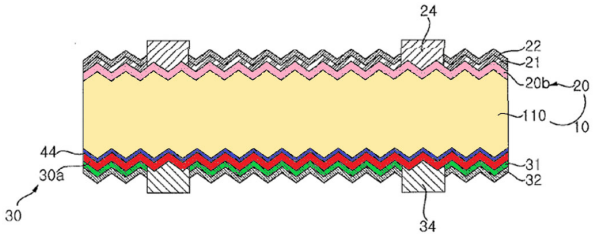


FIG. 8



g) [1.g] First Electrode

Chang discloses "*a first electrode formed on the first passivation film and connected to the first conductive type semiconductor region through an opening formed in the first passivation film*," shown as "electrode 34" (orange) formed on the passivation film 31 and "electrically connected to the back surface field area 30 [*polysilicon layer*] via an opening formed in the second passivation film 31." EX1013-Chang, ¶¶67, 36; Figs. 1, 8. According to Chang, electrode 34 may comprise finger electrodes 34a that "pass through the second passivation film 31" and bus bar electrodes 34b "formed on the second passivation film 31." EX1013-Chang, ¶70.

FIG. 1

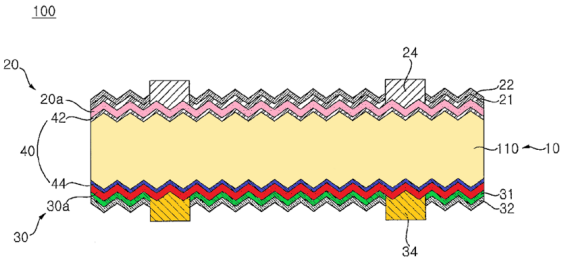
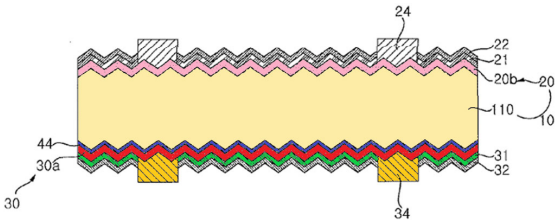


FIG. 8



h) [1.h] Second Passivation Film

Chang discloses "*a second passivation film on the second conductive type semiconductor region*," shown as "passivation film 21" (light green), which "passivates defects present in the emitter area 20." EX1013-Chang, ¶¶51-52, 100, Figs. 1, 8; EX1003-Decl., ¶221.

FIG. 1

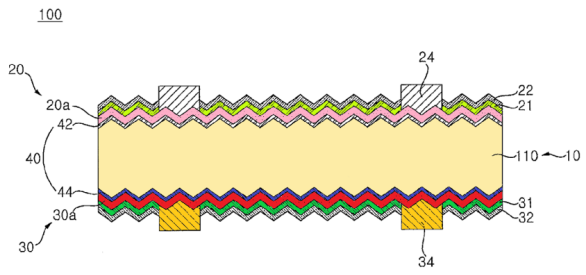
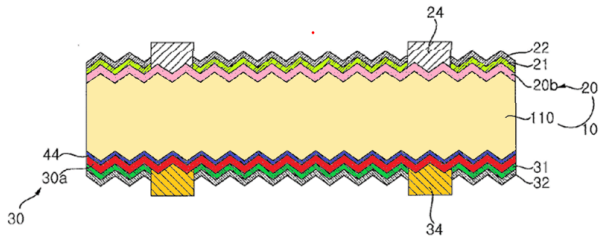


FIG. 8



i) [1.i] Second Electrode

Chang discloses "*a second electrode formed on the second passivation film and connected to the second conductive type semiconductor region through an opening formed in the second passivation film*," shown as "electrode 24" (brown) formed on the front passivation film 21 and "electrically connected to the emitter area 20 via an opening formed in the [front side] passivation film 21." EX1013-Chang, ¶¶55, Figs. 1, 8. According to Chang, electrode 24 may comprise finger electrodes 24a that "pass through the first passivation film 21" and bus bar electrodes 24b "formed on the first passivation film 21." EX1013-Chang, ¶70.

FIG. 1

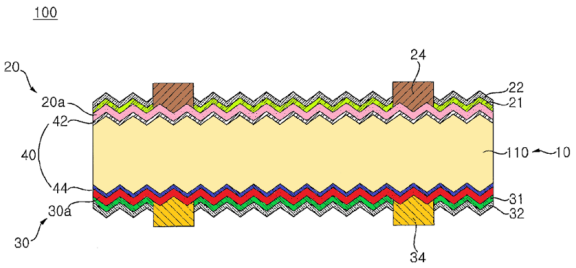
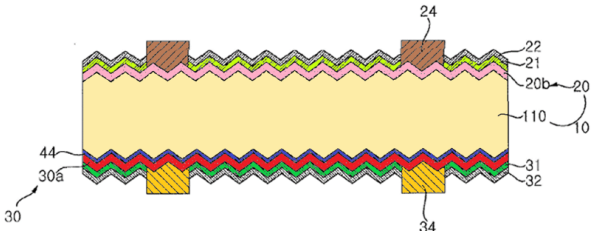


FIG. 8



j) [1.j] Isolation Portion

Chang discloses "*an isolation portion for preventing a contact between the first conductive type semiconductor region and the second conductive type semiconductor region, wherein the isolation portion excludes the tunnel layer and the first conductive type semiconductor region, and is in an edge portion of the first surface of the semiconductor substrate*." Chang's "isolation region" is synonymous with the claimed "*isolation portion*" that excludes the "tunneling layer 44" ("*tunnel layer*") and "back surface field area 30" ("*first conductive type semiconductor region*"). EX1003-Decl., ¶223; EX1013-Chang, ¶¶56, 62. Chang discloses that the "tunneling layer 44 is **entirely formed** over" the back surface of the substrate 10, and the back surface field area 30 "may be **entirely formed** over the second tunneling layer." *Id.* Chang specially defined the phrase "entirely formed" to have an embodiment that excludes a "periphery region" or "isolation region":

> As 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 over in an entire area* ***excluding*** *pre-designated or inevitably formed regions such as* ***periphery region****,* ***isolation region*** *or the like*.

Id. (emphasis added). Thus Chang discloses an isolation region where the tunneling layer 44 and back surface field area 30 are **not** formed, and therefore excluded, at the back surface of the substrate. EX1003-Decl., ¶223.

Further, "isolation" means the introduction of a non-conductive separation between electrical or conductive components. EX1003-Decl., ¶224. The Skilled Artisan would understand that Chang's "isolation region" electrically isolates, and thus prevents contact between, the conductive front emitter area 20 from the conductive BSF 30. *Id.*, ¶225. The isolation concept was well-known to prevent shorting of the front emitter and BSF. *Id*. ¶224.

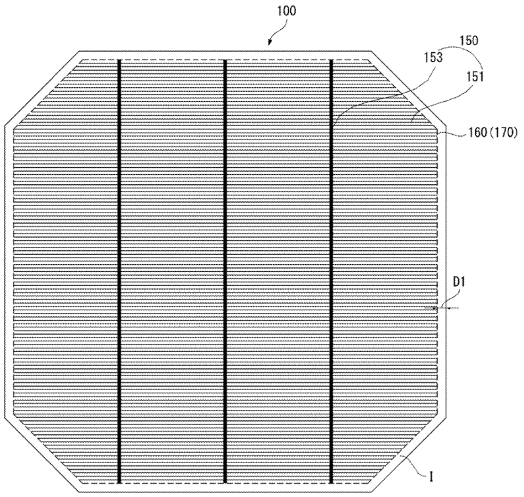
In Chang's solar cell, when the tunneling layer 44 and BSF 30 are not formed in the isolation region, it leaves a physical gap, which prevents the conductive front emitter area 20 from contacting the conductive BSF 30. EX1003-Decl., ¶226.

Chang also specifically refers to the "periphery region," as the location that excludes the tunneling layer 44 and BSF 30, i.e., the location of the "isolation region." EX1013-Chang, ¶¶56, 62. Webster's Dictionary defines "periphery" as "the perimeter of a circle or other closed curve, *also*: the perimeter of a polygon."

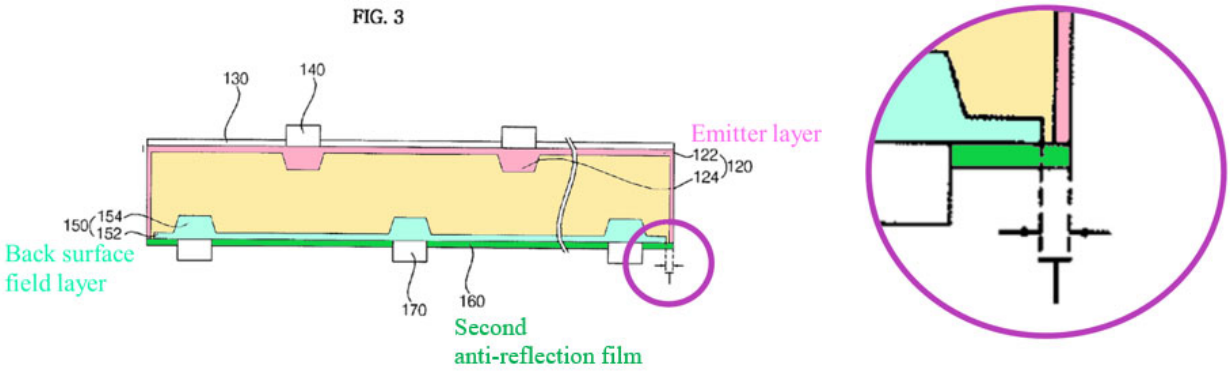
EX1027-Webster, 865. The Oxford College Dictionary defines "periphery" as "the outer limits or edge of an area or object." EX1029-Oxford, 1020.

The Skilled Artisan would understand that Chang's "periphery region" refers to the solar cell/substrate's perimeter or edge portion, as seen in the peripheral white space of Fig. 3 of the 104 Patent. EX1003-Decl., ¶228. Since Chang's tunneling layer 44 is formed on the substrate's back surface, and the BSF 30 is formed on the tunneling layer 44, the Skilled Artisan would further understand that the isolation region in Chang is "*in an edge portion of the first surface of the semiconductor substrate*," as claimed. *Id.*

FIG. 3



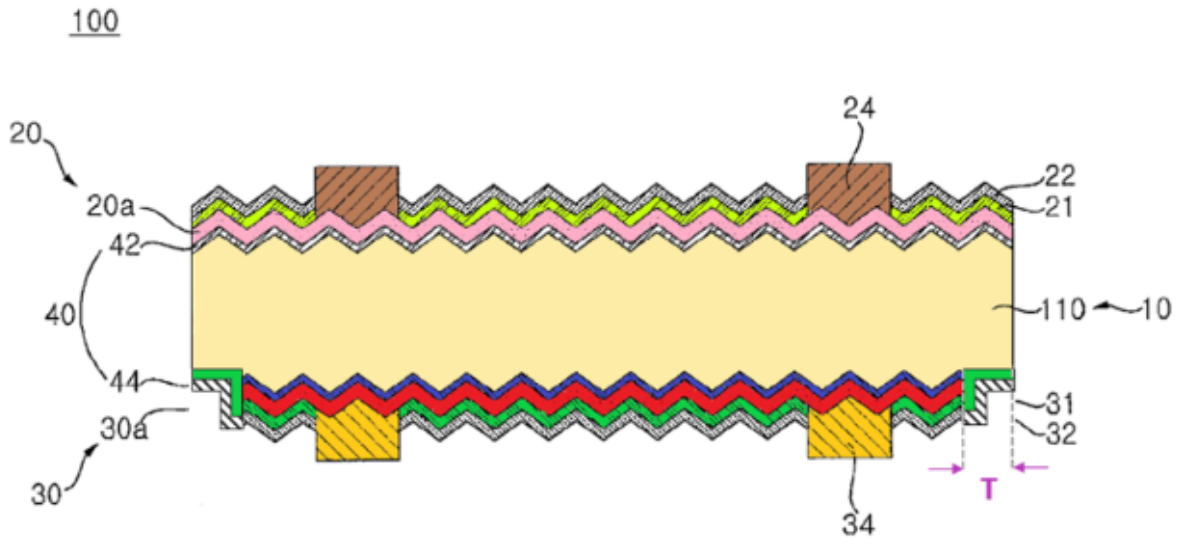
Chang's "isolation region" in the "periphery region" is shown in Jin, which discloses additional details and illustrates the isolation region of Chang. EX1003-Decl., ¶229; EX1009-Jin, ¶¶57-58, Fig. 3.



Like Chang, the emitter layer 120 of Jin is formed by "heat diffusion" which is the same as the "thermal diffusion" of Chang's Fig. 8. EX1003-Decl., ¶230. In thermal diffusion, dopants diffuse into the front and lateral side surfaces of the substrate. *Id*. Thus, like Chang, Jin prevents contact between the emitter 120 and the BSF 150 by forming a gap is T between the BSF 150 and the edge of the back surface to prevent contact between the emitter 120 and BSF 150. *Id.*

Chang's isolation region corresponds to Jin's gap T, which (like the isolation portion of the 104 Patent) inhibits electrical shorting between the back surface field layer and the emitter layer caused by conductive dopants being present along the edge of the substrate's back surface. EX1003-Decl., ¶231.

Combination of Chang and Jin



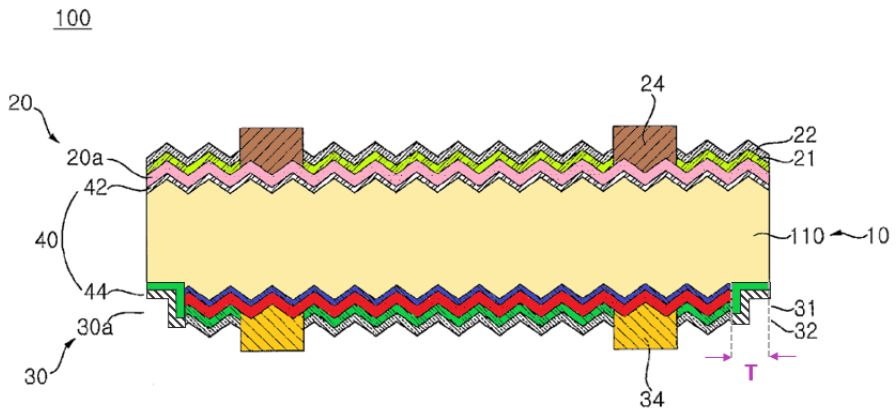
k) [1.k] First Passivation Film Covering Isolation Portion

The Chang/Jin combination discloses that "*the first passivation film covers the first surface of the silicon semiconductor substrate and the isolation portion together*." As discussed in §X.C.1.f, Chang's "passivation film 31" is the *first passivation film.* In Chang, the passivation film 31 "may be formed in a substantially entire region over the front surface of the back surface field area 30, excluding a region corresponding to the second electrode 34." EX1013-Chang, ¶63, Fig. 1.

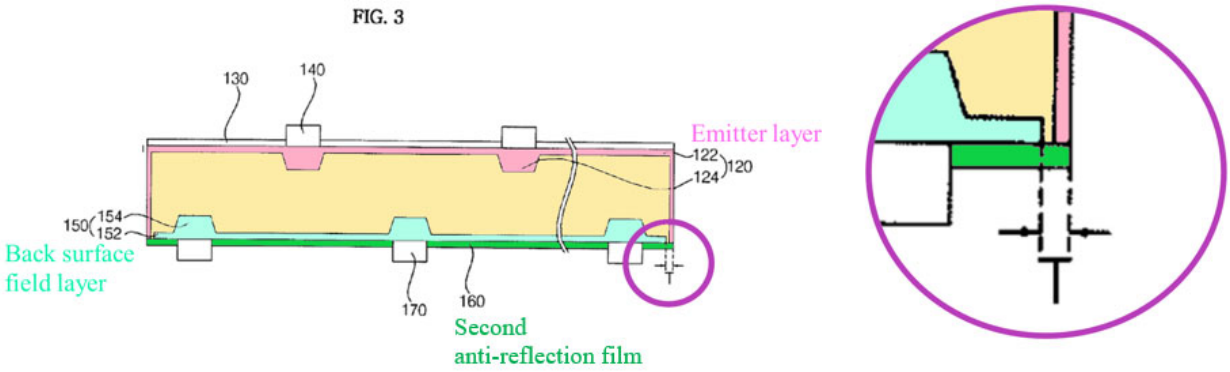
Notably, Chang does **not** use the especially defined expression of "entirely formed" to describe the passivation film 31's coverage over the silicon back surface. Instead, Chang describes the second passivation film using the general

phrase "formed in a substantially entire region" over the back area, which does not have any such exclusions except for the electrode locations. EX1013-Chang, ¶63. Thus, Chang does not indicate that the isolation region is excluded from being covered by the second passivation film. *Id.*; EX1003-Decl., ¶¶234-237.

Combination of Chang and Jin

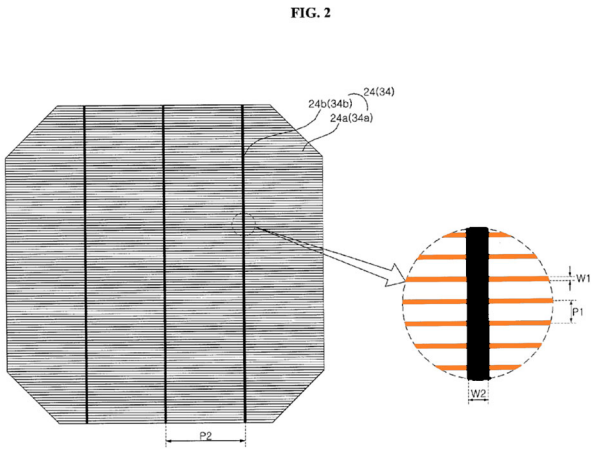


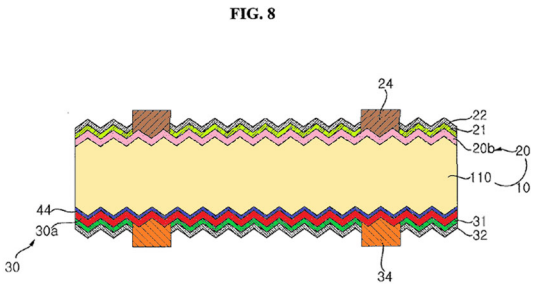
To the extent Trina argues that Chang does not disclose this element, it would have been obvious as expressly taught by Jin. EX1003-Decl., ¶¶237-38. It was well known that a bare silicon surface provides recombination sites, and the isolation region constitutes an area of bare silicon surface that was well known to likewise need passivation and removal of recombination sites. EX1003-Decl., ¶236. Thus, the Skilled Artisan would be motivated to passivate the isolation region, as shown in Jin. *Id.*



2. Claim 2 – Finger Electrodes

Chang discloses "*a plurality of first [second] finger electrodes spaced apart from each other and extended in parallel in a [the] first direction,*" shown as the front and back electrodes 24/34. EX1013-Chang, Fig. 2. The fingers are thin horizontal lines (orange) extending in the same *first direction*. EX1003-Decl., ¶239.

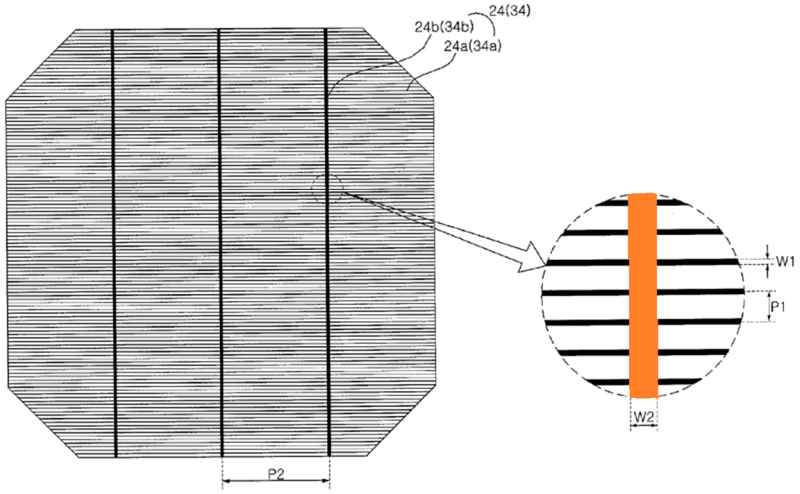




3. Claim 3 – Bus Bars

Chang discloses "*a first [second] bus bar connected to the plurality of first [second] finger electrodes*," as shown by the three vertical thick lines (orange) in Fig. 2. These bus bars "connect the finger electrodes 24a and 34a." EX1013-Chang, ¶69.

FIG. 2



4. Claim 4 – Polycrystalline and Single-Crystal Silicon

Chang discloses that "*the first conductive type semiconductor region includes a polycrystalline silicon material, and the second conductive type semiconductor region includes a single crystal silicon material.*" Chang states that the silicon substrate 10 may be made of a monocrystalline semiconductor, including monocrystalline silicon. EX1013-Chang, ¶38; EX1003-Decl., ¶241. In Figure 8, the emitter area 20 ("*second conductive type semiconductor region*")

"ha[s] the same crystalline structure as the base area 110," *i.e.*, single crystal silicon. EX1013-Chang, ¶98 Chang also discloses that "the back surface field area 30 ["*first conductive type semiconductor region*"] may include [] polycrystalline silicon." EX1013-Chang, ¶61; EX1003-Decl., ¶241.

5. Claim 5 – Isolation Width

Although Chang does not disclose "*a width of the isolation portion is 1 nm to 1 mm*," Jin discloses that the width of the isolated gap T "may range from 2 to 300 μm," which is between 1 nm and 1 mm. EX1009-Jin, ¶¶60, 86; EX1003-Decl., ¶242.

6. Claim 6 – Decreasing Polysilicon

In the Chang/Jin combination, the "*thickness of an edge region in the first conductive type semiconductor region progressively decreases towards the isolation portion.*" A common way to form Chang's BSF 30 in the Chang/Jin combination, with Chang's isolation region on the periphery, would be to use a "shadow" mask configured like Jin's Fig. 9, to cover the periphery of the substrate before depositing the BSF 30. EX1003-Decl. ¶243 (citing EX1031-Scherff, §§1-2); *see also* §IX.C.6, §X.B. This process would result in "overspray"—small amounts of polysilicon that deposit beneath the edge of the mask—resulting in a taper of the polysilicon as depicted below. EX1003-Decl., ¶¶243-247. This phenomenon was well known prior to 2015. *Id.*, ¶246.

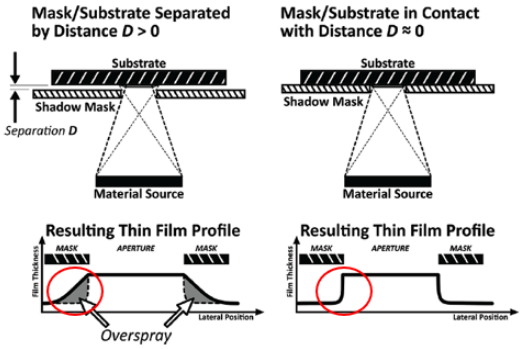


Figure 4. Thin film height profile for deposition with shadow mask separated by distance *D* from substrate (left) and shadow mask in close contact with substrate (right).

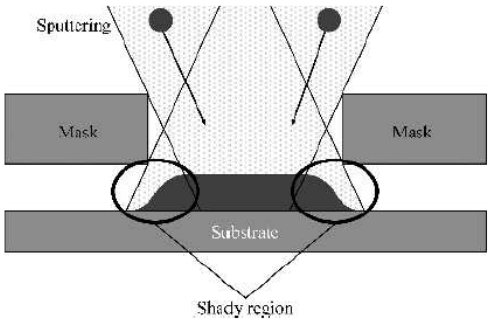
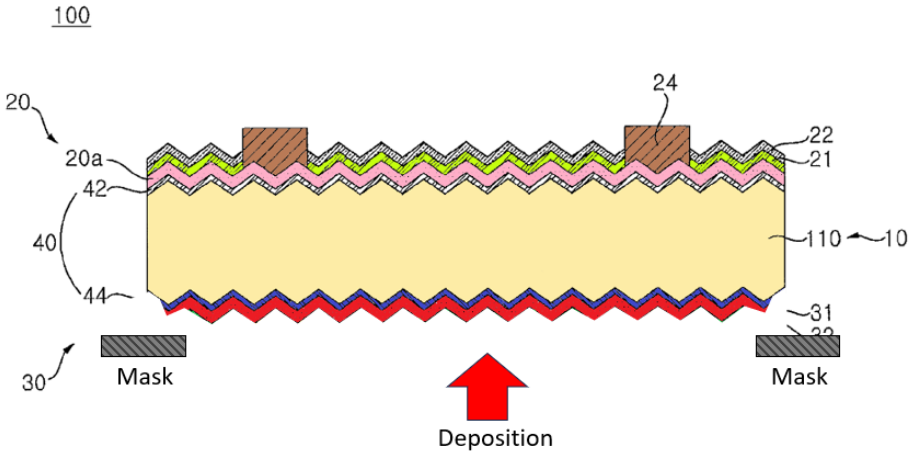
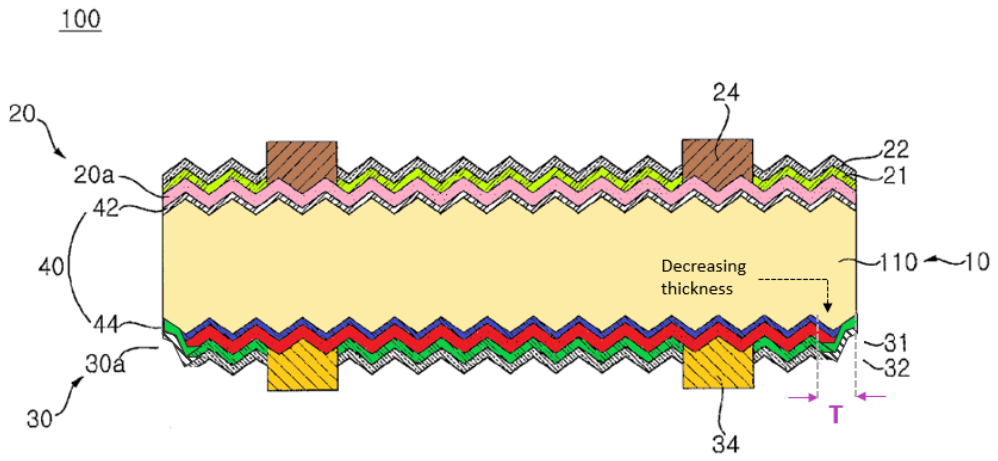


FIG. 4. Schematic of the "shadow effect" that appeared through the mask pattern. The pattern edges thin down because of deposition of shaded sputtered atoms under the mask edges (indicated by the oval).

A Skilled Artisan would therefore find it obvious that the BSF layer in Chang/Jin would decrease in thickness toward Chang's periphery isolation region, as depicted in modified Chang Fig. 1. *Id.*, ¶¶243-247.





7. Claim 9 – Electrodes Connected to the First Conductive Type Semiconductor Region

Chang discloses that "*all of the plurality of first finger electrodes and the first bus bar are connected to the first conductive type semiconductor region through the first passivation film*," as shown in Figs. 1, 8. Chang discloses that "the finger electrode 34a and the bus bar electrode 34b of the second electrode 34 may pass through the second passivation film 31 and the second anti-reflective film 32." EX1013-Chang, ¶70, Figs. 1-2, 8. In addition, "[t]he second electrode 34 is electrically connected to the back surface field area 30 via an opening formed in the second passivation film 31." *Id.*, ¶67, 69, Figs. 1, 8. The "back surface field area 30" is the "*first conductive type semiconductor region.*" EX1003-Decl. ¶248.

8. Claim 10 – Single Layer Electrodes

Jin discloses that "*all of the plurality of first finger electrodes and the first bus bar have a single layer or double layer structure*." Chang discloses that the

finger electrode 34a and the bus bar electrode 34b "may be formed by a variety of methods such as … **printing**" and materials. EX1013-Chang, ¶71.

Jin teaches using mask pattern 420 to form both the rear finger electrodes 170 and rear surface bus electrode 190. EX1009-Jin, ¶¶88-89, Fig. 10 Jin explains that the rear finger electrodes 170 can be screen printed using silver paste, resulting in a single layer of silver. EX1009-Jin, ¶52; EX1022-Luque, 277-78. Screen printing using the mask 420 would result in both the finger electrode 34a and the bus bar electrode 34b of Chang having a single layer structure of silver. EX1003-Decl., ¶¶249-51.

XI. GROUNDS 3 & 4: CLAIMS 7 & 8 ARE UNPATENTABLE OVER THE COMBINATION OF EITHER JIN/FELDMAN OR CHANG/JIN IN FURTHER VIEW OF SEO

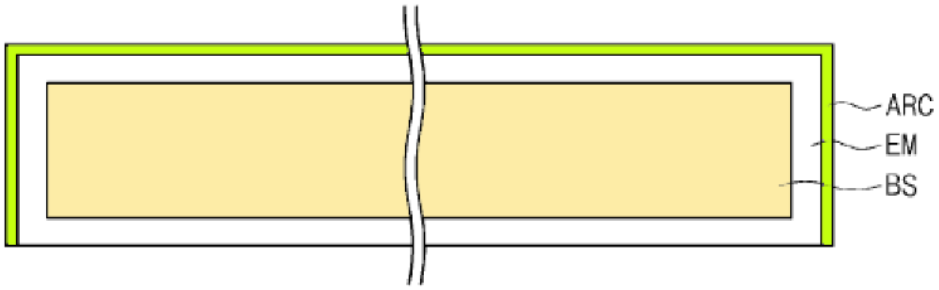
Claims 7-8 relate to the passivation layers covering the lateral side surfaces of the substrate and the order in which the front and back passivation layers are formed, features both taught by Seo. Each of the combinations of Grounds 1 and 2 in view of Seo would have rendered these claims obvious. EX1003-Decl., ¶¶169-181, 252-264.

A. Overview of Seo

U.S. Patent No. 8,647,914 ("Seo") issued on February 11, 2014. EX1015-Seo, face. Seo is prior art under 35 U.S.C. §102(a)(1). Seo was not considered during the 104 Patent's prosecution.

Seo teaches a solar cell with a base substrate BS, an emitter layer EM on its front surface, and a BSF on its rear surface. EX1015-Seo, 3:44-50, 4:11-13, 5:32-35, Fig. 1. An "anti-reflection layer ARC is formed directly on the emitter layer EM" using chemical vapor deposition ("CVD"), resulting in the ARC layer being deposited on both the front, back, and lateral sides of the substrate BS. *Id.*, 6:39-48.

Fig. 2C



After etching/removing the EM layer on the backside (FIG. 2E), a backside "passivation layer PSV may be formed" on both the back of the substrate BS and on the ARC layer on the lateral sides of the substrate, as shown in Figure 2F. *Id.*, 7:60-66.

Fig. 2E

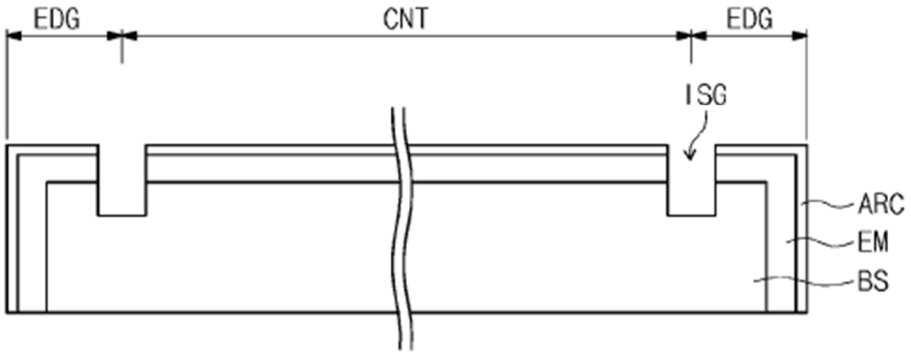
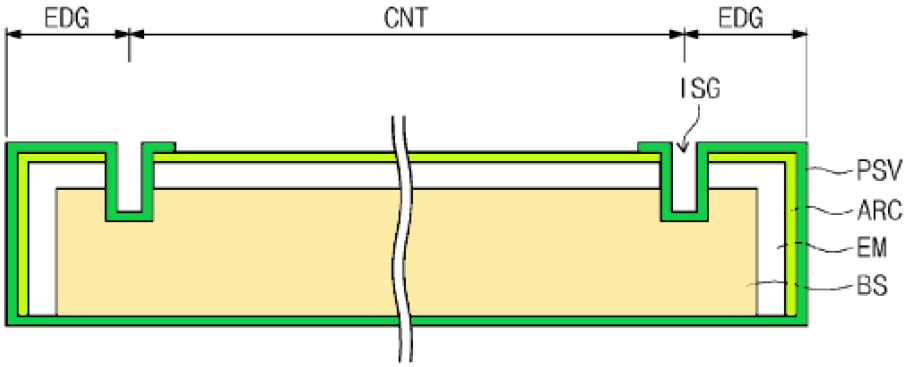


Fig. 2F

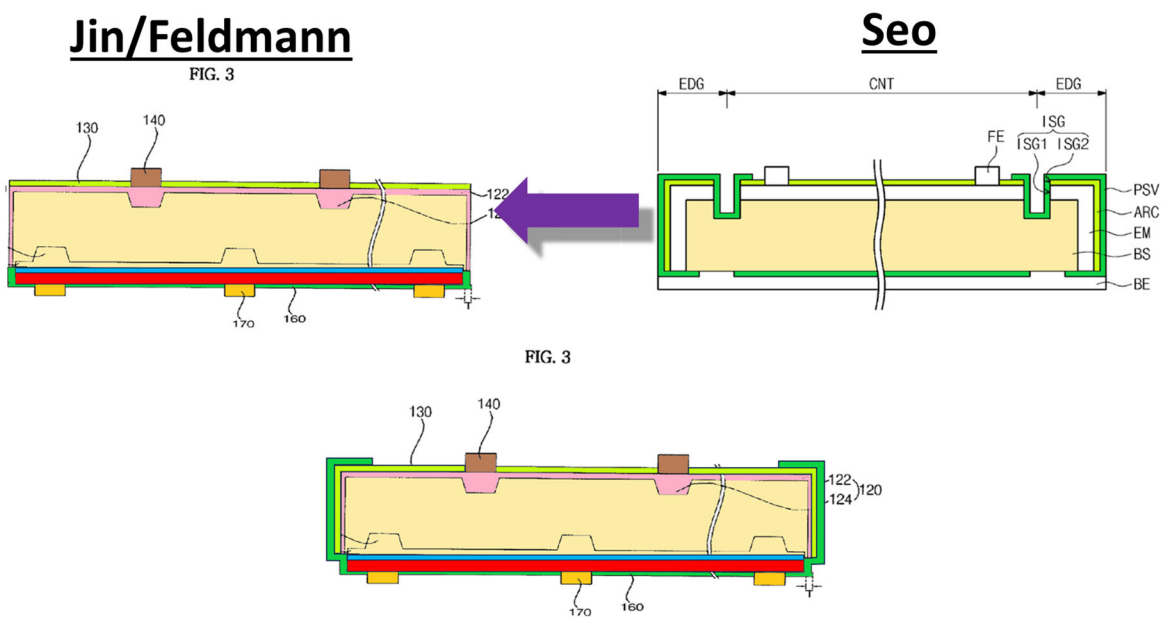


Thus, Seo discloses the results of Jin's passivation layer and anti-reflection film 160 and Chang's passivation films 21/31 formed by CVD. EX1003-Decl., ¶¶172, 255. Neither Jin nor Chang indicates that the lateral sides of the substrate are masked during CVD, or that the passivation/anti-reflection films are removed from the lateral side of the substrate. A Skilled Artisan would expect that CVD

would form the passivation/anti-reflection films on the lateral sides of the substrate as shown in Seo. EX1003-Decl., ¶¶169-181, 252-264.

B. Ground 3: Jin, Feldmann, and Seo

The combination of Jin/Feldmann with Seo applies the layout of Seo's ARC and PSV layers to Jin's passivation layer and anti-reflection film 160, respectively. EX1003-Decl. ¶¶169-176.



1. Motivation to "Modify" Jin/Feldmann with Seo

Jin, Feldmann, and Seo are analogous art because each is in the field of solar cell design and are pertinent to increasing solar cell efficiency. EX1003-Decl., ¶173.

The combination of Jin/Feldmann with Seo simply applies the configuration of Seo's ARC and PSV layers to Jin's front passivation layer and rear anti-reflection film 160, respectively. *Id.* ¶174. A Skilled Artisan would have been motivated to look to Seo to understand details not disclosed by Jin regarding Jin's fabrication process because both Jin and Seo disclose using CVD for these layers. *Id*. A Skilled Artisan would be motivated to build the Jin/Feldmann combination such that the passivation layer and anti-reflection film 160 cover the lateral sides of the substrate—as taught by Seo—because surface recombination would occur in these regions if not passivated. *Id*. Eliminating the passivation layer and anti-reflection film 160 from the lateral sides would require extra process steps to mask the substrate's sides during deposition, or would require etching to remove these layers after deposition. *Id*. Such steps would not only increase complexity, drive up costs, and increase the risk of manufacturing error, but would also not result in any benefit to the solar cell, and in fact would create recombination sites, reducing solar cell efficiency. *Id*.

2. Reasonable Expectation of Success

The Skilled Artisan would have considered the Jin/Feldmann and Seo combination to be merely an arrangement of like elements (and their corresponding fabrication steps) with each performing the same function it had been known to perform (the passivation layer and anti-reflection film 160 of Jin, and the anti-

reflection layer ARC and passivation layer PSV of Seo, respectively) and yielding no more than what one would expect: a solar made using Jin's manufacturing process having the passivation/anti-reflection film configuration shown in Seo. EX1003-Decl., ¶¶175-176.

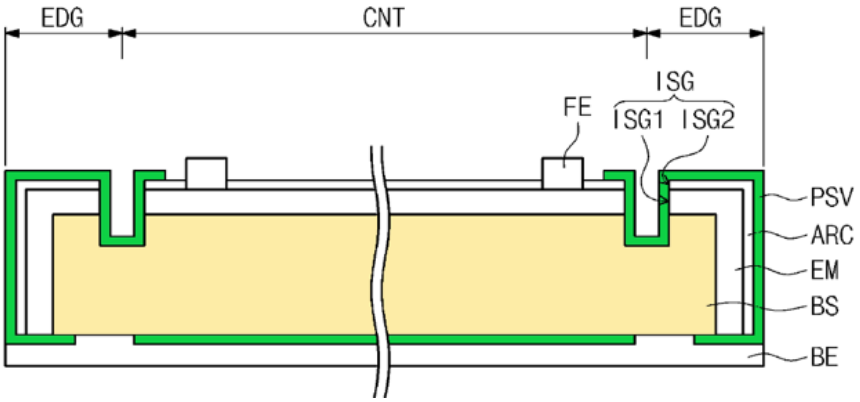
On the front side, Seo's ARC and Jin's passivation layer may both be silicon oxide such that a Skilled Artisan would understand the two layers to be interchangeable and serve equivalent functions. EX1009-Jin, ¶37; EX1015-Seo, 4:45-47; EX1003-Decl., ¶175. Likewise, on the back side, both Jin's second anti-reflection film 160 and Seo's PSV may be formed from silicon oxide, silicon nitride, or silicon oxynitride, and "perform[] the function of a passivation layer." EX1009-Jin, ¶50; EX1015-Seo, 5:12-15; EX1003-Decl., ¶175.

Combining Jin/Feldmann and Seo would have been well within the level of ordinary skill in the art, would not have resulted in any unpredictable results, and could have been readily accomplished without undue experimentation and with a reasonable expectation of success. EX1003-Decl., ¶176. The combination would simply require the omission of any additional (and unnecessary) steps in Jin's manufacturing process to shield or remove anti-reflection/passivation layers from the lateral sides of the substrate, to yield predictable results. *Id*.

3. Claim 7 – First Passivation on Substrate Sides

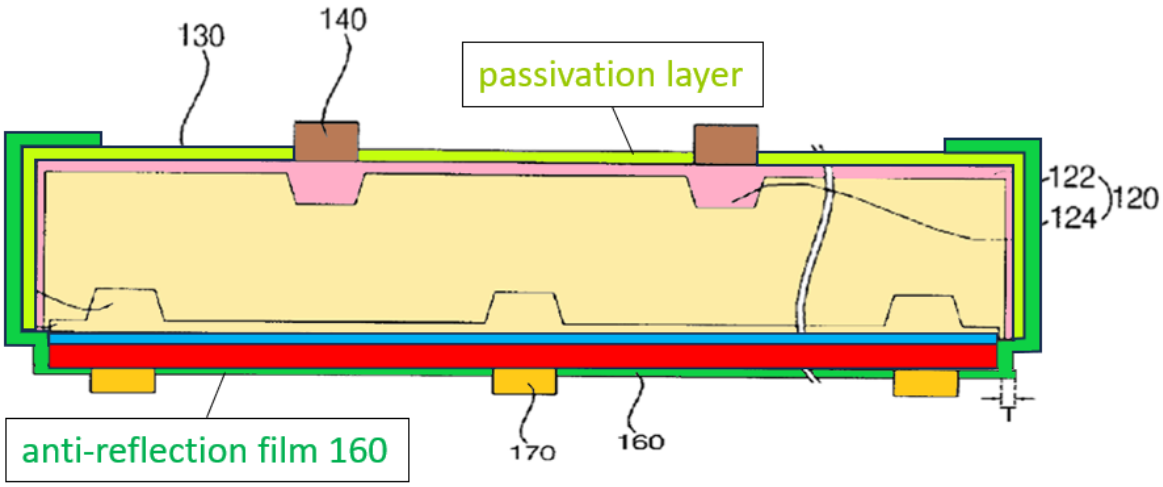
Seo discloses that "*the first passivation film comprises a side portion extending up a side surface of the semiconductor substrate*." In Seo, the passivation layer PSV (dark green) is "**on the side surfaces of the base substrate BS**. EX1015-Seo, 4:60-62, Fig. 1; EX1003-Decl., ¶183.

Fig. 1



As discussed above in §IX.C.1.f, Jin's anti-reflection/passivation film 160 is the claimed "*first passivation film.*" In the Jin/Feldmann/Seo combination, film 160 is formed by CVD, resulting in the layout of Seo's PSV, as illustrated in Jin's modified Fig. 1. EX1003-Decl., ¶¶177-78.

Combination of Jin, Feldmann, and Seo



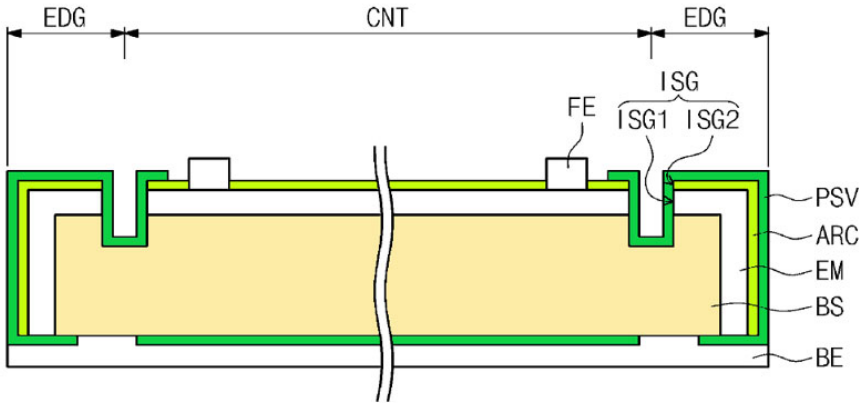
4. Claim 8 – Second Passivation on Substrate Sides

Seo discloses that "*the second passivation film comprises a side portion formed on the side surface of the semiconductor substrate, and the side portion of the first passivation film on the side surface of the semiconductor substrate is on the side portion of the second passivation film*." In short, the back (first) passivation film covers the front (second) passivation film in the lateral side regions of the substrate.

In Seo, an "antireflection layer ARC" (light green) on the front extends down the lateral sides of the substrate, satisfying the *second passivation film* portion of the claim. EX1015-Seo, 4:43-51, 4:60-63. A passivation layer PSV (dark green) on the back side extends up the lateral sides, corresponding to the *first passivation film*. Seo explains that "[t]he passivation layer PSV [*first passivation*

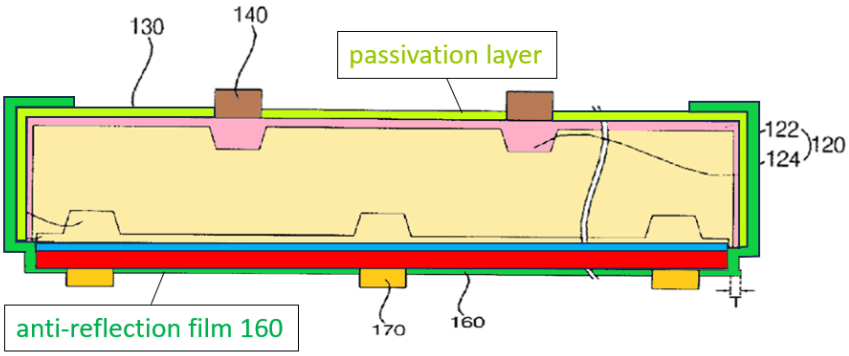
film] is on the anti-reflection layer ARC [*second passivation film*] in a region … on the side surfaces of the base substrate BS." *Id.*, 4:60-63, Fig. 1.

Fig. 1



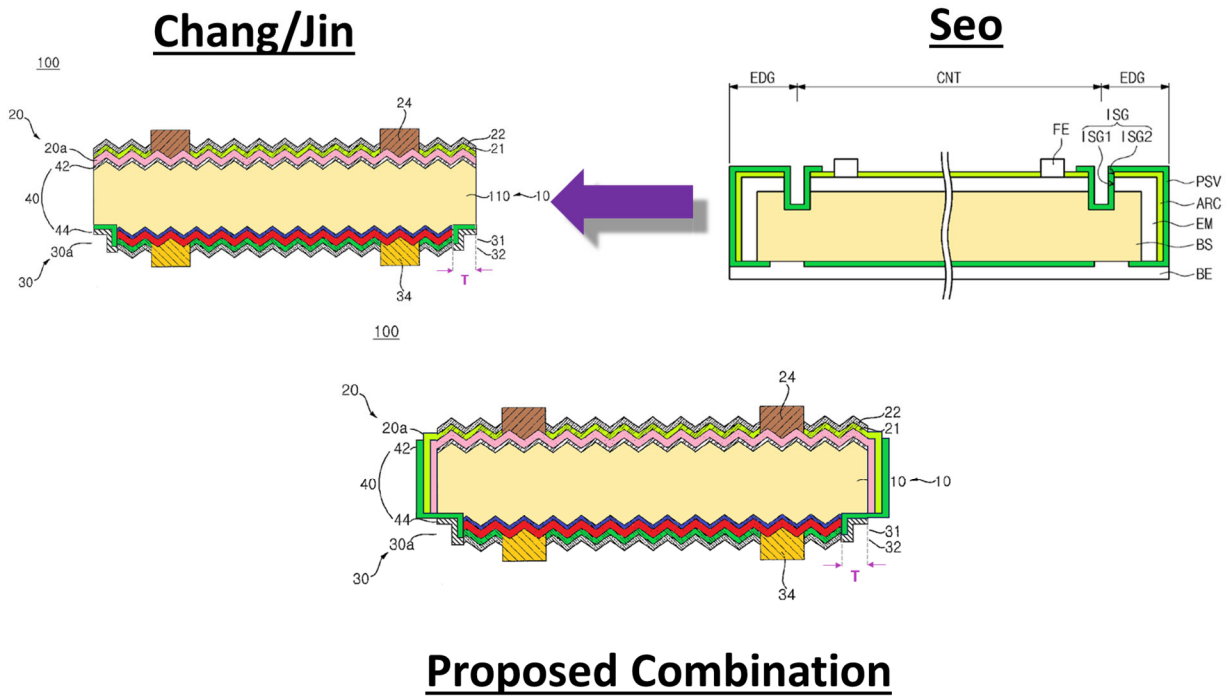
As discussed above in §IX.C.1.h, Jin's emitter layer 120 is a "*second passivation film*" as claimed. Seo discloses that the front surface antireflection layer ARC may be made of "silicon oxide," the same material as Jin's passivation layer. EX1015-Seo, 4:45-47; EX1009-Jin, ¶37. A Skilled Artisan would understand that Seo's ARC functions as a passivation layer as taught by Jin. EX1003-Decl., ¶181. Moreover, a Skilled Artisan would understand that forming Jin's passivation layers and anti-reflection film 160 in the order taught by Seo would minimize manufacturing defects. *Id*.

Combination of Jin, Feldmann, and Seo



C. Ground 4: Chang, Jin, and Seo

Just like in Ground 3, the combination of Chang/Jin with Seo likewise applies the layout of Seo's ARC and PSV layers to Chang's passivation films 21/31, respectively. EX1003-Decl. ¶¶252-259.



Chang, Jin, and Seo are analogous art. EX1003-Decl., ¶256. The combination of Chang/Jin and Seo simply applies the configuration of Seo's ARC and PSV layers to Chang's passivation films 21/31. *Id.*, ¶257. A Skilled Artisan would have been motivated to look to Seo to understand details not disclosed by Chang because both Chang and Seo disclose using CVD for these layers. *Id*. A Skilled Artisan would be motivated to have the Chang's passivation films 21/31 cover the lateral sides of the substrate—as taught by Seo—because surface recombination would occur in these regions if not passivated. *Id*.

The Skilled Artisan would have considered the Chang/Jin and Seo combination to be merely an arrangement of like elements (and their corresponding fabrication steps) with each performing the same function it had been known to perform (the passivation films 21/31 of Jin with the anti-reflection layer ARC and passivation layer PSV of Seo, respectively) and yielding no more than what one would expect: a solar cell made using Chang's manufacturing process having the passivation film configuration shown in Seo. EX1003-Decl. ¶258.

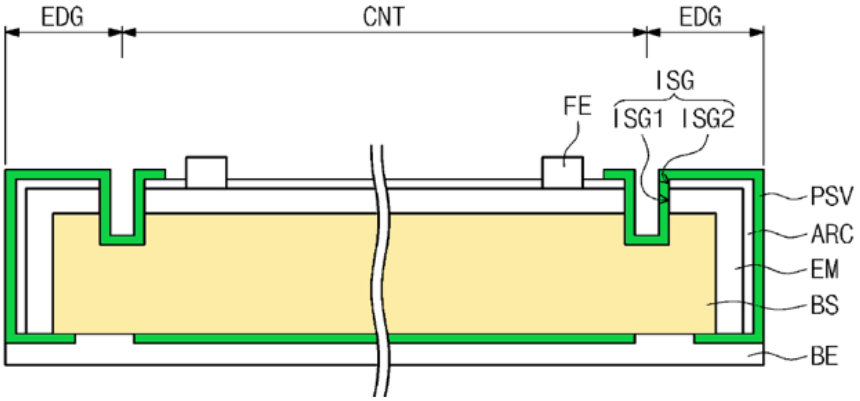
On the front side, Seo's anti-reflection layer ARC and Chang's passivation film 21 may both be silicon oxide such that a Skilled Artisan would understand the two layers to be interchangeable and serve equivalent functions. EX1003-Decl., ¶258. Likewise, on the back side, both Chang's passivation film 31 and Seo's passivation layer PSV may be formed from silicon oxide or silicon nitride.

EX1003-Decl., ¶258. Combining Chang/Jin and Seo would have been well within the level of ordinary skill in the art, would not have resulted in any unpredictable results, and could have been readily accomplished without undue experimentation and with a reasonable expectation of success. EX1003-Decl., ¶259.

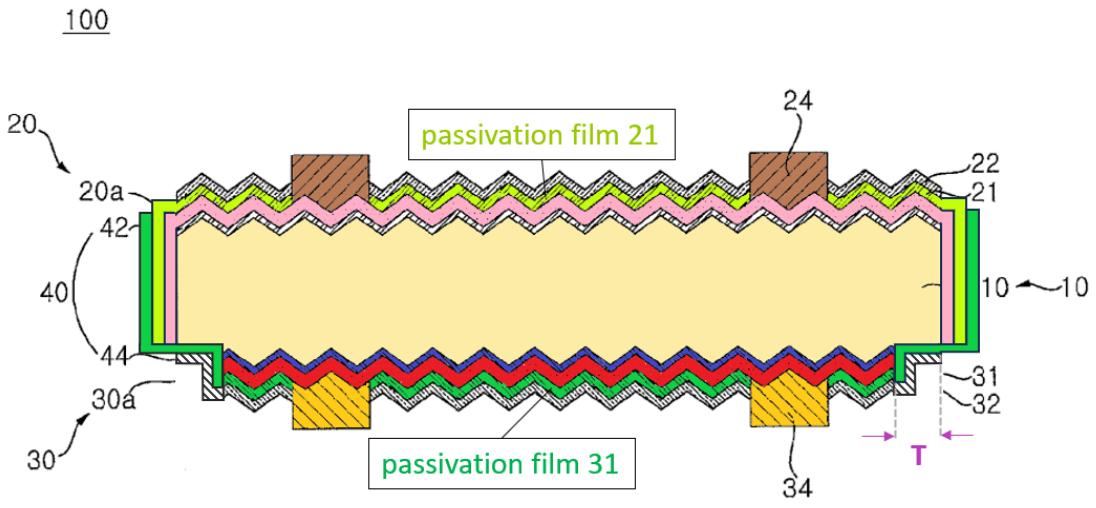
1. Claim 7 – First Passivation on Substrate Sides

Seo discloses that "*the first passivation film comprises a side portion extending up a side surface of the semiconductor substrate*." EX1015-Seo, 4:60-62, Fig. 1; EX1003-Decl., ¶260.

Fig. 1



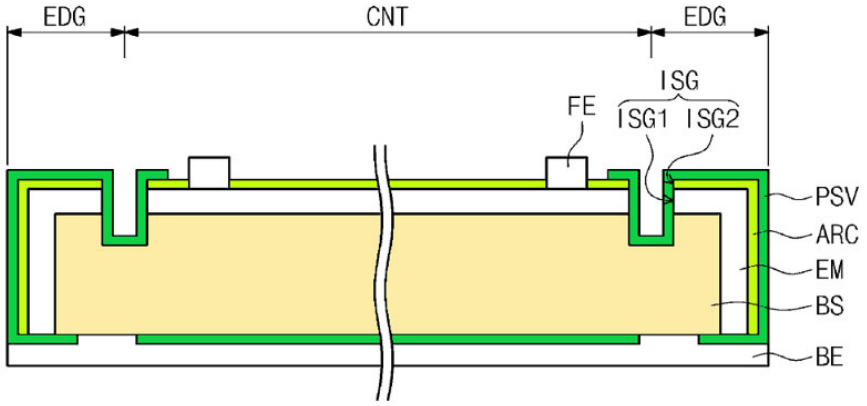
In the Chang/Jin combination, passivation film 31 is formed by CVD, resulting in the layout of Seo's PSV, as illustrated Chang's modified Fig. 1. EX1003-Decl. ¶¶260-61. The same combination could also be implemented using Chang's Fig. 8. *Id.*



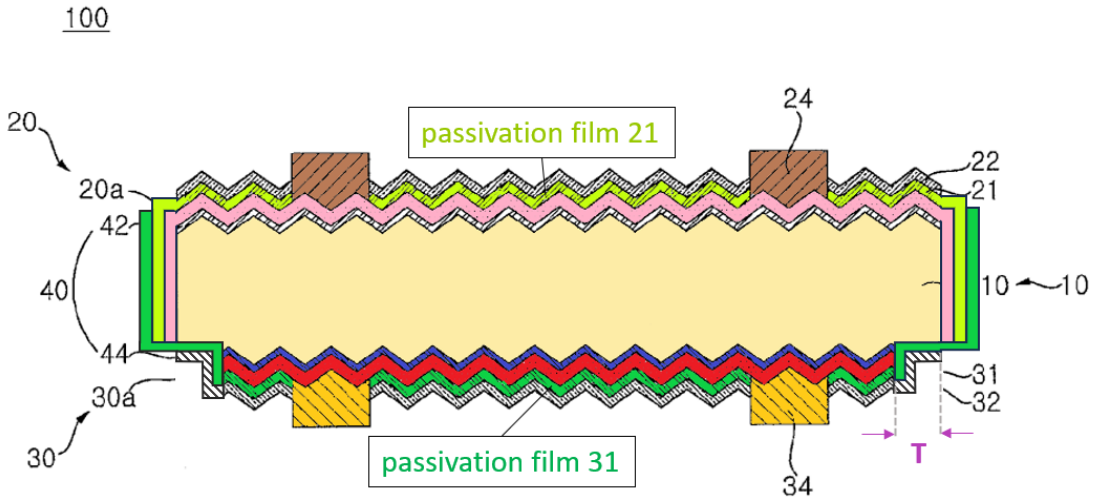
2. Claim 8 – Second Passivation on Substrate Sides

Seo discloses that "*the second passivation film comprises a side portion formed on the side surface of the semiconductor substrate, and the side portion of the first passivation film on the side surface of the semiconductor substrate is on the side portion of the second passivation film*." EX1015-Seo, 4:43-51, 4:60-63, Fig. 1; EX1003-Decl., ¶¶262-63.

Fig. 1



As discussed above in §X.C.1.h, Chang discloses passivation film 21 on emitter 20 that is a "*second passivation film*" as claimed. Seo discloses that the front surface antireflection layer ARC may be made of "silicon oxide," the same material as Chang's passivation film 21. EX1015-Seo, 4:45-47; EX1013-Chang, ¶53. A Skilled Artisan would understand that Seo's ARC functions as a passivation layer as taught by Chang. EX1003-Decl. ¶264. Moreover, a Skilled Artisan would understand that forming Chang's passivation layers 21/31 in the order taught by Seo would minimize manufacturing defects. *Id.* The same combination could also be implemented using Chang's Fig. 8. *Id.*



XII. GROUNDS 5 & 6: CLAIM 11 IS UNPATENTABLE OVER THE COMBINATION OF EITHER JIN/FELDMAN OR CHANG/JIN IN FURTHER VIEW OF WATABE

Claim 11 relates to the bus electrode having a double layer structure, a feature taught by Watabe. Each of the combinations of Grounds 1 and 2 in view of Watabe would have rendered claim 11 obvious.

A. Overview of Watabe

Japanese Patent Publication No. JP2010186862A ("Watabe") published on August 26, 2010. EX1014, face. Watabe is prior art under 35 U.S.C. §102(a)(1). Watabe was submitted in an IDS filed June 1, 2018 during prosecution of the 104 Patent. EX1002, 15.

Watabe discloses that finger and bus bar electrodes are commonly made by screen printing and firing silver paste to bond the paste to the substrate. EX1014-Watabe, ¶2. Multiple solar cells are connected together by soldering wires to the bus bar electrodes. *Id.*, ¶4. While copper has good conductivity and is inexpensive, it has "poor solder wettability compared to that of silver." *Id.*, ¶¶3-4.

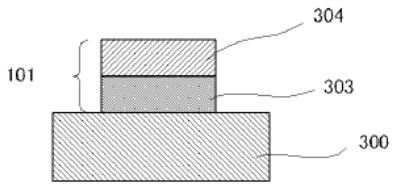
Watabe discloses that because the finger electrodes are not used to connect solar cells, they can be made with screen printed copper "for cost reduction." *Id.*, ¶10. The bus bar electrodes, however, are used to connect between solar cells. *Id.*, ¶4. Recognizing that copper does not solder well to the coupling wires, Watabe discloses that "at least the bus-bar electrode has a multilayer structure with two or

more layers." *Id.*, ¶¶4, 12. The first layer of the bus bar that is "directly bonded to the semiconductor substrate" is made of copper while "the outermost electrode layer to be bonded to the wiring" is formed from silver such that "the adhesive strength to the wiring is maintained." *Id.*, ¶¶13, 17.

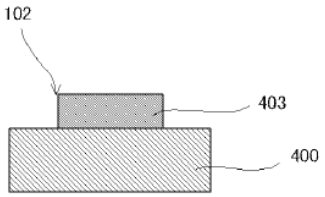
Watabe discloses that the finger and bus bar structure is formed "on at least one side of the semiconductor substrate." *Id.*, ¶¶9, 28. Bifacial solar cells like that of Jin and Chang can receive light on both the front and back sides of the solar cell. EX1003-Decl., ¶101. The Skilled Artisan would understand that when the electrode structure of Watabe is used in the bifacial Jin/Feldmann and Chang/Jin solar cells, such electrode structure would be used on both sides of the substrate. EX1003-Decl., ¶101.

Watabe discloses a dual layer busbar structure with copper 303 adhering to the substrate and silver on the outermost layer 304 to increase "the reliability of the bonding strength to wiring by soldering." EX1014-Watabe, ¶28, Fig. 3. In Fig. 4, Watabe discloses that the finger electrode can be a single layer structure of copper 403. *Id.*, ¶28.

【図 3】



【図 4】



The bifacial solar cells of Jin/Feldmann (Ground 1) and Chang/Jin (Ground 2) in combination with the single layer copper finger and dual layer copper/silver bus bar electrodes of Watabe would have rendered Claim 11 obvious. The combinations would have been nothing more than replacing the screen printed silver finger and bus electrodes of Jin[5] with the screen printed copper finger electrodes and screen printed copper and silver bus electrodes of Watabe. EX1009-Jin, ¶¶52, 88-89; EX1014-Watabe, ¶¶16-17, 28; EX1003-Decl. ¶¶182, 265.

[5] Grounds 1 and 2 both rely on Jin's disclosure of the silver single-layer structure of the finger and bus electrodes. *See* §§IX.C.8, X.C.8.

B. Motivation to Modify Jin/Feldmann and Chang/Jin with Watabe

Jin, Feldmann, Chang, and Watabe are analogous art because each is in the field solar cell design, and each is reasonably pertinent to improvements in solar cell designs. EX1003-Decl. ¶¶183, 266.

Jin discloses that both the rear finger 170 and rear surface bus electrodes 190 can be made by screen printing using silver paste, resulting in a single layer of silver. EX1009-Jin, ¶52. Watabe similarly discloses that its finger and bus electrodes can be made by screen printing. EX1014-Watabe, ¶28. To reduce cost, Watabe discloses a dual layer bus bar structure, in which the first electrode layer that is bonded directly to the substrate is formed with a copper paste and the uppermost electrode that is bonded to the connecting wiring is formed with a silver paste. *Id.*, ¶9.

The Skilled Artisan reviewing Jin/Feldmann and Chang/Jin would have been motivated to replace the front and rear screen printed silver finger 170 and bus electrodes 190 of Jin with the screen printed copper finger and copper/silver bus electrodes of Watabe to provide for "a significant reduction in solar cell production costs without compromising solar cell performance and while maintaining the reliability of soldering to the wiring." EX1014-Watabe, ¶14; EX1003-Decl. ¶¶185, 268. In the combinations, the solar cells of Jin/Feldmann and Chang/Jin would

continue to function as before, but with the benefit of lower cost. *Id.*; EX1003-Decl. ¶¶185, 268.

C. **Reasonable Expectation of Success**

The Skilled Artisan would have considered the Jin/Feldmann/Watabe and Chang/Jin/Watabe combinations to be merely an arrangement of old elements (and their corresponding fabrication steps) with each performing the same function it had been known to perform, with screen printed silver fingers and bus bar of Jin replaced by the screen printed copper fingers and copper/silver bus bar of Watabe. EX1003-Decl. ¶¶186-87, 269-70.

Combining Jin/Feldmann/Watabe and Chang/Jin/Watabe would have been well within the level of ordinary skill in the art, would not have resulted in any unpredictable results, and could have been readily accomplished without undue experimentation and with a reasonable expectation of success. *Id.*, ¶¶187, 270. The combination would simply have been the combination of well-known prior art steps in solar cell and semiconductor fabrication to yield predictable results. *Id.* Likewise, substituting Jin's screen printed silver rear surface electrode with the screen printed copper finger and copper/silver bus bar electrodes of Watabe would have been a simple substitution of one known element and corresponding fabrication step for another to obtain predictable results. *Id.*

D. Ground 5: Jin, Feldmann, and Watabe (Claim 11)

The Jin/Feldman combination in view of Watabe discloses that "*the plurality of first finger electrodes have a single layer structure, and the first bus bar has a double layer structure.*" In applying Watabe teaching to the Jin/Feldman combination, the finger electrodes are screen printed using a copper paste. EX1014-Watabe, ¶9; EX1003-Decl. ¶¶188-89. To maintain solderability and adhesive strength to the wiring between cells, the bus electrodes would be first screen printed with copper and then with silver, as taught by Watabe. EX1014-Watabe, ¶¶12, 28. The result would be finger electrodes "*hav[ing] a single layer structure*" and copper/silver bus electrodes "*ha[ving] a double layer structure.*" EX1003-Decl. ¶¶188-89.

E. Ground 6: Chang, Jin, and Watabe (Claim 11)

The Chang/Jin combination in view of Watabe would also have rendered Claim 14 obvious for the same reasons discussed in §XII.D because the Chang/Jin combination likewise relies primarily on Jin's finger and bus electrodes. *See* X.C.8; EX1003-Decl., ¶¶271-72. In addition, Chang discloses that its rear finger and bus bar electrodes "may be formed by a variety of methods such as coating, deposition, printing or the like," EX1013-Chang ¶71, such as the methods taught by Jin and Watabe.

XIII. OBJECTIVE FACTORS SUPPORT OBVIOUSNESS

Trina cannot demonstrate that there has been a commercially successful product with nexus to the 104 Patent. Trina alleges that it commercially sells "TOPCon" modules, but Trina makes no mention in any of its materials of an "isolation portion" located on the edge of the backside surface—the only feature that the Examiner deemed novel to allow the claims during prosecution. *See* §V.C The novel features that Trina touts of its TOPCon products are unrelated to the claims. EX1023 ("The 210R rectangular cell, the selective boron emitter, the backside microstructure reflector, and the highly doped TOPCon structure with PECVD ***are four innovations key*** to the new-generation TOPCon Advanced technology," said Dr. Chen Yifeng, associate vice president of technology at Trina.)

Neither evidence of unexpected results, nor of long felt and unsolved need exists. An "isolation portion" on the solar cell's backside to prevent shorting of the electric current was well known, as seen from Jin. And there is nothing unexpected in adopting this feature in TOPCon cells. EX1003-Decl., ¶274. Indeed, Chang disclosed this very structure before the 104 Patent. There is no evidence of failure or skepticism by others, copying, praise for the alleged invention of the 104 Patent, or any other indicia of non-obviousness.

And even if Trina should come forward with some secondary consideration evidence, it would be insufficient to overcome the strong showing of obviousness in this petition.

XIV. DISCRETIONARY DENIAL IS INAPPLICABLE

The PTAB should not deny institution based on §315(d). The combinations relied on here were not considered during the 104 Patent's prosecution. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 5-6 (PTAB Mar. 20, 2020) also weighs against discretionary denial:

Factors 1, 2 & 4: On October 8, 2024, Trina filed a complaint against Petitioner in the District of Delaware alleging infringement of the 009 Patent and 104 Patent. That case is currently stayed due to the ITC investigation filed by Patent Owner against Petitioner (now terminated). Petitioner has not yet answered the district court complaint, but expects Patent Owner to resume its infringement claims in Delaware. Petitioner intends to seek a further stay of the case pending the resolution of Runergy IPR and co-pending IPR2025-007, both instituted April 21, 2025, as well as any copycat IPRs. Hence, there is unlikely to be an active district court proceeding during the pendency of this IPR. EX1020, 1.

Factor 3: Petitioner filed this Petition expeditiously, less than seven months after Trina's Delaware complaint, which favors institution. Institution has already been granted in the Runergy IPR for which Petitioner is requesting joinder,

and Petitioner has not yet even answered the Delaware complaint. Petitioner also gains no advantage and the PTAB and Patent Owner suffer no prejudice from the filing of this petition.[6]

Factor 5: The statutory estoppel provision of §315(e)(2) weighs strongly in favor of institution. The Final Written Decision in the Runergy IPR for which joinder is sought is due April 21, 2026. The Delaware court has not even set a trial date yet.

Factor 6: The merits here are compelling, favoring institution. The PTAB already granted institution on the exact same grounds in the Runergy IPR (IPR2025-00007, Paper 11).

XV. CONCLUSION

Claims 1-11 should be canceled.

Dated: April 28, 2025

Respectfully submitted,

/Samuel N. Tiu/

[6] Petitioner and the Runergy IPR petitioners are competitors that share no relationship beyond being commonly accused of infringing the 104 Patent and sharing common counsel for this IPR, which are insufficient to trigger denial under *General Plastic*. *Cellco Partnership v. General Access Solutions, Ltd.*, IPR2023-00978, Paper 20 at 18-19 (PTAB Dec. 14, 2023).

Samuel N. Tiu
Registration No. 47,997
Sidley Austin LLP
350 S. Grand Avenue
Los Angeles, CA 90071

CERTIFICATE OF COMPLIANCE

I hereby certify that this brief complies with the type-volume limitations of 37 C.F.R. § 42.24, because it contains 13,088 words (as determined by the Microsoft Word word-processing system used to prepare the brief), excluding the parts of the brief exempted by 37 C.F.R. § 42.24.

Dated: April 28, 2025

Respectfully submitted,

/Samuel N. Tiu/

Samuel N. Tiu
Registration No. 47,997
Sidley Austin LLP
350 S. Grand Avenue
Los Angeles, CA 90071

PETITION FOR INTER PARTES REVIEW

OF U.S. PATENT NO. 9,722,104

Attachment A:

Proof of Service of the Petition

CERTIFICATE OF SERVICE

I hereby certify that on this 28th day of April 2025, a copy of this Petition, including all attachments, appendices and exhibits, has been served in its entirety by overnight mail on the following attorney shown as the Correspondence Address for the Patent Owner:

909 - Pillsbury Winthrop Shaw Pittman, LLP
PO Box 10500
McLean, VA
UNITED STATES

Courtesy electronic copies were also served on the following counsel of record for patent owner in the district court litigations.

Josh Pond
Orrick, Herrington, & Sutcliffe, LLP
2100 Pennsylvania Ave NW
Washington, DC 20037
jpond@orrick.com

Dated: April 28, 2025

Respectfully submitted,

/Samuel N. Tiu/
Samuel N. Tiu
Registration No. 47,997
Sidley Austin LLP
350 S. Grand Avenue
Los Angeles, CA 90071

PETITION FOR INTER PARTES REVIEW

OF U.S. PATENT NO. 9,722,104

Attachment B:

List of Evidence and Exhibits Relied Upon in Petition

Exhibit #	Reference Name
1001	U.S. Patent No. 9,722,104 ("104 Patent")
1002	Not Used
1003	Declaration of Dr. Sanjay Banerjee
1004	Curriculum Vitae of Dr. Sanjay Banerjee
1005	File History of U.S. Patent No. 9,722,104
1006	File History of U.S. Patent No. 10,014,419
1007	Korean Patent App. No. 10-2014-0168624 with certified translation
1008	Korean Patent App. No. 10-2015-0122846 with certified translation
1009	U.S. Patent App. Publication No. 2013/0056051 to Y. Jin, *et al.* ("Jin")
1010	F.A. Lindholm, *et al*., Heavily Doped Polysilicon-Contact Solar Cells, IEE Electron Device Letters, Vol. EDL-6, No. 7, (IEEE 1985) ("Lindholm")
1011	Y.H. Kwark, *et al*., N-Type SIPOS and Poly-Silicon Emitters, Solid-State Electronics, Vol. 30, No. 11, 1121-l 125 (1987) ("Kwark")
1012	F. Feldmann, *et al*., "Passivated rear contacts for high-efficiency n-type Si solar cells providing high interface passivation quality and excellent characteristics," Solar Energy Materials & Solar Cells 120 (2014) 270-274 (2013 Elsevier B.V.) ("Feldmann")
1013	U.S. Patent App. Publication No. 2014/0299187 to J. Chang, *et al.* ("Chang")
1014	Japanese Patent App. Publication No. JP 2010-186862 to T. Watabe, *et al*. ("Watabe") with certified translation
1015	U.S. Patent No. 8,647,914 to K. Seo, *et al*. ("Seo")
1016	Not used
1017	Not used

Exhibit #	Reference Name
1018	Not used
1019	Not used
1020	C. Kraning and K. Del Dotto, Stays Pending IPR In Del. District Courts Are Here To Stay (Law360 Mar. 11, 2022)
1021	M. Quirk, *et al*., Semiconductor Manufacturing Technology (Prentice-Hall Inc. 2001)
1022	A. Luque, *et al*., Handbook of Photovoltaic Science and Engineering (John Wiley & Sons Ltd. 2003)
1023	Trina Solar n-type TOPCon Advanced technology steps onto the world stage, with efficiency reaching 26% in mass production and 700W+ in module power, *available at* https://www.trinasolar.com/us/trina-solar-n-type-vertex-to-reach-700gw (last visited August 19, 2024)
1024	Y. H. Kwark, *et al*. SIPOS Heterojunction contacts to silicon, 1984 International Electron Devices Meeting (1984): 742-745 ("Kwark II")
1025	SY Lien, *et al.*, Tri-layer antireflection coatings (SiO2/SiO2—TiO2/TiO2) for silicon solar cells using a sol-gel technique, Solar Energy Materials & Solar Cells 90, 2710-2719 (2006)
1026	D. Kray, *et al.*, Study on the edge isolation of industrial silicon solar cells with waterjet-guided laser, Solar Energy Materials & Solar Cells, 91, 1638–1644 (2007)
1027	Merriam-Webster's Collegiate Dictionary, 10th Ed. (Merriam-Webster, Inc. 1998) (definition of "periphery")
1028	S. Duttagupta, *et al*., Progress in Surface Passivation of Heavily Doped n-Type and p-Type Silicon by Plasma-Deposited AlOx/SiNx Dielectric Stacks, IEEE Journal of Photovoltaics, Vol. 3, No. 4 (October 2013)
1029	Oxford College Dictionary, 2nd Ed. (Oxford University Press, Inc. 2002)

Exhibit #	Reference Name
1030	B. Streetman and S. Banerjee, Solid State Electronic Devices, 6th Ed. (Prentice-Hall Inc. 2006)
1031	M. Scherff, Novel method for preparation of interdigitated back contacted a-Si:H/c-Si heterojunction solar cells, 26th European Photovoltaic Solar Energy Conference and Exhibition (2011)
1032	W. Decker, *et al*., "Novel low pressure sputtering source and improved vacuum deposition of small patterned features using precision shadow masks," 59th Annual Technical Conference Proceedings (Society of Vacuum Coaters 2016)
1033	H. Okuyama, *et al.*, Position-selective growth of carbon nanotubes on Ni catalysts/Mo underlayers by thermal chemical vapor deposition, J. Mater. Res., Vol. 21, No. 11 (Materials Research Society 2006)
1034	T. Saga, Advances in crystalline silicon solar cell technology for industrial mass production, NPG Asia Materials, Volume 2, 96–102 (2010)
1035	Declaration of James Mullins
1036	U.S. Patent Pub. No. 2012/0003781 to Yun, *et al*. ("Yun")
1037	Supplemental Declaration of Sanjay Banerjee, Ph.D.
1038	Supplemental Declaration of James Mullins, Ph.D.

PETITION FOR INTER PARTES REVIEW

OF U.S. PATENT NO. 9,722,104

Attachment C:

Listing of the Claims of U.S. Patent No. 9,722,104

Claim Element	Claim Language
[1.a]	A solar cell comprising:
[1.b]	a semiconductor substrate;
[1.c]	a tunnel layer on a first surface of the semiconductor substrate;
[1.d]	a first conductive type semiconductor region on the tunnel layer and containing impurities of a first conductive type;
[1.e]	a second conductive type semiconductor region on a second surface opposite to the first surface of the semiconductor substrate and containing impurities of a second conductive type opposite to the first conductive type;
[1.f]	a first passivation film on the first conductive type semiconductor region;
[1.g]	a first electrode formed on the first passivation film and connected to the first conductive type semiconductor region through an opening formed in the first passivation film;
[1.h]	a second passivation film on the second conductive type semiconductor region;
[1.i]	a second electrode formed on the second passivation film and connected to the second conductive type semiconductor region through an opening formed in the second passivation film; and
[1.j]	an isolation portion for preventing a contact between the first conductive type semiconductor region and the second conductive type semiconductor region,

	wherein the isolation portion excludes the tunnel layer and the first conductive type semiconductor region, and is in an edge portion of the first surface of the semiconductor substrate, and
[1.k]	wherein the first passivation film covers the first surface of the semiconductor substrate and the isolation portion together.
[2]	The solar cell of claim 1, wherein the first electrode comprises a plurality of first finger electrodes spaced apart from each other and extended in parallel in a first direction, and the second electrode comprises a plurality of second finger electrodes spaced apart from each other and extended in parallel in the first direction.
[3]	The solar cell of claim 2, wherein the first electrode further comprises a first bus bar connected to the plurality of first finger electrodes, and the second electrode further comprises a second bus bar connected to the plurality of second finger electrodes.
[4]	The solar cell of claim 1, wherein the first conductive type semiconductor region includes a polycrystalline silicon material, and the second conductive type semiconductor region includes a single crystal silicon material.
[5]	The solar cell of claim 1, wherein a width of the isolation portion is 1 nm to 1 mm.
[6]	The solar cell of claim 1, wherein a thickness of an edge region in the first conductive type semiconductor region progressively decreases towards the isolation portion.

[7]	The solar cell of claim 1, wherein the first passivation film comprises a side portion extending up a side surface of the semiconductor substrate.
[8]	The solar cell of claim 7, wherein the second passivation film comprises a side portion formed on the side surface of the semiconductor substrate, and the side portion of the first passivation film on the side surface of the semiconductor substrate is on the side portion of the second passivation film.
[9]	The solar cell of claim 3, wherein all of the plurality of first finger electrodes and the first bus bar are connected to the first conductive type semiconductor region through the first passivation film.
[10]	The solar cell of claim 9, wherein all of the plurality of first finger electrodes and the first bus bar have a single layer or double layer structure.
[11]	The solar cell of claim 9, wherein: the plurality of first finger electrodes have a single layer structure, and the first bus bar has a double layer structure.