IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

MAXEON SOLAR PTE. LTD., Plaintiff, Counterdefendant v. CANADIAN SOLAR INC., Defendant, Counterclaimant.	CIVIL ACTION NO. 2:24-cv-210-JRG

DEFENDANT AND COUNTERCLAIMANT CANADIAN SOLAR INC.'S INVALIDITY CONTENTIONS

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A. P.R. 3-4(a): Source code, specifications, schematics, flow charts, artwork, formulas, or other documentation sufficient to show the operation of any aspects or elements of an Accused Instrumentality identified by the patent claimant in its P. R. 3-1(c) chart 81

B. P.R. 3-4(b): A copy of each item of prior art identified pursuant to P. R. 3-3(a) which does not appear in the file history of the patent(s) at issue. To the extent any such item is not in English, an English translation of the portion(s) relied upon must be produced. 81

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I. INTRODUCTION

Pursuant to the Court's Docket Control Order (Dkt. No. 33) and the United States District Court for the Eastern District of Texas Local Patent Rules ("P.R.") 3-3 and 3-4, Defendant and Counterclaimant Canadian Solar Inc. ("Canadian Solar" or "Defendant") hereby serves these Invalidity Contentions ("Contentions") in conjunction with its accompanying document production.[1]

Plaintiff and Counterdefendant Maxeon Solar Pte. Ltd. ("Maxeon" or "Plaintiff") has asserted claims 9 and 10 of U.S. Patent No. 8,222,516 (the "'516 Patent"), claims 9, 12, and 14-20 of U.S. Patent No. 8,878,053 (the "'053 Patent), claims 10, 13-16, and 19 of U.S. Patent No. 11,251,315 ("the '315 Patent") (hereinafter, the "Asserted Claims" of the "Asserted Patents") against Canadian Solar. *See* Plaintiff Maxeon's Disclosure of Asserted Claims and Infringement Contentions, dated July 12, 2024 ("Infringement Contentions"). Each of these claims are invalid under 35 U.S.C. §§ 102, 103, 112.

Canadian Solar hereby provides its disclosures pertaining only to the Asserted Claims identified by Plaintiff in its Infringement Contentions. These Contentions should not be construed to suggest that any of the other, non-asserted claims of the Asserted Patents are valid or enforceable. These Contentions are based on the issues raised in Plaintiff's Complaint, Canadian Solar's responsive pleadings, Plaintiff's Infringement Contentions, and Canadian Solar's investigations to date. Canadian Solar makes these Contentions based on its current knowledge, recognizing that its investigation is ongoing. Canadian Solar reserves the right to amend, modify, and/or supplement these Contentions based on, among other things, amendments, modifications or supplements to Plaintiff's Infringement Contentions, further

[1] To the extent that any item of prior art identified in these Invalidity Contentions is not included in the accompanying document production, such prior art is available for inspection and copying.

investigation, third-party discovery, fact or expert discovery and/or evaluation of the scope and content of the prior art (including, for example, the prior art from all other cases in which Plaintiff or its predecessor(s)- in-interest asserts one or more of the Asserted Patents), disclosure of the parties' claim constructions, an order construing the Asserted Claims, new developments in the case, or any other basis contemplated by the Federal Rules of Civil Procedure, the Court's Local Rules, and any other applicable order entered by the Court.

Canadian Solar incorporates by reference the Petitions for *Inter Partes* Review and exhibits in *Canadian Solar Inc. v. Maxeon Solar Pte. Ltd.*, IPR2024-01039, IPR2024-01040, IPR2024-01038, and IPR2024-01194; and *Hanwha Sols. Corp. v. Maxeon Solar Pte. Ltd.*, IPR2024-01203, IPR2024-01199, and IPR2024-01198 before the Patent Trial and Appeal Board. Canadian Solar also incorporates the Declarations of Dr. Sanjay Banerjee (EX1003) and Dr. Sylvia D. Hall-Ellis (EX1024) in the IPRs, IPR2024-01039, IPR2024-01040, IPR2024-01038, and IPR2024-01194. Canadian Solar further incorporates by reference any invalidity contentions or other prior art relating to the Asserted Patents disclosed in connection with *Maxeon Solar Pte. Ltd. v. Hanwha Solutions Corporation et al*, No. 2:24-cv-00262 and *Maxeon Solar Pte. Ltd. v. REC Solar Holdings AS*, No. 2:24-cv-00260, in the Eastern District of Texas.

Nothing in these Contentions constitutes an admission concerning the priority dates, conception date or reduction to practice of the Asserted Claims of the Asserted Patents. Moreover, nothing in these Contentions shall be treated as an admission that any of Canadian Solar's accused products and/or technology meets any limitations of the Asserted Claims.

II. P.R. 3-3(a)-(b): INVALIDITY BASED ON 35 U.S.C. §§ 102, 103

The concepts disclosed and claimed in each of the Asserted Patents are not new, and had been publicly disclosed, and actively practiced by others prior to the claimed invention date or effective filing date. The prior art includes various documents, products, patents and inventions

that separately and together render the Asserted Claims invalid. In addition, as described in more detail below, claims of certain of the Asserted Patents are invalid under § 112.

A. P.R. 3-3(a): Identification of Prior Art

Each of the Asserted Claims would have been anticipated and/or rendered obvious by at least the prior art listed in the tables below.

Canadian Solar also intends to rely upon inventor admissions concerning the scope of the prior art relevant to the Asserted Patents found in, among other places, the prosecution history of the Asserted Patents and any related patents, patent application, and/or reexaminations or post-grant proceedings.

1. Prior Art to the ’516 and ’053 Patents

a. Patents and Patent Publications

Patent or Patent Pub. Number	Country	Date of Issue / Publication	Prior Art Status
U.S. Patent No. 6,262,359 B1 to Meier, titled “Aluminum Alloy Back Junction Solar Cell and a Process for Fabrication thereof” (“Meier”)	U.S.A.	July 17, 2001	§102(b) (pre-AIA)
Japanese Patent Application Publication No. JP07-106611 to Okayasu, titled “Method for Manufacturing BSF Solar Cell” (“Okayasu”)	Japan	Apr. 21, 1995	§102(b) (pre-AIA)
WO 2009/094578 to Borden, titled “Improved HIT Solar Cell Structure” (“Borden”)	WIPO	July 30, 2009	§102(e) (pre-AIA)
U.S. Provisional Appl. 61/023,342 A1 to Borden, titled “Improved Hit Solar Cell Structure” (“Borden Provisional”)[2]	U.S.A.	July 30, 2009	§102(e) (pre-AIA)

[2] Under *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1380-82 (Fed. Cir. 2015), Borden Provisional provides sufficient support for at least claim 1 of Borden. Claim 1 of Borden-575 recites: “A solar cell comprising an amorphous semiconductor layer formed over a substrate; a dielectric layer interposed between the substrate and the amorphous semiconductor layer, wherein the dielectric layer is sufficiently thin so as to support a tunnel current therethrough.” Support in Borden can be found in at least Claim 1 and paragraphs 14-16 of the Borden provisional.

U.S. Patent Application Publication No. 2005/0268963 A1 to Jordan, titled "Process for Manufacturing Photovoltaic Cells" ("Jordan")	U.S.A.	Dec. 8, 2005	§102(b) (pre-AIA)
U.S. Patent Application Publication No. 2002/0142500 A1 to Foglietti, titled "Ultra-Thin Interface Oxidation by Ozonated Water Rinsing for Emitter Poly Structure" ("Foglietti")	U.S.A.	Oct. 3, 2002	§102(b) (pre-AIA)
EP1732142 A1 to Froitzheim, titled "Si Solar Cell and its Manufacturing Method" ("Froitzheim")	E.U.	Dec. 13, 2006	§102(b) (pre-AIA)
WO 2009/094575 A2 to Borden, titled "Buried Insulator Isolation for Solar Cell Contacts" ("Borden-575")	WIPO	July 30, 2009	§102(e) (pre-AIA)
U.S. Provisional Appl. 61/023,354 to Borden, titled "Buried Insulator Isolation for Solar Cell Contacts" ("Borden-575 Provisional")[3]	U.S.A.	July 30, 2009	§102(e) (pre-AIA)
CN1929545A to Li, titled "Crystalline Silicon Solar Cell with Novel Structure" ("Li-545")	China	Apr. 18, 2007	§102(a) (pre-AIA)
U.S. Patent No. 6,998,288 B1 to Smith, titled "Use of Doped Silicon Dioxide in the Fabrication of Solar Cells" ("Smith")	U.S.A.	Feb. 14, 2006	§102(b) (pre-AIA)
US. Patent No. 4,158,591 to Avery, titled "Solar Cell Manufacture" ("Avery")	U.S.A.	June 19, 1979	§102(b) (pre-AIA)

b. Publications

Publication	Date of Publication	Prior Art Status
J. Y. Gan and R. M. Swanson, "Polysilicon Emitters for Silicon Concentrator Solar Cells," May 1990, Proceedings of the 21st IEEE-PVSC ("Gan")	Publicly presented in 1990 Published 1994, but no later than August	§102(a), (b) (pre-AIA)

[3] Under *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc*., 800 F.3d 1375, 1380-82 (Fed. Cir. 2015), Borden-575 Provisional provides sufficient support for at least claim 1 of Borden-575. Claim 1 of Borden-575 recites: "A solar cell comprising an emitter layer formed on a semiconductor substrate and an insulating layer between the emitter layer and the surface of the substrate, the insulating later being patterned to include contact holes that allow current flow therethrough." Borden-575 Provisional's paragraph 6 provides written description support for claim 1, disclosing: "The present invention relates to methods and apparatuses for providing a buried insulator isolation for solar cell contacts. According to certain aspects, the invention places a buried oxide under the emitter of a polysilicon emitter solar cell…. Holes in the oxide provide contact areas, increasing the current density to enhance efficiency…."

	6, 2002 at IEEEXplore or before February 20, 2007	
Y. H. Kwark, R. Sinton, and R. M. Swanson, "SIPOS Heterojunction contacts to silicon." 1984 International Electron Devices Meeting (1984): 742-745 ("Kwark")	Publicly presented in 1984 Published February 1, 1986, but no later than August 26, 1997 or August 9, 2005 at IEEEXplore or before February 20, 2007	§102(a), (b) (pre-AIA)
B. Hartiti, S. Sivoththaman, R. Schindler, J. Nijs, J.C. Muller, and P. Siffert, "Low Temperature Formation of Emitter and BSF by Rapid Thermal Co-Diffusion of P, Al or B." Dec. 5-9, 1994, IEEE, First WCPEC ("Hartiti")	Publicly presented in 1994 Published no later than in June 29, 1995 or before February 20, 2007	§102(a), (b) (pre-AIA)
S. Sivoththaman, W. Laureys, P. De Schepper, J. Nijs, and R. Mertens, "Rapid Thermal Processing of Conventionally and Electromagnetically Case 100 cm^2 Multicrystalline Silicon." May 13-17, 1996, IEEE, 25th PVSC ("Sivoththaman")	Publicly presented in 1996 Published no later than in September 1997 or before February 20, 2007	§102(a), (b) (pre-AIA)
Yablonovitch, Eli et al., "A Study of n^+-SIPOA:p-Si Heterojunction Emitters." Nov. 1985, IEEE Election Device Letters, Vol. EDL-6, No. 11 ("Yablonovitch")	November 1985 or before February 20, 2007	§102(a), (b) (pre-AIA)
Sinton, R. A. et al., "Design Criteria for Si Point-Contact Concentrator Solar Cells." Oct. 1987, IEEE Trans. on Electron Devices, Vol. ED-34, No. 10 ("Sinton")	Oct. 1987 or before February 20, 2007	§102(a), (b) (pre-AIA)
Luque, A. et al., "Handbook of Photovoltaic Science and Engineering." Wiley (2003) ("Luque")	August 7, 2003 or before February 20, 2007	§102(a), (b) (pre-AIA)
Lindholm, F.A., et al., "Heavily Doped Polysilicon-Contact Solar Cells." July 1985, IEEE Electron Device Letters, Vol. EDL-6, No. 7 ("Lindholm")	July 1985 or before February 20, 2007	§102(a), (b) (pre-AIA)
Silvestre, S. et al., "Series Resistance in Double-Polysilicon-Contacted Silicon Solar Cells." May 13-17, 1996, IEEE 25th PVSC ("Silvestre")	1996 or before February 20, 2007	§102(a), (b) (pre-AIA)
Duerinckx, F. et al., "Defect passivation of industrial multicrystalline solar cells based on PECVD silicon nitride." 2002, Elsevier, Solar Energy Materials & Solar Cells ("Duerinckx")	2002 or before February 20, 2007	§102(a), (b) (pre-AIA)

Ashburn, P. et al., “Comparison of Experimental and Theoretical Results on Polysilicon Emitter Bipolar Transistors.” July 1984, IEEE Trans. on Electron Devices, Vol. ED-31, No. 7 (“Ashburn”)	July 1984 or before February 20, 2007	§102(a), (b) (pre-AIA)
Green, M.A. et al., “High Efficiency N-Silicon Solar Cells Using Rear Junction Structures.” IEEE (1993) (“Green”)	1993 or before February 20, 2007	§102(a), (b) (pre-AIA)
M. Lemiti, B. Semmache, Q. N. Le, D. Barbier and A. Laugier, “Physical properties of RT-LPCVD and LPCVD polysilicon thin films: application to emitter solar cell,” Proceedings of 1994 IEEE 1st World Conference on Photovoltaic Energy Conversion – WCPEC (A Joint Conference of PVSC, PVSEC ands PSEC), Waikoloa, HI, USA, 1994, pp. 1375-1378 vol.2. (“Lemiti”)	1994 or before February 20, 2007	§102(a), (b) (pre-AIA)
Nolan, M. et al., “Spectroscopic Investigations of Borosilicate Glass and Its Application as a Dopant Source for Shallow Junctions.” 2000, Journal of The Electrochemical Society (ResearchGate) (“Nolan”)	2000 or before February 20, 2007	§102(a), (b) (pre-AIA)
Murarka, S. et al., “Electronic Materials Science and Technology.” 1989, Academic Press, Inc. (“Murarka”)	1989 or before February 20, 2007	§102(a), (b) (pre-AIA)
P. Doshi, J. Mejia, K. Tate and A. Rohatgi, "Modeling and characterization of high-efficiency silicon solar cells fabricated by rapid thermal processing, screen printing, and plasma-enhanced chemical vapor deposition," in IEEE Transactions on Electron Devices, vol. 44, no. 9, pp. 1417-1424, Sept. 1997 (“Doshi-1997”)	Sept 1997 or before February 20, 2007	§102(a), (b) (pre-AIA)
P. Doshi and A. Rohatgi, "18% efficient silicon photovoltaic devices by rapid thermal diffusion and oxidation," in IEEE Transactions on Electron Devices, vol. 45, no. 8, pp. 1710-1716, Aug. 1998 (“Doshi-1998”)	Aug 1998 or before February 20, 2007	§102(a), (b) (pre-AIA)
A. Rohatgi, P. Doshi, J. Moschner, T. Lauinger, A. G. Aberle and D. S. Ruby, "Comprehensive study of rapid, low-cost silicon surface passivation technologies," in IEEE Transactions on Electron Devices, vol. 47, no. 5, pp. 987-993, May 2000 (“Rohatgi”)	May 2000 or before February 20, 2007	§102(a), (b) (pre-AIA)
A. M. Jorgensen, T. Clausen and O. Leistiko, "Novel light trapping scheme for thin crystalline cells utilizing deep structures on both wafer sides [solar cells]," Conference Record of the Twenty Sixth IEEE Photovoltaic Specialists Conference - 1997, Anaheim, CA, USA, 1997, pp. 263-266	1997 or before February 20, 2007	§102(a), (b) (pre-AIA)

("Jorgensen")		

2. Prior Art to the '315 Patent

a. Patents and Patent Publications

Patent or Patent Pub. Number	Country	Date of Issue / Publication	Prior Art Status
U.S. Patent Application Publication No. 2011/0214719 A1 to Li, titled "Method of Fabricating a Back-Contact Solar Cell and Device Thereof" ("Li")	U.S.A.	Sept. 8, 2011	§102(a)(1) (AIA)
U.S. Patent No. 4,234,352 to Swanson, titled "Thermophotovoltaic Converter and Cell for Use Therein" ("Swanson-352")	U.S.A.	Nov. 18, 1980	§102(a)(1) (AIA)
U.S. Patent No. 4,053,335 to Hu, titled "Method of Gettering Using Backside Polycrystalline Silicon" ("Hu")	U.S.A.	Oct. 11, 1977	§102(a)(1) (AIA)
U.S. Patent Application Publication No. 2014/0311567 A1 to Choi, titled "Solar Cell and Method for Manufacturing the Same" ("Choi")	U.S.A.	Oct. 23, 2014	§102(a)(1), (a)(2) (AIA)
KR10-2013-0044982 to Choi, titled "Solar Cell and Manufacturing Method Thereof" ("Choi-KR")	Korea	Apr. 23, 2013	§102(a)(1), (a)(2) (AIA)
U.S. Patent No. 8,207,444 B2 to Cousins, titled "Front Contact Solar Cell with Formed Electrically Conducting Layers on the Front Side and Backside" ("Cousins")	U.S.A.	June 26, 2012	§102(a)(1) (AIA)
U.S. Patent No. 7,468,485 to Swanson ("Swanson-485")	U.S.A	Dec. 23, 2008	§102(a)(1) (AIA)
U.S. Patent Pub. No. 2010/0105190 A1 ("Tomas")	U.S.A	Apr 29, 2010	§102(a)(1) (AIA)
U.S. Patent Pub. No. 2006/0118868 A1 ("Yoshimura")	U.S.A.	Jun 8, 2006	§102(a)(1) (AIA)

b. Publications

Publication	Date of Publication	Prior Art Status
R. R. King, R. A. Sinton, and R. M. Swanson, "Studies of Diffused Phosphorous Emitters: Saturation Current, Surface Recombination Velocity, and Quantum Efficiency," IEEE Transactions On Electron Devices, Vol 37, No. 2 (Feb. 1990) ("King")	Jan. 25, 1990 or before December 22, 2014	§102(a)(1) (AIA)
D. C. Marvin and S. L. Froedge, "Analysis of Interdigitated Back Contact Silicon Solar Cells for Space Use," IEEE (1989) ("Marvin-IEEE")	Aug. 1989 or before December 22, 2014	§102(a)(1) (AIA)
D. C. Marvin and S. L. Froedge, "Interdigitated Back Contact Silicon Solar Cell Analysis and Design Recommendations for Space Use," AD-A220-414 (Sept. 30, 1989)" ("Marvin-DTIC")	Apr. 11, 1990 or before December 22, 2014	§102(a)(1) (AIA)
R. Muller, C. Reichel, J. Benick, M. Hermle, "Ion Implantation for All-Alumina IBC Solar Cells with Floating Emitter," Energy Procedia 55 (2014), 265-271 ("Muller")	Sept. 19, 2014 or before December 22, 2014	§102(a)(1) (AIA)
Ramappa and Benley, "Diffusion of Iron in Silicon Dioxide," Journal of the Electrochemical Society 146(1) 3773-3777 (1999) ("Ramappa")	Oct. 21, 1999 or before December 22, 2014	§102(a)(1) (AIA)
F. Granek, "High-Efficiency Back Contact Back-Junction Silicon Solar Cells" (Ph.D. Dissertation, Fraunhofer Institute for Solar Energy Systems ISE) (2009) ("Granek")	July 31, 2009 or before December 22, 2014	§102(a)(1) (AIA)
A. A. Istratov, H. Väinölä, W. Huber, and E. R. Weber, "Gettering in silicon-on-insulator wafers: experimental studies and modelling," Semicond. Sci. Technol. 20: 568-575 (April 2005) ("Istratov")	Apr. 15, 2005 or before December 22, 2014	§102(a)(1) (AIA)
Luque and Hegedus, Handbook of Photovoltaic Science and Engineering (2002) ("Luque")	August 7, 2003 or before December 22, 2014	§102(a)(1) (AIA)
J. Y. Gan and R. M. Swanson, "Polysilicon Emitters for Silicon Concentrator Solar Cells," May 1990, Proceedings of the 21st IEEE-PVSC ("Gan")	Publicly presented in 1990 Published no later than August 6, 2002 at IEEEXplore or before February 20, 2007	§102(a), (b) (pre-AIA)
J. Y. Gan and R. M. Swanson, "Polysilicon Emitters for Silicon Concentrator Solar Cells,"	Publicly presented in 1990	§102(a), (b) (pre-AIA)

May 1990, Proceedings of the 21st IEEE-PVSC ("Gan")	Published no later than in 1994 or December 22, 2014	
Neuhaus and Munzer, *Industrial Silicon Wafer Solar Cells*, Advances in OptoElectronics, 1-15, at 11 (2007) ("Neuhaus")	2007 or before December 22, 2014	§102(a)(1) (AIA)
Seibt et al., "Gettering in silicon photovoltaics: current state and future perspectives," phys. stat. sol. (a) 203, No. 4, 696–713 (2006) ("Seibt")	2006 or before December 22, 2014	§102(a)(1) (AIA)
Ferre, et al., "Simultaneous gettering and emitter formation in multicrystalline-Si wafers by annealing phosphorus doped amorphous silicon compounds," Applied Physics Letters 98, 022102 (2011) ("Ferre")	2011 or before December 22, 2014	§102(a)(1) (AIA)
Vahanissi et al., "Gettering of Iron in Silicon Solar Cells with Implanted Emitters," IEEE Journal of Photovoltaics (Volume: 4, Issue: 1, January 2014) ("Vahanissi")	Jan 2014 or before December 22, 2014	§102(a)(1) (AIA)
2013 Renewable Energy Data Book, U.S. Department of Energy (2013) ("REDB-2013")	2013 or before December 22, 2014	§102(a)(1) (AIA)
Rohatgi et al, "High-Throughput Ion-Implantation for Low-Cost High Efficiency Silicon Solar Cells," Energy Procedia 15 (2012), 10-19 ("Rohatgi")	2012 or before December 22, 2014	§102(a)(1) (AIA)
Kiyota et al., "Phosphorus Direct Doping from Vapor Phase into Silicon for Shallow Junctions," J. Electrochem. Soc. 141(8) 2241-2244 (August 1994) ("Kiyota")	1994 or before December 22, 2014	§102(a)(1) (AIA)
French, "Polysilicon: a versatile material for microsystems," Sensors and Actuators A 99 (2002) 3-12.	2002 or before December 22, 2014	§102(a)(1) (AIA)
Green, "Intrinsic concentration, effective densities of states, and effective mass in silicon," J. Appl. Phys. 67, 2944 (1990) ("Green")	1990 or before December 22, 2014	§102(a)(1) (AIA)
Henry, "Limiting efficiencies of ideal single and multiple energy gap terrestrial solar cells," J. Appl. Phys. 51, 4494 (1980) ("Henry")	1980 or before December 22, 2014	§102(a)(1) (AIA)
Birkmire et al., "Harnessing the Sun with Thin-Film Photovoltaics," NREL (April 1999) ("Birkmire")	April 1999 or before December 22, 2014	§102(a)(1) (AIA)

Ghoshtagore, "Silicon Dioxide Masking of Phosphorus Diffusion in Silicon," Solid-State Elements Vol. 18 (1975) ("Ghoshtagore")	1975 or before December 22, 2014	§102(a)(1) (AIA)

c. Sales or Public Disclosures

Canadian Solar contends that the Maxeon® third generation solar cells, or otherwise referred to as Generation 3 Solar Cells in some of SunPower's publications, which have been incorporated into SunPower's X-Series solar panels, constitute prior art under post-AIA 35 U.S.C. §102(a)(1). The X-Series solar panel incorporating the Generation 3 Solar Cells was commercially launched by SunPower no later than April 3, 2013. https://newsroom.sunpower.com/press-releases?item=122903. SunPower offered for sale and sold the X-Series solar panels with the Generation 3 Solar Cells more than one year before December 22, 2014 and thus would be prior art under 35 U.S.C. §102(a)(1) and (b)(1).

At this time, Canadian Solar is seeking discovery from Plaintiff and SunPower relating to the circumstances of the sale and offer for sale of this product, which is in the sole possession f Plaintiff and/or SunPower. *See, e.g.*, July 2, 2024 Letter from Samuel Tiu to Erik Shallman; August 12, 2024 letter from Samuel Tiu to Erik Shallman; and August 14, 2024 Subpoena by Canadian Solar Inc. to SunPower. Canadian Solar will supplement its contentions as discovery progresses.

B. P.R. 3-3(b): Invalidity Due to Anticipation

To the extent Maxeon's infringement contentions are accepted, Borden-575 anticipates Claims 9 and 10 of the 516 Patent. *See* Ex. 516-8.

On information and belief, the Generation 3 Solar Cell incorporated into SunPower X-Series anticipated at least claims 10, 15, 16, and 19 of the '315 Patent and would have rendered these claims invalid. *See* Ex. 315-9.

C. P.R. 3-3(b): Invalidity Due to Obviousness

As set forth more fully below, Canadian Solar asserts that each prior art reference may be read in light of or combined with (1) information known to persons skilled in the art at the time of the alleged invention, (2) any of the other prior art references, and/or (3) any of the additional prior art identified above and in the charts attached hereto. In addition, Canadian Solar incorporates by reference each and every prior art reference of record in the prosecution of the Asserted Patents and related applications, including the statements made therein by the applicant, as well as the prior art discussed in the specification.

1. The ’516 Patent

Claims 9 and 10 of the ’516 Patent would have been obvious based on the following exemplary prior art combinations, as discussed below. The identification of primary references, secondary references, and obviousness combinations is not intended to be exhaustive—there are many possible combinations of the references that one of ordinary skill in the art would have been motivated to make—and it is not practical to provide details of all such possible combinations:

Exhibit	Asserted Claim(s)	Exemplary Combinations
516-1	9-10	Meier, Okayasu, Borden, and Jordan
516-2	9-10	Meier, Okayasu, Foglietti, Gan, and Jordan
516-3	9-10	Froitzheim and Gan
516-4	9-10	Froitzheim and Kwark
516-5	9-10	Froitzheim and Borden
516-6	9-10	Froitzheim and Borden-575
516-7	9-10	Li-545 and Gan Li-545 and Kwark Li-545 and Borden-575

a. Motivation to Combine

In the following paragraphs, Canadian Solar identifies the motivation to combine the prior art identified in the exemplary combinations above.

As a general matter, before the ’516 Patent, those in the field already recognized that replacing diffused in-substrate emitters with deposited polysilicon emitters would improve both bipolar transistors and solar cell performance. Deposited polysilicon emitters with an interfacial oxide layer were first used to improve the performance of bipolar transistors in 1984. *Id.*, ¶58. “Interfacial oxide layer” refers to a layer of silicon dioxide between the substrate and polysilicon emitter. *Id.*, ¶58.

Around the same time, a number of publications suggested that this polysilicon emitter improvement can be achieved in solar cells as well. *See*, *e.g.*, Yablonovitch, 597 (“There have been a considerable number of reports recently on improved bipolar transistor emitters made of polycrystalline silicon…. Such heterojunctions are valuable not only for emitter efficiency in bipolar transistors, but also for solar cells”); Kwark, 742 (“Incorporation of these films into the emitter structure of an NPN bipolar transistor … translates into potential improvements of energy conversion efficiency for solar cells….”).

Subsequently in 1987, another publication noted that “[i]t is interesting to project what should be possible if the best available emitter technology were applied to point contact cells rather than the diffused emitters from the current process.” Sinton, 2122. The authors modeled the projected efficiencies of what would be possible incorporating “SIPOS” emitters versus diffused emitters, and showed a more than one percent absolute increase in efficiency for the solar cell. *Id*.

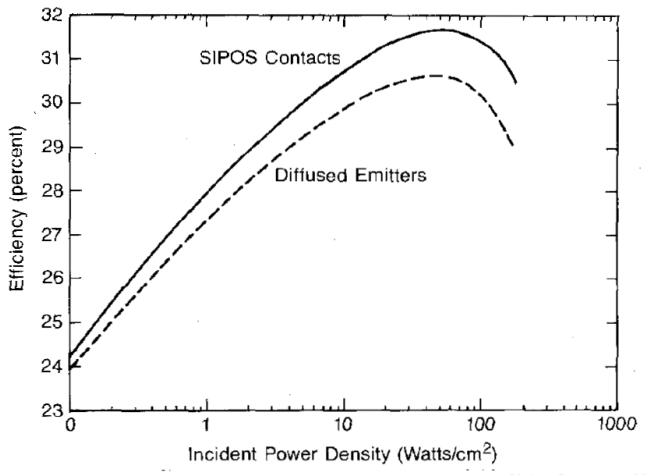


Fig. 9. A comparison of the projected efficiencies possible for a cell incorporating SIPOS emitters (solid curve), compared to projections for diffused emitters as used to date (dashed curve).

"SIPOS" refers to "semi-insulating polysilicon," which are formed by introducing a small amount of oxygen bearing species into the chemical vapor deposition of polysilicon. But as researchers found in 1984, even a pure polysilicon emitter layer with a chemically formed interfacial oxide layer led to a "surprising" improvement. Kwark, 84. Following these suggestions, Gan examined the use of deposited polysilicon emitters with an interfacial oxide layer in concentrator solar cells in 1990 and noted that the "cell performance can be improved if the diffused-emitter is replaced with the polysilicon emitter." Gan, 245. Gan also pointed to the earlier 1987 modeling work showing one percent absolute increase in solar cell efficiency for "backside contact solar cells." *Id.*, 249. Backside contact solar cells have their PN junction on the back of the solar cells.

A month before the '516 Patent filing, Peter Borden of Applied Materials filed two provisional applications disclosing polysilicon emitter solar cells with an interfacial oxide layer, which also appeared in the later filed PCT applications:

> The present invention relates to improved HIT type or polysilicon emitter solar cells. According to certain aspects, the invention includes forming a masking oxide layer on the front and back of the cell and then patterning holes in the

> masking oxide. A HIT cell structure or polysilicon emitter solar cell structure is then formed over the patterned oxide….

Borden Provisional, Abstract; Borden, Abstract.

In the second provisional application, Borden disclosed:

> The present invention relates to methods and apparatuses for providing a buried insulator isolation for solar cell contacts. According to certain aspects, the invention places a buried oxide under the emitter of a polysilicon emitter solar cell. The oxide provides an excellent passivation layer over most of the surface. Holes in the oxide provide contact areas, increasing the current density to enhance efficiency. The oxide isolates the contacts from the substrate, achieving the advantage of a selective emitter structure without requiring deep diffusions. The oxide further enables use of screen printing on advanced shallow emitter cells. Positioning of the grid lines close to the openings also enables use of a very thin emitter to maximize blue response.

Borden-575 Provisional, Abstract; Borden-575, Abstract.

Texturing the front surface and applying an antireflective layer to the solar cell was also well known in the art. Luque, 268-269.

Specifically, as addressed further below, a person of ordinary skill in the art ("the Skilled Artisan") would have been motivated to combine the teachings of the prior art charted in Ex. 516-1 to Ex. 516-7 to reach the purported inventions of the asserted claims of the '516 Patent because doing so would have improved the problems of efficiency and cost-effectiveness of solar cell designs. Such combinations would have involved applying known solar cell designs such as a polysilicon emitter, oxide layer, textured front surface, and antireflective layer to a back junction solar cell. Such combinations would have required only routine skill and techniques to implement. Such designs and their usage were widely known long before the purported invention of the '516 Patent.

For example, placing the emitter/PN junction at the solar cell's backside, where the emitter is P-doped and the substrate is N-doped, was well known before the alleged invention of the '516 Patent and is described in, among other references, Meier, Froitzheim, and Li-545. As

shown in at least Meier, Froitzheim, Li-545, and known in the art, such a well-known solar cell design created a back junction solar cell. A POSITA at the time of the invention would have been well aware of the use, implementation, and benefits of this well-known solar cell design.

Also for example, as shown in at least Okayasu, Foglietti, Gan, Kwark, Borden, and Borden-575, it was well known before the alleged invention of the ’516 Patent to deposit doped polysilicon layers in a solar cell rather than diffuse dopants into the substrate because the deposition could be performed at lower temperatures, prevents damage to the substrate, allows for more accurate control of emitter thickness, and ultimately improve solar cell efficiency. The advantage of a polysilicon emitter over a diffused emitter would have motivated the Skilled Artisan to replace diffused backside emitter, as disclosed in Meier, Froitzheim, and Li-545, for example, with a backside polysilicon emitter.

Also for example, as shown in at least Borden, Foglietti, Gan, Kwark, and Borden-575, it was well known before the alleged invention of the ’516 Patent for solar cells to have an oxide layer between the doped polysilicon layer and the monocrystalline substrate, because the oxide layer would reduce recombination, improve J_o and solar cell efficiency, prevent epitaxial growth of the emitter layer, and further protect the surface from plasma damage of the deposited emitter layer. The benefits of an oxide layer in between the doped polysilicon layer and the monocrystalline substrate would have motivated the Skilled Artisan to replace the diffused backside emitter, as disclosed in Meier, Froitzheim, and Li-545, for example, with a backside polysilicon emitter.

Also for example, as shown in at least Jordan and Froitzheim, it was well known before the alleged invention of the ’516 Patent to texture the front surface of a solar cell in order to increase the incidence of light in order to prevent reflection, and therefore improve efficiency.

Also for example, as shown in at least Froitzheim, Borden-575, and Li-545, it was well known before the alleged invention of the ’516 Patent to have an antireflective layer over the textured front surface of a solar cell in order to improve the efficiency of the cell.

The Skilled Artisan would have been motivated to combine the teachings of the prior art references described above for the ’516 Patent because these references are generally all directed to solar cell design. Such combinations, using well-known and conventional designs, would yield the predictable results of providing a back junction solar cell with a deposited emitter layer, oxide layer, textured front surface, and antireflective layer.

i. 516-1: Meier, Okayasu, Borden, Jordan

Meier disclosed a “Back Junction Solar Cell” having a substrate (218). Meier, Title and FIG. 3D. A “p+ [emitter] layer 220 [] forms a backside junction with the n-Si base layer 218.” US Appl. 14/504,771 (771 Application) File History, Appeal Brief, 316; Meier, 6:51-55. Meier also disclosed coating the front surface with an anti-reflective layer 214 and the front and back metal contacts 212 and 222, as shown in FIG. 3D. Meier, 6:20-54, 7:10-35.

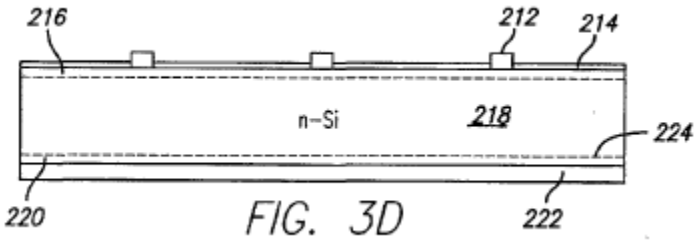


FIG. 3D

During the ’516 Patent prosecution, the only elements that the Examiner found lacking in the prior art were (1) an oxide layer in between the emitter and the substrate and (2) that the emitter was polysilicon. However, Okayasu disclosed replacing in-substrate emitters with deposited polysilicon emitters, and Borden disclosed adding a tunnel oxide layer in between Okayasu, ¶44, Fig. 1; Borden, ¶16. Jordan supplied the element of a textured front surface of the

solar cell, which the Examiner used to combine with Meier, and was well-known in the solar cell art for reducing reflection. Jordan, ¶¶7, 22; Luque, 269.

Thus, it was obvious to a Skilled Artisan to modify Meier's back emitter, back junction solar cell by (1) replacing the p-type diffused in-substrate emitter with a deposited p-type *polysilicon* emitter as taught by Okayasu; (2) placing an interfacial oxide layer between the emitter and the substrate, as taught by Borden; and (3) texturing the front substrate as taught by Jordan, thereby would have rendered claims 9-10 invalid.

Meier, Okayasu, Borden, and Jordan are analogous art because each is in the same field of endeavor—solar cell design. Each is also reasonably pertinent to the problems of efficiency and cost-effectiveness of solar cell designs.

Specifically, in the '771 Application appeal proceeding, the PTAB affirmed the Examiner's finding "that Okayasu discloses an alternative method for forming a doped emitter or a surface field on a doped substrate." '771 Application, 512. The PTAB also affirmed the Examiner's motivation finding "that Okayasu teaches that its method of depositing doped polysilicon layers is preferable to that of thermal diffusion (as taught in Meier) because it can be performed at lower temperatures, preventing damage to the substrate, and allows more accurate control of the emitter thickness." *Id.*; *see also* '771 Application at 479-81. Moreover, the PTAB affirmed the Examiner's finding that although "Meier as modified by Okayasu does not disclose a tunneling dielectric oxide between the emitter/front surface field and the substrate," "Borden discloses that tunnel oxides can be used in solar cells between doped polysilicon and monocrystalline substrates on both front and back surfaces of the monocrystalline substrate." *Id.* at 513. The PTAB rejected SunPower's argument that the "combined references fail to teach a backside junction emitter with a tunnel dielectric" and arguments against the combination. '771

Application, 515-518. And the PTAB affirmed the Examiner's conclusion that "it would have been obvious to the skilled artisan to modify the interface between polycrystalline layers and a monocrystalline substrate front and back surface by having a tunneling oxide at the interfaces for the benefits expressed by Borden." *Id*. The Examiner found that Borden disclosed that "by providing the tunneling layer it prevents epitaxial growth of the emitter layer and further it protects the surface from plasma damage of the deposited emitter layer [0015]." '771 Application, 449.

The previous conclusion of the Examiner and the PTAB were correct.

As the Examiner found during the '516 Patent examination and the '035 Application proceeding, the Skilled Artisan would have been motivated to modify Meier's solar cell with a textured front surface in view of Jordan, because texturing increases light absorption and thus solar cell efficiency. US Application No. 16/460,035 File History ("'053 Application"), 76; '516 Patent File History, 77. Further, texturing the front surface of the solar cell to increase light absorption and solar cell efficiency was well known and well practiced in the industry before the 516 Patent. Thus, there is nothing non-obvious about texturing the front surface of the solar cell.

Maxeon should be collaterally estopped from arguing that Claims 9 and 10 of the '516 Patent are not invalid as obvious in view of Meier, Okayasu, Borden, Jordan.

ii. 516-2: Meier, Okayasu, Foglietti, Gan, Jordan

The combination of Meier, Okayasu, Foglietti, Gan and Jordan would have rendered Claims 9 and 10 obvious. The reasons for combining Meier, Okayasu, and Jordan are the same as discussed in the prior ground. The only difference between this ground and the prior ground is that Foglietti and Gan are used for the teaching of the oxide layer instead of Borden.

Meier, Okayasu, Foglietti, Gan, and Jordan are analogous art because each is in the same field of endeavor—solar cell or bipolar transistor designs. Each is also reasonably pertinent to the problems of efficiency and cost-effectiveness of solar cell designs.

Both Foglietti and Gan, like Borden, taught the benefits of having an oxide layer in between the polysilicon emitter and the substrate, and Gan specifically taught the benefits in the solar cell context. This would have motivated the Skilled Artisan to combine an oxide layer with the solar cell of Meier, as modified by Okayasu and Jordan. In the '771 Application appeal proceeding, the PTAB affirmed the Examiner's obviousness rejection based on combining the modified Meier with Foglietti and Gan:

> The Examiner finds that Foglietti discloses that polycrystalline growth directly on crystalline silicon results in partial realignment of the polycrystalline grains and this effect can be suppressed by growth of a thin oxide. Final Act. 7 (citing Foglietti ¶ 46). The Examiner finds that Gan teaches that he presence of a stable thermal oxide between a polysilicon emitter and a CZ layer. Id. The Examiner concludes that it would have been obvious to one of ordinary skill in the art to modify the interface between the doped polysilicon regions and the monocrystalline substrate by adding an interfacial oxide as disclosed by Foglietti and Gan to allow for optimal growth of the polysilicon region and result in recombination occurring primarily at the oxide interface. Id.
>
> Appellant's arguments against combining Foglietti or Gan with the modified Meier is substantially the same as that made in opposing Rejection I. Compare App. Br. 10-11 with App. Br. 6-7.
>
> For the reasons provided supra relating to Rejection 1, we do not find Appellant's arguments persuasive to show reversible error, and sustain Rejection 2.

'771 Application, 519. The PTAB's prior findings and conclusions were correct.

iii. 516-3: Froitzheim, Gan

Froitzheim disclosed all elements of claims 9-10 except for the oxide layer in between the emitter and substrate in claim 9. However, Gan would have supplied the teaching for this missing element, and the Skilled Artisan would be motivated to combine Froitzheim and Gan.

Froitzheim and Gan are analogous art because each is in the same field of endeavor—solar cell design. '516 Patent, 1:15-17; Froitzheim, Abstract, ¶¶1,9; Gan, 245, 249. Each is also reasonably pertinent to the problems of efficiency and cost-effectiveness of solar cell designs. 516 Patent, 1:40-42; Froitzheim, Abstract, ¶¶1,9; Gan, 245, 249.

The Skilled Artisan would have been motivated to replace Froitzheim's diffused emitter with a polysilicon emitter along with an oxide layer because Gan taught and suggested that this modification would improve the solar cell. Gan disclosed that "***the cell performance can be improved if the diffused-emitter [of Froitzheim] is replaced with the polysilicon emitter***,…." Gan, 245 (emphasis added). Gan also noted that "the J_o [i.e., indication of surface recombination] of the p-type polysilicon emitter (Fig 5) [beneficially] appears to be much lower than what has been previously reported," and suggested that it "may have to do with the use of thermal oxide as the interfacial layer in our samples." Gan, 248. Gan explained that "because the dominant recombination is likely at the oxide interface, it implies that the oxide must only be broken by a very small fraction, which is consistent with what was observed in Fig. 2." Gan, 248.

Gan went on to provide lowered J_o and ρ_c data in Figure 6 and concluded the characteristics brought about by the polysilicon emitter with interfacial oxide layer structure is "***quite useful for silicon solar cells***." Gan, 249 (emphasis added). Froitzheim likewise used silicon solar cells. Froitzheim, Abstract. Gan further pointed to prior modeling and determined that "more than one absolute percent of the cell efficiency is obtained for a backside contact solar cell with polysilicon emitters with characteristics shown here …." Gan, 249. It is noteworthy that Gan's calculations are in the context of a backside contact solar cell which, like Froitzheim, would place the emitter and PN junction on the backside of the solar cell, which would further suggest the combination.

While Gan referred in part to silicon concentrator solar cells, it also more broadly suggested that a polysilicon emitter with interfacial oxide is "quite useful for silicon solar cells" generally (Gan, 249), and the Skilled Artisan would interpret Gan as recommending the feature for solar cells in general. Gan also disclosed that the benefits apply to both N- and P-type polysilicon emitters, including those formed on the back side of the solar cell, and thus would have suggested replacing Froitzheim's rear p-type diffused *silicon* emitter with a rear p-type *polysilicon* emitter plus the beneficial interfacial oxide layer. Gan, 249.

The Skilled Artisan would further have been motivated specifically to leave the emitter on the solar cell's back side because Froitzheim disclosed that the back junction design "shows improved stability and good efficiency." Froitzheim, ¶9. It was well known that back junction solar cells often lead to higher solar cell efficiency than front junction cells. In the combination, Froitzheim's modified emitter would continue to function as before, but with the expected additional improvement provided by the polysilicon emitter and interfacial oxide layer. And replacing the diffused emitter with the polysilicon emitter and the interfacial oxide layer, as taught by Gan, merely substitutes one element for another already known in the field, yielding a predictable result. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

Aside from Gan, numerous other prior art references taught the inclusion of an interfacial oxide layer when replacing a diffused emitter with a polysilicon emitter. For example, the 771 Application Examiner found that Foglietti taught the beneficial formation of an interfacial oxide with a polysilicon emitter as it suppresses the "partial realignment of the polycrystalline grains."[4] Foglietti, ¶¶2-3. Foglietti further disclosed other benefits of the interfacial oxide including "hole

[4] While Foglietti is directed to a bipolar transistor, the Skilled Artisan would have looked to it when designing solar cells as was commonly done in the art, as seen by the suggestion of Yablonovitch and others. Yablonovitch, 597; Lindholm, 363; Silvestre, 497; Gan, 245. Indeed, the use of polysilicon emitters in solar cells was an idea adapted from bipolar transistors.

current therewith is minimized and the transistor gain is increased" and "is substantially repeatable from wafer to wafer." Foglietti, ¶¶28,46. The Skilled Artisan would have thus further been motivated to include a polysilicon emitter with an interfacial oxide in Froitzheim because these benefits are equally transferable to solar cells.

In the solar cell context, the Skilled Artisan would have further been motivated to include a polysilicon emitter with an interfacial oxide in Froitzheim because Kwark taught that addition of an interfacial chemically grown oxide (chemox) between polysilicon and the substrate "greatly decreases the J_{oe}," which "translates into potential improvements of energy conversion efficiency for solar cells." Kwark, 742, 745. Kwark provided data comparing polysilicon emitters with and without the oxide layer, and noted "the large difference when the interfacial oxide is missing." Kwark, 745 Fig. 4.

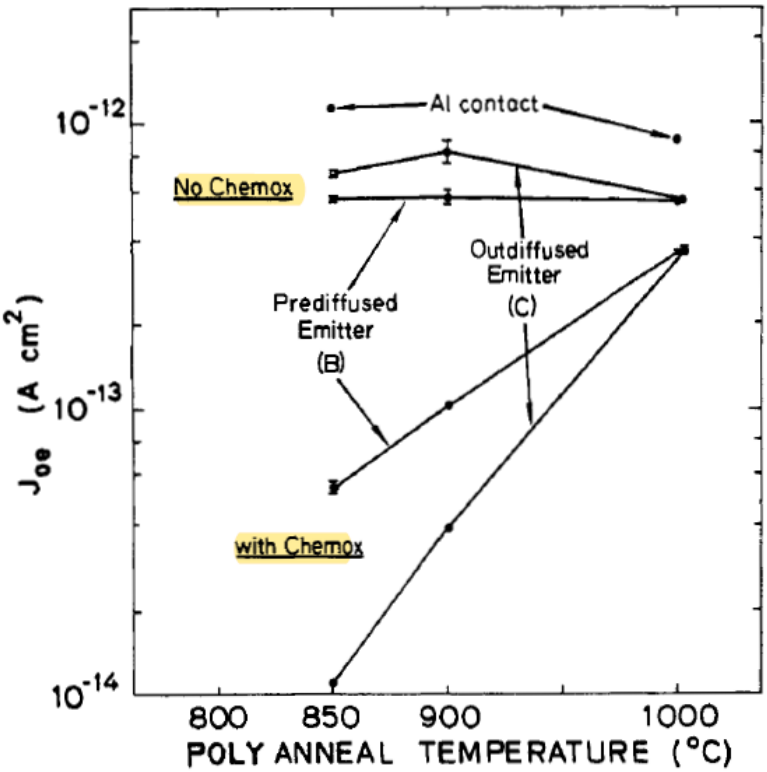


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

Borden also disclosed in the context of solar cells that the tunnel oxide "prevents epitaxial growth," allowing for "optimum band structure" and "provides a layer to protect the surface from plasma damage." Borden, Abstract. These benefits apply to both amorphous silicon and polysilicon. Borden-575 also disclosed that the oxide layer passivates and reduces recombination. Borden-575, Abstract.

The Skilled Artisan would have considered the Froitzheim/Gan combination to be merely an arrangement of old elements with each performing the same function it had been known to perform (the emitter of Froitzheim continuing to act as an emitter, but modified to be polysilicon

with an interfacial oxide) and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance).

Specifically, before introducing the boron dopant by diffusion at the rear side of the substrate (e.g., as described in Froitzheim's ¶¶40-41), the Skilled Artisan would perform Gan's steps of thin thermal oxide growth to form the interfacial layer and polysilicon deposition to form the polysilicon on the back side of the wafer, after which the polysilicon would be doped instead of the substrate to form the polysilicon emitter. Gan, 246.

Combining Froitzheim/Gan as described here would have been well within the level of ordinary skill in the art and would not have resulted in any unpredictable results. It could have been readily accomplished without undue experimentation and with a reasonable expectation of success. Substituting Froitzheim's in-substrate emitter with a deposited polysilicon emitter and oxide layer would be a simple substitution of prior art elements according to known methods to yield predictable results. It would further constitute use of a known technique (depositing polysilicon emitters with an oxide layer) to improve similar devices (Froitzheim's solar cell) that was ready for improvement in the same way.

iv. 516-4: Froitzheim, Kwark

Froitzheim disclosed all elements of claims 9-10 except for the oxide layer in between the emitter and substrate in claim 9. However, Kwark would have supplied the teaching for this missing element, and the Skilled Artisan would be motivated to combine Froitzheim and Kwark.

Froitzheim and Kwark are analogous art because each is in the same field of endeavor—solar cell design.[5] '516 Patent, 1:15-17; Froitzheim, Abstract, ¶¶1,9; Kwark, 742. Each is

[5] To the extent it is argued Kwark is directed to a bipolar transistor, a Skilled Artisan would have looked to it when designing solar cells as was commonly done in the art. Lindholm, 363; Silvestre, 497; Gan, 245; Yablonovitch, 597.

reasonably pertinent to the problems of efficiencies in solar cell designs. ’516 Patent, 1:40-42; Froitzheim, Abstract, ¶¶1,9; Kwark, 742.

The Skilled Artisan would have been motivated to modify Froitzheim’s emitter to be a polysilicon emitter with an oxide layer because Kwark taught that this modification would be an improvement. Kwark first taught that replacing the conventional emitter with an “SIPOS” emitter “has been previously shown to reduce the emitter saturation current, Joe, by at least a factor of fifty.” Kwark, Abstract. Kwark then showed that using pure polysilicon emitter produced “surprising[ly]” similar “good results” as the SIPOS emitter. Kwark, 742. Kwark further taught, with supporting data in FIG. 4, that the addition of an interfacial chemically grown oxide (chemox) between the polysilicon emitter and the substrate “greatly decreases the J_{oe},” which “translates into potential improvements of energy conversion efficiency for solar cells.” Kwark, 742, 745.

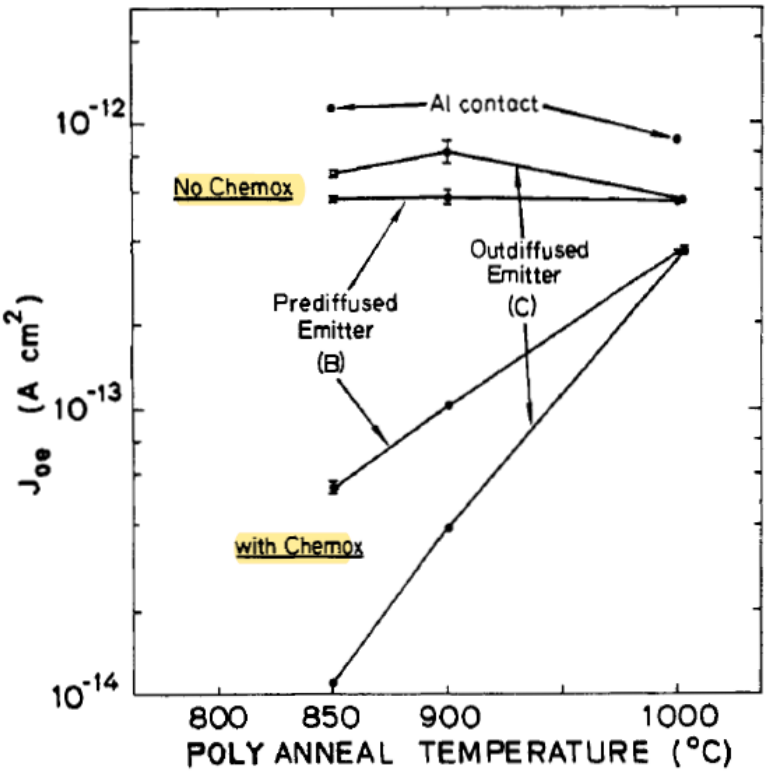


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

The teachings of Gan, Foglietti, Borden, and Borden-575 discussed above would similarly have motivated a Skilled Artisan to integrate a polysilicon emitter with interfacial oxide layer in Froitzheim in view of Kwark.

The Skilled Artisan would have considered the Froitzheim/Kwark combination to be merely an arrangement of old elements with each performing the same function it had been known to perform (the emitter of Froitzheim continuing to act as an emitter, but modified to be polysilicon with an interfacial oxide) and yielding no more than what one would expect from such an modification as taught by Kwark (a solar cell with improved performance).

Combining Froitzheim/Kwark as described here would have been well within the level of ordinary skill in the art. It would not have resulted in any unpredictable results and could have been readily accomplished without undue experimentation and with a reasonable expectation of success. Substituting Froitzheim's emitter with a polysilicon emitter and oxide layer would be simple substitution of one known prior art element for another to obtain predictable results. It would further constitute use of a known technique (polysilicon emitters with an oxide layer) to improve similar devices (Froitzheim's solar cell) in the same way.

v. 516-5: Froitzheim, Borden

Froitzheim disclosed all elements of claims 9-10 except for the oxide layer in between the emitter and substrate in claim 9. However, Borden would have supplied the teaching for this missing element, and the Skilled Artisan would be motivated to combine Froitzheim and Borden.

Froitzheim and Borden are analogous art because each is in the same field of solar cell design. Froitzheim, Abstract, ¶¶1,9; Borden, ¶16. Each is reasonably pertinent to addressing the problems of solar cell designs. Froitzheim Abstract, ¶¶1,9; Borden, ¶16.

The Skilled Artisan would have been motivated to replace Froitzheim's emitter with a polysilicon emitter with an oxide layer because polysilicon emitter increases solar cell efficiency as previously taught by Gan and Kwark and Borden further taught that the oxide layer "prevents epitaxial growth," allowing for "optimum band structure" and "provides a layer to protect the surface from plasma damage." Borden, Abstract, ¶8. The teachings of Gan, Foglietti, Kwark, Borden, and Borden-575 discussed above would similarly have motivated the Skilled Artisan to integrate a polysilicon emitter with interfacial oxide layer.

The Skilled Artisan would have considered the Froitzheim/Borden 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.

Combining Froitzheim/Borden as described here would also 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. It constitutes nothing more than applying a known technique to a known device ready for improvement to yield predictable results.

vi. 516-6: Froitzheim, Borden-575

Froitzheim disclosed all elements of claims 9-10 except for the oxide layer in between the emitter and substrate in claim 9. However, Borden-575 would have supplied the teaching for this missing element, and the Skilled Artisan would be motivated to combine Froitzheim and Borden.

Froitzheim and Borden-575 are analogous art because each is in the same field of solar cell design. Froitzheim, Abstract, ¶¶1,9; Borden-575, Abstract. Each is reasonably pertinent to addressing the problems of solar cell designs. Froitzheim, Abstract, ¶¶1,9; Borden-575, ¶2.

The Skilled Artisan would have been motivated to replace Froitzheim's emitter with a polysilicon emitter with an oxide layer because polysilicon emitter increases solar cell efficiency as previously taught by Gan and Kwark and Borden-575 further taught that the oxide layer "provides an excellent passivation layer" and "isolates the [polysilicon] contacts from the substrate, achieving the advantage of a selective emitter structure without requiring deep diffusions." Borden-575, ¶7; *see also* Borden-575, Abstract. The teachings of Gan, Foglietti, Kwark, and Borden discussed above would similarly have motivated the Skilled Artisan to integrate a polysilicon emitter with interfacial oxide layer.

Borden-575 also explains that adding an oxide layer between a substrate and polysilicon emitter "provides passivation between the substrate and the polysilicon, while allowing for tunnel current flow." Borden-575, ¶22. The passivation would reduce recombination and the

tunnel current flow would reduce contact resistance, both of which would increase solar cell efficiency.

Borden-575 also explains that its polysilicon emitter and oxide layer are compatible with a back junction solar cell where "the front of the cell has a texture." Borden-575, ¶29. Because Froitzheim's solar cell has a textured front surface, the Skilled Artisan would have been motivated to combine Froitzheim with Borden-575.

The Skilled Artisan would have considered the Froitzheim/Borden-575 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. Combining Froitzheim/Borden-575 as described here would also 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. It constitutes nothing more than applying a known technique to a known device ready for improvement to yield predictable results. *Id*.

vii. 516-7: Li-545 in view of Gan or Kwark or Borden 575

Li-545 disclosed all elements of claims 9-10 except for the oxide layer in between the emitter and substrate in claim 9. However, Gan would have supplied the teaching for this missing element, and the Skilled Artisan would be motivated to combine Li-545 and Gan.

Li-545 and Gan are analogous art because each is in the same field of endeavor—solar cell design. Each is also reasonably pertinent to the problems of efficiency and cost-effectiveness of solar cell designs.

As with Froitzheim, Li-545 also teaches designing solar cell structures with a rear PN junction with an n-type substrate and p-type emitter. Li-545 further discloses a silicon film 2 deposited on the substrate and acting as the emitter for the backside junction. The Skilled Artisan

would have been motivated to additionally include an oxide layer in between as taught by Gan because of the passivation benefits of the oxide layer disclosed by Gan. Gan noted that "the J_o [i.e., indication of surface recombination] of the p-type polysilicon emitter (Fig 5) [beneficially] appears to be much lower than what has been previously reported," and suggested that it "may have to do with the use of thermal oxide as the interfacial layer in our samples." Gan, 248. Gan explained that "because the dominant recombination is likely at the oxide interface, it implies that the oxide must only be broken by a very small fraction, which is consistent with what was observed in Fig. 2." Gan, 248.

Gan went on to provide lowered J_o and ρ_c data in Figure 6 and concluded the characteristics brought about by the polysilicon emitter with interfacial oxide layer structure is "***quite useful for silicon solar cells***." Gan, 249 (emphasis added). Li-545 likewise used silicon solar cells.

Kwark likewise taught that addition of an interfacial chemically grown oxide (chemox) between polysilicon and the substrate, which "greatly decreases the J_{oe}," which "translates into potential improvements of energy conversion efficiency for solar cells." Kwark, 742, 745; Kwark provided data comparing polysilicon emitters with and without the oxide layer, and noted "the large difference when the interfacial oxide is missing." Kwark, 745 Fig. 4.

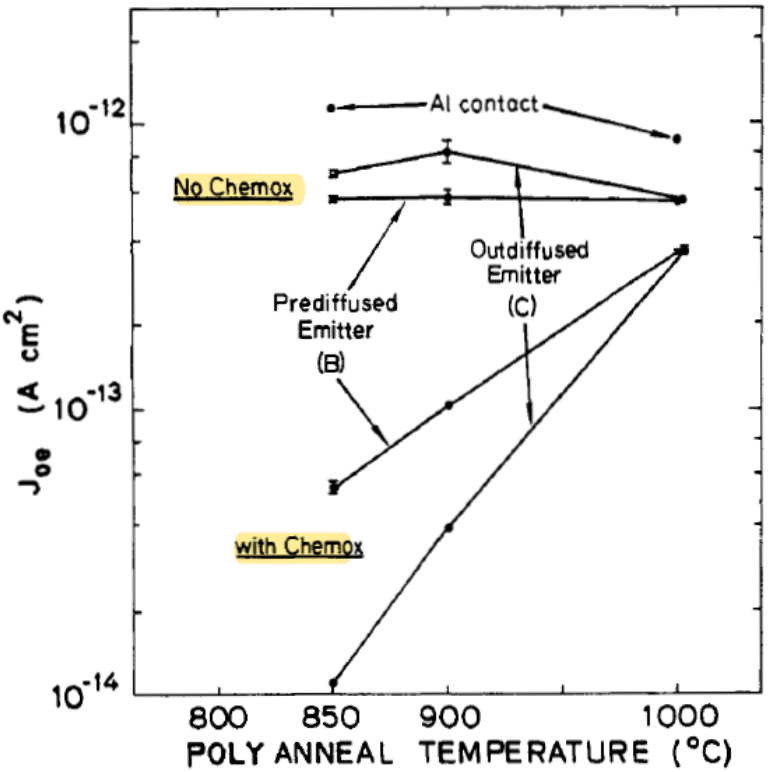


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

And as discussed above, Borden-575, like Kwark, discloses that the oxide layer in between the polysilicon film and substrate passivates and reduces recombination, which benefits the efficiency of the solar cells. Borden-575, Abstract, ¶22.

The Skilled Artisan would have considered the combination of Li-545 with Gan, Kwark, or Borden-575 to be merely an arrangement of old elements with each performing the same function it had been known to perform (the emitter of Li-545 continuing to act as an emitter, but modified to include an interfacial oxide) and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance).

Combining Li-545 with Gan or Kwark or Borden-575 as described here would have been well within the level of ordinary skill in the art and would not have resulted in any unpredictable results. It could have been readily accomplished without undue experimentation and with a reasonable expectation of success.

2. The ’053 Patent

The following table shows exemplary combinations of references that would have rendered each Asserted Claim of the ’053 Patent obvious. The identification of primary references, secondary references, and obviousness combinations is not intended to be exhaustive—there are many possible combinations of the references that one of ordinary skill in the art would have been motivated to make—and it is not practical to provide details of all such possible combinations:

Exhibit	Asserted Claim(s)	Exemplary Combinations
053-1	9, 12, 14-20	Froitzheim and Gan
053-2	9, 12, 14-20	Froitzheim, Gan, and Hartiti Froitzheim, Gan, and Sivoththaman
053-3	9, 14, 16-17, 19-20	Froitzheim and Kwark
053-4	9, 12, 14-20	Froitzheim, Kwark, and Hartiti Froitzheim, Kwark, and Sivoththaman
053-5	9, 12, 14-20	Froitzheim, Gan, Smith, and Avery
053-6	9, 12, 14-20	Froitzheim, Kwark, Smith, and Avery

a. Motivation to Combine

In the following paragraphs, Canadian Solar identifies the motivation to combine the prior art identified in the exemplary combinations above.

As a general matter, forming a backside junction solar cell by dopant diffusion in which the substrate and the backside emitter have opposite dopant polarities was already known by the

Skilled Artisan before the effective filing date of the 053 Patent. For example, European Patent Publication No. EP1732142A1 by Froitzheim published in 2006 disclosed a back junction solar cell with a p-type doped emitter that forms a backside junction with the n-type doped substrate, and ***its emitter was formed by dopant diffusion***. Froitzheim, ¶¶25-26, 40. Froitzheim was not considered by Examiner during prosecution. Froitzheim supplies the missing element of dopant diffusion that the Applicant used to overcome the back junction solar cell of Meier during prosecution. Froitzheim likewise supplies the "backside junction" element that the Applicant used to overcome Silvestre or Lindholm during prosecution.

Moreover, long before the effective filing date of the '053 Patent, those skilled in the art recognized that replacing diffused in-substrate emitters, such as the emitter in Froitzheim, with deposited polysilicon emitters would improve solar cell performance. For example, deposited polysilicon emitters with an interfacial oxide layer were first used to improve the performance of bipolar transistors in 1984. *See* Ashburn, 1984. "Interfacial oxide layer" refers to a thin layer of silicon oxide in between the substrate and the polysilicon emitter.

Around the same time, a number of publications suggested that this improvement with a polysilicon emitter can be achieved in solar cells as well. *See, e.g.*, Yablonovitch, 597 ("There have been a considerable number of reports recently on improved bipolar transistor emitters made of polycrystalline silicon or of SIPOS (a mixture of microcrystalline silicon and silicon dioxide)…. Such heterojunctions are valuable not only for emitter efficiency in bipolar transistors, but also for solar cells"); Kwark, 742 ("Incorporation of these films into the emitter structure of an NPN bipolar transistor had been found to reduce the emitter saturation current fifty fold; this translates into potential improvements of energy conversion efficiency for solar cells and enhanced high frequency performance of bipolar structures.").

Subsequently in 1987, another publication noted that "[i]t is interesting to project what should be possible if the best available emitter technology were applied to point contact cells rather than the diffused emitters from the current process." Sinton, 2122. The authors modeled the projected efficiencies of what would be possible incorporating "SIPOS" emitters versus diffused emitters, and showed a more than one percent absolute increase in efficiency for the solar cell. Sinton, 2122.

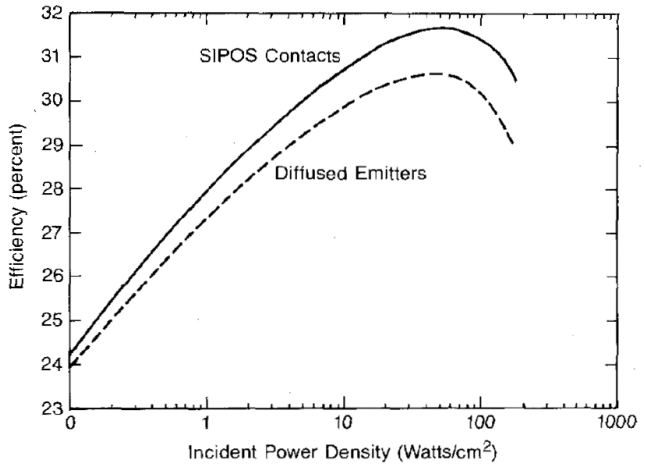


Fig. 9. A comparison of the projected efficiencies possible for a cell incorporating SIPOS emitters (solid curve), compared to projections for diffused emitters as used to date (dashed curve).

"SIPOS" refers to "semi-insulating polysilicon," which are formed by introducing a small amount of oxygen bearing species into the chemical vapor deposition of polysilicon. But as researchers have found in 1984, even a pure polysilicon emitter layer with a separate chemically formed interfacial oxide layer led to "surprising" improvement. Kwark, 84.

Following these suggestions, Gan examined the use of polysilicon emitters with a separate interfacial oxide layer in concentrator solar cells in 1990 and noted that the "cell performance can be improved if the diffused-emitter is replaced with the polysilicon emitter." Gan, 245. Gan also pointed to the earlier 1987 modeling showing one percent absolute increase

in solar cell efficiency for a "backside contact solar cells." Backside contact solar cells have their PN junction (i.e., junction with opposite p and n polarity) at the back of the solar cells.

A month before the earliest possible effective filing date of the '053 Patent, Peter Borden of Applied Materials filed two provisional applications disclosing polysilicon emitter solar cells with an interfacial oxide layer, which also appeared in the later filed PCT applications. In the first provisional application, Borden disclosed:

> The present invention relates to improved HIT type or polysilicon emitter solar cells. According to certain aspects, the invention includes forming a masking oxide layer on the front and back of the cell and then patterning holes in the masking oxide. A HIT cell structure or polysilicon emitter solar cell structure is then formed over the patterned oxide….

Borden Provisional, Abstract; Borden, Abstract.

In the second provisional application, Borden disclosed:

> The present invention relates to methods and apparatuses for providing a buried insulator isolation for solar cell contacts. According to certain aspects, the invention places a buried oxide under the emitter of a polysilicon emitter solar cell. The oxide provides an excellent passivation layer over most of the surface. Holes in the oxide provide contact areas, increasing the current density to enhance efficiency. The oxide isolates the contacts from the substrate, achieving the advantage of a selective emitter structure without requiring deep diffusions. The oxide further enables use of screen printing on advanced shallow emitter cells. Positioning of the grid lines close to the openings also enables use of a very thin emitter to maximize blue response.

Borden-575 Provisional, Abstract; Borden-575, Abstract.

None of these prior art references were before the 053 Patent Examiner.

i. 053-1: Froitzheim, Gan

The combination Froitzheim and Gan would have rendered Claims 9, 12, 14-20 obvious and unpatentable. To improve upon the back junction solar cell of Froitzheim, the Skilled Artisan would have replaced the p-type diffused in-substrate emitter of Froitzheim with a p-type deposited polysilicon emitter and an interfacial oxide layer, as taught by Gan. The combination

would be nothing more than inserting the steps of forming the oxide layer and polysilicon emitter in Gan on the backside of the substrate into Froitzheim's fabrication process before dopant application and diffusion; and thereafter diffusing the same p-type dopants from a boron diffusion source as in the manufacturing of Froitzheim's solar cell. This would form a backside junction polysilicon emitter with an interfacial oxide layer rather than a diffused in-substrate emitter layer.

Froitzheim and Gan are analogous art because each is in the same field of endeavor—solar cell design. Froitzheim, Abstract, ¶¶1,9; Gan, 245, 249. Each is reasonably pertinent to the problems of efficiencies and cost-effectiveness of solar cell designs. Froitzheim, Abstract, ¶¶1,9; Gan, 245, 249.

The Skilled Artisan would have been motivated to replace Froitzheim's diffused emitter with a deposited polysilicon emitter along with an oxide layer because Gan taught and suggested that this modification would be an improvement. Gan disclosed that "***the cell performance can be improved if the diffused-emitter [e.g., of Froitzheim] is replaced with the polysilicon emitter***…." Gan, 245. As to the oxide layer, Gan noted that "the J_o [i.e., measure of surface recombination] of the p-type polysilicon emitter (Fig 5) [beneficially] appears to be much lower than what has been previously reported," and suggested that it "may have to do with the use of thermal oxide as the interfacial layer in our samples." Gan, 248. Gan explained that "because the dominant recombination is likely at the oxide interface, it implies that the oxide must only be broken by a very small fraction, which is consistent with what was observed in Fig. 2." Gan, 248.

Gan provided lowered J_o and ρ_c data in Figure 6 and concluded the characteristics brought about by the polysilicon emitter with interfacial oxide layer structure is "***quite useful for silicon solar cells***." Gan, 249. Froitzheim likewise used silicon solar cells. Froitzheim, Abstract.

Gan further pointed to prior modeling and determined that "***more than one absolute percent of the cell efficiency is obtained for a backside contact solar cell with polysilicon emitters*** with characteristics shown here …." Gan, 249. Gan's calculations are in the context of a backside contact solar cell which, like Froitzheim, would place the emitter and PN junction on the backside of the solar cell, which would further suggest the combination.

While Gan referred in part to silicon concentrator solar cells, it more broadly suggested that a polysilicon emitter with interfacial oxide is "quite useful for silicon solar cells" generally (Gan, 249), and the Skilled Artisan would interpret Gan as recommending the feature for solar cells in general. Gan also disclosed that the benefits apply to both n- and p-type polysilicon emitters, including those formed on the back side of the solar cell, and thus would have suggested replacing Froitzheim's rear p-type diffused *in-substrate* emitter with a rear p-type deposited *polysilicon* emitter plus the beneficial interfacial oxide layer. Gan, 249 (discussing "both n- and p-type polysilicon emitters.").

A Skilled Artisan would further have been motivated specifically to leave the emitter on the back side of the solar cell because Froitzheim disclosed that its design "shows improved stability and good efficiency." Froitzheim, ¶9. It was well known that back junction solar cells often lead to higher solar cell efficiency than front junction cells. In the combination, Froitzheim's modified emitter would continue to function as before, but with the expected additional improvement provided by the polysilicon emitter and interfacial oxide layer. And replacing the diffused emitter with the polysilicon emitter and interfacial oxide layer, as taught by Gan, merely substitutes one element for another already known in the field, yielding a predictable result. *See also*, *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

Aside from Gan, numerous other prior art references taught the inclusion of an interfacial oxide layer when replacing a diffused emitter with a polysilicon emitter. For example, as discussed above, the Skilled Artisan would have further been motivated because Kwark taught that addition of an interfacial chemically grown oxide (chemox) between polysilicon and the substrate "greatly decreases the J_{oe}," which "translates into potential improvements of energy conversion efficiency for solar cells." Kwark, 742, 745. Kwark provided data comparing polysilicon emitters with and without the oxide layer, and noted "the large difference when the interfacial oxide is missing." Kwark, 745 Fig. 4.

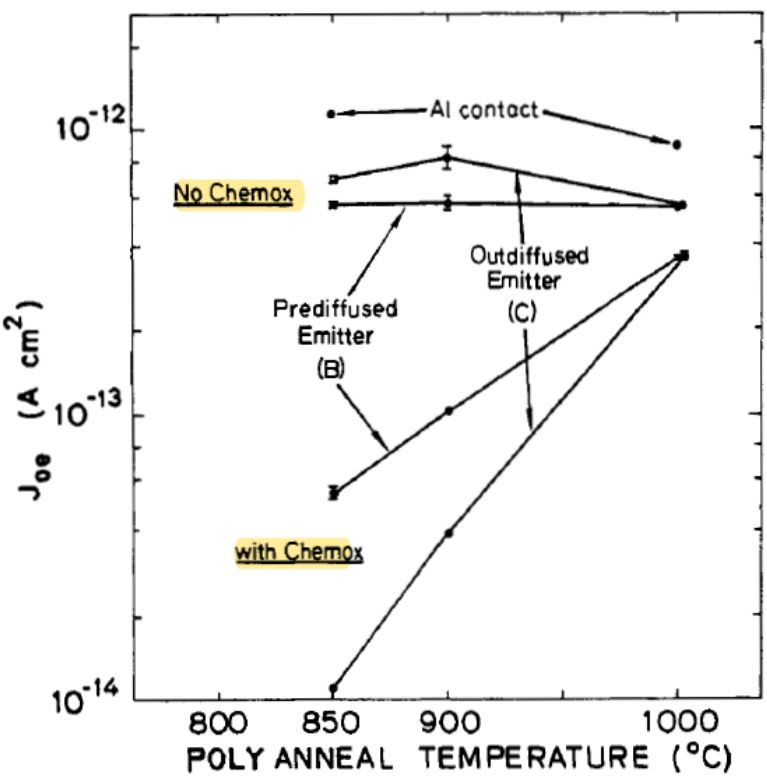


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

And Borden also disclosed in the context of solar cells that the tunnel oxide "prevents epitaxial growth," allowing for "optimum band structure" and "provides a layer to protect the surface from plasma damage." Borden, Abstract. These benefits apply to both amorphous silicon and polysilicon. *See also* Foglietti, ¶¶8-9,28,46 (discussing beneficial effects of an interfacial oxide layer). Borden also disclosed in another application that the oxide layer passivates and reduces recombination. Borden-575, Abstract.

The Skilled Artisan would have considered the Froitzheim/Gan combination 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 (the emitter of Froitzheim continuing to act as an emitter, but modified to be of a polysilicon material with an interfacial oxide layer in between it and the substrate) and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance).

Specifically, before introducing the boron dopant by diffusion at the rear side of the substrate (for example, as described in ¶¶40-41 of Froitzheim), the Skilled Artisan would perform Gan's steps of growing a thin thermal oxide to form the interfacial layer followed by polysilicon deposition to form the polysilicon on the oxide layer on the back side of the wafer, after which the polysilicon would be doped instead of the substrate to form the polysilicon emitter. Gan.

Combining Froitzheim/Gan as described here would have been well within the level of ordinary skill in the art. It would not have resulted in any unpredictable results and could have been readily accomplished without undue experimentation and with a reasonable expectation of success. The combination would simply have been the combination of well-known prior art steps in solar cell fabrication to yield predictable results. Likewise, substituting Froitzheim's emitter in

the substrate with a polysilicon emitter and oxide layer deposited on the substrate would be a simple substitution of one known element and corresponding fabrication steps for another to obtain predictable results. It would further constitute use of a known technique (depositing polysilicon emitters with an oxide layer) to improve similar devices (Froitzheim's solar cell) in the same way. It is nothing more than applying a known technique to a known device ready for improvement to yield predictable results.

For claims 12, 15, and 18, Gan likewise discloses a second dopant source layer deposited on the front of the substrate and to diffuse the polysilicon layer using a single co-diffusion drive-in step. The Skilled Artisan would have been motivated to use Gan's single co-diffusion drive-in process to reduce the number of high temperature processing steps and simplify the manufacturing process, just as described in Hartiti and Sivoththaman discussed below.

ii. 053-2: Froitzheim, Gan, in view of Hartiti or Sivoththaman

The combination Froitzheim and Gan in further view of Hartiti or Sivoththaman would have rendered Claims 9, 12, 14-20 obvious and unpatentable. The combination of Froitzheim and Gan are discussed in the previous section. As to Hartiti and Sivoththaman, the Skilled Artisan would have been motivated to replace the phosphorus gas diffusion source of Froitzheim with a spin-on or APCVD deposited phosphosilicate glass (PSG), as taught by Hartiti or Sivoththaman. Doing so would allow the co-diffusion of the phosphorus and boron at the front and back sides of the solar cell in a single drive-in diffusion step, as disclosed by Hartiti and Sivoththaman. Co-diffusion in a single step would reduce the number of high temperature processing steps, as disclosed by Hartiti, resulting in energy savings and cost reduction and simplification in the manufacturing process. Hartiti, 1522.

The spin-on or APCVD PSG films, as taught by Hartiti or Sivoththaman would be a "*a second dopant source layer*" deposited over the front of the substrate, as recited in claim 12. The

Skilled Artisan would have reasonably expected that Froitzheim's phosphorus gas source can be substituted with the PSG film and still result in a working solar cell.

For example, Froitzheim's preferred method for the backside boron diffusion was the spin-on technique, which is also the technique used by Hartiti to deposit both the front and back dopants. Froitzheim does not require that the phosphorus be diffused from a gas source, or that the boron be diffused only from a spun-on source. Froitzheim disclosed that diffusion can be performed as was "known in the art, including diffusion from the gas phase, or from liquid and *solid phases applied to the surface*." Froitzheim, ¶40 (emphasis added).

The Skilled Artisan would have considered the implementation of Hartiti or Sivoththaman's spin-on or APCVD deposited PSG with the Froitzheim/Gan combination of solar cell to be merely an arrangement of old method steps with each performing the same function it had been known to perform as a diffusion source layer for phosphorus and yielding no more than what one would expect from such an arrangement—a configuration that allows for co-diffusion of the front and back dopants.

Combining Froitzheim/Gan with Hartiti or Sivoththaman as described here 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. The combination would simply have been the combination of well-known prior art steps in solar cell fabrication to yield predictable results. It would further constitute use of a known technique (depositing PSG as a diffusion source layer) to improve the process of manufacturing a solar cell in the same way.

iii. 053-3: Froitzheim, Kwark

The combination Froitzheim and Kwark would have rendered Claims 9, 14, 16-17, and 19-20 obvious and unpatentable. The combination of Froitzheim and Kwark is similar to the

previous combination of Froitzheim and Gan, except that Kwark, instead of Gan, supplies the elements for forming the polysilicon emitter and the oxide layer in between.

Froitzheim and Kwark are analogous art because each is in the same field of endeavor—solar cell design.[6] Froitzheim, Abstract, ¶¶1,9; Kwark, 742. Each is reasonably pertinent to the problems of efficiency and cost-effectiveness of solar cell designs. Froitzheim, Abstract, ¶¶1,9; Kwark, 742.

The Skilled Artisan would have been motivated to modify Froitzheim's emitter to be a polysilicon emitter with an oxide layer because Kwark taught and suggested that this modification would be an improvement transferable to solar cells. Kwark taught that addition of an interfacial chemically grown oxide (chemox) between polysilicon and the substrate "greatly decreases the J_{oe}," which "translates into potential improvements of energy conversion efficiency for solar cells." Kwark, 742, 745. Kwark provided data comparing polysilicon emitters with and without the oxide layer, and noted "the large difference when the interfacial oxide is missing." Kwark, 745 Fig. 4.

[6] To the extent it is argued Kwark is directed to a bipolar transistor, a Skilled Artisan would have looked to it when designing solar cells as was commonly done in the art. Lindholm, 363; Silvestre, 497; Gan, 245; Yablonovitch, 597.

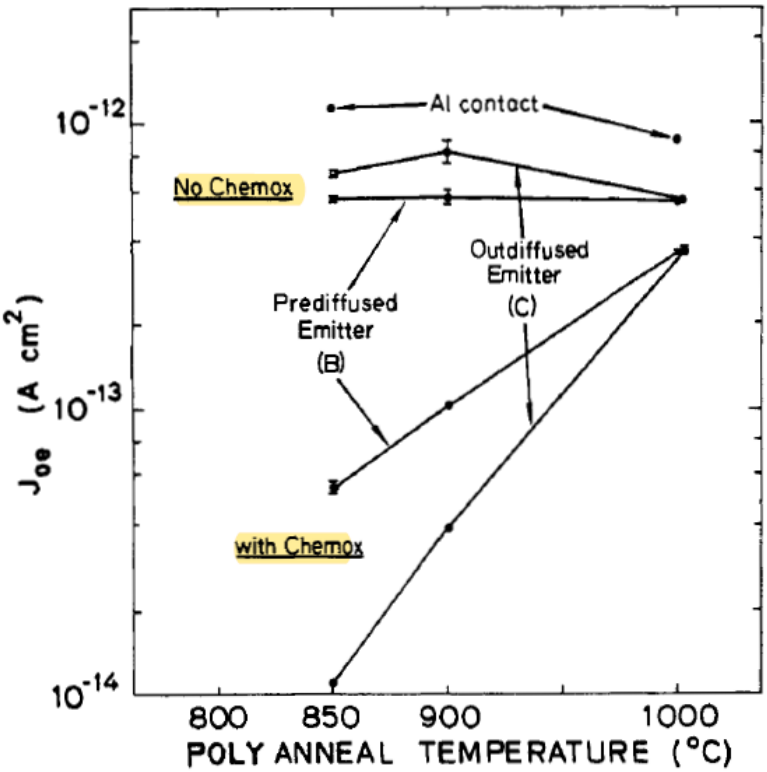


Fig. 4: emitter saturation current for POLY contacts with and without a chemically grown interfacial layer vs. anneal temperature. Thicknesses range from 3000-3600 angstroms. Note the large difference when the interfacial oxide is missing.

The teachings of Froitzheim, Gan, Foglietti, Borden, and Borden-575 discussed above would similarly have motivated a Skilled Artisan to integrate a polysilicon emitter with interfacial oxide layer in Froitzheim in view of Kwark because of the benefits of polysilicon emitter and interfacial oxide layer.

The Skilled Artisan would have considered the Froitzheim/Kwark combination to be merely an arrangement of old method steps with each performing the same function it had been known to perform (the emitter of Froitzheim continuing to act as an emitter, but modified to be polysilicon with an interfacial oxide) and yielding no more than what one would expect from such an arrangement (a solar cell with improved performance).

Combining Froitzheim/Kwark as described here 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. The combination would simply have been the combination of prior art elements according to known methods to yield predictable results. Likewise, substituting Froitzheim's in-substrate diffused emitter with a polysilicon emitter and oxide layer would be simple substitution of one known element for another to obtain predictable results. It would further constitute use of a known technique (polysilicon emitters with an oxide layer) to improve similar devices (Froitzheim's solar cell) in the same way. It would also constitute applying a known technique to a known device ready for improvement to yield predictable results.

iv. 053-4: Froitzheim, Kwark, in view of Hartiti or Sivoththaman

The combination Froitzheim and Kwark in further view of Hartiti or Sivoththaman would have rendered Claims 9, 12, 14-20 obvious and unpatentable. The motivation to combine Froitzheim and Kwark is discussed in the previous section. As to Hartiti and Sivoththaman, the Skilled Artisan would be motivated to replace the phosphorus gas diffusion source of Froitzheim with a spin-on or APCVD deposited phosphosilicate glass (PSG), as taught by Hartiti or Sivoththaman. Doing so would allow the co-diffusion of the phosphorus and boron at the front and back sides of the solar cell in a single drive-in diffusion step, as disclosed by Hartiti and Sivoththaman. Co-diffusion would enhance the diffusion kinetics and reduce the number of high temperature processing steps, as disclosed by Hartiti, which results in energy savings and cost reduction in the manufacturing process. Hartiti, 1522.

v. 053-5: Froitzheim, Gan, Smith, Avery

The combination Froitzheim and Gan in further view of Smith and Avery would have rendered Claims 9, 12, 14-20 obvious and unpatentable. The motivation to combine Froitzheim

and Gan is discussed in the previous section. The Skilled Artisan would have been motivated to further combine Froitzheim/Gan with Smith and Avery as they are in the same endeavor of solar cell manufacture. Smith discloses the diffusion of dopants to a backside and the diffusion of phosphorus-oxychloride to the front side of the solar cell as in-situ steps in a "one loading of the wafer 102 into the wafer processing tool." Smith, 3:40-42. Like Gan, Smith discloses depositing dopant source layers on the backside to diffuse dopants at the backside. Smith, 3:19-30. On the front side, Smith discloses using phosphorus-oxychloride ($POCl_3$) as the dopant with oxygen (Smith 3:58-61), which as Avery explained, also deposits a phosphorus pentoxide layer from which the phosphorus is diffused into the substrate. Avery, 1:19-30.

The Skilled Artisan would understand that the combination of Froitzheim, Gan, Smith, and Avery amounts to apply a known technique (Smith's manufacturing steps) and known feature (Gan's polysilicon and oxide layer) to a known device (Froitzheim's back-junction solar cell).

The Skilled Artisan fabricating the combination of Froitzheim and Gan would have considered ways to improve the cost-effectiveness of the solar cell manufacturing by using Gan or Smith's "techniques for simplifying the fabrication of solar cells." Smith, 1:36-40. Specifically, Smith discloses that the in situ steps to drive dopants "simplifies the fabrication process." Smith, 4:1-2. The Skilled Artisan would have been motivated to combine either Gan's or Smith's in situ steps of dopant diffusion with Froitzheim's solar cell as modified by Gan's polysilicon and oxide layers.

vi. 053-6: Froitzheim, Kwark, Smith, Avery

The combination Froitzheim and Gan in further view of Smith and Avery would have rendered Claims 9, 12, 14-20 obvious and unpatentable. The motivation to combine Froitzheim and Kwark is discussed in the previous section. The Skilled Artisan would have been motivated

to further combine Froitzheim/Kwark with Smith and Avery as they are in the same endeavor of solar cell manufacture. As discussed above, Smith discloses the diffusion of dopants to a backside and the diffusion of phosphorus-oxychloride to the front side of the solar cell as in-situ steps in a "one loading of the wafer 102 into the wafer processing tool." Smith 3:40-42. Smith discloses depositing dopant source layers on the backside to diffuse dopants at the backside. Smith, 3:19-30. On the front side, Smith discloses using phosphorus-oxychloride ($POCl_3$) as the dopant with oxygen (Smith 3:58-61), which as Avery explained, also deposits a phosphorus pentoxide layer from which the phosphorus is diffused into the substrate. Avery, 1:19-30.

The Skilled Artisan would understand that the combination of Froitzheim, Kwark, Smith, and Avery amounts to apply a known technique (Smith's manufacturing steps) and known feature (Kwark's polysilicon and oxide layer) to a known device (Froitzheim's back-junction solar cell).

The Skilled Artisan fabricating the combination of Froitzheim and Kwark would have considered ways to improve the cost-effectiveness of the solar cell manufacturing by using Smith's "techniques for simplifying the fabrication of solar cells." Smith, 1:36-40. Specifically, Smith discloses that the in situ steps to drive dopants "simplifies the fabrication process." Smith, 4:1-2. The Skilled Artisan would have been motivated to combine Smith's in situ steps of dopant diffusion with Froitzheim's solar cell as modified by Kwark's polysilicon and oxide layers.

3. The '315 Patent

The following table shows exemplary combinations of references that would have rendered each Asserted Claim of the '315 Patent obvious. The identification of primary references, secondary references, and obviousness combinations is not intended to be exhaustive—there are many possible combinations of the references that one of ordinary skill in

the art would have been motivated to make—and it is not practical to provide details of all such possible combinations:

Exhibit	Asserted Claim(s)	Exemplary Combinations
315-1	10, 15-16, 19	Li and King Li and Swanson-352 Li and Marvin-IEEE or Marvin-DTIC
315-2	10, 13-16, 19	Li and Muller
315-3	10, 13-16, 19	Li, King, Hu, and Ramappa Li, Swanson-352, Hu, and Ramappa Li, Marvin-IEEE or Marvin-DTIC, Hu, and Ramappa
315-4	10, 13-16, 19	Li, Muller, Hu, and Ramappa
315-5	10, 13-16, 19	Choi, Granek, and Istratov Choi, Marvin-DTIC or Marvin-IEEE, and Istratov Choi, Granek, Hu, and Ramappa Choi, Marvin-DTIC or Marvin-IEEE, Hu, and Ramappa
315-6	10, 13-16, 19	Choi, Muller, and Istratov Choi, Muller, Hu, and Ramappa
315-7	10, 13-16, 19	Cousins, Granek, and Istratov Cousins, Marvin-DTIC or Marvin-IEEE, and Istratov Cousins, Granek, Hu, and Ramappa Cousins, Marvin-DTIC or Marvin-IEEE, Hu, and Ramappa
315-8	10, 13-16, 19	Marvin-IEEE or Marvin-DTIC, and Gan
315-10	10, 13-16, 19	Generation 3 Solar Cell and Muller Generation 3 Solar Cell, Muller, and/or Istratov Generation 3 Solar Cell, Muller, and/or Hu and Ramappa

a. Motivation to Combine

In the following paragraphs, Canadian Solar identifies the motivation to combine the prior art identified in the exemplary combinations above. As a general matter, the basic concept and structures of back-contact solar cells, front surface doping in back-contact solar cells, and gettering of metal impurities in silicon substrate had been known in the art before the ’315 Patent.

Back-contact solar cells. The basic concept and structure of a "back-contact solar cell" had been known in the art for decades before December 22, 2014. The key feature of the back-contact solar cell is that all the metal contacts of the solar cell are on the back side opposite incident sunlight, such that incoming light is not blocked by having metal contacts on the front side. *Id*. "Interdigitated back contact (IBC) solar cells were investigated by Lammert and Schwartz" as far back as 1977. Neuhaus, 11.

Luque, a 2002 Handbook of Photovoltaic Science and Engineering published in 2003 disclosed a basic "[s]chematic of a back-contact solar cell," showing that the front side facing the sun has no metal contacts and the opposite/back side contains P-type and N-type doped regions, with both the positive and negative metal contacts formed at the backside and contacting the doped regions, respectively:

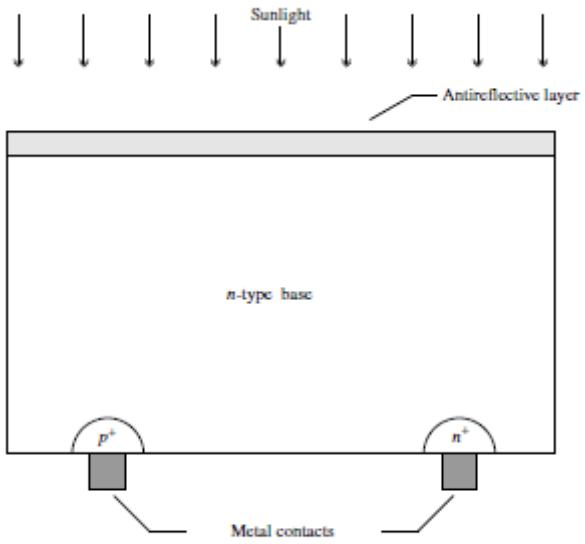


Figure 3.26 Schematic of a back-contact solar cell

Luque, 108. Similarly, a 2007 review by Neuhaus recognized "[k]ey design features that contribute to high efficiency" of back-contact solar cells include "localized back contacts" and "a gridless front surface which permits optimization of light trapping and passivation," as shown in the "IBC solar cell structure" of Neuhaus Figure 8. Neuhaus, 11. As shown below, the front side

also included a "front surface field" having the same dopant type (N-type) as the substrate and further passivated by silicon oxide and silicon nitride layers on top.

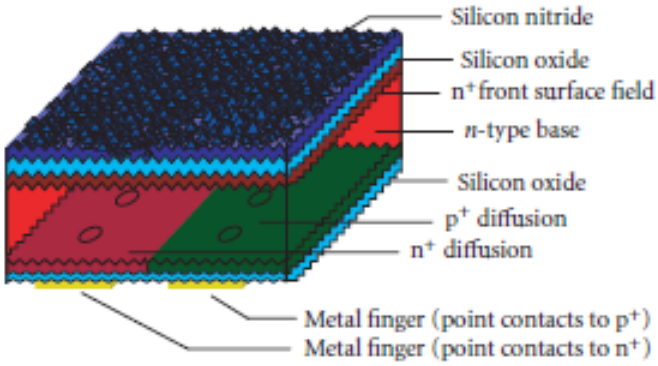
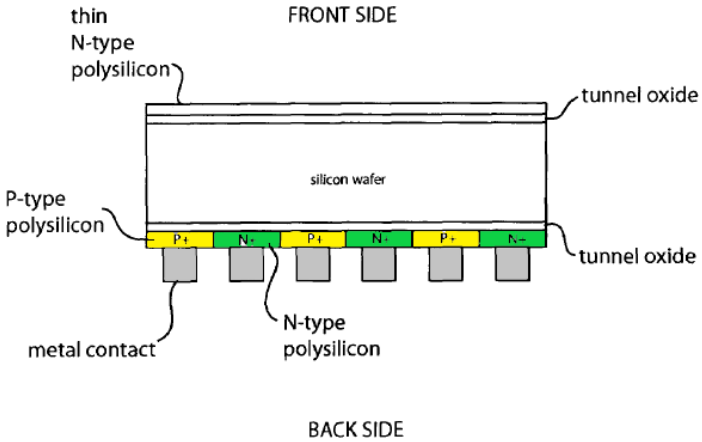


FIGURE 8: Schematic drawing of an IBC solar cell of SunPower.

Id.

U.S. Patent 7,468,485 ("Swanson-485") issued in 2008 and showed a back-contact solar cell having metal contacts (shown in gray) over doped polysilicon regions (shown in yellow and green) formed over a tunnel oxide layer on the back side:



Swanson-485, Fig. 1. Swanson-485's "Description of the Background Art" recognized that "[i]n a back side contact solar cell, the p-type and n-type regions are coupled to metal contacts on the back side of the solar cell to allow an external electrical circuit or device to be coupled to and be powered by the solar cell." Swanson-485,1:20-23. Forming metal contacts over doped

polysilicon was well known and within the level of ordinary skill in the art.. Indeed, according to Swanson-485, forming them can use "[c]onventional solar cell back-end processes." Swanson-485,6:38-46.

Front-surface doping in back-contact solar cells. By December 22, 2014, it had been known for decades that the front portion formed in the silicon substrate of a back-contact solar cell should be optimally doped at a concentration of approximately $2x10^{18}$ cm^{-3} or less. For example, a 1990 publication by King and Swanson ("King") reported that "[i]n the case of a back-contacted cell in which the sunside diffusion is used mainly to reduce surface recombination, not to collect current, the **optimum** emitter is the one with the **lowest** $\boldsymbol{J_0}$," and that for both textured and untextured surfaces this corresponds to a surface dopant concentration of approximately "**1×10^{18} cm^{-3} that is as thin as possible**." King, 369 (emphasis added). This lower front dopant concentration is preferred for back contact cells because it reduces surface recombination leading to higher cell efficiency.

Notably, one of the authors of King, Richard Swanson—referred to by Maxeon as "[t]he father of solar in the U.S." (Complaint, ¶2)—received a patent in 1980 (US4,234,352) that also described, consistent with King, that for a "photovoltaic cell" with contacts on the back surface, the "**maximum** surface dopant concentration" of the front diffused region "is **10^{18} atoms per cubic centimeter**." Swanson-352,4:38-51, 5:9-41, Figs. 3-10 (emphasis added).

Other studies have confirmed these findings. For example, Marvin, a 1989 study, concluded that optimal performance and efficiency of back-contact solar cells for space use should include a silicon substrate with a front portion having "**peak doping concentration of 1E18 [1×10^{18}] cm^{-3}**." Marvin-IEEE, 826-827 (emphasis added); *see also* Marvin-DTIC, 5, 21, 25. And, more recently, in September 2014, Muller published the results of a comparative study

of back-contact solar cells with either a boron or phosphorus ion-implanted front region, in both cases at dopant concentration less than or equal to approximately 2×10^{18} cm^{-3}. Muller, 269.

Gettering of metal impurities in silicon substrates. Recombination is one of the primary factors controlling solar cell efficiency. In solar cell manufacturing, the presence of other types of metallic impurities **in the substrate** such as iron, nickel, or gold have long been known to lead to recombination, in which energized electrons recombine with "holes," thus reducing the ability of the cell to generate electricity from those electrons..

To address this problem, it was well-known before December 2014 to remove these metal impurities from the substrate by "gettering" them into another location of the device where they do not affect the device's performance.. It was well known that "[g]ettering techniques eliminate or reduce contaminant impurities in a [silicon] wafer." Luque, 262. Before 2014, it was long recognized that "the incorporation of gettering steps into the processing scheme is a **prerequisite** for the production of efficient solar cells." Sebit, 696 (emphasis added).

Known gettering methods before 2014 included moving the metal impurities from the substrate and into a back side polysilicon layer. For example, a 1977 IBM issued patent by Hu (US4,053,335) disclosed that during heating in the range of 1000°C or less, "getterable impurities such as copper, lithium, sodium, potassium, iron, cobalt, nickel, chromium, and gold will diffuse to, and become trapped in, the polycrystalline silicon film impurity sink" formed on the back surface of the silicon substrate. Hu, 5:61-6:6.

In solar cell manufacturing, it was also standard industry practice before 2014 to use the dopant diffusion step to getter metal impurities. Numerous publications before 2014 described the simultaneous diffusion of dopants and gettering in solar cell fabrication. *See, e.g.*, Ferre, 1; Luque, 262; Seibt, 707.

At and around 2014, it was well known that multicrystalline silicon wafers were most commonly used for the production of wafer-based solar cells. Ferre, 1. For example, the National Renewable Energy Laboratory reported that as of 2013, multicrystalline silicon wafers accounted for the vast majority (at least 65%) of silicon substrates used for solar panels worldwide. REDB-2013, 66. The Skilled Artisan knew that because of their lower quality, multicrystalline silicon substrates were known to contain substantial concentrations of metal impurities. *See, e.g.*, Bounassisi, 402; Luque, 283; Tomas, ¶0006; Seibt, 696). For example, iron impurities in multicrystalline silicon substrates were known to be as high as 10^{14}-10^{16} cm^{-3} in concentration. Seibt, 696. Thus, gettering "[was] even more important to improve material quality" in multicrystalline silicon substrates before 2014. Luque, 283.

i. 315-1: Li in view of King or Swanson-352 or Marvin

Li disclosed a back-contact solar cell in which the front portion of the silicon substrate should include a doped region on the front side of the solar cell. Li, ¶49, FIG. 3 (318) and 5E (520). Although Li does not specify the precise concentration of dopants to be used for this front doped portion of the substrate, the optimal concentration for this front doped region was well known and would have been obvious in view of the teachings of King, Swanson-352, or Marvin.

Li, King, Swanson-352, and Marvin are analogous art, and they all relate to solar cell design and in particular, **back contact** solar cells. The Skilled Artisan would have been motivated to combine Li's back contact solar cell with the front portion doping concentration of $1x10^{18}$ cm^{-3} or less as disclosed in King, Swanson-352, or Marvin. All three disclosed this front dopant concentration. King taught that this concentration was the "optimum" for back-contact solar cells, and Swanson-352 taught to use it as the maximum concentration for this portion of a back contact solar cell.

Marvin likewise taught that for space applications, a "peak doping concentration of 1E18 [1 x 10^{18}] cm^{-3}" or lower with a "Gaussian doping profile with a characteristic width of 15 [micrometers]" resulted in better efficiency metrics than higher doping concentrations. Marvin-IEEE, 826-827. The government report version of Marvin's study (Marvin-DTIC) also confirmed this, thus bolstering the motivation to rely on Marvin's FSF doping concentration. For example, for cells of the same thickness, Marvin-DTIC reported that end-of-life efficiency as a function of cell thickness was consistently worse at higher FSF doping concentrations, including when comparing cells with thickness of 65 and 80 microns at concentrations of 1 x 10^{18} cm^{-3} and 5 x 10^{18} cm^{-3} (*see* Table 8 of Marvin-DTIC, annotated below):

Table 8. EOL Efficiency as a Function of cell Thickness and FSF at 100 Suns

Cell Thickness (μm)	Graded FSF (μm)	Step FSF (μm)	FSF Doping cm^{-3}	*Spacing a/b/c	Cell Efficiency (%)
50	15	—	1E18	10/20/10	14.64
50	15	—	1E18	5/10/5	15.44
65	15	—	1E18	5/10/5	11.57
80	15	—	1E18	5/10/5	8.97
200	15	—	5E18	5/10/5	1.18
65	—	0.5	5E18	5/10/5	8.17
80	—	0.5	5E18	5/10/5	6.83

*a,c = spaces between right and left edges of collectors and unit cell boundaries, resp.; b = space between collectors. All dimensions are in micrometers.

Based on this data, the report concluded that "to maximize the EOL performance," the "FSF is graded over 15 [microns] with a peak doping concentration of 1E17 to 1E18 cm^{-3}." Marvin-DTIC, 25.

Given Li's acknowledgement that "[e]fficiency is an important characteristic of a solar cell as it is directly related to the solar cell's capability to generate power" and that

"[a]ccordingly, techniques for increasing the efficiency of solar cells are generally desirable" (Li, ¶0005), the Skilled Artisan reviewing Li would further have been motivated to select the efficient front doping concentration disclosed by any of King, Swanson-352 or Marvin..

Notably, Maxeon has alleged that Dr. Richard Swanson, one of the authors of King and the inventor of Swanson-352, is often referred to as "[t]he father of solar in the U.S." Complaint, ¶2. It would thus be natural for the Skilled Artisan to look to Dr. Swanson's patents and publications (including King and Swanson-352) regarding the "optimum"/"maximum" doping concentrations for the front portion of back-contact solar cells to determine the dopant concentration to be used at the textured front portion of the back-contact solar cell disclosed in Li (Li, ¶0049, FIG. 5E). King, 369; Swanson-352,5:42-44.

Marvin's focus on high radiation environments, such as space, would not have deterred the Skilled Artisan from combining with Li because Li does not limit its back-contact solar cell to low radiation or terrestrial environments. Li stressed the importance of increased efficiency in solar cell design (Li, ¶0005), and increased solar cell efficiency is no less important in space environments than in terrestrial environments. And Marvin described the higher efficiency that can be achieved with its disclosed FSF doping concentration. Marvin-IEEE, 826-827.

Combining the back-contact solar cell of Li with the front dopant concentration taught by King or Swanson-352 or Marvin for back-contact solar cells would have been straightforward and done with a reasonable expectation of success by the Skilled Artisan. It is nothing more than using the same technique disclosed by Li to diffuse the front dopants to a certain concentration as taught by King, Swanson-352, or Marvin. Specifically, Li described using an N-type dopant for the front portion of the substrate. Li, ¶0049. The Skilled Artisan would have recognized that King and Swanson-352's teaching to dope the front portion with phosphorus (the same N-type

dopant disclosed in Li) to a surface concentration of 1 x 10^{18} cm^{-3} (King, 369, Fig. 3; Swanson-352,4:43-51) could be readily implemented using Li's disclosed process of heating the substrate in the presence of a gaseous N-type dopant (phosphorous). *See, e.g.*, Kiyota. Doping a silicon surface to a particular surface doping concentration would have been within the ordinary skill of the Skilled Artisan.

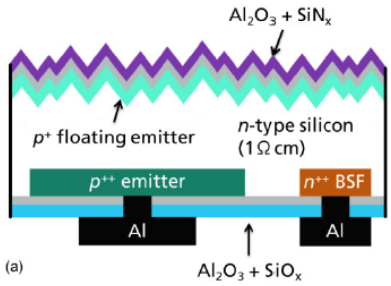
Although Marvin appears to have used a "p+" FSF on a P-type substrate[7] (Marvin-IEEE, 823; Marvin-DTIC, 15, 26), it would have been obvious to the Skilled Artisan that the **concentration** taught by Marvin is equally applicable to an N-type front doped region on an N-type substrate, as seen from the teachings of King and Swanson-352. See e.g., Green, 2946-47).

Finally, combining Li with the front portion's dopant concentration of King or Swanson-352 or Marvin would not have changed Li's inherent disclosure of gettering metal impurities from the silicon substrate to the backside emitter region. The natural result of Li's process of doping the backside emitter region at 950°C would be to getter metal impurities from the silicon substrate, through the 1-2 nm thick silicon oxide dielectric layer, and into the N-doped and P-doped regions of the polysilicon layer, according to the 315 Patent.

ii. 315-2: Li and Muller

The Skilled Artisan would have been motivated to combine the ion-implanted front floating emitter and aluminum oxide and silicon nitride passivation of Muller with Li because of its better solar cell efficiency and resistance to UV degradation, as disclosed by Muller. In the combination of Muller and Li, the ion-implanted boron-doped FFE of Muller (along with its frontside aluminum oxide and silicon nitride passivation) would replace the phosphorus (N-type) doped front portion 520 of Li's back-contact solar cell.

[7] "FSF" refers to front surface field, which reduces surface recombination. A FSF has the same dopant type as the substrate.



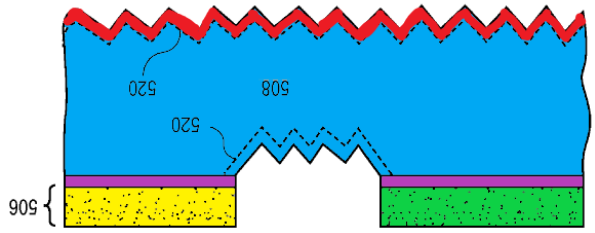


FIG. 5E

Li and Muller are both directed to back-contact solar cells and their fabrication. Li disclosed a back-contact solar cell in which the front portion 520 of the silicon substrate should be doped (Li, ¶0049), but Li did not specify the concentration of dopants that should be utilized at the front surface. Muller supplies that information by showing that, for a back-contact solar cell utilizing an N-type substrate (as in Li) using a boron-doped ion-implanted front floating emitter ("FFE") at a front dopant concentration of $2x10^{18}$ cm^{-3} or less and then passivating the front side with a Al_2O_3/SiN_x stack resulted in better resistance to surface recombination (J_o) and UV degradation, and overall efficiency of the solar cell, than a N-type back contact solar cell having a phosphorus-doped ion-implanted front surface field (FSF), passivated by SiO_x and/or SiN_x. Muller, Tables 1 and 2.

Moreover, as recognized in the art, using ion implantation for doping solar cells "provides a unique opportunity to obtain grid-parity because it simplifies the fabrication of advanced cell structures." Rohatgi, 10. Ion-implantation had also been shown before 2014 to increase solar cell efficiency while reducing the process sequence in production. *Id.*, 11.

And, as seen in Muller Table 1 (below), the solar cell with the ion-implanted boron-doped FFE and Al_2O_3 passivation had a lower *Jo* (leakage current, where a lower value indicates better passivation) than the ion-implanted phosphorus-doped FSF solar cell:

Table 1. Characteristics of the investigated profiles (best values achieved so far). Sheet resistance was measured by 4 point probe on planar reference samples. J_0 was extracted from QSSPC measurements (textured samples for FSF & FFE and planar samples for emitter and BSF) using the high injection method [11].

Sample type	Species	Implanted dose [cm^{-2}]	R_{Sheet} [Ω/sq]	J_0 [fA/cm^2]	Passivation
Floating emitter (FFE)	Boron	1e13	3900	5	Al_2O_3
		3e13	1500	6	
		1e14	650	7	
Front surface field (FSF)	Phosphorus	1e13	2200	12	SiO_2/SiN_x
		3e13	880	15	
		1e14	440	10	
Emitter	Boron	7e14	147	9	Al_2O_3
		1e15	108	22	
		1.5e15	73	24	
Back surface field (BSF)	Phosphorus	3e15	39	370	Al_2O_3

Further, as seen in Muller Table 2 (below), when the ion-implanted FFE and FSF were tested with 1.5X UV-illumination to assess degradation, the FSF solar cell conversion efficiency (η) dropped 2 fold from 20.9% to 9.6% after UV exposure, while the FFE η only dropped 1.1%:

Table 2. Degradation of IBC solar cells under UV-illumination in a sun tester for 36 h at 500 W/m^2.

Front side	State	V_{OC} [mV]	J_{SC} [mA/cm^2]	FF [%]	η [%]
Front surface field (FSF)	before UV exposure	672	39.2	79.6	20.9
	after UV exposure	612	19.8	79.3	9.6
Floating emitter (FE)	before UV exposure	673	39.9	77.3	20.7
	after UV exposure	668	38.2	76.7	19.6

Given Li's acknowledgement that "[e]fficiency is an important characteristic of a solar cell as it is directly related to the solar cell's capability to generate power" and that "techniques for increasing the efficiency of solar cells are generally desirable" (Li, ¶0005), the Skilled Artisan reviewing Li would have been motivated to modify Li's solar cells to replace the diffusion doped front portion 520 with the more efficient ion-implanted boron-doped FFE and passivation layers as disclosed by Muller. And, as between Muller's ion-implanted FSF and FFE, the Skilled Artisan would have been highly motivated to select the ion-implanted boron FFE

with concentration of approximately $2x10^{18}$ cm^{-3} because of its higher efficiency and stability. Muller, 267, Fig. 1.

Combining the back-contact solar cell of Li with the front side ion-implanted floating emitter of Muller would have been straightforward and done with a reasonable expectation of success by the Skilled Artisan, particularly given that Li does not disclose any other layers on the front surface of the solar cell (Li, Fig. 5E). The Skilled Artisan would have recognized that Muller's teaching to dope the front surface with an ion-implanted boron floating emitter to a peak dopant concentration of approximately 2×10^{18} cm^{-3} could be readily implemented. It would have been well within the level of the Skilled Artisan before 2014 to insert Muller's ion-implanted boron FFE process steps for the front side before Li's process of fabricating the back side of the solar cell.The fabrication of the front portion of the solar cell could have been done (and was often done) independently of the application and treatment of layers on the back surface of the solar cell, and without impacting the layers applied to the back surface of the solar cell.

Muller's FFE and passivation layers would also be entirely consistent with the solar cell fabrication process described in Li, even for the diffusion of the back side trench region 520 using a gaseous N-type dopant source. Li, ¶0049. No substantial changes would have been necessary in this combination. Diffusion masks (i.e., barriers) were well-known, and would allow diffusion of Li's trench between the backside doped "emitter regions" 310, 314 without cross-doping the substrate's front portion. *See, e.g.,* Ghoshtagore. Indeed, it was well known in the art that a silicon nitride layer would act as a diffusion barrier during phosphorus diffusion of other portions of the solar cell, in addition to its functions as an antireflection coating and surface passivation for the front surface. Luque, 291. Here, Muller taught to cap the front side of the

solar cell with a silicon nitride layer over the the boron ion-implanted FFE and aluminum oxide layer. Muller, 266 and Fig. 3. Thus, when Li's front portion of the substrate is replaced with an FFE with aluminum oxide layer and capped with a silicon nitride layer, as taught by Muller, the silicon nitride layer would prevent cross-doping of the boron implanted front portion of the substrate with phosphorus during doping of Li's trench region, while still maintaining its function as an anti-reflection and passivation layer.

Finally, combining Li with the front-side boron FFE of Muller would not have changed Li's inherent disclosure of gettering metal impurities from the silicon substrate to the emitter region, because the Skilled Artisan would have recognized that fabrication of the front side of the solar cells would have been independent of the fabrication of the back side of the solar cells.

iii. 315-3: Li in view of King or Swanson-352 or Marvin in further view of Hu and Ramappa

The Skilled Artisan would have had a strong motivation to remove metal impurities from the multicrystalline silicon substrate disclosed in Li by gettering, as discussed above. In 2013, over 65% of the silicon solar cells utilized multicrystalline silicon substrates, which were known to have substantial metal impurity concentrations (such as iron) in the substrate. REDB-2013, 66; Seibt, 696. Li disclosed using multicrystalline substrates for its solar cells. Li, ¶0037, 0042.

As discussed above, integrating a gettering step into solar cell fabrication processes simultaneously with the diffusion step was well known and used routinely to getter metal impurities from the silicon substrate in order to improve cell efficiency, especially with respect to multicrystalline silicon solar cells. Seibt, 696.

Incorporating the teachings of Hu and Ramappa using high temperatures, *e.g.*, 900°C to 1,000°C, to expressly getter metal impurities would have been obvious in view of the similarities to Li's teaching to heat at 950°C and Li's disclosure of polysilicon and thin silicon dioxide layers

on the back side of the silicon substrate. Specifically, Hu discloses gettering to a backside layer of polysilicon, just as Li also disclosed a polysilicon layer on the backside. It would likewise be obvious to the Skilled Artisan that at the high temperature processing step disclosed by Hu and Li (*i.e.* above 900°C), the silicon dioxide layer would not hinder gettering, as shown by Ramappa, and thus would not deter the Skilled Artisan from gettering the metal impurities. *Id*. Based on Ramappa, it would be apparent to the Skilled Artisan that iron would readily diffuse across the thin 1-2 nm silicon dioxide layer of Li into the polysilicon layer.

The Skilled Artisan would have recognized that the combination of any of the above Li combinations with Hu and Ramappa is merely an arrangement of old elements (i.e., known gettering steps and temperatures) with each performing the same function it had been known to perform (the gettering of iron metal impurities into backside polysilicon layer) and yielding no more than what one would expect from such an arrangement (a solar cell with metal impurities being present in the backside polysilicon emitter region).

The Skilled Artisan would have recognized from Hu and Ramappa that Li's description of heating the polysilicon layers to 950°C during the doping process (Li, ¶0045), would result in the gettering of metal impurities, such as iron, from silicon substrate, through the 1-2 nm dielectric layer, and into the doped polysilicon emitter region. This would not have required substantial changes to the process of Li, and heating steps could be combined into a single heating step as needed to simultaneously getter and diffuse dopants, as would have been known in the art, and would also have conserved energy and costs. Any adjustments, if needed at all, would have been routine and well within the level of skill of the Skilled Artisan. *Id*.

iv. 315-4: Li and Muller in view of Hu and Ramappa

The motivation to combine discussed in the 315-2 (Li and Muller) and 315-3 sections with respect to the combination of Li and Hu and Ramappa, are equally applicable here, and are incorporated by reference here.

v. 315-5: Choi in view of Granek or Marvin-DTIC/Marvin-IEEE in further view of Istratov

Choi, Granek, Marvin-DTIC, and Istratov are analogous art because each is reasonably pertinent to increasing efficiency by reducing recombination. Choi, ¶29; Granek, 117-136; Marvin 3-5; Istratov, 569-570. Further, Choi, Granek, and Marvin-DTIC are in the field of solar cell design, while Istratov is in the field of silicon semiconductor devices, which is an umbrella field that solar cells fall under. Choi, ¶¶3, 6, 9; Granek, Abstract; Marvin, 5, 15; Istratov, 569-570.

The Skilled Artisan would have been motivated to combine Choi with Granek or Marvin-DTIC/Marvin-IEEE. Choi discloses a back-contact solar cell with an N-type or P-type substrate that forms a front surface field. Choi, ¶¶26, 29. Though Choi discloses that the dopant concentration of the front surface field is higher than that of the semiconductor substrate for the purposes of reducing recombination, Choi does not specify the exact concentration. Nonetheless, the Skilled Artisan would have known that optimal front surface filed dopant concentration have been disclosed already in the literature such as by Granek or Marvin-IEEE/Marvin-DTIC and would have been motivated to combine their disclosures on the dopant concentration for a front surface field. Granek discloses that a front surface field dopant concentration of approximately 1×10^{18} cm^{-3} has the highest efficiency for a back-contact solar cell with a front surface field. Granek, Abstract, 120-122. Marvin discloses that a front surface field dopant concentration from 1×10^{17} to 1×10^{18} cm^{-3} for a back-contact solar cell with a front surface field helps reduce surface recombination and Auger recombination. Marvin-DTIC, 5, 15.

The Skilled Artisan would have considered the Choi/Granek or the Choi/Marvin-DTIC combination to be merely an arrangement of known elements to a known device. Choi discloses that doping the front surface field layer could be done by thermal diffusion, which are aligned with how Marvin and Granek teach doping of the front surface field, respectively. Granek, 117, 119, 124; Marvin-DTIC, 15.

A Skilled Artisan would have a reasonable expectation of success given the similarity between the references and the disclosed manufacturing techniques. The Skilled Artisan would have known that fabricating the cell in Choi with Granek and Marvin's dopant concentrations would have involved minor adjustments to a single doping step. Doping the front surface field of a silicon substrate to a specific concentration near the front would have been within the ordinary skill of a Skilled Artisan.

A Skilled Artisan would also be motivated to combine Istratov with the Choi/Granek or Choi/Marvin solar cell in order to getter metal impurities in a substrate to the polysilicon layer. Trapping the impurities in the polysilicon layer reduces recombination. Choi is already concerned with reducing recombination and improving efficiency. Choi, ¶¶6-7, 31. Istratov discloses a gettering technique to move metal impurities from the substrate to the polysilicon layer, which the Skilled Artisan would have been motivated to apply. Istratov, 569-571, Figs. 2, 4, 5.

The Skilled Artisan would have considered the Choi/Granek or the Choi/Marvin-DTIC combinations with Istratov to be an application of a known technique (gettering of metal impurities) to a known device. Further, Choi and Istratov's cell structures are the same—they each contain a silicon substrate, dielectric region, and polysilicon layers. Istratov, 569-571, Figs. 2, 4, 5.

The Skilled Artisan would have had a reasonable expectation of success with the above combinations because Choi discloses a thermal-treatment step during doping of the first and second polysilicon areas, but does not disclose the temperature used. The Skilled Artisan would have understood that this heating step would have been used to getter impurities from the substrate to the polysilicon layers, using the specific heating and time conditions taught by Istratov. Choi, ¶¶36-37; Istratov, 569-571, Figs. 2, 4, 5.

vi. 315-6: Choi and Muller in view of Istratov or Hu and Ramappa

Choi, Muller, and Istratov are analogous art because each is reasonably pertinent to increasing efficiency by reducing recombination. Choi, ¶29; Muller, Abstract, 266; Istratov, 569-570. Further, Choi and Muller are in the field of solar cell design, while Istratov is in the field of silicon semiconductor devices, which is an umbrella field that solar cells fall under. Choi, ¶¶3, 6, 9; Muller, Abstract; Istratov, 569-570.

The Skilled Artisan would have been motivated to combine Choi with Muller. Choi discloses a back-contact solar cell with an N-type or P-type substrate that forms a front surface field. Choi, ¶¶26, 29. Choi discloses that the front surface field layer could be done by ion implantation (Choi, ¶74), and Muller used ion implantation of the front surface on a back contact solar cells. Muller, 271 ("Ion implantation is suitable to form lowly doped regions acting as front surface field (FSF) or front floating emitter (FFE) in n-type IBC solar cells.").

Though Choi discloses that the dopant concentration of the front portion is higher than that of the semiconductor substrate for the purposes of reducing recombination, Choi does not specify the exact concentration. Nonetheless, the Skilled Artisan would have ben motivated to use the dopant concentration of Muller's ion-implanted front surface (which are approximately $2x10^{18}$cm-3 or lower) because of its lower recombination or J_o, for both phosphorus and boron

dopants. Muller discloses that "[a]s the IBC solar cell relies on a perfect passivation on the front side, the formation of a very lowly doped FSF or FFE which allows for a low recombination would be quite beneficial for this type of cell."

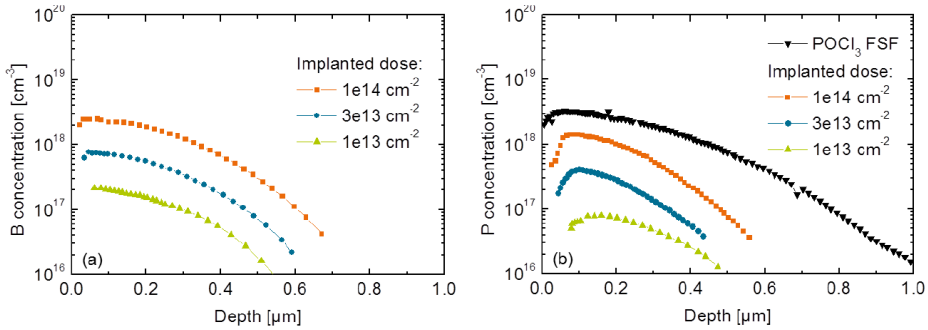


Fig. 1. ECV profiles measured on planar samples after ion implantation and annealing for 80 min at 1050 °C. (a) Low dose boron implantations for a floating emitter; (b) low dose phosphorus implantations for a front surface field. A conventional $POCl_3$-diffused FSF used in Ref [8] is shown for comparison.

Table 1. Characteristics of the investigated profiles (best values achieved so far). Sheet resistance was measured by 4 point probe on planar reference samples. J_0 was extracted from QSSPC measurements (textured samples for FSF & FFE and planar samples for emitter and BSF) using the high injection method [11].

Sample type	Species	Implanted dose [cm^{-2}]	R_{Sheet} [Ω/sq]	J_0 [fA/cm^2]	Passivation
Floating emitter (FFE)	Boron	1e13	3900	5	Al_2O_3
		3e13	1500	6	
		1e14	650	7	
Front surface field (FSF)	Phosphorus	1e13	2200	12	SiO_2/SiN_x
		3e13	880	15	
		1e14	440	10	
Emitter	Boron	7e14	147	9	Al_2O_3
		1e15	108	22	
		1.5e15	73	24	
Back surface field (BSF)	Phosphorus	3e15	39	370	Al_2O_3

Moreover, as between ion-implanted boron and phosphorus on the front surface, Muller taught the boron-implanted FFE performed better and thus would motivate the Skilled Artisan to use boron (a p-type dopant) on the front surface.

Table 2. Degradation of IBC solar cells under UV-illumination in a sun tester for 36 h at 500 W/m^2.

Front side	State	V_{OC} [mV]	J_{SC} [mA/cm^2]	FF [%]	η [%]
Front surface field (FSF)	before UV exposure	672	39.2	79.6	20.9
	after UV exposure	612	19.8	79.3	9.6
Floating emitter (FE)	before UV exposure	673	39.9	77.3	20.7
	after UV exposure	668	38.2	76.7	19.6

A Skilled Artisan would have a reasonable expectation of success given the similarity between the references and the disclosed manufacturing techniques.

The Skilled Artisan would also be motivated to combine Istratov or Ramappa with the Choi/Muller modified solar cell in order to improve gettering metal impurities in a substrate to the polysilicon layer. As discussed in Section II.C.3.a above, gettering of metal impurities in silicon substrates performed simultaneously with the thermal diffusion process of doping was well known in the art before December 22, 2014. Choi disclosed using thermal diffusion to dope the polysilicon regions. Choi, ¶70. Both Hu and Istratov taught that gettering at high temperature can be achieved with polysilicon layer on the backside of the substrate. Moreover, the diffusivity of metal impurities through silicon dioxide was also well known (as disclosed by Ramappa and Istratov) and it was known that the metal impurities can diffuse across a silicon dioxide into the polysilicon layer at high temperatures. Based on data from Ramappa and Istratov, it was known that the diffusivity across the silicon oxide increases with temperature. See Istratov, Figure 1 and Ramappa, Figure 1. Thus, to getter additional metal impurities out of the substrates (and to reduce recombination and improve solar cell efficiency), the Skilled Artisan would have been motivated to increase the diffusion temperature to improve the gettering of metal impurities into the polysilicon layer.

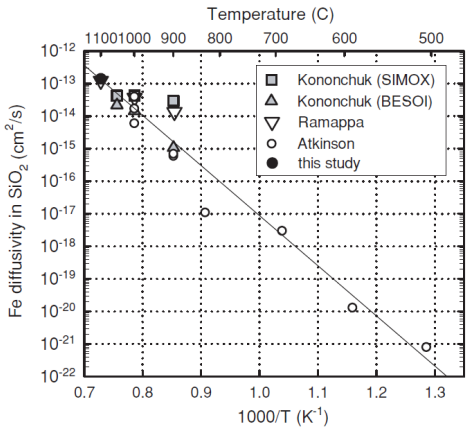


Figure 1. Diffusivity of iron in silicon dioxide, according to the data of Atkinson *et al* [2], Kononchuk *et al* [4] and Ramappa *et al* [3]. Black circle at 1100 °C denotes our data point obtained from the analysis of iron diffusion profile in figure 3.

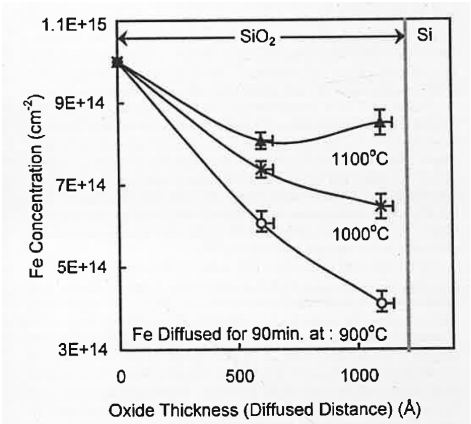


Figure 1. Iron concentration profile in SiO_2 following in-diffusion at temperatures of 900, 1000, and 1100°C for 90 min. Iron concentrations were measured by TXRF.

vii. 315-7: Cousins in view of Granek or Marvin-DTIC in further view of Istratov

Cousins, Granek, Marvin-DTIC, and Istratov are analogous art because each is reasonably pertinent to increasing efficiency by reducing recombination. Cousins, 1:15-18, 2:22-23, 2:49-58; Granek, 117-136; Marvin 3-5; Istratov, 569-570. Further, Choi, Granek, and Marvin-DTIC are in the field of solar cell design, while Istratov is in the field of silicon semiconductor devices, which is an umbrella field that solar cells fall under. Choi, ¶¶3, 6, 9; Granek, Abstract; Marvin, 5, 15; Istratov, 569-570.

Similar to Granek and Marvin, Cousins discloses an N-type doped front portion of the silicon substrate in order to reduce recombination at the front of the solar cell. Cousins, 2:49-54. Similar to Choi, Cousins leaves the specific concentration up to the Skilled Artisan. Cousins, 2:49-55. For reasons similar to the 315-5 combination, a Skilled Artisan would have been motivated to reference Granek or Marvin to determine the specific dopant concentration for Cousins' doped region at the front of the cell. A Skilled Artisan would have understood that the sheet resistance disclosed in Cousins is consistent with the front surface field dopant concentration disclosed in Granek. Cousins, 2:49-55; Granek, 123, Fig. 7-4.

A Skilled Artisan would have had a reasonable expectation of success in combining Cousins with Granek or Marvin. Cousins teaches a phosphorus diffusion of dopants into the front side of the substrate, and it would have been within a Skilled Artisan's ordinary skill to do so. Cousins, 5:49-6:13.

A Skilled Artisan would also be motivated to combine Istratov with the Cousins/Granek or Cousins/Marvin solar cell in order to getter metal impurities in a substrate to the polysilicon layer. The Skilled Artisan would have considered the Choi/Granek or the Choi/Marvin-DTIC combinations with Istratov to be an application of a known technique (gettering of metal impurities) to a known device. Further, Cousins' and Istratov's cell structures are the same—they each contain a silicon substrate and polysilicon layers where the metal impurities would be gettered into. Istratov, 569-571, Figs. 2, 4, 5.

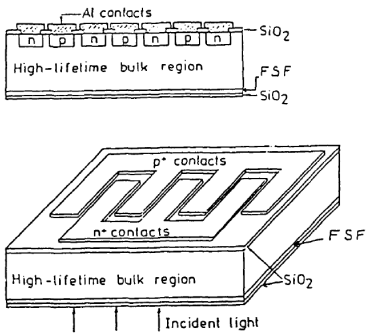
The Skilled Artisan would have had a reasonable expectation of success with the above combinations for the same reasons as discussed for 315-5, which is incorporated by reference here.

viii. 315-8: Marvin-IEEE or Marvin-DTIC and Gan

Each of Marvin-IEEE and Marvin-DTIC disclosed a back contact solar cell that included all elements of Claims 10, 13-16, and 19, except for a dielectric region between the first and second emitter regions on the backside and that the emitter regions comprising polysilicon and metal impurities. However, Gan disclosed these missing elements.

Marvin-IEEE, Marvin-DTIC and Gan are analogous art, and they both relate to solar cell design and improving its efficiency. The Skilled Artisan would understand that the n+ and p+ regions of Marvin-IEEE and Marvin-DTIC would have been formed by thermal diffusion into the substrate, as they are shown to be part of the substrate.

IBC SOLAR CELL



The Skilled Artisan have been motivated to combine Marvin's back contact solar cell with Gan's teaching of replacing the diffused emitter regions with a polysilicon emitter regions having an oxide layer (i.e., dielectric region) in between the emitter regions and substrate. Gan disclosed that "***the cell performance can be improved if the diffused-emitter [of Marvin] is replaced with the polysilicon emitter***,…." Gan, 245 (emphasis added). Gan also noted that "the J_o [i.e., indication of surface recombination] of the p-type polysilicon emitter (Fig 5) [beneficially] appears to be much lower than what has been previously reported," and suggested that it "may have to do with the use of thermal oxide as the interfacial layer in our samples." Gan, 248. Gan explained that "because the dominant recombination is likely at the oxide interface, it implies that the oxide must only be broken by a very small fraction, which is consistent with what was observed in Fig. 2." Gan, 248.

Gan went on to provide lowered J_o and ρ_c data in Figure 6 for both p-type polysilicon and n-type polysilicon and concluded the characteristics brought about by the polysilicon emitter with interfacial oxide layer structure is "***quite useful for silicon solar cells***." Gan, 249 (emphasis added). Gan further pointed to prior modeling and determined that "more than one absolute percent of the cell efficiency is obtained for a backside contact solar cell with polysilicon

emitters with characteristics shown here ….” Gan, 249. It is noteworthy that Gan’s calculations are in the context of a backside contact solar cell because the solar cell described in Marvin-IEEE and Marvin-DTIC was a back contact solar cell.

As also discussion in Section II.C.1.a above, other references also taught incorporating an oxide layer (i.e., dielectric region) into a polysilicon emitter, which are incorporated by reference herein. *See* Kwark, Broden, Foglietti. The Skilled Artisan would readily have been able to implement the polysilicon emitter regions in a back contact solar cell, as seen for example, in Swanson-485.

With respect with metal impurities in the polysilicon, Gan taught that the dopants are diffused/driven into the polysilicon at temperatures above 900ºC, which, according to the 315 Patent, would inherently have gettered metal impurities into the polysilicon layer/regions.

ix. 315-10: Generation 3 Solar Cell in view of Muller and/or Istratov, or Hu and Ramappa

To the extent that Maxeon contends that the SunPower Generation 3 solar cells did not anticipate Claims 10, 13-16, and 19, these claims would have been obvious in view of the combination of the Generation 3 Solar Cell and Muller and/or Istratov, or Hu and Ramappa.

For example, to the extent that Maxeon contends that the Generation 3 solar cells did not have a front dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3}, it would have been obvious to the Skilled Artisan to replace the front surface field in the Generation 3 solar cells with the boron FFE of Muller at a boron dopant concentration of approximately less than or equal to $2x10^{18}cm^{-3}$. Both the Generation 3 Solar Cell and Muller’s solar cell are back contact solar cells, and thus they are in the same field of endeavor and are analogous art. Muller demonstrated that a boron-doped ion-implanted front floating emitter (“FFE”) at a front dopant concentration of $2x10^{18}$ cm^{-3} or less and then passivating the front side with a Al_2O_3/SiN_x stack

resulted in better resistance to surface recombination (J_o) and UV degradation, and overall efficiency of the solar cell, than a N-type back contact solar cell having a phosphorus-doped ion-implanted front surface field (FSF), passivated by SiO_x and/or SiN_x. Muller, Tables 1 and 2.

Moreover, as recognized in the art, using ion implantation for doping solar cells "provides a unique opportunity to obtain grid-parity because it simplifies the fabrication of advanced cell structures." Rohatgi, 10. Ion-implantation had also been shown before 2014 to increase solar cell efficiency while reducing the process sequence in production. *Id*., 11.

To obtain these benefits, the Skilled Artisan would have been motivated to modify the Generation 3 solar cell to replace the front surface field with the more efficient ion-implanted boron-doped FFE and passivation layers as disclosed by Muller. And, as between Muller's ion-implanted FSF and FFE, the Skilled Artisan would have been highly motivated to select the ion-implanted boron FFE with concentration of approximately $2x10^{18}$ cm^{-3} because of its higher efficiency and stability. Muller, 267, Fig. 1.

Combining the Generation 3 solar cell with the front side ion-implanted floating emitter of Muller would have been straightforward and done with a reasonable expectation of success by the Skilled Artisan. The fabrication of the front portion of the solar cell could have been done (and was often done) independently of the application and treatment of layers on the back surface of the solar cell, and without impacting the layers applied to the back surface of the solar cell.

To the extent that Maxeon contends that the Generation 3 solar cells did not have metal impurities in the first and second polysilicon emitter regions, it would have been obvious to the Skilled Artisan that such metal impurities would be present by gettering at high temperatures into the polysilicon, as taught by Istratov, or Hu and Ramappa. As discussed in Section II.C.3.a

above, gettering of metal impurities in silicon substrates performed simultaneously with the thermal diffusion process of doping was well known in the art before December 22, 2014. Both Hu and Istratov taught that gettering at high temperature can be achieved with polysilicon layer on the backside of the substrate. Moreover, the diffusivity of metal impurities through silicon dioxide was also well known (as disclosed by Ramappa and Istratov) and it was known that the metal impurities can diffuse across a silicon dioxide into the polysilicon layer at high temperatures. Based on data from Ramappa and Istratov, it was known that the diffusivity across the silicon oxide increases with temperature. *See* Istratov, Figure 1; Ramappa, Figure 1. Thus, to getter additional metal impurities out of the substrates (and to reduce recombination and improve solar cell efficiency), the Skilled Artisan would have been motivated to increase the diffusion temperature to improve the gettering of metal impurities into the polysilicon layer.

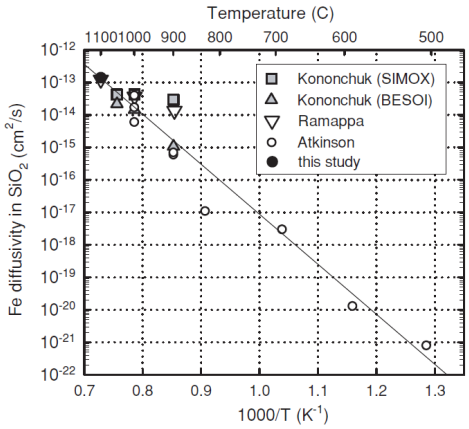


Figure 1. Diffusivity of iron in silicon dioxide, according to the data of Atkinson *et al* [2], Kononchuk *et al* [4] and Ramappa *et al* [3]. Black circle at 1100 °C denotes our data point obtained from the analysis of iron diffusion profile in figure 3.

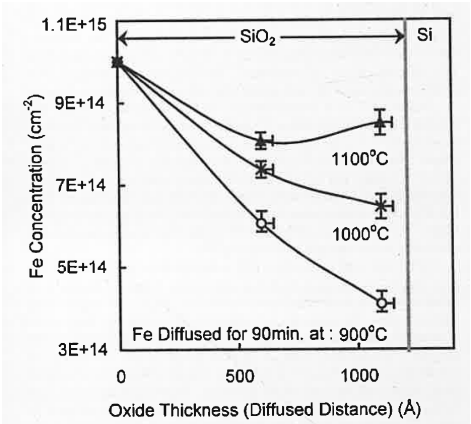


Figure 1. Iron concentration profile in SiO_2 following in-diffusion at temperatures of 900, 1000, and 1100°C for 90 min. Iron concentrations were measured by TXRF.

III. P.R. 3-3(c): INVALIDITY CHARTS

In the attached exhibits, Canadian Solar provides "chart[s] identifying where specifically in each alleged item of prior art each element of each asserted claim is found, including for each

element that such party contends is governed by 35 U.S.C. § 112 ¶ 6, the identity of the structure(s), act(s), or material(s) in each item of prior art that performs the claimed function."

'516 Patent:

Exhibit	Asserted Claim(s)	Exemplary Combinations and References
516-1	9, 10	Meier, Okayasu, Borden, and Jordan
516-2	9, 10	Meier, Okayasu, Foglietti, Gan, and Jordan
516-3	9, 10	Froitzheim and Gan
516-4	9, 10	Froitzheim and Kwark
516-5	9, 10	Froitzheim and Borden
516-6	9, 10	Froitzheim, Borden-575
516-7	9, 10	Li-545 and Gan Li-545 and Kwark Li-545 and Borden-575
516-8	9, 10	Borden-575

'053 Patent:

Exhibit	Asserted Claim(s)	Exemplary Combinations and References
053-1	9, 12, 14-20	Froitzheim and Gan
053-2	9, 12, 14-20	Froitzheim, Gan, and Hartiti Froitzheim, Gan, and Sivoththaman
053-3	9, 14, 16-17, 19-20	Froitzheim and Kwark
053-4	9, 12, 14-20	Froitzheim, Kwark, and Hartiti Froitzheim, Kwark, and Sivoththaman
053-5	9, 12, 14-20	Froitzheim, Gan, Smith, and Avery
053-6	9, 12, 14-20	Froitzheim, Kwark, Smith, and Avery

‘315 Patent:

Exhibit	Asserted Claim(s)	Exemplary Combinations
315-1	10, 15-16, 19	Li and King Li and Swanson-352 Li and Marvin-IEEE or Marvin-DTIC
315-2	10, 13-16, 19	Li and Muller
315-3	10, 13-16, 19	Li, King, Hu, and Ramappa Li, Swanson-352, Hu, and Ramappa Li, Marvin-IEEE or Marvin-DTIC, Hu, and Ramappa
315-4	10, 13-16, 19	Li, Muller, Hu, and Ramappa
315-5	10, 13-16, 19	Choi, Granek, and Istratov Choi, Marvin-DTIC or Marvin-IEEE, and Istratov Choi, Granek, Hu and Ramappa Choi, Marvin-DTIC or Marvin-IEEE, Hu, and Ramappa
315-6	10, 13-16, 19	Choi, Muller, and Istratov Choi, Muller, Hu, and Ramappa
315-7	10, 13-16, 19	Cousins, Granek, and Istratov Cousins, Marvin-DTIC or Marvin-IEEE, and Istratov Cousins, Granek, Hu, and Ramappa Cousins, Marvin-DTIC or Marvin-IEEE, Hu, and Ramappa
315-8	10, 13-16, 19	Marvin-IEEE or Marvin-DTIC, and Gan
315-9	10, 15-16, 19	Generation 3 Solar Cell
315-10	10, 13-16, 19	Generation 3 Solar Cell and Muller Generation 3 Solar Cell, Muller, and/or Istratov Generation 3 Solar Cell, Muller, and/or Hu and Ramappa

In these Contentions, Canadian Solar identifies exemplary disclosures of the prior art references that would have anticipated and/or rendered obvious the Asserted Claims and/or show the state of the art in the relevant timeframe. Although Canadian Solar has identified at least one citation per element for each reference, each and every disclosure of the same or similar elements in said reference is not necessarily identified. In an effort to focus the issues, and for the sake of concision, Canadian Solar identifies exemplary portions of the cited references. Of course, the

Skilled Artisan would generally read a prior art reference as a whole and in the context of other publications, literature, and general knowledge in the field. To understand and interpret any specific statement or disclosure in a prior art reference, the Skilled Artisan would rely upon other information including other publications and general scientific or engineering knowledge. Canadian Solar therefore relies on all disclosures set forth in the prior art references and reserve the right to rely upon other portions of the prior art references not specifically cited herein as well as the right to rely on other patents, publications and expert testimony to provide context, demonstrate the general state of the art and the knowledge of one of ordinary skill in the art at the time the purported inventions of the Asserted Patents were made, and to aid understanding and interpretation of the identified portions and to provide information relating to the motivation to modify and/or combine references with either the knowledge of a person of skill in the art or with other references.

Where Canadian Solar identifies a particular figure in a prior art reference, that identification encompasses the caption and description of the figure as well as any text relating to the figure in addition to the figure itself. Similarly, where an identified portion of text refers to a figure or other material, that identification includes the referenced figure or other material as well.

Although certain elements of the Asserted Claims have been correlated to certain prior art disclosures, Canadian Solar believes that some of the elements are indefinite, not enabled, or otherwise fail to comply with section 112. As such, Canadian Solar does not concede that the elements are adequately disclosed or delineated in the Asserted Patents merely because they have been correlated to specific prior art disclosures.

IV. P.R. 3-3(d): INVALIDITY BASED ON 35 U.S.C. § 112

Canadian Solar hereby identifies grounds of invalidity based on 35 U.S.C. § 112. Canadian Solar reserves the right to assert that additional claim terms or phrases from the Asserted Patents lack written description support, are not enabled, or are indefinite based on additional discovery, claim construction, or positions taken by Plaintiff as the case progresses.

A. The Asserted Claims Lack an Adequate Written Description

1. The ’516 Patent

Plaintiff contends in its Infringement Contentions for the ’516 Patent that “an emitter layer formed over a back surface of the substrate, the emitter layer forming a backside junction with the substrate” (independent claim 9) covers a back surface field where the substrate and a backside polysilicon layer are doped with the same dopant type. To the extent that Plaintiff’s Infringement Contentions are accepted, Claim 9 (and any claims depending therefrom) are invalid for lack of written description.

The specification of the ’516 Patent does not contain written description support for the full scope of this claimed “emitter layer” that “form[s] a backside junction with the substrate. The specification of the ’516 Patent discloses only that the “backside junction” is formed with *opposite* dopants in the substrate and emitter layer. *See, e.g.*,

- Abstract (“A bipolar solar cell includes a backside junction formed by an N-type silicon substrate and a P-type polysilicon emitter formed on the backside of the solar cell.”).
- ‘516 Patent at 1:22-24 (“A solar cell includes P-type and N-type diffusion regions that form a junction.”)
- ‘516 Patent at 1:45-48 (“Summary: A bipolar solar cell includes a backside junction formed by an N-type silicon substrate and a P-type polysilicon emitter formed on the backside of the solar cell.”);

- ‘516 Patent. at 2:28-31 (“In the example of FIG. 1, the solar cell 100 includes a backside junction formed by a P-type doped polysilicon emitter 108 serving as a P-type diffusion region and an N-type silicon substrate 101 serving as an N-type diffusion region.”);
- ‘516 Patent at 3:47-4:10 (“FIG. 4, which comprises FIGS. 4A-4M, schematically illustrates the fabrication of the solar cell 100 in accordance with an embodiment of the present invention. In FIG. 4A, an N-type silicon substrate 101 is prepared for processing into a solar cell by undergoing a damage etch step…. In FIG. 4C, a P-type dopant source 461 is formed on the polysilicon emitter 108. As its name implies, the P-type dopant source 461 provides a source of P-type dopants for diffusion into the polysilicon emitter 108 in a subsequent dopant drive-in step.”)

A solar cell with a back surface field, where the substrate and a backside polysilicon layer are doped with the same dopant type, is nowhere disclosed in the ’516 Patent’s specification.

2. The ’053 Patent

Plaintiff contends in its Infringement Contentions for the ’053 Patent that “diffusing dopants from the first dopant source layer to the layer of polysilicon to form a backside junction with the silicon substrate” (independent claim 9) and “diffusing dopants into the layer of polysilicon to form a backside junction with the silicon substrate” (independent claim 16) cover diffusing dopants to form a back surface field where the substrate and a backside polysilicon layer are doped with the same dopant type. To the extent that Plaintiff’s Infringement Contentions are accepted, Claims 9 and 16 (and any claims depending therefrom) invalid for lack of written description.

The specification of the ’053 Patent does not contain written description support for the full scope of these claimed steps. The specification of the ’053 Patent discloses only that the “backside junction” is formed by diffusing dopants into the polysilicon emitter that are the *opposite* of the dopant type in the substrate. *See e.g.*,

- Abstract (“A bipolar solar cell includes a backside junction formed by an N-type silicon substrate and a P-type polysilicon emitter formed on the backside of the solar cell.”).
- ’053 Patent at 1:28-29 (“A solar cell includes P-type and N-type diffusion regions that form a junction.”)
- ’053 Patent at 1:53-55 (“Summary: A bipolar solar cell includes a backside junction formed by an N-type silicon substrate and a P-type polysilicon emitter formed on the backside of the solar cell.”);
- ’053 Patent. at 2:35-38 (“In the example of FIG. 1, the solar cell 100 includes a backside junction formed by a P-type doped polysilicon emitter 108 serving as a P-type diffusion region and an N-type silicon substrate 101 serving as an N-type diffusion region.”);
- ’053 Patent at 3:56-4:18 (“FIG. 4, which comprises FIGS. 4A-4M, schematically illustrates the fabrication of the solar cell 100 in accordance with an embodiment of the present invention. In FIG. 4A, an N-type silicon substrate 101 is prepared for processing into a solar cell by undergoing a damage etch step…. In FIG. 4C, a P-type dopant source 461 is formed on the polysilicon emitter 108. As its name implies, the P-type dopant source 461 provides a source of P-type dopants for diffusion into the polysilicon emitter 108 in a subsequent dopant drive-in step.”)

Making a solar cell with a back surface field, where the substrate and a backside polysilicon layer are doped with the same dopant type, is nowhere disclosed in the ’516 Patent specification.

Plaintiff also contends in its Infringement Contentions that diffusion of dopants into the polysilicon layer (e.g., claim 16) either from a dopant source layer (e.g., Claims 9, 12, 17-18) or diffusion of dopants “in-situ” (e.g., Claim 15) somehow does not require dopant diffusion. To the extent that Plaintiff’s Infringement Contentions are accepted, Claims 9 and 16 and any claims depending therefrom are also invalid for lack of written description for the full scope of the claims. The specification discloses only doping by diffusion, even in the situation when it is referring to diffusion in situ. *See e.g.*,

- ’053 Patent at 4:14-18 (“In FIG. 4C, a P-type dopant source 461 is formed on the polysilicon emitter 108. As its name implies, the P-type dopant source 461 provides a source of P-type dopants for *diffusion* into the polysilicon emitter 108 in a subsequent dopant drive-in step.”)
- ’053 Patent at 4:42-50 (“In FIG. 4F, an N-type dopant source 412 is formed on regions of the textured surface 113 where contact holes 120 (see FIG. 1) will be subsequently formed to allow subsequently formed metal contacts 102 to electrically connect to the substrate 101. As its name implies, the N-type dopant source 412 provides a source of N-type dopants for *diffusion* into the front side of the substrate 101. In one embodiment, the N-type dopant source 412 is formed by inkjet printing the dopant material directly onto the substrate 101.”)
- ’053 Patent at 4:60-66 (“In FIG. 4G, a *dopant drive-in step is performed to diffuse* N-type dopants from the N-type dopant source 412 into the substrate 101 to form

the N-type dope region 106, to *diffuse* P-type dopants from the P-type dopant source 461 to the polysilicon emitter 108, and to *diffuse* N-type dopants into the front side of the substrate 101 to form the N-type doped region 105.")

- '053 Patent at 5:9-27 ("The *drive-in step* to dope the polysilicon emitter 108 on the backside and to form the N-type doped regions 105 and 106 on the front side may be formed in-situ, which in the context of the present disclosure means a single manual (i.e., by fabrication personnel) loading of the substrate 101 in a furnace or other single chamber or multi-chamber processing tool. In one embodiment, the drive-in step is performed in a diffusion furnace. The preceding sequence of steps leading to the drive-in step allows for *in-situ diffusion*, which advantageously helps in lowering fabrication cost. It is to be noted that the step of using an N-type dopant source 412 to *diffuse* dopants into the N-type doped region 106 may be omitted in some applications. That is, in an alternative process, the formation of the N-type dopant source 412 in FIG. 4F may be omitted. In that case, the N-type doped regions 105 and 106 will be both doped by introduction of an N-type dopant in the *diffusion furnace* during the drive-in step. All other process steps disclosed herein remain essentially the same.").

The specification does not disclose doping of the polysilicon layer using a process other than by dopant diffusion in a diffusion furnace. It does not disclose a process wherein the dopant is added and incorporated into the polysilicon layer during deposition, which is called "in situ doping." "In-situ doping" is different from "in situ diffusion," as described by the '053 Patent.

3. The '315 Patent

Plaintiff contends in its Infringement Contentions for the '315 Patent that "a first emitter region" and "a second emitter region" (claims 10, 16) can include a polysilicon layer doped with

a single dopant type of the same type as the substrate. Plaintiff also contends that a "first metal contact formed over a first emitter region" and "second metal contact formed over a second emitter region" (claims 10, 16) can include a backside continuous metal contact of the same polarity. To the extent that Plaintiff's Infringement Contentions are accepted, Claims 10 and 16 (and any claims depending therefrom) are invalid for lack of written description.

The specification of the '315 Patent does not contain written description support for the full scope of the claims. The specification of the '315 Patent discloses only that the first and second emitter regions are two different regions of opposite dopant types. *See, e.g.*,

- '315 Patent at 6:54-57 ("the solar cell 300 can have first and second emitter regions 312, 314. In an example, the first and second emitter regions 312, 314 can be P-type and N-type doped polysilicon regions, respectively.");
- '315 Patent at 7:67-8:3 ("the solar cell 500 can have first and second emitter regions 512, 514. In an example, the first and second emitter regions 512, 514 can be P-type and/or N-type doped polysilicon regions, respectively.")

It follows that the first and second metal contacts formed respectively over the first and second emitter regions are also of opposite polarity.

The specification does not disclose that the first and second emitter regions can be formed of the same dopant type, or that the first and second metal contacts are of the same polarity.

Claims 10, 13-16, and 19 of the '315 Patent are also invalid for lack of written description to the extent that Plaintiff contends that a solar cell with a front dopant concentration above $2x10^{18}$ cm^{-3} falls within the scope of the claims.

B. The Asserted Claims Are Indefinite

1. The '315 Patent

Claims 10, 13-16, and 19 are also invalid for indefiniteness under 35 U.S.C. §112(b).

Independent claim 10 recites "a portion of the silicon substrate has a dopant concentration of approximately less than or equal to 2×10^{18} cm^{-3} and wherein the portion of the silicon substrate is formed at the front side of the solar cell." Specifically, the phrase "approximately less than or equal to 2×10^{18} cm^{-3}" is indefinite as the exact contours of what constitute "approximately … equal to 2×10^{18} cm^{-3}" cannot be ascertained by the person of ordinary skill in the art based on the claims, specification, or prosecution history. Moreover, the phrase "portion" at the "front side of the solar cell" is also indefinite as the contours of the this phrase cannot be ascertained by the person of ordinary skill in the art based on the claims, specification.

Claims 10, 13-16, and 19 of the '315 Patent are also invalid 35 U.S.C. §112(b) to the extent that Plaintiff contends that a solar cell with a front dopant concentration above $2x10^{18}$ cm^{-3} falls within the scope of the claims. A solar cell with a front dopant concentration above $2x10^{18}$ cm^{-3} is not what the inventors regard as their invention.

V. P.R. 3-4: DOCUMENT PRODUCTION ACCOMPANYING INVALIDITY CONTENTIONS

A. P.R. 3-4(a): Source code, specifications, schematics, flow charts, artwork, formulas, or other documentation sufficient to show the operation of any aspects or elements of an Accused Instrumentality identified by the patent claimant in its P. R. 3-1(c) chart

Accompanying its contentions, Canadian Solar is producing documents responsive to P.R. 3-4(a) with the following Bates numbers: CSIEDTX0007958-CSIEDTX0008225; CSIEDTX0023879-CSIEDTX0028036; CSIEDTX0022510-CSIEDTX0022511.

Canadian Solar provides disclosures and related documents pertaining only to the Asserted Claims as identified by Plaintiff in its Infringement Contentions. Canadian Solar will supplement its document production should it later find additional, responsive documents.

B. P.R. 3-4(b): A copy of each item of prior art identified pursuant to P. R. 3-3(a) which does not appear in the file history of the patent(s) at issue. To the extent any such item is not in English, an English translation of the portion(s)

relied upon must be produced.

Accompanying its contentions, Canadian Solar is producing documents responsive to P.R. 3-4(b) with the following Bates numbers: CSIEDTX0000001-CSIEDTX0007957; CSIEDTX0008395-CSIEDTX0008398; CSIEDTX0010625-CSIEDTX0010647; CSIEDTX12808-CSIEDTX22228; CSIEDTX0022520-CSIEDTX0023837.

Canadian Solar's search for prior art references, additional documentation, and/or corroborating evidence concerning prior art systems is ongoing. Accordingly, Canadian Solar reserves the right to continue to supplement its production as Canadian Solar obtains additional prior art references, documentation, and/or evidence concerning invalidity during the course of discovery.

VI. RESERVATION OF RIGHTS

Fact discovery is ongoing, and Canadian Solar has not obtained complete production of documents from Plaintiff and third party or deposition testimony from any of the named inventors of the Asserted Patents or any third party, including, without limitation, documents and deposition of Plaintiff and SunPower whose products or technologies are identified below as being prior art. Canadian Solar expects further discovery will reveal additional prior art, including related disclosures and corresponding evidence for many of the prior art references identified herein. As such, Canadian Solar has not yet completed its investigation, discovery or analysis of matters relating to the validity or enforceability of the Asserted Claims, including, without limitation, invalidity due to on-sale statutory bars, public use statutory bars, improper inventorship, or unenforceability due to inequitable conduct. The disclosures herein are not and should not be construed as a statement that no other persons have discoverable information, that no other documents, data compilations, and/or tangible things exist that Canadian Solar may use to support its claims or defenses, or that no other legal theories or factual bases will be pursued.

Accordingly, Canadian Solar reserves the right to amend, modify and/or supplement these Contentions as additional information is discovered, identified or otherwise appreciated, including testimony about the scope and content of the prior art and the claimed inventions.

These Contentions are based on Canadian Solar's present understanding of Plaintiff's Infringement Contentions served on Canadian Solar on July 12, 2024. Nothing in these Contentions should be regarded as conceding that Plaintiff's Infringement Contentions are legally or factually adequate or as necessarily reflecting the proper interpretation of the claims or an interpretation of the claims that Canadian Solar agrees with or proposes. Canadian Solar's Contentions raised herein may be conditionally raised in the alternative (e.g., where resolution of a particular claim construction or factual dispute (1) in one party's favor will result in non-infringement, or (2) in the other party's favor will result in invalidity). Canadian Solar disputes Plaintiff's apparent claim interpretations, to the extent that Plaintiff's apparent constructions can be understood, and Canadian Solar will identify claim constructions for specific claim terms under the Docket Control Order governing this case. To the extent additional information regarding Plaintiff's Infringement Contentions becomes available, Canadian Solar anticipates that it will provide corresponding invalidity contentions correlating Plaintiff's interpretation of the claims with the prior art and Canadian Solar may thus amend its Contentions accordingly as applicable.

Nothing in these Contentions shall be treated as an admission that any of Canadian Solar's accused products meets any limitation of the Asserted Claims. Canadian Solar denies that it infringes any claim of the Asserted Patents. To the extent that any prior art reference identified by Canadian Solar contains a claim element that is the same as or similar to an element in an accused product, inclusion of that reference in Canadian Solar's Contentions shall not be deemed

a waiver of any claim construction or non-infringement position. Any use of these Contentions to support any allegation of infringement would be misleading, false and wrong as a matter of law and fact.

The Court has not yet construed the Asserted Claims. Canadian Solar reserves the right to identify other prior art or to supplement its Contentions because Canadian Solar's positions on invalidity of certain claims may depend on how those claims are construed by the Court. Canadian Solar's Contentions are based, at least in part, on its present understanding of the claim constructions Plaintiff appears to be using—based on Plaintiff's Infringement Contentions—whether or not Canadian Solar agrees with such claim constructions. Further, to the extent that these Contentions reflect constructions of claim terms that may be consistent with or implicit in Plaintiff's Infringement Contentions, no inference is intended or should be drawn that Canadian Solar agrees with such claim construction(s) and contentions. Any statement or citation of prior art in these Contentions describing or tending to describe any claim element or comparing any claim element to a disclosure in prior art is provided for the purpose of understanding the relevant prior art, how the prior art may apply to the claims, and for responding to Plaintiff's apparent infringement positions, not for claim construction. Canadian Solar expressly reserves the right to (1) propose any claim construction that it considers appropriate, and (2) contest any claim construction it considers inappropriate.

Canadian Solar hereby reserves the right to incorporate by reference the testimony of any fact witnesses who are deposed, who provide declarations, or who otherwise testify in this lawsuit. Canadian Solar also reserves the right to incorporate by reference the reports and testimony of Canadian Solar's expert witnesses regarding invalidity of the Asserted Patents.

Canadian Solar further incorporates by reference any invalidity contentions served by other entities accused of infringing one or more of the Asserted Patents.

Canadian Solar further reserves the right to seek discovery regarding any alleged conception and reduction to practice dates, as appropriate, should these issues be raised, and to demonstrate earlier invention by other parties under 35 U.S.C. § 102(g). Canadian Solar further reserves the right to take discovery on the issues of improper inventorship and/or derivation under 35 U.S.C. § 102(f), public use and/or the on-sale bar under 35 U.S.C. § 102(b), and/or applicants' failure to comply with 35 U.S.C. § 112. Canadian Solar therefore reserves all rights to further supplement or amend these Contentions if and when further information becomes available.

Canadian Solar reserves all rights to further supplement or modify these Contentions, including the prior art disclosed and stated grounds of invalidity, pursuant to the Federal Rules of Civil Procedure and the Local Patent Rules. In addition, Canadian Solar reserves the right to prove the invalidity of the Asserted Claims on bases other than those required to be disclosed in these disclosures and contentions.

Dated: September 6, 2024

Respectfully submitted,

/s/ Samuel N. Tiu

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CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the above and foregoing document has been served electronically on all counsel of record via electronic service on September 6, 2024.

/s/ Samuel N. Tiu
Samuel N. Tiu