

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner

v.

MAXEON SOLAR PTE. LTD.,
Patent Owner

Case IPR2024-01038¹
U.S. Patent No. 11,251,315

PATENT OWNER'S RESPONSE

¹ IPR2024-01194 has been consolidated with the instant proceeding.

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PATENT OWNER'S EXHIBIT LIST

Exhibit	Description
2001	Declaration of David Carroll, Ph.D. in Support of Patent Owner Preliminary Response
2002	<i>Intentionally Left Blank</i>
2003	<i>Intentionally Left Blank</i>
2004	Results charted from DocketNavigator.com Document Search, run on October 8, 2024, for Motion to Stay Pending <i>Inter Partes</i> Review Decided by Judge Rodney Gilstrap
2005	Results charted from DocketNavigator.com Document Search, run on October 8, 2024, for Motion to Stay Pending <i>Inter Partes</i> Review Decided by Judge Rodney Gilstrap with "Stipulated/Agreed" Motions Removed
2006	Federal Court Management Statistics (June 30, 2024)
2007	Order Denying Maxeon Partial Motion to Dismiss (Dkt. 26), <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG (E.D. Tex.), July 3, 2024
2008	Docket Control Order (Dkt. No. 33), <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG (E.D. Tex.), August 7, 2024
2009	Canadian Solar Inc.'s Invalidity Contentions, <i>Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.</i> , Case No. 2:24-cv-00210-JRG (E.D. Tex.), September 6, 2024
2010	<i>Intentionally Left Blank</i>
2011	<i>Intentionally Left Blank</i>
2012	<i>Intentionally Left Blank</i>
2013	<i>Intentionally Left Blank</i>
2014	<i>Intentionally Left Blank</i>
2015	Granek et al., "Front surface passivation of n-type high-efficiency back junction silicon solar cells using front surface," <i>Solar Energy Materials and Solar Cells</i> , 91(7) (2007)

Exhibit	Description
2016	“Nanotechnology improves solar cell efficiency,” <i>EarthSky</i> , August 28, 2007 (accessible at https://earthsky.org/humanworld/nanotechnology-improves-solar-cell-efficiency ; last accessed October 14, 2024)
2017	“New Plastic Solar Cell Breaks Efficiency Record,” <i>ScienceDaily</i> , April 20, 2007 (accessible at https://www.sciencedaily.com/releases/2007/04/070419140902.htm), last accessed October 14, 2024)
2018	Capshaw-Mack, C., “Power Games: Project seeks to improve methods of harnessing solar energy,” <i>Winston-Salem Journal</i> , August 4, 2013 (accessible at https://journalnow.com/news/local/article_1d243ff0-fc9e-11e2-b607-001a4bcf6878.html ; last accessed October 15, 2024)
2019	<i>Intentionally Left Blank</i>
2020	Declaration of David L. Carroll, Ph.D. in Support of Patent Owner Preliminary Response for IPR2024-01194
2021	Declaration of David Carroll, Ph.D. in Support of Patent Owner Response for IPR2024-01038
2022	Transcript of deposition of Sanjay Banerjee, Ph.D. taken March 21, 2025
2023	Transcript of deposition of Sanjay Banerjee, Ph.D. taken March 20, 2025
2024	Lamers et al., “Towards 21% Efficient N-CZ IBC Based on Screen Printing,” <i>26th European Photovoltaic Solar Energy Conference and Exhibition</i> , (2011) (“Lamers”)
2025	Desa et al., “Optimization of p-type Screen Printed Interdigitated Back Contact Silicon Solar Cell with Aluminum Back Surface Field,” <i>International Journal of Engineering & Technology IJET-IJENS</i> , 14(2) (2014) (“Desa”)
2026	Procel et al., “Analysis of the Impact of Doping Levels on Performance of Back Contact – Back Junction Solar Cells,” <i>4th International Conference on Silicon Photovoltaics, SiliconPV 2014</i> , Italy, 2014, pp 128-132, ScienceDirect (“Procel”)

Exhibit	Description
2027	U.S. Patent No. 8,790,957 to Li et al.
2028	Schulz, M., "Interface States at the SiO ₂ -Si Interface," <i>Surface Science</i> 132 (1983)
2029	Aoki, M., et al., "Intrinsic Gettering of Iron Impurities in Silicon Wafer," <i>Japanese Journal of Applied Physics</i> , Vol. 30, No. 12B, pp. 3580-3583 (Dec. 1991)
2030	Ziebarth, B., et al., "Interstitial Iron Impurities at Grain Boundaries in Silicon: A First-Principles Study," <i>Physical Review B</i> 91 (2015)
2031	Portavoce A., et al., "Redistribution of Metallic Impurities in Si During Annealing and Oxidation: W and Fe," <i>Defect and Diffusion Forum</i> , Vol. 383, pp. 17-22 (2018)
2032	Hajjiah, A., et al., "The Impact of Interstitial Fe Contamination on N-Type Cz-Silicon for High Efficiency Solar Cells," <i>Solar Energy Materials & Solar Cells</i> 211 (2020)
2033	Coletti, G., "Sensitivity of State-of-the-Art and High Efficiency Crystalline Silicon Solar Cells to Metal Impurities," <i>Prog. Photovolt: Res. Appl.</i> 2013; 21:1163-1170 (2012)
2034	Castellanos S., et al., "Exceeding 3 ms Minority Carrier Lifetime in n-Type Non-Contact Crucible Silicon," <i>Energy Procedia</i> 92, pp. 779-784 (2016)
2035	Sopori, B., "Impurities and Defects in Photovoltaic Si Devices: A Review," <i>10th Int'l Workshop on the Physics of Semiconductor Devices</i> , Delhi, India, Dec. 13, 1999
2036	EAG Laboratories, "SIMS Detection Limits of Selected Elements in Si and SiO ₂ Under Normal Depth Profiling Conditions"
2037	Haarahiltunen, A., et al. "Detection of Iron Contamination in Internally Gettered P-Type Silicon Wafer by Lifetime Measurements"
2038	Liu, A., et al, "Understanding the Impurity Gettering Effect of Polysilicon/Oxide Passivating Contact Structures Through Experiment and Simulation," <i>Solar Energy Materials and Solar Cells</i> 230 (2021)

Exhibit	Description
2039	Declaration of Dr. Mary K. Bolin

I. INTRODUCTION

Each of Petitioner's four grounds should be rejected for multiple reasons.

First, all grounds rely on the erroneous contention that metal impurities in the substrate of Li migrate out of the substrate, through Li's oxide layer, and into Li's material layer. Petitioner relies on inherency for this contention. However, Petitioner fails to adduce evidence sufficient to show that any metal impurities in Li's substrate necessarily would travel through the layers and interfaces that Petitioner's theory demands. Although Petitioner presents Grounds 3 and 4 ostensibly as obviousness alternatives to Grounds 1 and 2 (which explicitly rely on inherency), upon inspection, the back-up grounds are nothing more than repackaged versions of Grounds 1 and 2. Thus, all grounds should be rejected for this failure alone.

Second, Grounds 1 and 3 suffer from the additional deficiency that it would not have been obvious to implement the dopant concentration of $1 \times 10^{18} \text{ cm}^{-3}$ that is disclosed in King, Swanson-352, and Marvin. Those values are design-specific, and Petitioner does not explain why it would have been obvious to import that design parameter from the secondary references into Li. This failure is especially pronounced in view of stark differences between the three secondary references and Li. Indeed, Li is more similar to other references that disclose dopant

concentrations outside of the claimed range. This is an independent basis on which to reject Grounds 1 and 3.

Third, Grounds 2 and 4 should be rejected for the additional reason that it would not have been obvious to combine Li and Muller in the fashion proposed by Petitioner. Drastic changes to Li are necessary to arrive at the Li-Muller combination, and Petitioner fails to put forward any legitimate benefits to such modifications much less benefits sufficient to outweigh the drawbacks that would attend the modifications. Indeed, the combination appears to have been driven by hindsight. This is an independent basis on which to reject Grounds 2 and 4.

Technical facts cited in this Response are supported by the declaration testimony of Patent Owner's expert Dr. David Carroll. *See generally* Ex. 2021.

II. THE '315 PATENT

A. Solar Cell Background

The '315 patent is directed to a solar cell. Simply, a solar cell converts energy from sunlight, i.e., electromagnetic energy, into electricity. This conversion takes place when a photon strikes a solar cell—often made of silicon—and dislodges an electron (also thereby creating a “hole” or electron vacancy). Ex. 2021, ¶ 32. Ideally, the dislodged electrons do not recombine with holes before migrating to an emitter, which is connected to an electric circuit. *Id.* Such electrons would then flow through the circuit and rejoin with the holes, but only

after travelling through the circuit and thereby providing electrical power. *Id.*

Solar cells often reside in a solar panel. Ex. 2021, ¶ 33. This allows the electricity of multiple solar cells to be joined into a single device. *Id.*

A solar cell designer is often concerned with numerous attributes, for example, mechanical reliability, cost, and efficiency. Ex. 2021, ¶ 34. “Efficiency” in the solar field refers to the ratio of energy that is output by a solar cell relative to the amount of energy in the sunlight that it receives. *Id.* In 2014—the time of the invention of the ’315 patent—solar cells often had efficiencies of around 20%. *Id.* Two factors that heavily influence efficiency are “lifetime” and “passivation.” The term “lifetime” refers to the time during which a dislodged electron lasts before “recombining” with a hole. *Id.* If an electron recombines before it is collected at the emitter and travels through the circuit, no electric power is harnessed from that electron. *Id.* A “lifetime” is often much less than one second. *Id.* A longer lifetime translates into a greater chance for an electron to be harnessed as useful electricity before prematurely recombining with holes. *Id.* This increases efficiency.

Two techniques to reduce recombination and thereby increase lifetime (and thus efficiency) are “passivation” and “doping.” Ex. 2021, ¶ 35.

Passivation is the process of covering a surface of a substrate with a material (often an oxide) to reduce recombination at the surface. Ex. 2021, ¶ 36. Electrons

and holes tend to recombine at such surfaces due to “dangling bonds” at a material’s surface. *Id.* Simply, a “dangling bond” refers to a valence band of electrons that is not fully satisfied (or “filled”). *Id.* This has the tendency to attract electrons or holes. *Id.* The idea behind passivation is to satisfy or fill the valence bands thereby reducing or eliminating their tendency to attract electrons or holes. *Id.*

Doping is the introduction of a charged impurity into the substrate. Ex. 2021, ¶ 37. This charge will repel one of either an electron or hole, but not the other. *Id.* This repulsion helps maintain separation of electrons and holes, i.e., it prevents recombination, thereby increasing lifetime and efficiency. *Id.*

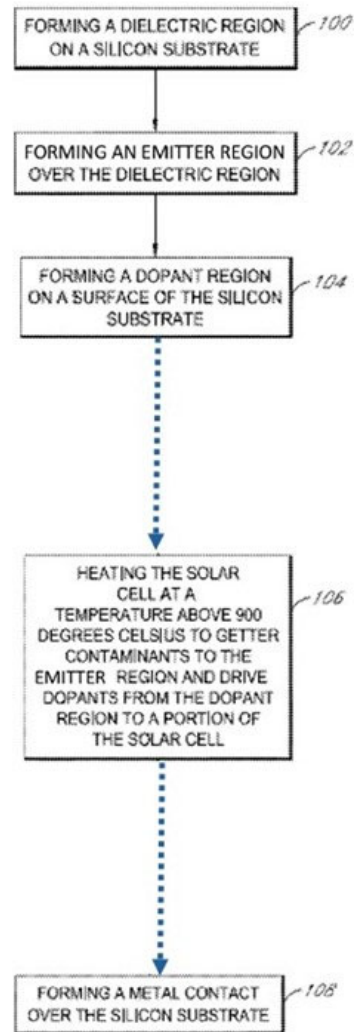
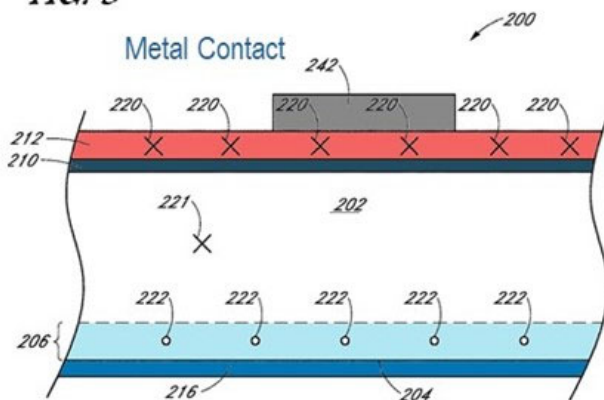
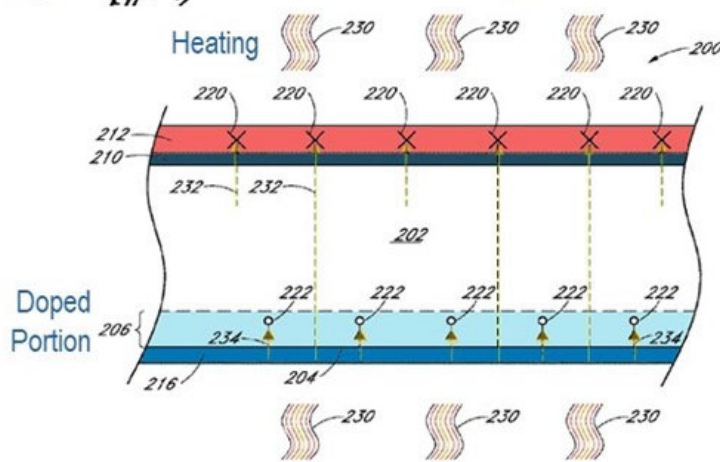
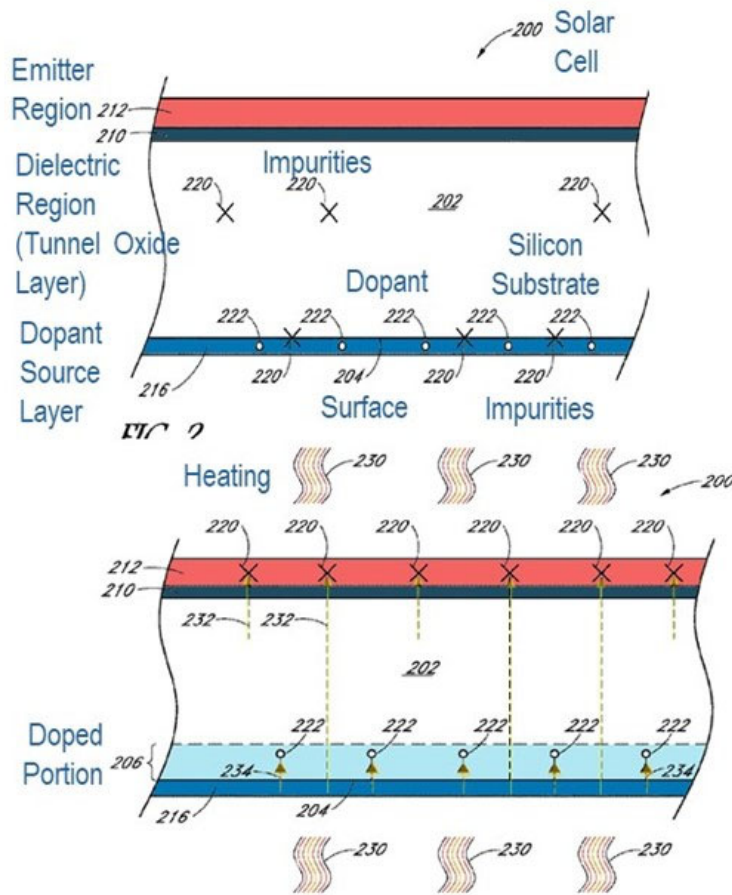
Another impediment to solar efficiency is the presence of impurities (e.g., metals) within the silicon substrate. Ex. 2021, ¶ 38. Two common ways of reducing such impurities were to (1) begin with pure or near pure (“impurity free”) substrates or (2) remove the impurities through a process called “gettering.” *Id.*

B. The '315 Patent's Novel Solar Cell Fabrication Technique

The '315 patent is directed at improving solar cell lifetime, passivation, and/or efficiency in tunnel oxide passivated contact ("TOPCon")² solar cell configurations. '315 patent, 3:17-21.

The '315 patent discloses a solar cell fabricated by the following steps: (1) forming a dielectric region (e.g., a tunnel oxide layer) over a silicon substrate, (2) forming an emitter region over the dielectric region, (3) forming a dopant region (e.g., a dopant source layer) on a surface of the silicon substrate, and (4) heating the solar cell above 900°C such that (i) the surface of the solar cell is doped to a concentration of less than or equal to $2 \times 10^{18} \text{ cm}^{-3}$ and (ii) the emitter region contains contaminants gettered from the silicon substrate through the dielectric region. These fabrication steps are illustrated as follows:

² The TOPCon moniker appears to have been coined in 2013 by researchers at the Fraunhofer Institute for Solar Energy Systems. However, SunPower—the original assignee of the '315 patent—had been developing and optimizing solar cells employing tunnel oxide layers between a silicon substrate and doped polysilicon regions prior to that date.



'315 patent, Figs. 1-4 (annotated).

The '315 patent explains that this particular combination of steps increased efficiency in a unique and unexpected way. The inventors of the '315 patent

examined four processes under which the heating temperature and surface dopant concentrations were altered. The gettering location, surface passivation, lifetime, and efficiency results were measured. The results are reflected in Figure 11 of the '315 patent.³

Variables			Results			
Example Process	Temp	Surface Dopant Conc.	Gettering Location	Surface Passivation	Lifetime	Efficiency
A	≤ 900 deg-C	$2 \times 10^{18} \text{ cm}^{-3}$	non-poly	2 fA/cm^2	$\sim 3 \text{ msec}$	Baseline
B	≤ 900 deg-C	$4 \times 10^{18} \text{ cm}^{-3}$	non-poly	5 fA/cm^2	$\sim 10 \text{ msec}$	Baseline
> 900 deg-C C	≤ 900 deg-C	$2 \times 10^{18} \text{ cm}^{-3}$	poly	2 fA/cm^2	$\sim 10 \text{ msec}$	+0.5 % abs.
> 900 deg-C D	≤ 900 deg-C	$4 \times 10^{18} \text{ cm}^{-3}$	poly	5 fA/cm^2	$\sim 10 \text{ msec}$	Baseline

Table 1. Example Processes for Solar Cell Fabrication

'315 patent, Fig. 11 (annotated).

In Example Process A, the solar cell was heated at a relatively low temperature (i.e., $\leq 900^\circ\text{C}$) and the substrate was doped at a relatively low concentration (i.e., $2 \times 10^{18} \text{ cm}^{-3}$). The '315 patent explains that “[o]xides and/or

³ The parties agree that Figure 11 includes a typographical error and that the temperature for Example Processes C and D should show that the temperature was greater than 900°C . See Petition at 8 n.1; Paper 28 at 13 n.3; Ex. 1002, p. 43; Ex. 2021, ¶ 40 n.4.

tunnel oxides, such as the dielectric region . . . can be barriers to gettering of the metal impurities 220 to emitter regions” and that “heating at temperature at 900 degrees Celsius or below can be insufficient to diffuse metal impurities through a tunnel oxide and into a polysilicon region.” ’315 patent, 5:15-20. Accordingly, the “Gettering Location” for Example Process A is the “non-poly” silicon substrate, rather than the “poly” emitter region. The combination of variables in Example Process A yielded good surface passivation but poor lifetime.

Example Process B also uses low temperature heating, but a relatively high surface dopant concentration (i.e., $4 \times 10^{18} \text{ cm}^{-3}$). Like Example Process A, the gettering location remains in the “non-poly” silicon substrate. The variables of low temperature and relatively high surface dopant concentration results in a good lifetime, but poor surface passivation. Example Processes A and B demonstrate the kind of trade-offs that are made when designing solar cells. Having a low surface dopant concentration may result in good surface passivation but poor lifetime; whereas a high surface dopant concentration may result in good lifetime but poor surface passivation. For both Example Processes A and B, the efficiency of the solar cell remained at the same baseline level.

The unexpected result came from Example Process C, where high-temperature (i.e., $> 900^{\circ}\text{C}$)⁴ heating and low surface dopant concentration are used. In this process, contaminants from the silicon substrate gettered through the dielectric region and into the “poly” emitter region. At the time of the invention, it was not known whether high-temperature heating would getter impurities through the dielectric region, while leaving this region intact and functional. Ex. 2021, ¶ 43. Further, a person of ordinary skill in the art would not have expected lifetime to improve by high-temperature heating because the silicon substrate also contains oxygen defects, which would be enlarged at higher temperatures and increase the likelihood of Ingot Ring Defects, which would reduce lifetime. *Id.* Notably, as the results of Example Process C show, surface passivation and lifetime both improved, resulting in a 0.5% increase in efficiency over the other example processes.

In Example Process D, a high-temperature (i.e., $> 900^{\circ}\text{C}$) was used, but this did not further improve the lifetime beyond what a high surface dopant concentration already produced in a TOPCon solar cell configuration (e.g., Example Process B). Thus, Example Process D demonstrates that high-

⁴ As noted in the preceding footnote, Figure 11 includes a typographical error. The temperature for Example Processes C was greater than 900°C .

temperature heating alone does not yield improved efficiency, but instead that such heating should be performed with a relatively low dopant concentration. Thus, the '315 patent requires a specific combination of fabrication steps and dopant concentration to improve the performance of the TOPCon solar cell structure.

C. Prosecution of the '315 Patent

The '315 patent issued from an application that was the fifth in a chain of applications. '315 patent, Field (60). That chain of applications underwent thorough examination. Certain aspects of the claims of the '315 patent were the subject of rejections and argument during the prosecution of the preceding four applications. All applications in the chain were deemed allowable. *Id.*

The application from which the '315 patent issued was filed on May 18, 2020, and claims priority through the chain to an application filed on December 22, 2014. '315 patent, Fields (22), (60). Petitioner does not dispute that the disclosure in the first application fully supports the challenged claims of the '315 patent. Accordingly, the date of invention for this proceeding is December 22, 2014.

III. THE LEVEL OF ORDINARY SKILL

For purposes of this IPR, Patent Owner accepts the level of ordinary skill in the art that is proposed in the Petitions. *See* Paper 1 (IPR2024-01038 Petition) at 5-6; Paper 28 (IPR2024-01194 Petition) at 11.⁵

IV. CLAIM CONSTRUCTION

Patent Owner applies the plain and ordinary meaning of the claim terms as those terms would have been understood by a person of ordinary skill in the art at the time of the invention.

V. THE GROUNDS

This Response follows the numbering of the grounds that Petitioner provided in (i) the table on page 5 of Paper 1 (IPR2024-01038 Petition) and (ii) the table on pages 3-4 of Paper 28 (IPR2024-01194 Petition). Those two tables may be consolidated as follows:

Ground	Claims Challenged	35 U.S.C. §	References/Basis
1	10-12, 15, 16, 19	103	Li combined with King or Swanson-352 or Marvin
2	10, 13-16, 19	103	Li combined with Muller

⁵ Unless otherwise indicated, references to papers and exhibits by number refer to the numbering in IPR2024-01038.

Ground	Claims Challenged	35 U.S.C. §	References/Basis
3	10-12, 15, 16, 19	103	Li combined with King or Swanson-352 or Marvin, in further view of Hu, Ramappa
4	10, 13-16, 19	103	Li combined with Muller, in further view of Hu, Ramappa

VI. PETITIONER HAS NOT SHOWN THAT ANY CHALLENGED CLAIM IS UNPATENTABLE

All of Petitioner's grounds fail to satisfy two limitations of claim 10 of the '315 patent – (1) “a first emitter region having metal impurities formed over the dielectric region” and (2) “wherein a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2 \times 10^{18} \text{ cm}^{-3}$.” All of claims 11-16 and 19 depend directly or indirectly from claim 10. Accordingly, Petitioner fails to show that any of the challenged claims is unpatentable.

A. Li Does Not Inherently Disclose “a first emitter region having metal impurities formed over the dielectric region”

All grounds rest on the faulty premise that Li necessarily includes metal impurities in its material layer 506. Inherency is a “high standard.” *PAR Pharm., Inc. v. TWI Pharms., Inc.*, 773 F.3d 1186, 1195-96 (Fed. Cir. 2014). Specifically, a party that relies on inherency must show that “the limitation at issue is the *natural result* of the combination of prior art elements. *Id.* at 1195 (emphasis added) (internal quotations omitted). “The mere fact that a certain thing *may* result from a

given set of circumstances is not sufficient to render the result inherent.”

Millennium Pharms., Inc. v. Sandoz Inc., 862 F.3d 1356, 1367 (Fed. Cir. 2017)

(emphasis added) (internal quotations omitted). Inherency is not proven by

showing that a particular feature would be more cost-effective. *TC Tech. LLC v.*

Sprint Corp., 379 F. Supp. 3d 305, 322 (D. Del. 2019). Inherency also is not

proven when a result, if present, would be “undetectable.” *In re Seaborg*, 328 F.2d

996, 999-1000 (C.C.P.A. 1964) (“The record before us . . . is replete with showings

that the claimed product, if it was produced in the Fermi process, was produced in

such miniscule amounts and under such conditions that its presence was

undetectable.”). Similarly, an unrecognized *de minimis* quantity is not sufficient.

Crown Packaging Tech., Inc. v. Ball Metal Beverage Container Corp., 635 F.3d

1373, 1383 (Fed. Cir. 2011).

Petitioner fails to show that any metal impurities that are originally present in Li's substrate 508 would travel to Li's material layer 506 in a recognized and non-*de minimis* amount. Petitioner concedes that Li does not disclose that material layer 506 includes metal impurities. Instead, Petitioner relies on a series of faulty assumptions in arguing that metal impurities would necessarily be introduced into Li's material layer 506. Each of these errors serves as an independent basis to reject Grounds 1 and 2.

1. *Petitioner Improperly Assumes that Li's Substrate Will Include a "Quite Large" Level of Metal Impurities*

Petitioner's inherency argument heads in the wrong direction from the start. Petitioner theorizes that Li's substrate 508 necessarily includes "**substantial** metal impurities" because such levels of impurities allegedly "were known to exist in **all** such [single crystalline or multicrystalline silicon] substrates." Petition at 45-46 (emphasis added); *accord* Paper 28 at 47-48. For support, Petitioner cherry picked a reference that mentions that some materials have 10^{14} - 10^{16} cm⁻³ levels of iron impurities. Petition at 18 (citing Ex. 1016); Paper 28 at 20 (same). However, Petitioner's expert, Dr. Sanjay Banerjee, conceded that the reference discusses a "quite large" level of impurities. Ex. 2022 at 84:2. Dr. Banerjee admitted that he did not search for what **low** levels of metal impurities were in 2014, nor did he know what level that may have been. *Id.* at 84:13-16.

Li's silicon substrate need not include the "quite large" level of impurities that Petitioner assumes. In 2014 substrates with impurity concentrations as low as 10^{11} or 10^{12} were widely known. Ex. 2021, ¶ 52. Li does not disclose that its substrate 508 includes any metal impurities and certainly does not disclose that substrate 508 has the "substantial" or "quite large" levels of impurities that Petitioner presumes. Indeed, the evidence surrounding Li suggests that substrate 508 would **not** include high levels of impurities. Neuhaus (Ex. 1011) states that "the IBC [Interdigitated Back Contact] solar cell design requires extraordinarily

high lifetime silicon starting material” and “SunPower is using wafers with lifetimes greater than 1 millisecond and a thickness of 200 μm .” Ex. 1011 at 11. SunPower is identified as the assignee of the Li patent at the time of its issuance. Ex. 2027 at Field (73) (Assignee: SunPower Corporation). Thus, not only is Li silent regarding Petitioner’s asserted “high” impurity concentration, but it could have been premised upon the use of “extraordinarily high lifetime silicon starting material.” Such material would have had relatively low impurities. Ex. 2021, ¶ 53.

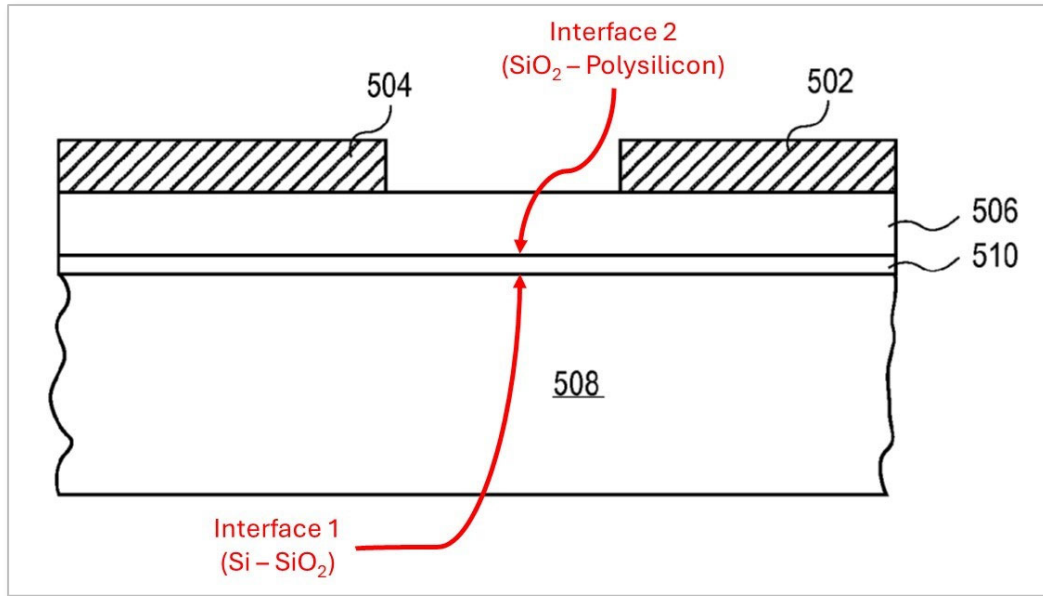
Dr. Banerjee’s opinions based on perceived “costs” are unsound. That a particular feature would be more cost-effective is not probative of inherency. *TC Tech.*, 379 F. Supp. 3d at 322. Dr. Banerjee ignores that principle when he discusses silicon “that’s made more cheaply” than other available alternatives and that accepting more impurities is “the price you pay for the lower cost.” Ex. 2022 at 76:4-10. Similarly, Dr. Banerjee errs in considering “the bounds of reasonable cost . . . [b]ecause all products are cost-sensitive.” *Id.* at 82:1-3. Providing a more efficient solar cell may mean that Li does not need to be “cost-sensitive” as Dr. Banerjee appears to assume.

Petitioner’s error in this regard undermines its inherency allegations. Whether metal impurities would necessarily migrate from Li’s substrate 508 to Li’s material layer 506—and if so whether that amount would rise beyond an

undetectable *de minimis* amount—depends on the initial impurity concentration in Li's substrate 508. Ex. 2021, ¶ 50. This is because diffusion is related to the differential in concentration. *Id.* Dispersed material (e.g., impurities in a matrix) diffuse from regions of high concentration to regions of lower concentration. *Id.*; *see also* Ex. 2022 at 154:9-10. Generally, the smaller the difference between the higher and lower concentrations, the less diffusion occurs. Ex. 2021, ¶ 50. By improperly assuming a “substantial” or “quite large” level of impurities, Petitioner sets itself up to believe that metal impurities are in Li's material layer 506 when they are not necessarily there.

2. Petitioner Ignores “Pileup” at Interfaces

Petitioner fails to account for a “pileup” effect that would occur at two interfaces in Li's system. Even if Li's substrate 508 included impurities, and even if those impurities were forced out of Li's substrate 508 during Li's dopant diffusion step, such impurities would be required to traverse two interfaces before reaching Li's polysilicon material layer 506: (1) the interface of substrate 508 and dielectric film 510, and (2) the interface of dielectric film 510 and material layer 506. Ex. 2022 at 68:13-21. These are illustrated below.



Ex. 1005, Fig. 5A (annotated).

Petitioner fails to show that impurities would pass over either interface. Either Petitioner assumes (incorrectly) that impurities would pass over the interfaces without restriction, or Petitioner failed to consider the interfaces at all. Either way, Petitioner's analysis is fatally flawed.

Interfaces serve as “impurity sinks,” i.e., locations where impurities permanently deposit. Ex. 2022 at 78:3-79:4, 141:3-7. This phenomenon is known as “pileup” and is a result of the misalignment of the electronic bands and energy levels of the two materials. Ex. 2021, ¶ 55. Imperfections in the interface, which are often quite high, especially in the case of the Si-SiO₂ interface (Interface 1, above), can lead to an assortment of energy states within the bandgap of the semiconductor. Thus, charge will become trapped at the interface, and atoms

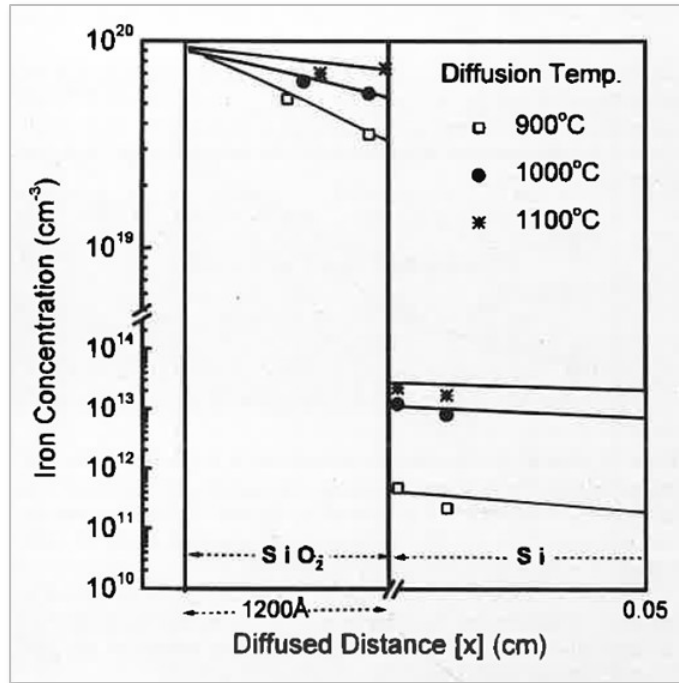
attempting to pass through the interface will become captured through donation or acceptance of those charges. Ex. 2028 at 422-23. The imperfections depend on many factors, including the method and temperature of the silicon dioxide (SiO₂) film formation, the quality of the surface of the silicon substrate (which is formed by cutting a cylindrical ingot into disc-like wafers), and the temperature of subsequent annealing steps.

Ramappa (upon which Petitioner relies) explains the pileup phenomenon well. Ramappa discloses that the interface between silicon dioxide and silicon “is known to act as a sink for impurities.” Ex. 1025, p. 3775. Similarly, Ramappa states as follows:

Metallic impurities including iron have been reported to have a tendency to *accumulate* in the oxide near the interface. This “*pileup*” *characteristic* introduces a discontinuity in the concentration profile of iron from the oxide into silicon.

Ex. 1025, p. 3775 (emphasis added).

Thus, Ramappa makes clear that iron impurities do not freely travel across a Si-SiO₂ interface; rather, they tend to accumulate there. This phenomenon is illustrated in Figure 5 of Ramappa:



Ex. 1025, Fig. 5.

As shown above, concentrations of iron were measured under three different diffusion temperatures. On one side of the Si-SiO₂ interface, those measurements are on the order of 10¹⁹ cm⁻³. Ex. 2021, ¶ 59. By contrast, the concentrations on the other side of the interface are as low as approximately 2×10¹¹ cm⁻³ and at most approximately 2×10¹³ cm⁻³. *Id.* Thus, Ramappa shows that iron concentrations in a silicon dioxide layer and a silicon substrate differ by more than **six to eight orders of magnitude**. With particular reference to the concentrations at 900°C, the lowest measured value in the SiO₂ is above 3×10¹⁹ cm⁻³, and the highest measured value in the Si was approximately 5×10¹¹ cm⁻³. *Id.* That is a difference of a factor of over sixty million (60,000,000). *Id.* Stated differently, for every 60,000,000

atoms of iron measured on one side of the SiO₂-Si interface, only one atom was measured on the other side. *Id.*

Accounting for the “pileup” phenomenon, and applying Ramappa’s teaching in particular, defeats Petitioner’s gettering argument. Assuming a beginning impurity concentration in Li’s substrate of $1 \times 10^{11} \text{ cm}^{-3}$, a decrease in concentration across the SiO₂-Si interface by a factor of sixty million (as Ramappa teaches) would result in a concentration in the silicon oxide layer of $\sim 1.67 \times 10^3 \text{ cm}^{-3}$. Ex. 2021, ¶ 60. Even if there were perfect gettering through the silicon oxide layer (an assumption that is highly charitable in favor of Petitioner), assuming a similar decrease across the SiO₂-polysilicon layer would result in a concentration in the polysilicon of approximately $2.7 \times 10^{-5} \text{ cm}^{-3}$, i.e., 2.7 atoms of iron per 100,000 cubic centimeters of silicon.⁶ *Id.* This is far less than one atom per cubic centimeter. Such *de minimis* amounts would be far less than could be detected by any reasonable detection means. *Id.* For example, Liu-1 shows that the detection limit for iron is $5 \times 10^{15} \text{ cm}^{-3}$. Ex. 1028, Fig. 4; *see also* Ex. 2022 at 128:8-130:1

⁶ The actual value likely is much lower at least because the duration of the heating step in Li is likely much shorter than that of Ramappa. *See* section VI.A.3 *infra*; *see also* Ex. 2021 at ¶ 61.

(Dr. Banerjee admitting that the detection limit of iron impurities in Liu-1 is 5×10^{15} cm⁻³).

Both Petitioner and Dr. Banerjee ignore the pileup phenomenon. Instead, Petitioner erroneously concludes that because Ramappa reported that iron diffuses across a 2 nm distance in silicon oxide (albeit with some change in concentration), metal impurities necessarily would have diffused “across the thin silicon oxide layer” of Li. Petition at 48; Paper 28 at 50. That is an overly simplistic analysis because it ignores the “pile up” characteristic of the substrate-oxide interface.

When cross-examined on the issue, Dr. Banerjee failed to adequately explain away his failure to consider pileup. He readily admitted that he did not consider the phenomenon. Ex. 2022 at 68:22-69:4. Curiously, he testified that “in some sense it’s irrelevant.” *Id.* at 69:4-5. Dr. Banerjee stated that the “important thing” is the removal of impurities from the substrate; thus, whether impurities are “stuck in the polysilicon emitter or the interface within the polysilicon and the oxide interface ***I don’t believe would matter.***” Ex. 2022 at 69:5-11 (emphasis added).

Dr. Banerjee is wrong. In an obviousness analysis, even claim limitation must be satisfied. *Kimberly-Clark Corp. v. Johnson & Johnson*, 745 F.2d 1437, 1448 (Fed. Cir. 1984) (“The proper approach to the obviousness issue must start with the claimed invention ***as a whole.***”) (emphasis in original). Thus, while determining whether impurities reached Li’s material layer 508 may not have “mattered” to Dr.

Banerjee, it should have. Indeed, only by analyzing the extent of pileup would one be able to determine whether any metal impurities that begin in Li's substrate 508 would necessarily getter to Li's material layer 506. Ex. 2021, ¶ 62. It matters because this is a requirement of claim 10, i.e., "a first emitter region *having metal impurities* formed over the dielectric region." Ex. 1001, col. 10, lines 59-60 (emphasis added).

3. *Petitioner Failed to Consider the Duration of Li's Dopant Diffusion Step*

Petitioner ignored a key parameter of Li that would impact any alleged gettering—the duration of Li's dopant diffusion step. Petitioner points to that step, which occurs at approximately 950°C, as the period during which gettering occurs. Petition at 51; Paper 28 at 53. However, Li does not disclose the time duration during which its solar cell is exposed to that temperature. That detail is critical to whether any impurities in Li's substrate 508 would, during the dopant diffusion step, (i) getter out of Li's substrate 508, (ii) migrate across the Si-SiO₂ interface, (iii) getter through oxide layer 510, (iv) migrate across the SiO₂-polysilicon interfacial region, and (v) become trapped in Li's material layer 506. Ex. 2021, ¶ 84.

Petitioner's failure to consider this key variable is fatal to its inherency argument. Petitioner has not and cannot show that metal impurities necessarily would take the journey that Petitioner's theory requires during Li's dopant

diffusion step when it fails to show the duration of that step. Dr. Banerjee admits that time is a key factor in determining the extent of impurity diffusion. Ex. 2022 at 69:20-22 (“For gettering to happen, you have to allow the metal impurities to diffuse, which depends on *the time* and the temperature.”) (emphasis added). Patent Owner's expert Dr. Carroll agrees. Ex. 2021, ¶¶ 84-85.

Furthermore, the evidence indicates that Li's dopant diffusion step likely would be much shorter than the durations used in the references that allegedly show gettering. Specifically, while Petitioner ignores the issue of duration, Dr. Banerjee comes somewhat close to suggesting a duration in a footnote of his declaration. Dr. Banerjee cites a “Handbook of Photovoltaics” for the contention that Li's dopant diffusion step may have lasted 5-15 minutes. Ex. 1003, ¶ 107 n.1; Ex. 1100, ¶ 109 n.2. Dr. Banerjee stops short of contending that those times necessarily would have been involved in the process of Li. Instead, he testified only that “[i]t probably would have been in that range.” Ex. 2022 at 92:5-6. Dr. Carroll opines that the dopant diffusion step in Li could reasonably be as short as 5 minutes, although Li's failure to specify other parameters makes determining the precise duration uncertain. Ex. 2021, ¶ 87. Both experts agree that Li's dopant diffusion step would not be prolonged beyond the time necessary to introduce dopants to Li's material layer 506. Ex. 2021, ¶ 88; Ex. 2022 at 93:20-94:5.

Regardless, under either expert's estimation, Li's dopant diffusion step would have been only a fraction of the durations examined in the references upon which Petitioner relies. Ramappa discloses heating samples for 90 minutes. Ex. 1025, p. 3773 ("Iron at the surface of the SiO₂ was then diffused by thermal annealing in a nitrogen ambient for *a duration of 90 min* at several temperatures over the range of 700-1100°C.") (emphasis added). Hu does not disclose a duration in the portion cited in the Petition⁷ (i.e., Ex. 1017, 5:61-6:6); however, in an example cited by Dr. Banerjee in his deposition, wafers were oxidized at 970°C for 70 minutes. Ex. 1017, 8:24-28 ("These were then oxidized at 970° C in the ambients, sequentially dry oxygen for *5 minutes*, steam *60 minutes*; and dry oxygen *5 minutes* to form 2700 Angstroms of SiO₂ films on both sides of each wafer."). Liu-1 and Liu-2 disclose heat treatment processes that occur over a total of 78 minutes. Those references disclose that samples were loaded in furnaces at 700°C, the temperature was ramped up at the rate of 10°C per minute until 890°C was achieved (this would take 19 minutes), the temperature was held for 40 minutes, and then the temperature was ramped down at the rate of 10°C per minute until it reached 700°C (this would take another 19 minutes). Ex. 2021, ¶ 89 (*citing*

⁷ References to "the Petition" refer to Paper 1 in IPR2024-01038.

Ex. 1028, p. 2776 and Ex. 1029, p. 137). These figures are summarized in the table below.

Reference	Duration of Heat Treatment
Ramappa	90 minutes
Hu	70 minutes
Liu-1 / Liu-2	78 minutes
Li	Unspecified – as short as 5 minutes

The disparity in the duration between Li's dopant diffusion step on the one hand and the Ramappa's, Hu's, and Liu's durations on the other hand undermines Petitioner's contention that gettering necessarily would have occurred in Li.

Indeed, whether impurities in Li's substrate 508 would even make it to the Si-SiO₂ interface is heavily dependent on the duration at which the substrate is exposed to elevated temperatures. Any impurities in Li's substrate likely would not all be on the top surface of the substrate. Ex. 2021, ¶ 85. In fact, due to surface cleaning operations that were common in 2014, it is possible that fewer impurities would have been at the surface of substrate 508 than in the interior of substrate 508. *See, e.g.,* Ex. 1011 at 2 ("After etching, the wafer is cleaned to remove metal and organic contaminants that would cause an increase of surface

and bulk recombination during the following high-temperature process steps.”);

see also Ex. 2021, ¶ 85.

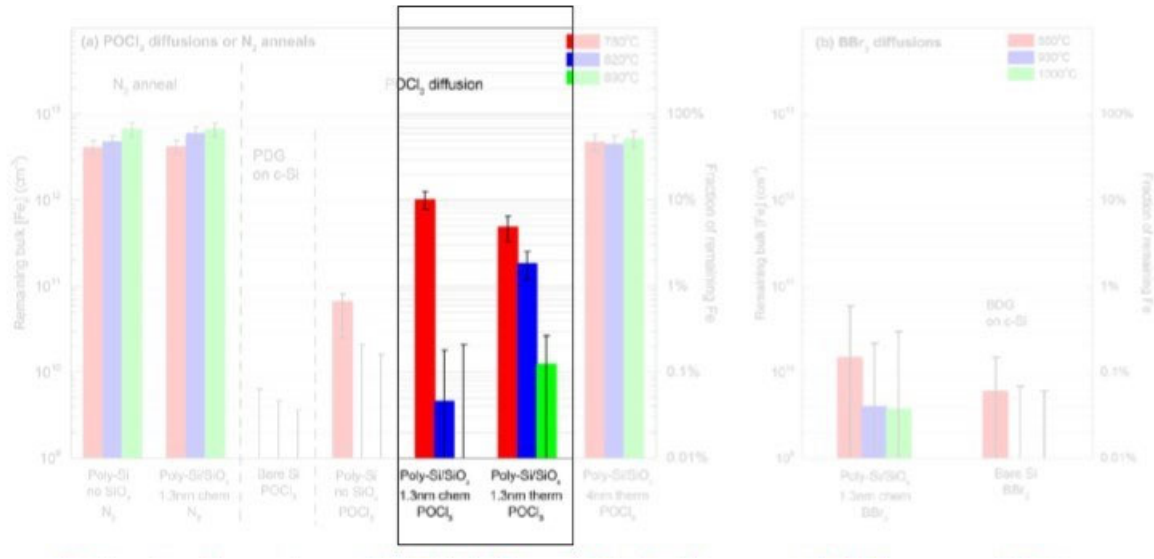
Petitioner's failure to consider the duration of Li's dopant diffusion step defeats its inherency contention.

4. *Petitioner Failed to Consider Key Characteristics of Li's Dielectric Film 510*

Petitioner failed to acknowledge that certain characteristics of Li's dielectric film 510 will impact its diffusivity and thus impact whether any metal impurities in Li's substrate 508 travel to Li's material layer 506. Specifically, Petitioner failed to consider the method of formation of Li's dielectric film 510 or the thermal history of that layer.

The method of formation of a dielectric layer can have a profound impact as to whether impurities will get through that layer. As Dr. Carroll explains, this is because a variety of variables contribute to the atomic order at the interface during formation, including temperature, time, and partial pressures of O₂. Ex. 2021, ¶ 92. Altering the values of these variables results in significant differences in the interface structure and internal stresses of a layer. *Id.* These differences translate to different diffusion characteristics. *Id.*

Liu-2 confirms Dr. Carroll's statements.



Ex. 1029, Fig. 3 (modified, annotated).

As shown above, gettering is more effective at higher temperatures (blue and green bars) in the presence of a chemically-grown oxide layer than for a thermally grown layer, all other things being equal. Liu-2 speculates as to the reason for this difference when it states that “[t]he different gettering effectiveness of the chemical and thermal oxides of the same thickness likely relate to the different oxide density achieved by the two growth methods.” Ex. 1029, p. 140. Liu-2 also reiterated that fabrication conditions impact gettering when it disclosed that “[t]he presence of the oxide interlayer hinders the gettering effectiveness, although at *optimum polysilicon fabrication conditions* . . . the blocking effect is small.” *Id.*, p. 141.

Dr. Banerjee agrees that the formation process of a layer impacts diffusivity. He speculated that Li’s oxide layer 510 could be grown by either a “wet” or “dry” process and that a person of ordinary skill in the art likely would have used a dry

process. Ex. 2022 at 109:9-110:4. Dr. Banerjee further testified that he “would expect higher diffusivity through wet versus dry.” *Id.* at 110:12-13. In other words, Dr. Banerjee suspects that Li would more likely be implemented with a process that would result in *less* diffusivity. Regardless, Petitioner did not acknowledge the impact that the method of formation would play much less compare that method to the method used to form the dielectric layers in Ramappa, Hu, or Liu-1/Liu-2. Petitioner's contention of inherency cannot be confirmed with this oversight.

The thermal history of a material is also important in the diffusivity of that material. Ex. 2021, ¶ 94. Material properties often change after being subjected to heat treatment regimens. *Id.* Thus, for example, a dielectric film may allow a certain amount of gettering under certain conditions when it has not previously been subjected to elevated temperatures for an extended period of time. However, that same film may act as a barrier afterwards. Dr. Banerjee admitted that the thermal history of Li's oxide layer could impact its diffusivity. Ex. 2022 at 115:7-11. Indeed, the references upon which Petitioner relies acknowledge the role that thermal histories play; that is why they spell out their respective processes in great detail. *See, e.g.*, Ex. 1028 at p. 2276 (providing temperature and time details for layer formation, diffusion, etc.); Ex. 1029 at p. 137 (same).

Petitioner fails to compare the thermal history of the dielectric film 510 of Li with that of the references. Dr. Banerjee admitted that he did not consider the temperature at which Li's oxide layer 510 is grown or the temperatures of subsequent heat treatments. Ex. 2022 at 109:9-11, 113:11-14, 115:7-11. The heightened bar for inherency is not cleared by ignoring such critical parameters.

5. *Petitioner Failed to Consider Key Characteristics of Li's Material Layer 506*

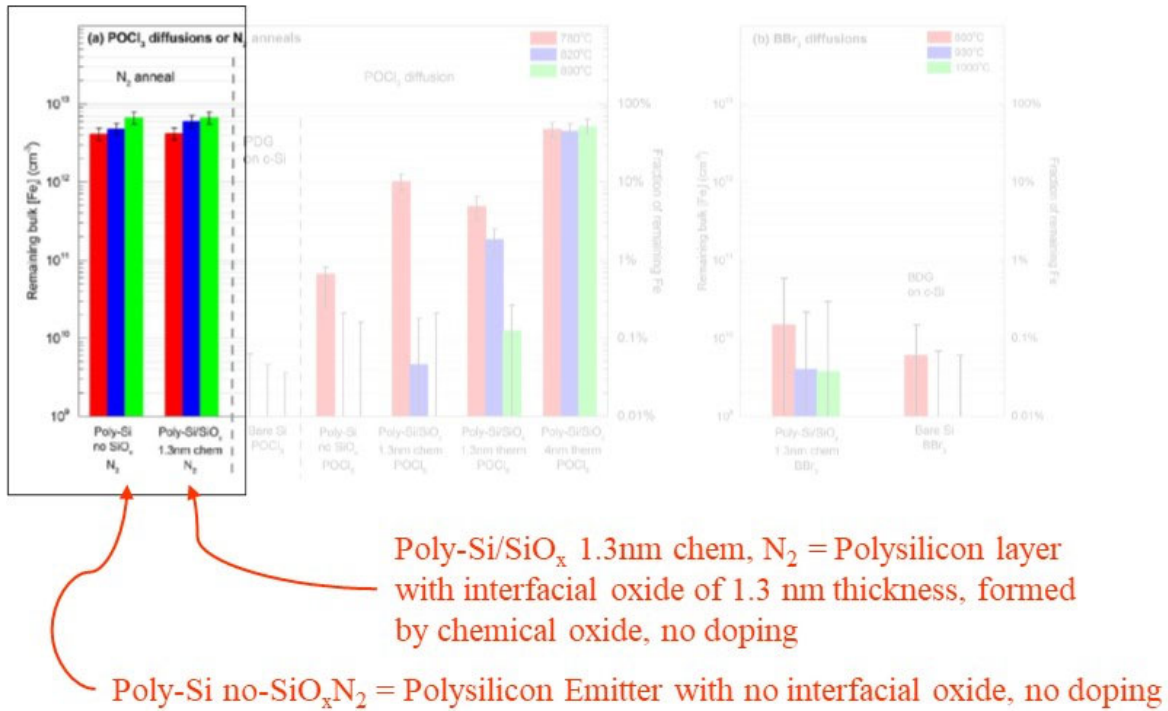
Petitioner's failures to consider relevant parameters of Li did not stop at the silicon oxide layer 510. Petitioner also failed to consider relevant parameters of Li's material layer 506. Whether impurities necessarily would be gettered into Li's material layer 506, as Petitioner alleges, would depend on the following characteristics: (i) the thermal history of material layer 506, (ii) the thickness of material layer 506 and the ratio of its thickness in relation to the thickness of substrate 508, and (iii) the doping concentration of material layer 506. Petitioner did not consider any of these.

The thermal history of material layer 506 is important for the same reasons the thermal history of oxide layer 510 is important. Ex. 2021, ¶ 94. Further, Hu, upon which Petitioner relies, states that “[t]he polycrystalline silicon deposition temperature has a diverse number of effects and must be optimized for suitable use in gettering.” Ex. 1017, 4:26-28. Yet, Petitioner did not burden itself with considering the deposition temperature of Li's polysilicon material layer 506 or

any other event in its thermal history. Petitioner's arguments that gettering necessarily would have occurred in Li should be rejected for this reason alone.

With respect to thickness, Liu-2 teaches that "the thickness ratio of the polysilicon film to the bulk crystalline silicon substrate, where impurities are gettered from, should be considered." Ex. 1029 at p. 139. Notwithstanding this admonition, Petitioner failed to consider the thickness of the material layer 506 of Li much less the ratio of the thickness of that layer to that of substrate 508. That was another consequential oversight, and Petitioner does not explain why it did not heed the instruction of Liu-2 (upon which Petitioner relies) to consider those factors. Ex. 2021, ¶ 97.

Further, Petitioner failed to consider the dopant concentration in Li's material layer 506. That factor would materially impact whether gettering would occur. Liu-2 discloses that "intrinsic [(i.e., undoped)] polysilicon films . . . do not have a significant gettering action . . . with or without the oxide interlayer." Ex. 1029, p. 139; *see also* Ex. 2021, ¶ 98. This is reflected in Figure 3 of Liu-2:



Ex. 1029, Fig. 3 (modified, annotated).

The two sets of bars on the left, which reflect results where the polysilicon layers were undoped, show insignificant gettering. Ex. 1029, p. 139 (“Fig. 3(a) shows that the intrinsic polysilicon films used in this work do not have a significant gettering action.”). This led Liu-2 to state that “more effective gettering could be achieved in more heavily doped samples.” *Id.*, p. 140.

Petitioner did not consider the doping levels of Li’s polysilicon material layer 506. Had Petitioner done so, it would have discovered that Li is more similar to the arrangements depicted on the left side of Figure 3 of Liu-2 than the other arrangement of Liu-2 (although there are many sharp distinctions between Li and all arrangements of Liu-2). Specifically, material layer 506 of Li is initially

undoped, just as with the arrangements of Liu-2 that exhibited ineffective gettering. Ex. 1029 at 139 (referencing “gettering ineffectiveness” for undoped polysilicon layer). Layer 506 of Li is later doped, but not until the very same process that Petitioner alleges causes gettering. Petition at 2 (“Li’s process of heating the solar cell to 950°C to diffuse dopants into the polysilicon regions will necessarily result in metal impurities being present in Li’s polysilicon emitter regions.”); *see also* Paper 28 at 47. Further, Li is silent as to the extent of doping of material layer 506. Ex. 2021, ¶ 99. Thus, while Liu-1 discloses impurity relocation when a “heavily phosphorous-doped polysilicon layer” is present, Ex. 1028 at p. 2275, neither CSI nor Dr. Banerjee shows that Li has such a “heavily” doped layer *at any time*. Thus, in view of Li’s silence as to the doping concentration of its polysilicon material layer 506, it cannot be said that the “natural result” of Li’s dopant diffusion step would be appreciable gettering of metal impurities into material layer 506. *See PAR Pharm.*, 775 F.3d at 1195; *see also* Ex. 2021, ¶ 99.

6. *Petitioner Failed to Account for Decreased Gettering In Its Li-Muller Combination*

The foregoing failures of Petitioner’s inherency arguments are further pronounced in Petitioner’s Li-Muller combination (Grounds 2 and 4). The references upon which Petitioner relies disclose that the use of boron as a dopant significantly reduces gettering, to the point of being “ineffective.” Liu-1 and Liu-2

observed decreased gettering when boron-doping is used and, more particularly, when ion-implantation is used (both of which are present in Petitioner's Li-Muller combination). According to Liu-1, "B[oron]-doped poly-Si layer on its own exhibits a poor gettering effect." Ex. 1028 at p. 2279; *see also id.* Fig. 7. Liu-2 discloses that ion implantation of boron leads to less gettering, speculating that the reason for this is because a boron-rich layers (BRLs) are effective gettering sites and that "[s]amples doped via ion implantation and subsequent annealing in inert gas do not have such BRLs." Ex. 1029 at p. 138.

In its discussion of Grounds 2 and 4 (i.e., based on a Li-Muller combination), Petitioner fails to acknowledge the decrease in gettering that its proposed adoption to Li would entail. Rather, Petitioner suggests that replacing phosphorus dopants via the method of Li with boron dopants via ion-implantation is an obvious and straightforward change. Petition at 64-65; Paper 28 at 66. Not only is that erroneous for the reasons set forth in section VI.D *infra*, but it also fails to recognize that the proposed change would further decrease the likelihood that any metal impurities in Li's substrate 508 would be gettered to Li's material layer 506. Ex. 2021, ¶ 110. Petitioner fails to appreciate that its proposed Li-Muller combination undermines its inherent gettering argument.

7. *Undetectable De Minimis Amounts Would Not Satisfy the Limitation*

Petitioner does not discharge its burden by merely raising a possibility that an undetectable *de minimis* amount of metal impurities may be present in Li's material layer 506. Under Federal Circuit precedent, "inherent anticipation requires more than mere probabilistic inherency . . . and more than the presence of an unrecognized *de minimis* quantity of claimed substance in the prior art." *Crown Packaging*, 635 F.3d at 1383. That principle can be traced to *In re Seaborg*, 328 F.2d 996 (C.C.P.A. 1964). In that case, the Federal Circuit's predecessor court rejected an argument that the element Americium would have been necessarily produced by a nuclear reactor disclosed in a prior art patent to Fermi et al. ("Fermi"). The record revealed that Fermi may have produced one billionth of a gram of Americium. *Id.* at 999. The *Seaborg* court found that even if such "minute quantities" would have been produced they "would have been completely undetectable." *Id.* On that basis, the court found Fermi did not inherently disclose the element. *Id.*

Crown Packaging has been used to prevent absurd applications of the inherency doctrine. For example, in *Ex Parte Landis*, 2014 WL 2989993 (PTAB July 1, 2014) the Board, applying *Crown Packaging*, reversed a rejection based on the notion that gravity and waterproof bonding would satisfy a claim limitation requiring that a piezoelectric assembly be "compressively held in [a] housing."

The Board held that the Examiner erred in speculating that “gravity or bonding compressively holds the transducer 132 [in the prior art] with greater than *de minimis* force.” *Id.* at *2. Similarly, in *Ex Parte Petzelt*, 2011 WL 5288877 (B.P.A.I. Nov. 2, 2011) the Board reversed a rejection of a claim that required xenon to be “administered with ambient air.” The Examiner had found that under the prior art, an initial dose and/or a final dosage would inevitably mix with ambient air. The Board held that “even if some ambient air entered the anesthetic circuit of [the prior art] while xenon and oxygen were being initially administered, this represents a *de minimis* treatment which does not fall within the scope of the claims, which require that the entire administration be performed using ambient air.” *Id.* at *6.

Cases that have held that “trace” amounts of a substance may be sufficient for purposes of inherency do not apply here. *E.g., Allergan, Inc. v. Apotex*, 754 F.3d 952, 961 (Fed. Cir. 2014) (“[A] chemical process that produces only a ‘trace’ amount of a compound inherently anticipates that compound.”). By definition, a “trace” amount is able to be detected. *See Ex Parte Nye*, 2011 WL 3798745, at *5 (B.P.A.I. Aug. 25, 2011) (distinguishing between “trace” amounts and an “unknown, possibly very small, amount”). Thus, in *Allergan*, the Federal Circuit did not purport to overrule *Crown Packaging* or *Seaborg*. Indeed, *Allergan*—as a panel decision—could not overrule that prior precedent. *Deckers Corp. v. United*

States, 752 F.3d 949, 964 (Fed. Cir. 2014) (“[A] panel of this court—which normally sits in panels of three, and not en banc—is bound by the precedential decisions of prior panels unless and until overruled by an intervening Supreme Court or en bac decision.”); *see also Amneal Pharms. LLC v. Almirall, LLC*, 960 F.3d 1368, 1371 (Fed. Cir. 2020) (noting that decisions of the Court of Customs and Patent Appeals are binding on the Federal Circuit).

Petitioner failed to show inherency under the relevant standard. Indeed, Dr. Banerjee appears to have assumed the law were otherwise. Under his view, all he had to show was “any amount of gettinging.” Ex. 2022 at 72:15-19. Thus, Dr. Banerjee did not attempt to calculate or otherwise quantify how many impurities he believed would be present in Li’s material layer 508. *Id.* at 73:3-20. However, in order to meet the proper standard set forth by *Crown Packaging*, he (or Petitioner) should have. That neither did is fatal to Petitioner’s inherency argument.

B. Grounds 3 and 4 Do Not Remedy Li’s Failure to Disclose “a first emitter region having metal impurities formed over the dielectric region”

1. Grounds 3 and 4 Merely Recast the Inherency Arguments of Grounds 1 and 2

Grounds 3 and 4 cite Hu and Ramappa for the same purpose that those references are used in Grounds 1 and 2—to explain what allegedly would have been the expected result of Li. The Petition states:

To the extent Maxeon disputes that claim 10's requirement that the 'emitter region having metal impurities' is inherently disclosed by Li alone, *it would have been obvious to the Skilled Artisan that such metal impurities would be present* in the emitter region due to gettering that occurs during Li's dopant diffusion step, as taught by Hu and Ramappa.

Petition at 69; *accord* Paper 28 at 70.

Thus, Petitioner uses the term "obvious" to refer to what a person of ordinary skill in the art allegedly would appreciate to be inherent. Petitioner does not use of "obvious" in the sense that a modification to Li would have been readily apparent, as is a typical use of the term when arguing invalidity under § 103. Petitioner does not propose a change to Li, and Dr. Banerjee confirmed that his opinions for Grounds 3 and 4 do not contemplate any change to Li:

Q: [Y]ou're not proposing a new step to Li that's not disclosed in Li; you're not proposing a new step to Muller that's not disclosed in Muller. Is that right?

A: No, we are not introducing new steps.

Ex. 2022 at 181:16-20. Indeed Dr. Banerjee confirmed that his opinions for Grounds 3 and 4 continue to rely on the contention that Li inherently discloses impurities in its material layer 506:

Q: Correct me if I'm wrong, but I believe, *in your four grounds or bases for invalidity, you're relying on the concept of inherency*;

specifically that Li inherently would getter impurities from the substrate into the material layer. Is that right?

A: Yes.

Ex. 2022 at 67:15-22.

Similarly, Petitioner states that Hu and Ramappa “confirm” that Li’s disclosed heating process would result in the gettering of metallic impurities from the silicon substrate through the silicon dioxide layer to the alleged emitter region. Petition at 74; Paper 28 at 75. Using a reference to “confirm” the expected consequence of another reference is not an obviousness combination; rather, it is an inherency argument. *Cf. Jones v. Hardy*, 727 F.2d 1524, 1529 (Fed. Cir. 1984) (holding that anticipation by inherency and obviousness are “separate and distinct concepts”).

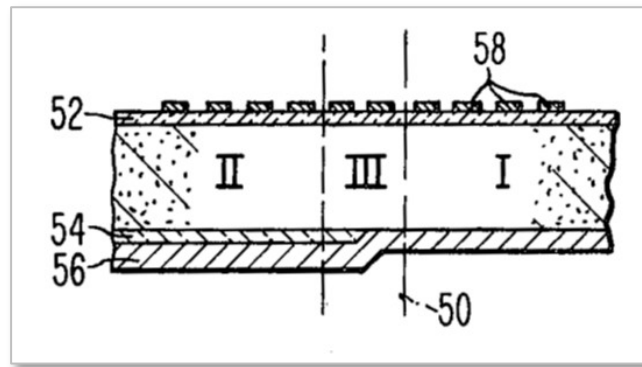
For the foregoing reasons, Grounds 3 and 4 fail for the same reasons that Grounds 1 and 2 fail—Petitioner has not established that Li inherently satisfies the limitation “a first emitter region having metal impurities formed over the dielectric region.”

2. *Hu and Ramappa Do Not Disclose Gettering Metal Impurities from a Silicon Substrate, Through an Oxide Layer, into a Polysilicon Layer*

Even if Petitioner had made out a proper obviousness argument, it would fail. Hu and Ramappa do not disclose what Li fails to do inherently, i.e., disclose

that metal impurities in a substrate naturally would travel through an oxide layer into a polysilicon layer.

Hu discloses gettering only where a silicon oxide layer is not present and discloses that gettering does not occur where an oxide layer is present. Hu analyzed three sections of a silicon wafer, as shown below by numerals I, II, and III.



Ex. 1017, Fig. 5.

In region I, a polycrystalline layer 56 is deposited directly on the back of silicon wafer 50. In region II, an oxide layer 54 is formed between the polycrystalline layer 56 and the silicon wafer 50. As Table I of Hu reveals, gettering was observed in region I but not in region II.

TABLE I			
Column	Region	Mean Generation Current Nano Amp/cm ²	Remarks
1-4	II	108	ungettered
5-6	III	3.4	transition region
7-10	I	1.7	gettered

Ex. 1017, 9:47-53 (annotated); *see also* Ex. 2021, ¶ 116.

To the extent Hu's disclosure—which pertains to integrated circuits—is relevant at all, it cuts against a conclusion that gettering necessarily occurs in Li.

Ramappa is equally unhelpful to Petitioner. At most, Ramappa discloses that metal impurities in an oxide layer may travel through that layer under the specific conditions set out in Ramappa. However, as Dr. Banerjee agrees, metal impurities in Li's substrate would first have to cross the Si-SiO₂ interface before they could travel through the SiO₂ layer. Ex. 2022 at 157:1-4. In this regard, Ramappa discloses that such an interface acts as an "impurity sink" due to the pileup phenomenon. Ex. 1025 at p. 3775; *see also* Ex. 2021, ¶ 119. As with Hu, Ramappa undermines rather than supports Petitioner's theories.

C. It Would Not Have Been Obvious to Use Dopant Concentrations of King, Swanson-352, or Marvin in Li

Petitioner's central error with respect to the dopant concentration limitation is to baselessly assume that a designer of a solar cell would select dopant concentrations from inapposite references. Contrary to Petitioner's theories, a person of ordinary skill in the art, in implementing Li, would not have selected the dopant concentrations in King, Swanson-352, or Marvin. Fundamental differences exist between Li and those references, and a person of ordinary skill would have understood that those differences suggest a different dopant concentration would have been preferable. This is especially true since other references (not considered

by Petitioner) that are more similar to Li taught using much higher dopant concentrations.

1. There Is No “Optimum” Dopant Concentration

Petitioner's assertion that the “optimum” dopant concentration is $1 \times 10^{18} \text{ cm}^{-3}$ is incorrect. There is no single value—or even range of values—that is “optimal” in all circumstances. Rather, the proper dopant concentration in a solar cell is dependent upon a number of factors. This is confirmed by (1) the references upon which Petitioner relies, (2) other references not considered by Petitioner, and (3) the parties' respective experts.

The references upon which Petitioner relies reveal that there is no “optimal” dopant concentration. For example, Marvin (Ex. 1035) discloses a solar cell designed for a terrestrial environment, i.e., on land, and states that such cell should have a dopant concentration of $5 \times 10^{18} \text{ cm}^{-3}$. Ex. 1035 at 827 (“The FSF should be an approximately 0.5 μm step with doping concentration of $5\text{E}18 \text{ cm}^{-3}$.”). Marvin also discloses a separate solar cell for a space environment, e.g., for use on a satellite, and the recommended dopant concentration for that application is $1 \times 10^{18} \text{ cm}^{-3}$. Ex. 1035 at 827. Thus, in the span of two paragraphs, Marvin discloses two different preferred dopant concentrations depending on the anticipated environment.

In this regard, Dr. Banerjee's attempt to explain away Marvin's disclosure of $5 \times 10^{18} \text{ cm}^{-3}$ (which is well outside of the claimed range) falls flat. Dr. Banerjee suggests that Marvin identifies that number only in a concentrator application, i.e., where the sun's rays are focused or concentrated to increase their power. Ex. 2022 at 60:15-21. To the contrary, Marvin clearly associates a doping concentration of $5 \times 10^{18} \text{ cm}^{-3}$ in a 1-sun (i.e., non-concentrator) environment. Ex. 2021, ¶ 138. For example, Marvin states that "the baseline cell [described in Table 2] was near optimum for 1 sun." Ex. 1035, p. 825. Table 2 states a doping concentration of $5 \times 10^{18} \text{ cm}^{-3}$.

Table 2. Baseline cell design	
p ⁺ width	35 μm
n ⁺ width	145 μm
p ⁺ thickness	1.0 μm
n ⁺ thickness	0.3 μm
p thickness	50 μm
t _n in base	136 μs (a)
	1.10 μs (a)
	0.32 μs (b)
t _n in p ⁺ contact	0.128 μs (a)
	78 ns (b)
	78 ns (b)
t _p in n ⁺ contact	32.6 ns (a)
	12 ns (b)
	12 ns (b)
FSF doping	5E18 p type
FSF thickness	0.5 μm
Doped region spacing	20 μm
(a) After radiation scenario 1:	
K _L = 2.5E-11 for p base	
K _L = 1.10E-9 for p ⁺ region	
K _L = 3.10E-8 for n ⁺ region	
(b) After radiation scenario 2:	
K _L = 8.40E-11 for p base	
Other K _L same as scenario 1	

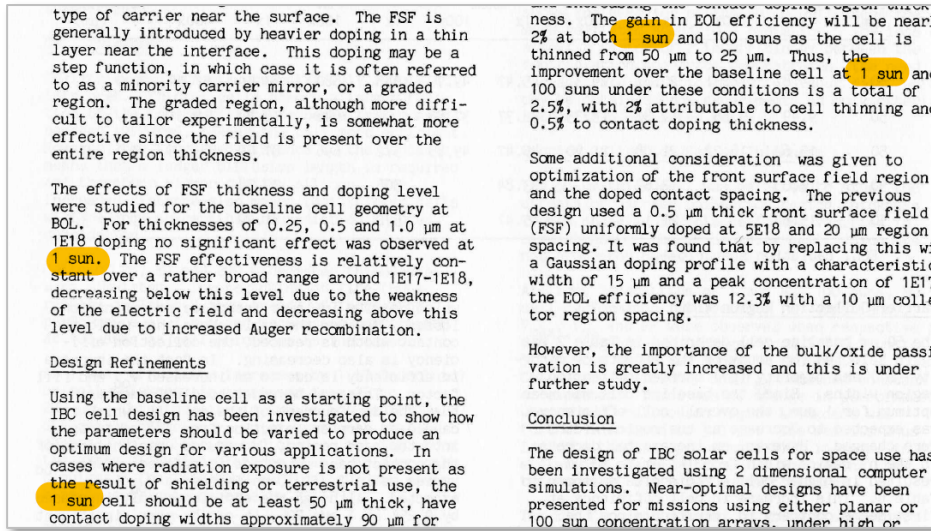
Ex. 1035, p. 823 (partial, annotated).

To be sure, Marvin *also* discloses that the same doping concentration is preferred in a terrestrial concentrator application. Ex. 1035, p. 827. However

Marvin makes clear that $5 \times 10^{18} \text{ cm}^{-3}$ is “near optimal” in both applications, i.e., “1 sun” (“planar”)⁸ and concentrator applications. *See* Ex. 1035 at 826.

Dr. Banerjee’s confusion regarding Marvin likely stems from his lack of a meaningful review of the reference. When asked whether he had ever heard the term “1 sun” solar cell, Dr. Banerjee admitted that he had not but that he could “hazard a guess” as to what it means. Ex. 2023 at 31:9-14. Had Dr. Banerjee even cursorily reviewed Marvin, he could not have avoided multiple references to “1 sun.” A small sample of Marvin—including the page cited in Dr. Banerjee’s declaration is provided below.

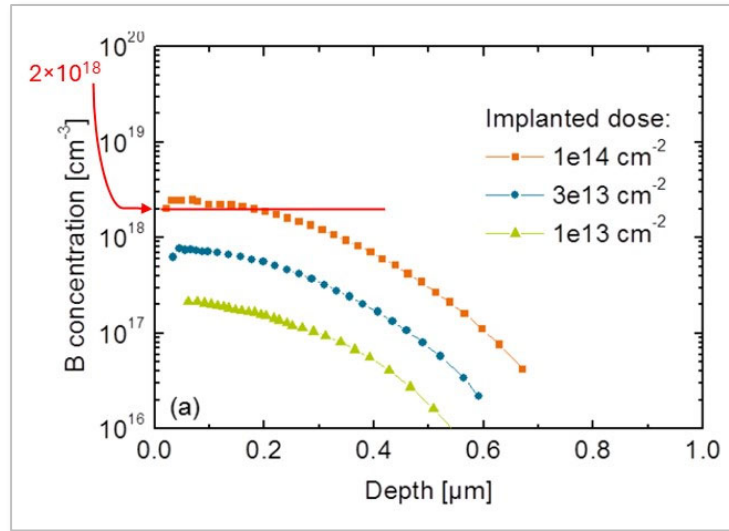
⁸ A person of ordinary skill in the art would understand that “planar,” as used in Marvin, refers to “1 sun” applications. Ex. 2021, ¶ 139.



Ex. 1035, p. 826 (partial, annotated). Marvin elsewhere refers to “1 sun” in many instances. Ex. 1035 at pp. 825, 827.

Further, Muller, a reference that Dr. Banerjee confesses he “hadn’t really looked at,” Ex. 2022 at 170:8,⁹ shows a dopant concentration greater than $2 \times 10^{18} \text{ cm}^{-3}$:

⁹ That admission is concerning since Muller, along with Li, form the bases for Petitioner’s Grounds 2 and 4.

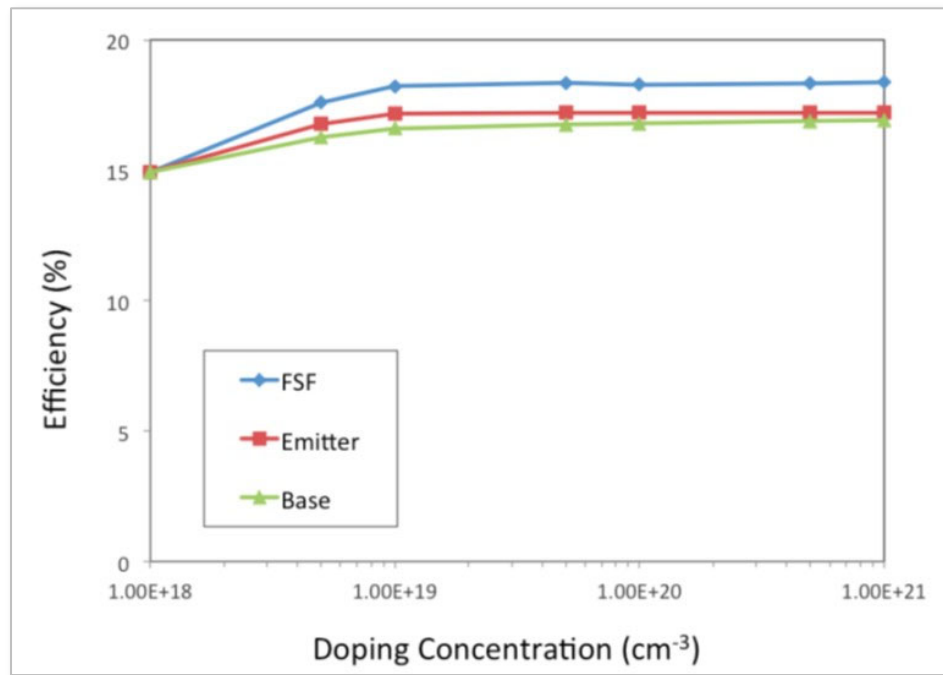


Ex. 1008, Fig. 1 (partial, annotated). Indeed, Petitioner *relies* on the dopant concentrations shown in orange. Petition at 59-60; Paper 28 at 61; Ex. 2022 at 160:5-6 (“I am using the orange line for the left hand figure for the boron.”).¹⁰

Other references likewise refute Petitioner’s contention that there was an optimal dopant concentration established by 2014. For example, the Lamers publication reflects the efforts of researchers that sought “to increase cell efficiencies and decrease production costs.” Ex. 2024, 1. The researchers

¹⁰ Petitioner reproduces Figure 1 of Muller at page 60 of the Petition (and on page 61 of Paper 28); however, the red line that Petitioner alleges was “added at $2 \times 10^{18} \text{ cm}^{-3}$ ” is in fact placed above that level. The offset obscures the true difference between the dopant concentration recited in claim 10 ($2 \times 10^{18} \text{ cm}^{-3}$) and the dopant concentration in Muller (which exceeds $2 \times 10^{18} \text{ cm}^{-3}$ and approaches $3 \times 10^{18} \text{ cm}^{-3}$).

discovered that the optimum dopant concentration for their solution was 3×10^{18} cm^{-3} . *Id.*, 2. The Desa publication likewise reflects the efforts of researchers that sought to maximize solar cell efficiency soon before the invention of the '315 patent. Ex. 2025, 69. They found that a concentration of 1×10^{19} cm^{-3} was superior to lower concentrations, i.e., those in the claimed range:



Id., Fig. 5(c); *see also id.*, 71 (“[A]chieving good FSF doping is essential for superior performance of the IBC solar cell.”).

Still further, Procel found that, in one design, “optimum values of peak doping” of a front surface field to be 3.47×10^{18} cm^{-3} , which yielded an efficiency of more than 22%. Ex. 2026, 132; *see also id.*, 131 Fig. 4(a).

Indeed, Dr. Banerjee readily admitted during his deposition that optimal design parameters depend on various factors. Ex. 2022 at 27:2-28:16, 95:4-6,

103:15-17, 183:1-2. This is one of the few points on which Dr. Banerjee (at least during his deposition) and Dr. Carroll agree. Dr. Carroll similarly opines that “an ‘optimum’ dopant concentration will vary based on design parameters.” Ex. 2021, ¶ 140.

For the foregoing reasons, a person of ordinary skill in the art would have known to implement Li with whatever dopant concentration was appropriate under the circumstances. They would not have been constrained to using an “optimal” concentration for all circumstances because that simply does not exist.

2. *A Skilled Artisan Would Not Have Been Motivated to Employ Li with the Dopant Concentrations of King, Swanson-352, or Marvin*

Petitioner fails to show that a person of ordinary skill in the art would have been prompted to use the dopant concentrations of King, Swanson-352, or Marvin in Li. Petitioner recognizes that Li does not disclose the concentration of dopants in region 520. Petitioner errs in assuming that a person of ordinary skill in the art would have looked to those references, which disclose dissimilar solar cells, to supply the missing information.

In order to prove obviousness, it is not enough to show that the elements of a claim were independently known. Rather, the patent challenger must demonstrate “a motivation to combine various prior art references.” *Palo Alto Networks, Inc. v. Centripetal Networks, LLC*, 122 F.4th 1378, 1384 (Fed. Cir. 2024). In this regard,

“it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007).

In designing a solar cell, many factors must be considered. The choice of a certain value for a certain parameter may be logical under certain circumstances, but such a choice could be senseless under other circumstances. Relevant considerations include, for example, the following:

- Amount of anticipated radiation exposure;
- Whether incident sunlight is concentrated;
- Thickness of silicon oxide passivation layer;
- Shape of dopant profile; and
- Whether application is terrestrial or space.

Ex. 2021, ¶ 140; Ex. 2022 at 27:2-28:16, 95:4-6, 103:15-17, 183:1-2.

Petitioner blithely suggests using dopant concentrations from King, Swanson-352, and Marvin without giving due consideration to the different environments and structures to which those references are directed.

a. King

King is directed at a solar cell that is passivated on both sides of the silicon substrate, which renders it unlike Li. King discloses that “[m]ost of the samples consisted of a lightly doped silicon substrate that has identical planar dopant

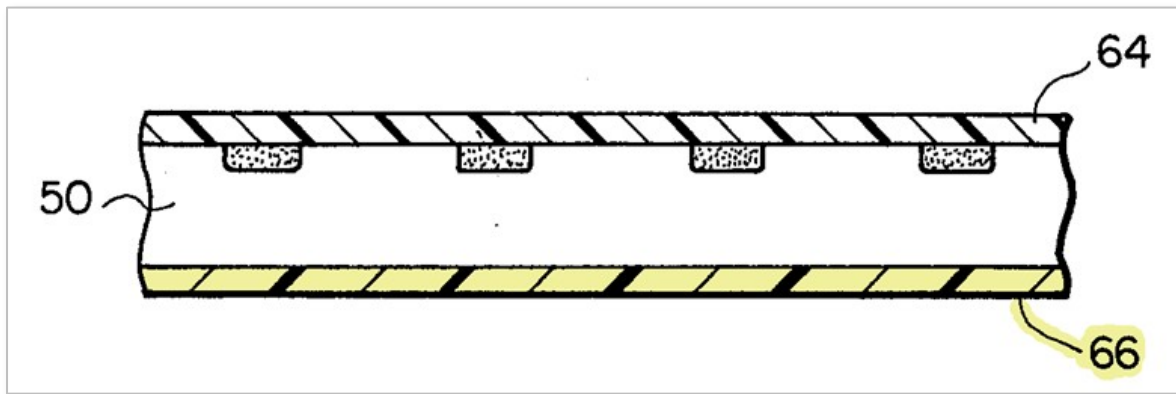
diffusions with thermal oxide passivation *on both sides of the wafer.*” Ex. 1006 at 366 (emphasis added). By contrast, the front surface of Li is not passivated with an oxide layer. Ex. 1005, ¶ [0049]. Rather, Li discloses that the surface of substrate 508 is textured and then exposed to a dopant source without any intervening oxide layer or dielectric film, as is present on the back side. Ex. 1005, ¶¶ [0047], [0049]; *see also* Ex. 1003, ¶ 199 (Dr. Banerjee admitting that “Li does not disclose any other layers on the front surface of the solar cell”); Ex. 1100, ¶ 217 (same); Ex. 2022 at 42:16-17 (Dr. Banerjee admitting that Li does not disclose a passivating layer explicitly or inherently). Dr. Banerjee confirmed that his obviousness opinions are not premised on a change to Li by which a passivation layer is added. Ex. 2022 at 49:8-18.

This distinction is critical. By 2014, it was well known that surface recombination could be lessened by two methods. The first was by adding an oxidation layer. Ex. 2021, ¶¶ 35-36. The second was by introducing dopants. *Id.*, ¶¶ 35, 37. Generally, a thicker oxidation layer coupled with fewer dopants provided the same effect as a thinner oxidation layer coupled with more dopants. Before the invention of the ’315 patent in 2014, the trend was toward thinner oxidation layers and higher dopant concentrations. Ex. 2021, ¶ 146.

Because King employs an oxide passivation layer and Li does not, a person of ordinary skill in the art would have been motivated to use a dopant concentration *higher* than that disclosed in King. Petitioner ignores that fact.

b. Swanson-352

Second, Swanson-352 is dissimilar from Li in at least two relevant respects. First, Swanson-352 includes a passivation layer on the side that is doped. Ex. 1015, 4:60.



Ex. 1015, Fig. 7 (annotated).

For the same reasons as those presented in the immediately preceding section, the presence of silicon oxide layer 66 over the front surface of substrate 50 would call for a lower dopant concentration than what would be appropriate for a non-passivated surface, such as in Li. Again, Petitioner overlooks that fact.

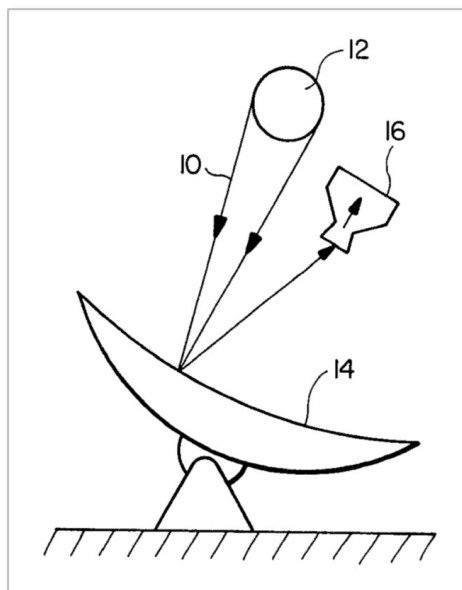
Second, Swanson-352 is directed to a concentrator solar cell. Such a solar cell is required to withstand far greater temperature gradients and photon fluxes

than a non-concentrator (or “1-sun”) solar cell, such as Li. In summarizing the invention, Swanson-352 provides as follows:

Briefly, in accordance with the invention, a thermophotovoltaic conversion system is provided which includes means for collecting and **concentrating** solar radiation, means for receiving the **concentrated** solar radiation and re-radiating energy, and a photovoltaic cell for receiving the re-radiated energy and generating an electric voltage.

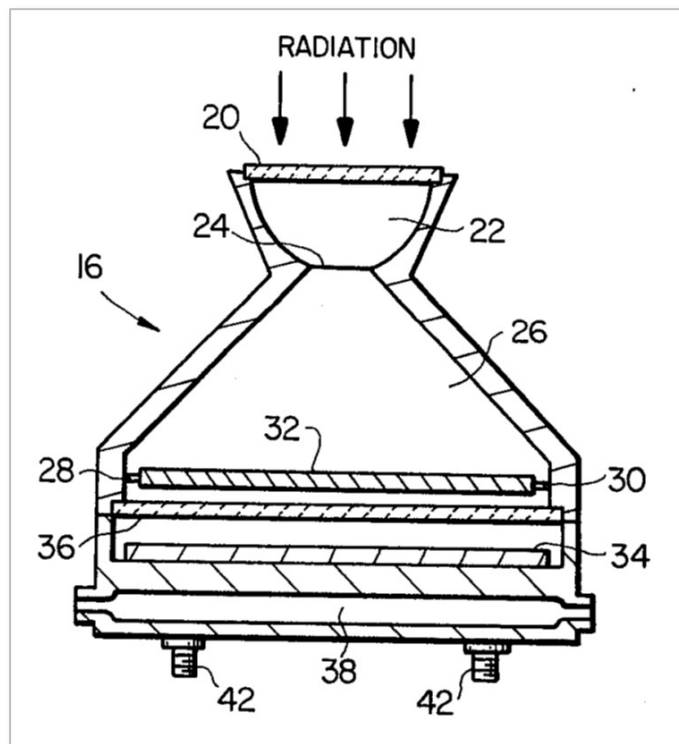
Ex. 1015, 2:7-13 (emphasis added).

Such a concentrator system is generally depicted in Figures 1 and 2 of Swanson-352. As shown in Figure 1, radiation 10 from the sun 12 is reflected off parabolic reflector 14 to converter 16.



Ex. 1015, Fig. 1.

Although only two light rays are shown as being emitted by the sun and directed to converter 16, due to the shape of parabolic reflector 14, nearly all light rays that impact parabolic reflector 14 are reflected to converter 16. In this way, converter 16 receives much more sunlight than it would without parabolic reflector 14, i.e., if converter 16 were instead in a “1 sun” environment. Further, as shown in Fig. 2, converter 16 includes a parabolic cone 22, which further concentrates the sunlight.



Ex. 1015, Fig. 2.

Swanson-352 discloses that through these concentrations, the radiation reaches **20,000 times** the normal amount. Ex. 1015, 3:22-26. Such concentration drastically increases the temperature in converter 16. Swanson-352 discloses that

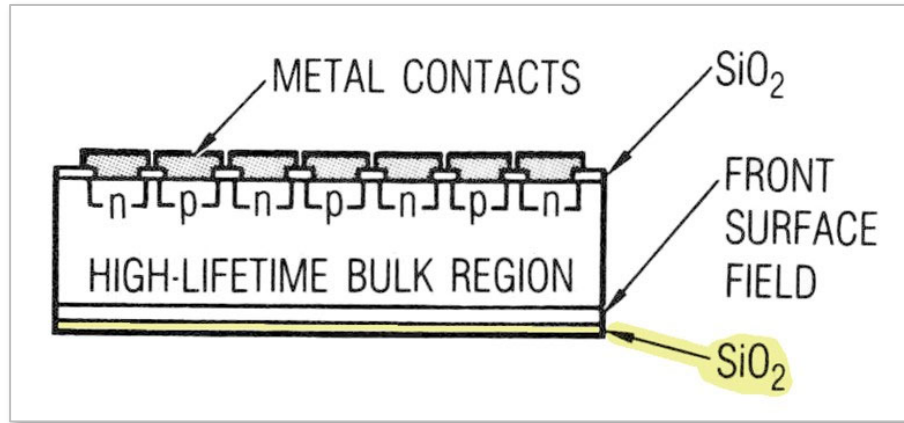
the radiator in the converter is heated to 1,800°C – 2,000°C. These intense temperatures are not transient; rather, the system of Swanson-352 must endure them during normal operation. Such a specialized environment calls for specialized parameters. Ex. 2021, ¶ 148. A person of ordinary skill in the art would understand that any specific parameter used in Swanson-352 should not be casually used in other systems, such as Li's. *Id.*

Dr. Banerjee agrees that dopant concentrations for a concentrator application may not be applicable in 1-sun environments. Specifically, Dr. Banerjee testified that “under the concentrator environments, the photon flux is of course much higher than under 1-sun conditions, and exact parameters for optimal performance would be different.” Ex. 2022 at 61:14-17. Similarly, Mr. Banerjee testified that “the specific value” of dopant concentration “that’s relevant for concentrators may not be relevant for nonconcentrator applications.” Ex. 2022 at 62:5-8. Further, Dr. Banerjee testified that he would expect the difference between the optimum dopant concentrations as between a 1-sun application and a concentrator application would be “more different” than as between a terrestrial application and a space application. Ex. 2022 at 64:16-65:6.

Petitioner's obviousness arguments seem to contemplate maintaining Li in a 1-sun (non-concentrator) environment. In view of Dr. Banerjee's testimony, Swanson-352 would not provide an obvious dopant concentration.

c. Marvin

Marvin is also unlike Li. First, as with the other references on which Petitioner relies, Marvin includes a passivating oxide layer on its front side. This is highlighted below:



Ex. 1035, Fig. 1 (partial, annotated).

Second, Marvin—or more specifically the portion of Marvin that Petitioner cherry picks—is directed at a space application. Ex. 1035, 826 (“For space use, where radiation is present . . .”). Space applications and terrestrial applications pose different challenges and are met with different solutions. For example, space applications are attended by (i) increased radiation, (ii) lower temperatures, and (iii) a different spectrum of electromagnetic radiation (because it is unshielded by the earth’s atmosphere). Ex. 2022 at 64:2-7, 97:3-6.

The fact that space application parameters may not be well suited to terrestrial applications is well documented by Marvin itself. In discussing solar panels that are not sent into orbit, Marvin states that the optimum dopant

concentration is $5 \times 10^{18} \text{ cm}^{-3}$. Ex. 1035, 827 (“The FSF should be an approximately $0.5 \text{ }\mu\text{m}$ step with doping concentration of $5 \times 10^{18} \text{ cm}^{-3}$.”). Thus, even if a person of ordinary skill in the art would have looked to Marvin for an appropriate dopant concentration—and they would not have because Marvin employs a passivating oxide layer over the substrate—that person would have naturally gravitated to Marvin’s terrestrial-application parameter ($5 \times 10^{18} \text{ cm}^{-3}$) more so than Marvin’s space-application parameter.

3. *A Skilled Artisan Would Have Been Motivated to Employ Higher Dopant Concentrations*

Instead of employing the dopant concentrations of the markedly different solar solutions of King, Swanson-352, or Marvin, a skilled artisan would have looked to industry trends and references more akin to the structure of Li.

As Dr. Carroll explains in his declaration, the trend in the industry around 2014 was to use thinner oxide layers and higher dopant concentrations. Ex. 2021 at ¶ 146. The industry had moved past the outdated designs with thick oxide layers such as King, Swanson, and Marvin. *Id.* Dr. Carroll’s opinions in this regard are un rebutted. Dr. Banerjee does not possess insight into the solar industry and confessed not knowing the industry trends in 2014. Ex. 2022 at 183:15-184:11.

The Lamers, Desa, and Procel references mentioned above reflect the industry trend. Those references disclose dopant concentrations of $3 \times 10^{18} \text{ cm}^{-3}$, $1 \times 10^{19} \text{ cm}^{-3}$, and $3.47 \times 10^{18} \text{ cm}^{-3}$, respectively. Ex. 2024, 2; Ex. 2025, Fig. 5(c); Ex.

2026, 132. All of those values exceed the $2 \times 10^{18} \text{ cm}^{-3}$ value recited in the claims.

In fact, because Li does not include an oxidation layer, a person of ordinary skill would have been motivated to use an even higher dopant concentration. Ex. 2021, ¶ 147. This is because they would have understood that the only guard against recombination would have been the dopants, as Li does not include a passivation layer. *Id.*; *see also* Ex. 2022 at 32:8-14 (Dr. Banerjee conceded that a designer should consider whether a surface is passivated in determining the appropriate dopant concentration).

D. The Proposed Li-Muller Combination Would Not Have Been Obvious

Grounds 2 and 4 fail because Petitioner fails to provide a sufficient motivation to modify Li in the drastic fashion proposed. In evaluating a proposed modification, “the benefits, *both lost and gained*, should be weighed against one another.” *Henny Penny Corp. v. Frymaster LLC*, 938 F.3d 1324, 1332 (Fed. Cir. 2019) (emphasis in original); *see also Winner Int’l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000) (“Trade-offs often concern what is feasible, not what is, on balance, desirable. Motivation to combine requires the latter.”). In this case, Petitioner proposes numerous significant changes to Li. Petitioner fails to show that those changes would have improved Li much less to such an extent as to outweigh the drawbacks of the modifications.

1. *The Proposed Li-Muller Combination Involves Major Detrimental Changes to Li*

Petitioner's journey from Li to its proposed Li-Muller combination is a long and tortuous one. The following changes would be necessitated:

- Replacing Li's gaseous dopant diffusion process with an ion implantation process;
- Adding an annealing step after the ion implantation;
- Switching the polarity of the dopants;
- Physically flipping the solar cell for ion implantation doping of Li's trench region; and
- Adding two passivation layers on the front surface of Li's substrate.

Ex. 2021, ¶ 151.

These changes would significantly increase the cost and significantly impact the operation of Li's solar cell. An objective of Li is to achieve "a reduction in the sheer number of process operations." Ex. 1005, ¶ [0024]. Adding the foregoing steps would frustrate that purpose, weighing against obviousness. *See Hynix Semiconductor Inc. v. Rambus Inc.*, 645 F.3d 1336, 1353 (Fed. Cir. 2011) (affirming non-obviousness where a combination was expected to increase cost).

2. *Petitioner Fails to Show Benefits to the Li-Muller Combination*

Petitioner fails to identify any benefit in modifying Li much less sufficient benefits to outweigh the above drawbacks. Among Petitioner's fatal errors is its

failure to compare the proposed Li-Muller combination to Li. Rather, Petitioner compares the proposed Li-Muller combination to other potential Li-Muller combinations. This is betrayed in the following passage from the Petition:

Muller . . . [shows] 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 $2 \times 10^{18} \text{ cm}^{-3}$ or less and then passivating the front side with a $\text{Al}_2\text{O}_3/\text{SiN}_x$ stack resulted in ***better*** resistance to surface recombination (J_0) and UV degradation, and overall efficiency of the solar cell, ***than a N-type back contact solar cell having a phosphorous-doped ion-implanted front surface field (FSF), passivated by SiO_x and/or SiN_x .***

Petition at 62; *accord* Paper 28 at 63-64.

Thus, it is apparent that the comparison Petitioner is relying upon is between different embodiments of Muller. Indeed, the remainder of the Petition's discussion regarding an alleged motivation to combine merely seeks to support the contention that one particular solution of Muller is superior to other solutions of Muller. Petition at 63-64; Paper 28 at 64-65. Dr. Banerjee confirmed as much during his deposition. When asked the basis for his belief that modifying Li in view of Muller would have resulted in a more efficient solar cell, Dr. Banerjee cited Muller's comparison of a front surface field with phosphorous doping and a front floating emitter with boron doping, both under the conditions outlined in Muller but not Li. Ex. 2022 at 175:9-176:7. Li does not follow any of the

arrangements analyzed by Muller. Indeed, Li does not have a surface passivation layer at all, a fact that Dr. Banerjee conceded. Ex. 1003, ¶ 199; Ex. 1100, ¶ 217; *see also* Ex. 2022 at 42:16-17 (Dr. Banerjee admitting that Li does not disclose a passivating layer explicitly or inherently).

Petitioner's citation to Rohatgi (Ex. 1036) is unavailing. Petition at 62; Paper 28 at 64. That reference states that ion-implantation "simplifies" the fabrication process, but fails to explain what the alleged simplification is relative to. In particular, Rohatgi fails to compare a process similar to that of Li to ion-implantation. Further, even if ion-implantation had advantages, that would not provide a motivation to perform the drastic changes to Li, which extend far beyond the means of introducing dopants.

Petitioner's suggestion that ion-implantation "increase[s] solar cell efficiency" is unsupported by the record. Petition at 63; Paper 28 at 64. The sole citation for that proposition is the declaration of Dr. Banerjee. *Id.* Dr. Banerjee makes the same statement without any explanation as to how and why that could be, and instead cites page 11 of Rohatgi. Ex. 1003, ¶ 194; Ex. 1100, ¶ 212. The reference does not support that conclusion. Rohatgi does not state that ion implantation increases efficiency. Ex. 1036, p. 11.

Indeed, it appears Dr. Banerjee did not engage in the requisite benefit-drawback weighing that Federal Circuit precedent mandates. *Henny Penny*, 938

F.3d at 1332; *Winner Int'l*, 202 F.3d at 1349. He did not perform any such analysis in his declaration. Further, when asked whether he considered any drawbacks to the Li-Muller combination, Dr. Banerjee testified only that he “did not see any roadblocks I think.” Ex. 2022 at 176:13-18. Of course, determining that a proposed combination was achievable (i.e., had no “roadblocks”) is not the same as weighing the drawbacks to a modification against the perceived benefits and determining that the latter outweigh the former.

3. *Petitioner's Failure to Show Perceived Benefits Outweigh Drawbacks Is a Sufficient Basis to Reject the Li-Muller Combination*

For the foregoing reasons, Petitioner failed to show any actual benefits in the Li-Muller combination relative to Li. Petitioner also failed to acknowledge the drawbacks of the proposed modifications. Necessarily then, Petitioner failed to show that any benefits in a Li-Muller combination outweigh the drawbacks. This failure is an independent basis to reject Grounds 2 and 4.¹¹ See *Mianyang Boe Optoelectronics Tech. Co., Ltd. v. Samsung Display Co., Ltd.*, 2025 WL 33657 (PTAB Jan. 6, 2025) (rejecting obviousness argument where “Petitioner has not

¹¹ The other basis is the failure to show that Li—especially when modified in view of Muller—would inherently disclose “a first emitter region having metal impurities formed over the dielectric region.” See section VI.A.7 *supra*.

even attempted to balance the alleged benefits of [secondary reference]'s teachings with the disadvantages of reducing aperture ratio in [primary reference], which is an explicit concern of [primary reference].”).

VII. CONCLUSION

For the foregoing reasons, the Board should confirm the patentability of the challenged claims.

Respectfully submitted,

Date: April 8, 2025

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that this Patent Owner Response, exclusive of the table of contents, table of authorities, certificate of service, certificate of word count, and list of exhibits, includes 11,782 words.

Pursuant to 37 C.F.R. § 42.24(d), Patent Owner has relied on the word count feature of the word-processing system used to prepare this paper.

Date: April 8, 2025

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CERTIFICATE OF SERVICE

I certify that the foregoing Patent Owner's Response was served on
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