Patent Owner's Demonstratives

Canadian Solar Inc. v. Maxeon Solar Pte. Ltd.

IPR2024-01038[1]

U.S. Patent No. 11,251,315

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

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

Maxeon's Exhibit 2040

Li Does Not Inherently Disclose “metal impurities” in Emitter Regions

Grounds 1 and 2 (as well as 3 and 4)

Inherency – Legal Standard

"A party must, therefore, meet a high standard in order to rely on inherency . . ."

"[T]he limitation at issue necessarily must be present, or the natural result of the combination of elements explicitly disclosed by the prior art."

PAR Pharms., Inc. v. TWI Pharms., Inc., 773 F.3d 1186, 1195-96 (Fed. Cir. 2014) (cited in POR at p. 12)



Inherency – Legal Standard

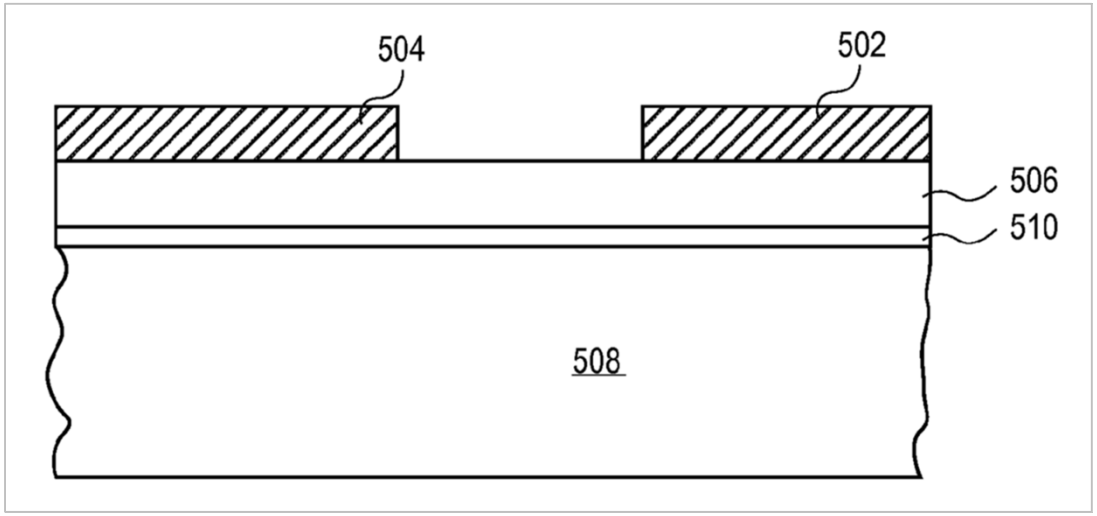
"The mere fact that a certain thing may result from a given set of circumstances is not sufficient to render the result inherent."

Millenium Pharms., Inc. v. Sandoz Inc., 862 F.3d 1356, 1367 (Fed. Cir. 2017) (cited in POR at pp. 12-13)



Petitioner Improperly Assumed a Large Level of Impurities in Li's Substrate

"Petitioner Improperly Assumes that Li's Substrate Will Include a 'Quite Large' Level of Metal Impurities"
POR at p. 14



Ex. 1005, Fig. 5A

Petitioner Improperly Assumed a Large Level of Impurities in Li's Substrate

CanadianSolar

5:9, 8:40-50, 9:1-9; EX1087, 29:20-30:10, 124:1-20, 146:16-148:22. Maxeon's expert Dr. Carroll agrees that, around 2014, "low-quality silicon" would have been used for solar cells. EX1087, 24:4-26:18, 28:18-29:18.

Pet.'s Reply at p. 2

A. So the processes that are used -- the processes that are used for commercial grade materials for commercial grade silicon on rooftops and in solar that's applied to concentrators and in solar that are applied to outer space are different, right. So if we are

...

that, the silicon solar industry typically uses a lower grade of silicon, and so post processing is necessary in order to make these materials perform better.

You don't have to do that. You can use the higher-quality stuff, but it will cost you more. And



Ex. 1087 (Carroll Depo. Tr.) at 25:5-18 (cited in Pet.'s Reply at p. 2)

PVLaw

Petitioner Improperly Assumed a Large Level of Impurities in Li's Substrate

First designs of interdigitated back contact (IBC) solar cells were investigated by Lammert and Schwartz [14]. For the carrier collection and transport, the doped areas and the electrode contacts are alternating (interdigitated arrangement). For the development of high-efficiency IBC solar cells, point contacts were introduced by Sinton et al. [64] to reduce the rear surface recombination. The rather complex manufacturing process in the beginning was simplified by a trench mesa design, which involves only one photolithography step and no alignment steps at all [65]. A first commercialization was carried out by the SunPower Corporation (CA, USA).

Ex. 1011, p. 11
(cited in PO's Sur-Reply at p. 3)

[14] M. D. Lammert and R. J. Schwartz, "The interdigitated back contact solar cell: a silicon solar cell for use in concentrated sunlight," *IEEE Translations on Electron Devices*, vol. 24, no. 4, pp. 337–342, 1977.

Ex. 1011, p. 13
(cited in PO's Sur-Reply at p. 3)

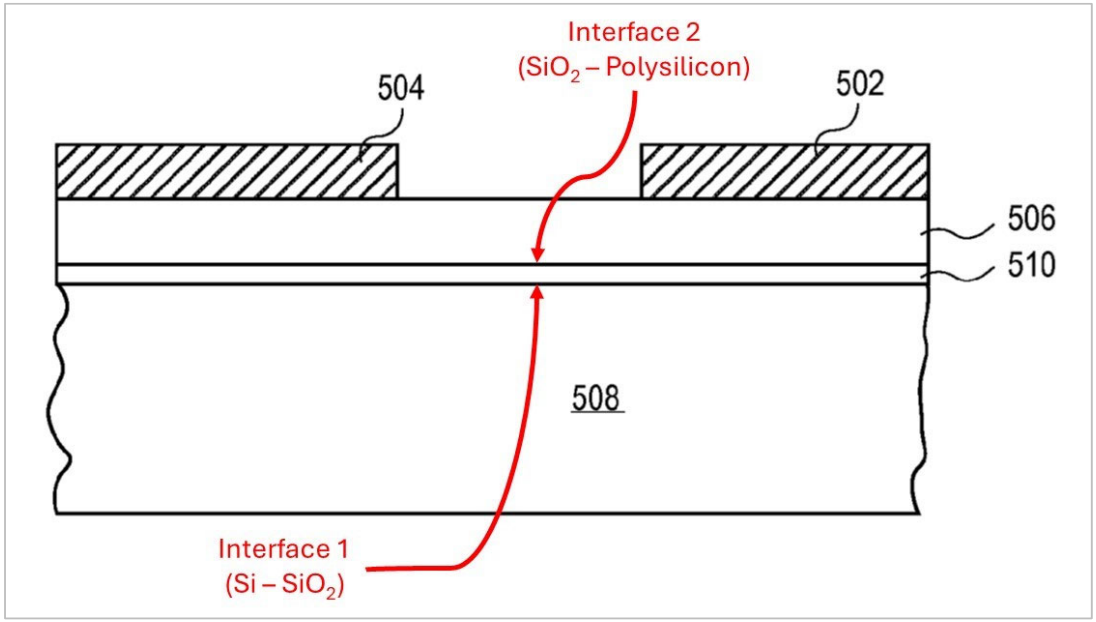
surface reflection and very low series resistance. Because the minority carriers must diffuse through the entire wafer thickness to reach the collecting junctions at the rear, the IBC solar cell design requires extraordinarily high lifetime silicon starting material. SunPower is using wafers with lifetimes greater than 1millisecond and a thickness of 200 μm [66].

Ex. 1011, p. 11
(cited in PO's Sur-Reply at p. 3)

PV Law

Petitioner Ignored “Pileup” at Interfaces

“Petitioner Ignores ‘Pileup’ at Interfaces”
POR at p. 16



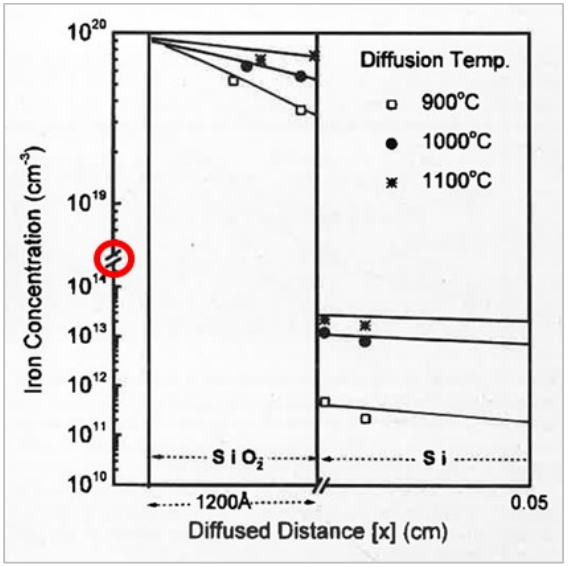
POR at p. 17
(reproducing Ex. 1005, Fig. 5A with annotations)

Petitioner Ignored "Pileup" at Interfaces

CanadianSolar

at the oxide interface. POR, 16-18. However, Ramappa confirmed that iron readily passes through the interface between the silicon oxide and silicon substrate, even with undoped surfaces and extremely thick oxides. EX1025, Fig. 5; EX1087, 81:15-82:19. Ramappa also observed that metal impurities such as iron "exhibit[]

Pet.'s Reply at p. 14



Patent Owner's Sur-Reply at p. 4 (reproducing Ex. 1025, Fig. 5 with annotation)

PVLaw

Inherency – Legal Standard

"The record before us . . . is replete with showings that the claimed product, if it was produced in the Fermi [prior art] process, was produced in such miniscule amounts and under such conditions that its presence was undetectable."

In re Seaborg, 328 F.2d 996, 998-99 (C.C.P.A. 1964)
(cited in POR at 13)



Inherency – Legal Standard

"[I]nherent anticipation requires . . . more than the presence of an unrecognized *de minimis* quantity of claimed substance in the prior art."

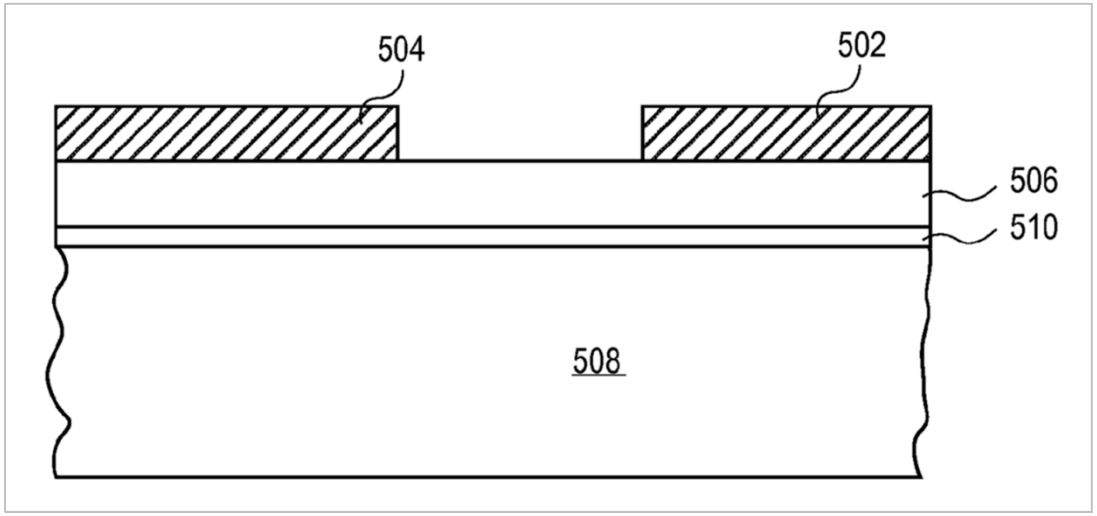
Crown Packaging Tech., Inc. v. Ball Metal Beverage Container Corp., 635 F.3d 1373, 1383 (Fed. Cir. 2011)

(cited in PO's Sur-Reply at p. 11)



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

"Petitioner Failed to Consider the Duration of Li's Dopant Diffusion Step"
POR at p. 22



Ex. 1005, Fig. 5A

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

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

POR at p. 25

84. The extent to which any impurities in Li's substrate 508 would, during Li's dopant diffusion step, (i) getter out of Li's substrate 508, (ii) migrate across the Si-SiO_2 interface, (iii) getter through oxide layer 510, (iv) migrate across the SiO_2-polysilicon interfacial region, and (v) become trapped in Li's material layer 506 would depend on the duration of that dopant diffusion step. CSI glosses over that crucial detail.

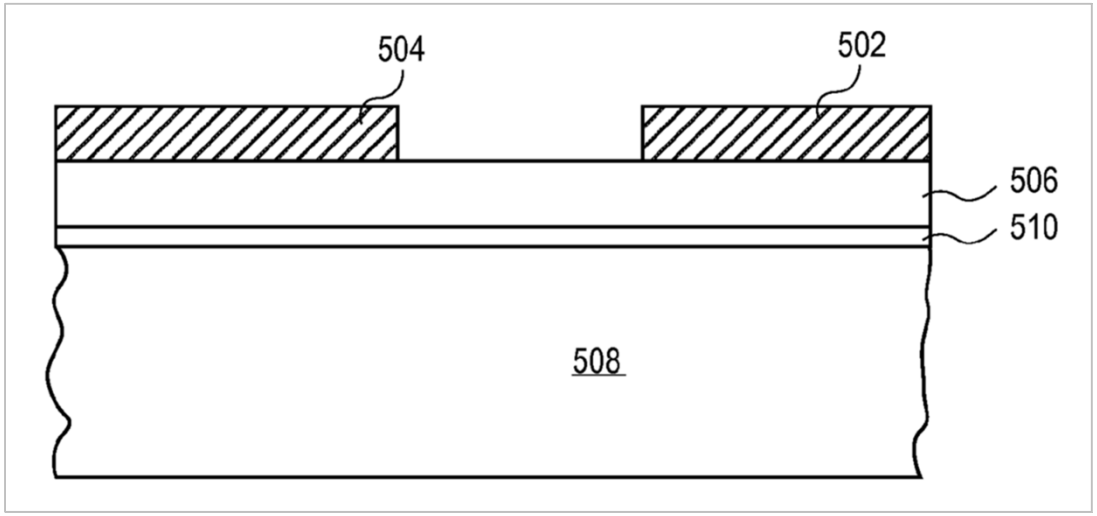
Ex. 2021, ¶ 84
(cited in Patent Owner's Sur-Reply at p. 6)



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Petitioner Failed to Consider Characteristics of Li's Dielectric Film

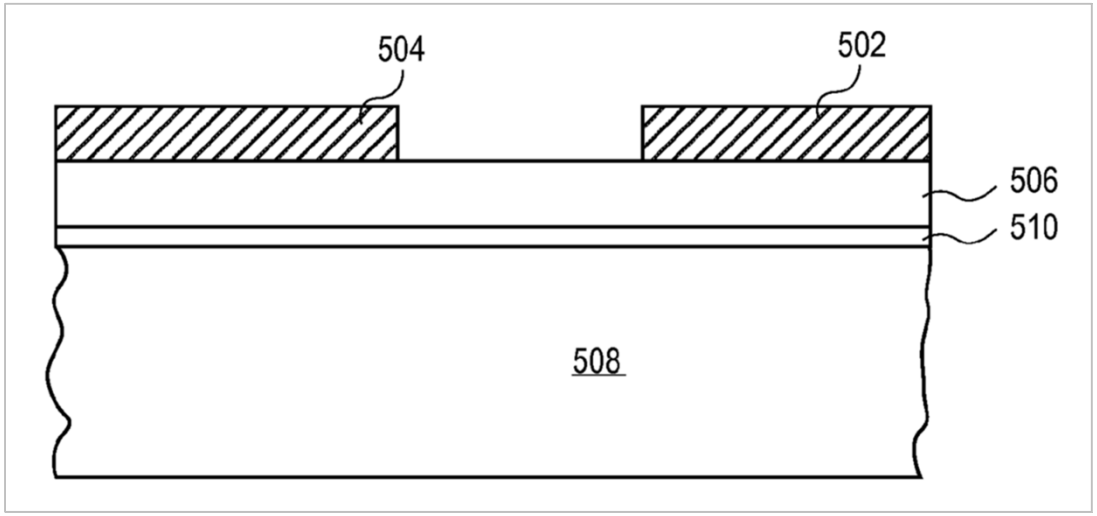
"Petitioner Failed to Consider Key Characteristics of Li's Dielectric Film 510"
POR at p. 26



Ex. 1005, Fig. 5A

Petitioner Failed to Account for Decreased Gettering into Boron-Doped Regions

"Petitioner's Admission that Boron Is Used in Its Proposed Combinations Further Undermines Its Inherency Arguments"
PO Sur-Reply at p. 17



Ex. 1005, Fig. 5A

Petitioner Failed to Account for Decreased Gettering into Boron-Doped Regions

CanadianSolar

of the fabrication of the back side of the solar cell[]"). The process of doping Li's backside polysilicon regions with boron and phosphorous via dopant source regions is the same in the Li-Muller combination as in all other combinations.

Pet.'s Reply at p. 20

As shown in Figure 7, unlike P-doped poly-Si, the B-doped poly-Si layer on its own exhibits a poor gettering effect, which is consistent with the literature regarding the inefficient gettering by heavily B-doped silicon for Fe at thermal diffusion temperatures[26,41] and the weak gettering effects of the undoped poly-Si layer alone.[8]

Ex. 1028 (Liu-1), p. 2279
(cited in PO's Sur-Reply at p. 18)

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Petitioner Failed to Account for Decreased Gettering into Boron-Doped Regions

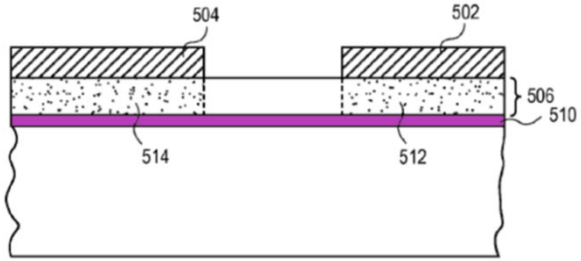


FIG. 5B

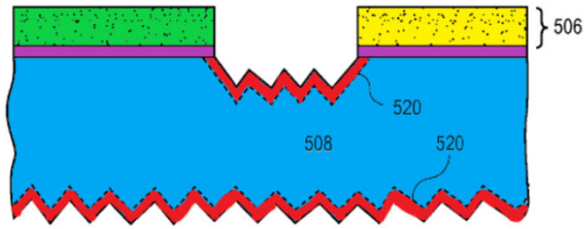


FIG. 5E

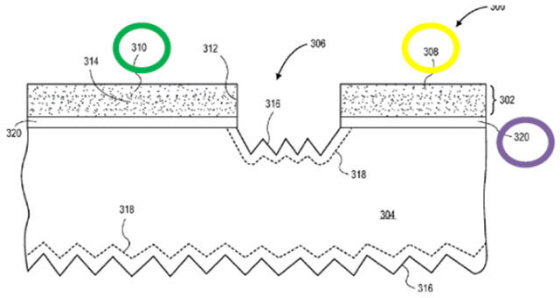


FIG. 3

Petition at pp. 40, 42

Petitioner Failed to Account for Decreased Gettering into Boron-Doped Regions

CanadianSolar

Because Li's polysilicon "P-type region 310" and "N-type region 308" (in FIG. 3 and corresponding green and yellow regions in FIG. 5E of Li) are the same structure, arrangement, and doping as the "P-type and N-type doped polysilicon regions" in FIG. 5 of the 315 Patent, they satisfy "*the first and second emitter regions*" of the 315 Patent claims. EX1003, ¶¶147-149.

Petition at pp. 41-42

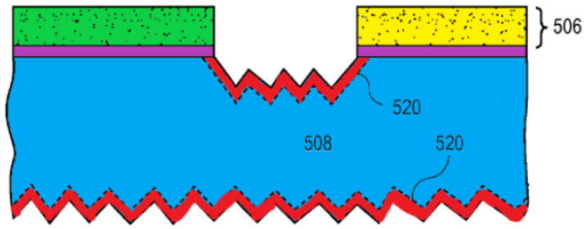


FIG. 5E

Petition at p. 42

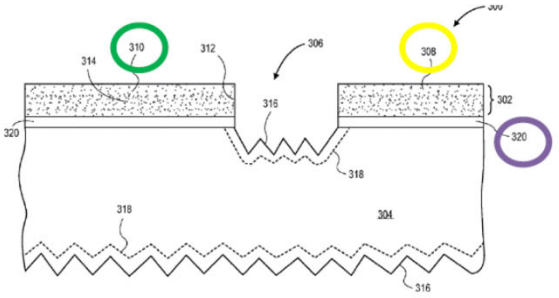


FIG. 3

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Petitioner's New "Dopant-as-Impurity" Argument Is Unavailing

CanadianSolar

> At his deposition, Dr. Carroll acknowledged that Li's n-type and p-type dopants in the polysilicon are also "metal impurities," which satisfy the limitations of claims 10 and 16 of the 315 Patent because gettering is not required. EX1087, 34:13-37:8, 122:22-123:11.

Pet.'s Reply, p. 7 n.3



Q. And a dopant can be considered a type of impurity, correct?

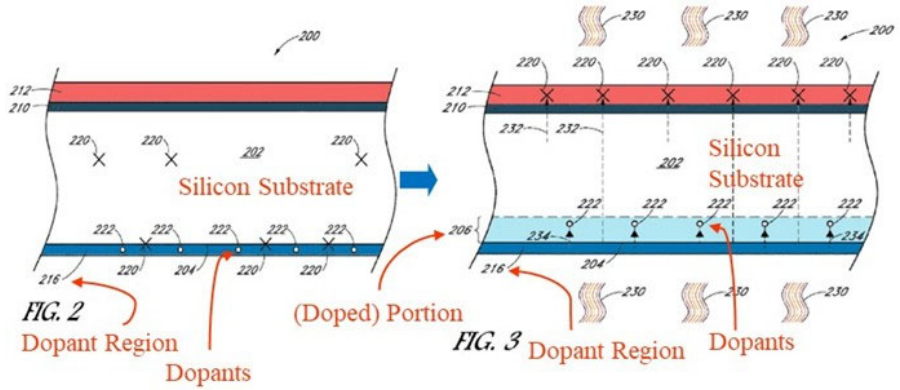
A. Well, I think that's -- so it is harder to answer that because one has to have the context of what someone's talking about. If you look at literature and they talk about impurities in solar cells, they almost never include the idea that a dopant is an impurity,

Ex. 1087 (Carroll Depo.) at 35:21-36:3
(cited in POR's Sur-Reply at p. 20)

PVLaw

The Differences Between Li and the ’315 Patent

The ’315 Patent



Ex. 2021, ¶ 101
(cited in PO’s Sur-Reply at p. 13)

Li

dopant source layer **504**, heating substrate **508**. In one embodiment, heating substrate **508** includes heating in the presence of a gaseous N-type dopant source and doping, with the gaseous N-type dopant source, substrate **508** at or near surfaces of substrate **508** not covered by material layer **506**, as

Ex. 1005 (Li), ¶ [0049]
(cited in PO’s Sur-Reply at pp. 13-14)

The Differences Between Li and the ’315 Patent

CanadianSolar

In Li, dopant diffusion is conducted above 900°C, just like in the 315 Patent,

Petition, p. 44
(cited in PO’s Sur-Reply at p. 14)

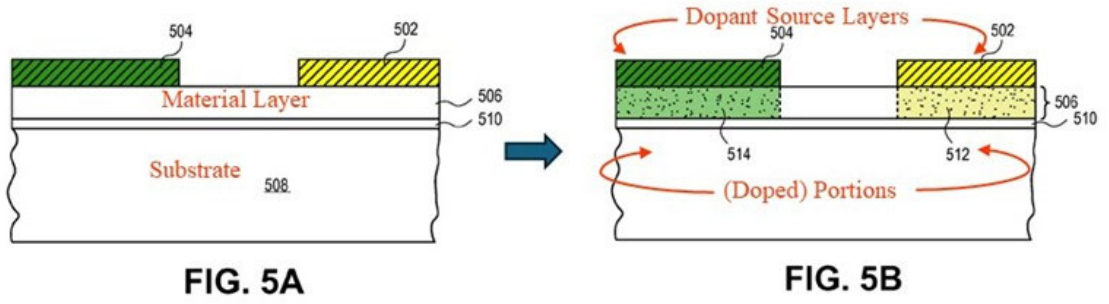


FIG. 5A FIG. 5B

Ex. 2021, ¶ 103
(cited in PO’s Sur-Reply at p. 15)

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Grounds 3 and 4 Are Duplicative of Grounds 1 and 2

Grounds 3 and 4

Petitioner Fails to Make Out a Prima Facia Case of Obviousness Under § 103

CanadianSolar

The obviousness grounds presented above disclose all limitations of the Claims 10-15. 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 p. 69

CanadianSolar

As discussed above, Hu and Ramappa confirm that Li's heating of the polysilicon material layers at 950°C during formation of the emitter region would result in metallic impurities such as iron being gettered from Li's multicrystalline silicon substrate, through the 1-2 nm silicon dioxide layer, and into the doped emitter region. EX1003, ¶225. Therefore, Hu and Ramappa in combination with Li would disclose this limitation.

Petition at p. 74

PVLaw

Grounds 3 and 4 Rely on Inherency

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 (Banerjee Depo.), 67:15-22
(cited in POR at pp. 37-38)

And so if I'm understanding correctly, you'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.

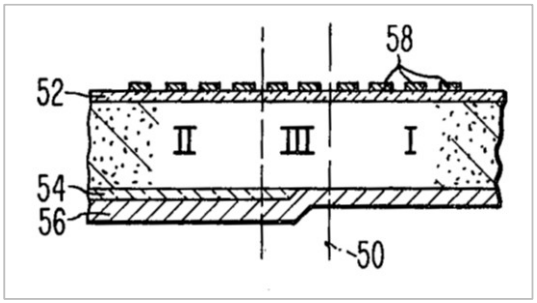
Is that right?

A No, we are not introducing new steps. So

Ex. 2022 (Banerjee Depo.), 181:16-20
(cited in POR at p. 37)



Hu and Ramappa Do Not Remedy the Deficiencies of Li



Ex. 1017 (Hu), Fig. 5
(cited in POR at p. 39)

TABLE I

Column	Region	Mean Generation Current Nano Amp/cm²	Remarks
1–4	II	108	ungettered
5–6	III	3.4	transition region
7–10	I	1.7	gettered

Ex. 1017 (Hu), 9:47-53 (annotated)
(cited in POR at p. 39)

Following thermal annealing iron diffuses through the silicon dioxide layer into the SiO_2-Si interface before being transported into the underlying silicon bulk. The SiO_2-Si interface is known to act as a sink for impurities.[23] Normally, an impurity tends to segregate or remain at the interface if it reduces the interfacial free energy or stress. Metallic impurities including iron have been reported to have a tendency to accumulate in the oxide near the interface.[13,14] This "pileup" characteristic introduces a discontinuity in the concentration profile of iron from the oxide into silicon.

Ex. 1025 (Ramappa), p. 3775
(cited in POR at p. 40)

It Would Not Have Been Obvious to Implement the Claimed “dopant concentration” in Li

Grounds 1 and 3

There Is No Optimal Dopant Concentration

CanadianSolar

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. EX1003, ¶¶74-80.

Petition at p. 15

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Li Is Unlike King

cluded in τ_{eff}. Most 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. The substrate was in high-level injection dur-

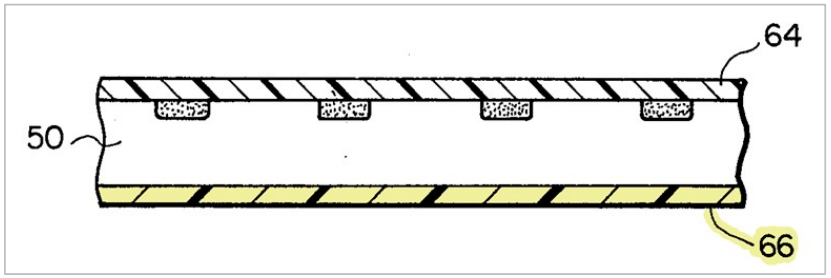
Ex. 1006 (King) at p. 366
(cited in POR at pp. 48-49)

with a reasonable expectation of success by the Skilled Artisan, given that Li does not disclose any other layers on the front surface of the solar cell (EX1005 at Fig. 5E). The Skilled Artisan would recognize that Muller's teaching to dope the front

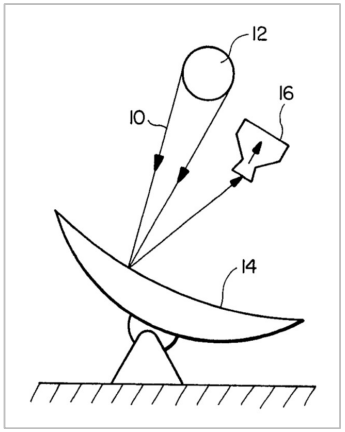


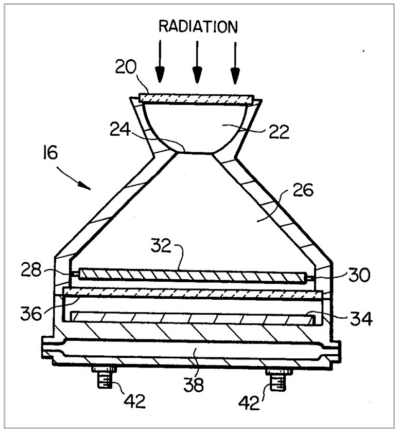
Ex. 1003 (Banerjee Dec.) at ¶ 199
(cited in POR at p. 49)

Li Is Unlike Swanson-352



POR at p. 50
(reproducing Ex. 1015, Fig. 7, with highlighting added)



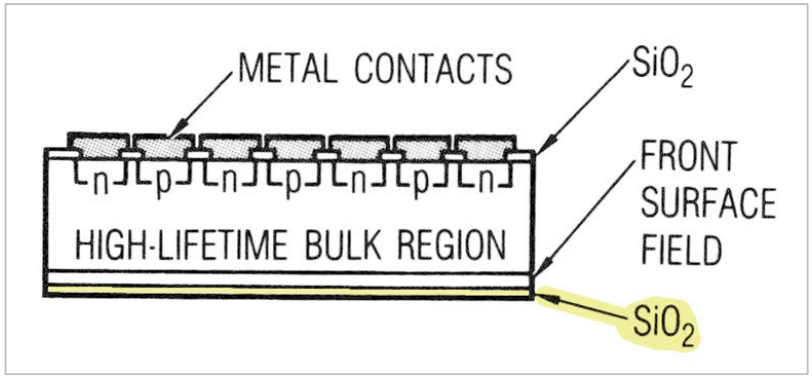


Ex. 1015, Figs. 1, 2
(cited in POR at pp. 51, 52)

greater wavelengths. The walls of the converter housing define a parabolic cone concentrator shown generally at **22** which provides a nonimaging concentration system and increases the concentration of the solar radiation to approximately 20,000 times at the throat **24**.

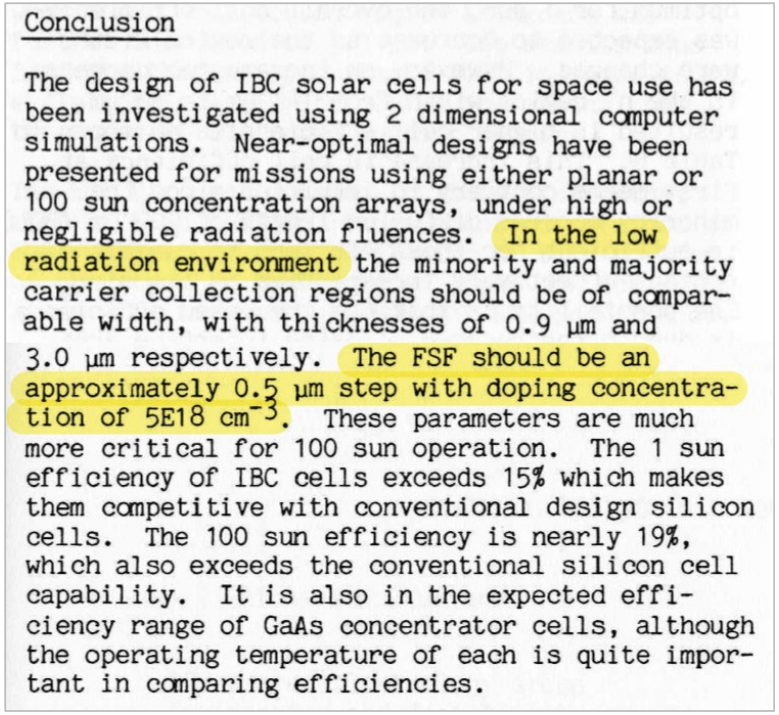
Ex. 1015, 3:22-26
(cited in POR at p. 52)

Li Is Unlike Marvin



POR at p. 54
(reproducing Ex. 1035, Fig. 1, partial, with highlighting added)

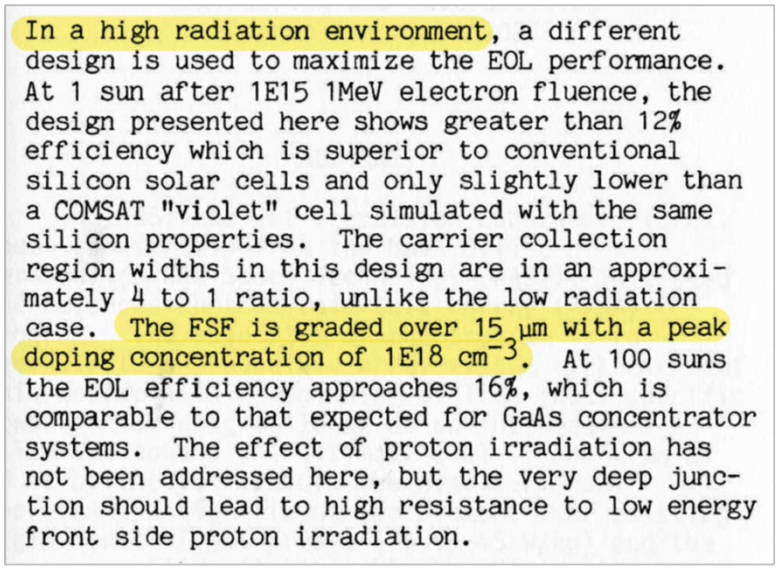
Li Is Unlike Marvin



Conclusion

The design of IBC solar cells for space use has been investigated using 2 dimensional computer simulations. Near-optimal designs have been presented for missions using either planar or 100 sun concentration arrays, under high or negligible radiation fluences. In the low radiation environment the minority and majority carrier collection regions should be of comparable width, with thicknesses of 0.9 μm and 3.0 μm respectively. The FSF should be an approximately 0.5 μm step with doping concentration of 5E18 cm^{-3}. These parameters are much more critical for 100 sun operation. The 1 sun efficiency of IBC cells exceeds 15% which makes them competitive with conventional design silicon cells. The 100 sun efficiency is nearly 19%, which also exceeds the conventional silicon cell capability. It is also in the expected efficiency range of GaAs concentrator cells, although the operating temperature of each is quite important in comparing efficiencies.

Ex. 1035, pp. 826-827 (highlighting added)
(cited in POR at pp. 54-55)



In a high radiation environment, a different design is used to maximize the EOL performance. At 1 sun after 1E15 1MeV electron fluence, the design presented here shows greater than 12% efficiency which is superior to conventional silicon solar cells and only slightly lower than a COMSAT "violet" cell simulated with the same silicon properties. The carrier collection region widths in this design are in an approximately 4 to 1 ratio, unlike the low radiation case. The FSF is graded over 15 μm with a peak doping concentration of 1E18 cm^{-3}. At 100 suns the EOL efficiency approaches 16%, which is comparable to that expected for GaAs concentrator systems. The effect of proton irradiation has not been addressed here, but the very deep junction should lead to high resistance to low energy front side proton irradiation.

Ex. 1035, p. 827 (highlighting added)
(cited in POR at p. 55)

DEMONSTRATIVE EXHIBIT – NOT EVIDENCE

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The Industry Trend Was Toward Higher Dopant Concentrations



> Regardless, under the terrestrial, 1-sun application upon which CSI's theory appears to be based, a person of ordinary skill in the art would have been more likely to employ a dopant concentration at least as high as those in Granek (greater than 2×10^{18}), Lamers (3×10^{18}), Desa (10^{19}), or Procel (3.47×10^{18}). These references reflect the trend in the industry before 2014 that it was preferable to use thinner passivation layers and higher dopant concentrations.

Ex. 2021, ¶ 146
(cited in POR at p. 55)

Petitioner's "Obvious to Try" Theory Is New and Unavailing

CanadianSolar

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. EX1003, ¶¶74-80.

Petition at p. 15

CanadianSolar

A Skilled Artisan in 2014 would have recognized that there were a "finite number of identified, predictable solutions" to the front dopant concentration issue, each of which could be adapted to fit Li's broadly-adaptable back-contact solar cell, and thus selecting a concentration at or below approximately $2x10^{18}$ cm^{-3} would have, at a minimum, been "obvious to try." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420-421 (2007) (particular method to fill "design need" left by the

Pet.'s Reply at p. 23

PVLaw

The Li + Muller Combination Is Unavailing

Grounds 2 and 4

Petitioner Fails to Proffer Any Benefits of Li + Muller Compared to Li

CanadianSolar

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. EX1003, ¶193; EX1008, Tables 1 and 2.

Petition at p. 62

PVLaw

Petitioner Fails to Proffer Any Benefits of Li + Muller Compared to Li

CanadianSolar

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." EX1036, 10. Ion-implantation had also been shown before 2014 to increase solar cell efficiency while reducing the process sequence in production. *Id.*, 11; EX1003, ¶194.

Petition at pp. 62-63



194. 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." EX1036, 10. Ion-implantation had also been shown before 2014 to increase solar cell efficiency while reducing the process sequence in production. *Id.* at11.

Ex. 1003 (Banerjee Dec.)
(cited in POR at p. 59)

PVLaw

Petitioner Ignores the Drawbacks to Modifying Li

maxeon

- 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.

POR at p. 57

Petitioner Ignores the Drawbacks to Modifying Li

CanadianSolar

process operations is achieved." EX1005, ¶[0024]. In fact, Li expressly contemplated undertaking "***additional*** heating or anneal operation[s]" in order to achieve improved solar cell efficiency. *Id.*; EX1087, 180:8-183:9. Further, ion-

Pet.'s Reply at p. 29

herein, as compared with conventional process flows. In some embodiments, using process flows such as those described in detail herein may be preferable over conventional flows even though some of the process flows described herein include an additional heating or anneal operation.

Ex. 1005 (Li) at ¶ [0024]
(cited in PO's Sur-Reply at pp. 24-25)

PVLaw