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Paper 52
Date: January 12, 2026

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner,

v.

MAXEON SOLAR PTE. LTD.,
Patent Owner.

IPR2024-01038[1]
Patent 11,251,315 B2

Before JO-ANNE M. KOKOSKI, KRISTINA M. KALAN, and AVELYN M. ROSS, *Administrative Patent Judges.*

KOKOSKI, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining No Challenged Claims Unpatentable
35 U.S.C. § 318(a)

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

I. INTRODUCTION

We have jurisdiction to conduct this *inter partes* review under 35 U.S.C. § 6, and issue this Final Written Decision pursuant to 35 U.S.C. § 318(a). For the reasons that follow, we determine that Canadian Solar, Inc. ("Petitioner") does not show by a preponderance of the evidence that claims 10–16 and 19 (the "challenged claims") of U.S. Patent No. 11,251,315 B2 ("the '315 patent," Ex. 1001) are unpatentable.

A. Procedural Background

Petitioner filed a Petition in IPR2024-01038 ("1038IPR") to institute an *inter partes* review of claims 10–15 of the '315 patent. Paper 1 ("Pet."). Petitioner also filed a Petition in IPR2024-01194 ("1194IPR") that challenges claims 16 and 19 of the '315 patent. Paper 28 ("1194IPR Pet."). Maxeon Solar Pte. Ltd. ("Patent Owner") filed Preliminary Responses in the 1038IPR (Paper 9) and the 1194IPR (Paper 8). With Board authorization, Petitioner filed a Preliminary Reply and Patent Owner filed a Preliminary Sur-reply to the Preliminary Response in each proceeding. Papers 10, 12; 1194IPR, Papers 9, 11.

Pursuant to 35 U.S.C. § 314(a), we instituted an *inter partes* review of claims 10–15 on the grounds advanced in the Petition in the 1038IPR on January 14, 2025. Paper 13 ("1038IPR Dec."). On January 24, 2025, we instituted an *inter partes* review of claims 16 and 19 in the 1194IPR. 1194IPR, Paper 12 ("1194IPR Dec."). We consolidated the 1194IPR with the 1038IPR and ordered that all future papers and exhibits addressing the claims at issue in both cases be filed in the 1038IPR. Paper 23; 1194IPR, Paper 22. Unless otherwise noted, we refer to the papers and exhibits filed in the 1038IPR in this Decision.

After the proceedings were consolidated, Patent Owner filed a Patent Owner Response ("PO Resp.," Paper 30), Petitioner filed a Reply ("Pet. Reply," Paper 42), and Patent Owner filed a Sur-reply ("PO Sur-reply," Paper 44).

We held an oral hearing on October 15, 2025, and a transcript is included in the record. Paper 51 ("Tr.").

B. Real Parties in Interest

Petitioner identifies CSI and Canadian Solar (USA) Inc. as the real parties in interest. Pet. 4; 1194IPR Pet. 2. Patent Owner identifies itself as the real party in interest. Paper 5 (Mandatory Notice), 2; 1194IPR, Paper 5 (Mandatory Notice), 2.

C. Related Matters

The parties indicate that the '315 patent is asserted in *Maxeon Solar Pte. Ltd. v. Canadian Solar, Inc.*, Case No. 2:24-cv-210 (E.D. Tex.), *Maxeon Solar Pte. Ltd. v. REC Solar Holdings AS*, Case No. 2:24-cv-00260 (E.D. Tex.), and *Maxeon Solar Pte. Ltd. v. Hanwha Sol'ns Corp.*, Case No. 2:24-cv-00262 (E.D. Tex.). Pet. 4; 1194IPR, Paper 5, 2. Patent Owner indicates that the '315 patent is also asserted in *Hanwha Sol'ns Corp. v. Maxeon Solar Pte. Ltd.*, IPR2024-01198 (PTAB). 1038IPR, Paper 6 (Updated Mandatory Notice), 2; 1194IPR, Paper 5, 2.

D. The '315 Patent

The '315 patent is directed to "solar cell fabrication techniques to improve solar cell lifetime, passivation and/or efficiency" and "example solar cells fabricated according to the disclosed techniques." Ex. 1001, 3:18–21. Figure 5 is reproduced below.

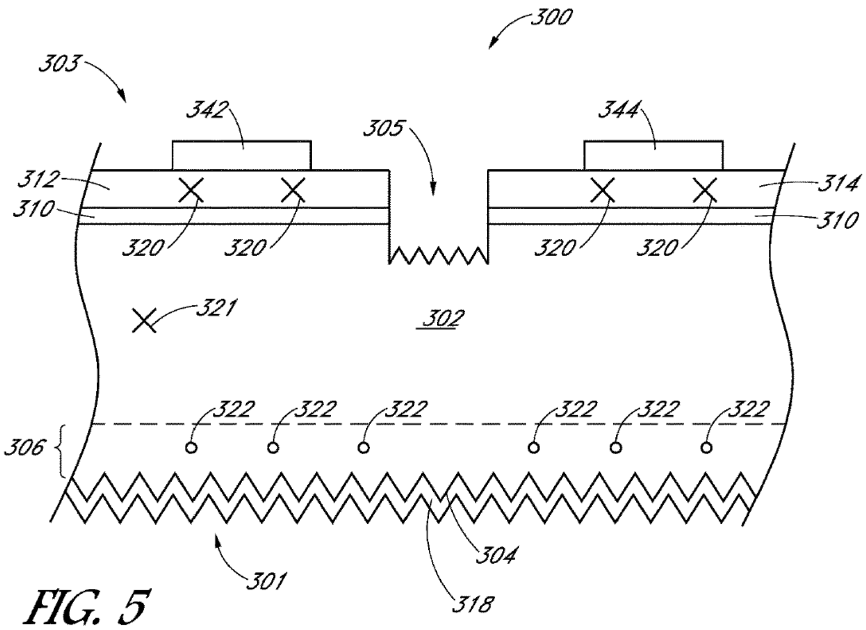

FIG. 5

Figure 5 is a cross-sectional view of a solar cell according to an embodiment described in the ’315 patent. *Id*. at 1:49–50. Solar cell 300 has front side 301 that faces the sun during normal operation and back side 303 opposite front side 301. *Id*. at 6:42–44. Silicon substrate 302 can be a N-type silicon substrate, portion 306 of which “can have a doping concentration 322 of approximately less than or equal to $2x10^{18}$ cm^{-3}. *Id*. at 6:44–49. Dielectric region 310 is formed over silicon substrate 302, which can be a tunnel oxide or silicon dioxide. *Id*. at 6:50–53. First and second emitter regions 312, 314 are P-type and N-type polysilicon regions, respectively. *Id*. at 6:54–57. Metal impurities 320 are located in first and second emitter regions 312, 314. *Id*. at 6:57–60. Silicon substrate 302 can have impurities 321 remaining after the gettering[2] process. *Id*. at 6:60–62.

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[2] Petitioner describes “gettering” as “a well-known process . . . in which metal impurities naturally present in the silicon substrate are moved into the polysilicon regions when heated at high temperatures.” Pet. 2.

First and second metal contacts 342, 344 are formed on first and second emitter regions 312, 314, respectively, with a trench region 305 separating first and second emitter regions 312, 314. Ex. 1001, 6:63–67. Textured surface 304 on front side 301 is a surface that can provide additional light absorption, and portion 306 of silicon substrate 302 is formed above textured surface 304. *Id*. at 7:1–6. Trench region 305 is also textured for additional light absorption from back side 303. *Id*. at 7:6–9. Anti-reflective region 318, which can be silicon nitride, is formed over textured surface 304. *Id*. at 7:9–12.

The '315 patent describes an example "where a surface, or a portion near the surface, of a silicon substrate was doped at approximately less than or equal to $2x10^{18}$ cm^{-3}" and the solar cell was "heated to a temperature above 900 degrees Celsius." Ex. 1001, 8:40–45. In this example, "gettering in a polysilicon region of the silicon substrate, improved surface passivation at approximately 5 fA/cm^2, improved lifetime, e.g. typical of approximately 10 μsec, and a >0.5% efficiency increase as compared to other solar cells." *Id*. at 8:45–50. In another example, the silicon substrate was doped at approximately less than or equal to $2x10^{18}$ cm^{-3} and the solar cell heated to a temperature below 900 degrees Celsius, "resulting in gettering in a non-polysilicon region of the solar cell, good surface passivation at approximately 2 fA/cm^2, poor lifetime, e.g. typical of approximately 3 μsec and no considerable, e.g., >0.5% efficiency increase from the baseline." *Id*. at 8:51–59.

E. Illustrative Claim

Petitioner challenges claims 10–16 and 19 of the '315 patent. Pet. 4–5; 1194IPR Pet. 3–4. Claim 10, the only independent claim, is representative of the challenged subject matter, and is reproduced below.

> 10. A solar cell, the solar cell having a front side which faces the sun during normal operation and a back side opposite the front side, the solar cell comprising:
>
> a silicon substrate, wherein a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3} and wherein the portion of the silicon substrate is formed at the front side of the solar cell;
>
> a dielectric region formed over the silicon substrate, wherein the dielectric region is formed over the back side of solar;
>
> a first emitter region having metal impurities formed over the dielectric region; and
>
> a first metal contact formed over the first emitter region.

Ex. 1001, 10:48–61.

F. Evidence

Petitioner relies on the following evidence.

Name	Patent Document	Exhibit
Hu	US 4,053,335, published Oct. 11, 1977	1017
Swanson-352	US 4,234,352, published Nov. 18, 1980	1015
Li	US 2011/0214719 A1, published Sept. 8, 2011	1005

Petitioner relies on the following non-patent literature evidence.

Name	Non-Patent Literature Title	Author	Exhibit
King	*Studies of Diffused Phosphorous Emitters: Saturation Current, Surface Recombination Velocity, and Quantum Efficiency*, Vol. 37, No. 2, pp. 365–371, Feb. 1990	R. R. King	1006

Name	Non-Patent Literature Title	Author	Exhibit
Marvin	*Analysis of Interdigitated Back Contact Silicon Solar Cells for Space Use*, IEEE, pp. 821–827 (1989)	D. C. Marvin	1035
Muller	*Ion implantation for all-alumina IBC solar cells with floating emitter*, Energy Procedia 55, pp. 265–271 (2014)	Ralph Müller	1008
Ramappa	*Diffusion of Iron in Silicon Dioxide*, Journal of Electrochemical Society, Vol. 145, No. 10, pp. 3773-3777 (1999)	Deepak A. Ramappa	1025

G. Asserted Grounds

Petitioner asserts that claims 10–16 and 19 would have been unpatentable on the following grounds:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
10–12, 15, 16, 19	103[3]	Li, King, Swanson-352, Marvin
10, 13–16, 19	103	Li, Muller
10–12, 15, 16, 19	103	Li, King, Swanson-352, Marvin, Hu, Ramappa
10, 13–16, 19	103	Li, Muller, Hu, Ramappa

Pet. 5; 1194IPR Pet. 3–4. Petitioner relies on the Declarations of Sanjay Banerjee, Ph.D. to support its contentions. Ex. 1003; Ex. 1100. Patent Owner relies on the Declaration of David L. Carroll, Ph.D. Ex. 2021.

[3] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112–29, 125 Stat. 284 (2011), revised 35 U.S.C. §§ 102 and 103 effective March 16, 2013. Because the '315 patent has an effective filing date after March 16, 2013 (Ex. 1001, codes (22), (60)), we refer to the AIA version of Sections 102 and 103.

II. ANALYSIS

A. Level of Ordinary Skill in the Art

Petitioner contends that a person of ordinary skill in the art ("Skilled Artisan") would have had "an advanced degree involving the discipline of electrical engineering, applied physics, chemistry, or materials science, and at least two years of experience designing, developing, or researching in the field," or "a bachelor's degree in electrical engineering, applied physics, or materials science, and at least three years of experience designing, developing, or researching in the field." Pet. 5–6 (citing Ex. 1003 ¶ 47); 1194IPR Pet. 11 (citing Ex. 1100 ¶ 47). Patent Owner states that it "accepts the level of ordinary skill in the art that is proposed in the Petition." PO Resp. 11.

In the Institution Decisions, we adopted the assessment offered by Petitioner. 1038IPR Dec. 5–6; 1194IPR Dec. 8. Because Petitioner's definition of the level of skill in the art is consistent with the '315 patent and the asserted prior art, we maintain it for purposes of this Final Written Decision. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir 2001).

B. Claim Construction

We construe each claim "in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent." 37 C.F.R. § 42.100(b). Under this standard, claim terms are generally given their plain and ordinary meaning as would have been understood by a person of ordinary skill in the art at the time of the invention and in the context of the entire patent disclosure. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc). Only those terms in controversy need to be construed, and only to the extent necessary to resolve the controversy. *Realtime Data LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019).

Based on our review of the complete trial record, we determine that it is not necessary to expressly construe any claim terms to resolve the parties' dispute. *Realtime Data*, 912 F.3d at 1375.

C. *Asserted Obviousness over Li and King, Swanson-352, or Marvin*

Petitioner contends that claims 10–12, 15, 16, and 19 would have been obvious over the combined teachings of Li and King, Swanson-352, or Marvin. Pet. 18–56; 1194IPR Pet. 37–58.

1. *Overview of Li*

Li is directed to "methods of fabricating back-contact solar cells and devices thereof." Ex. 1005 ¶ 3. Figure 3 is reproduced below.

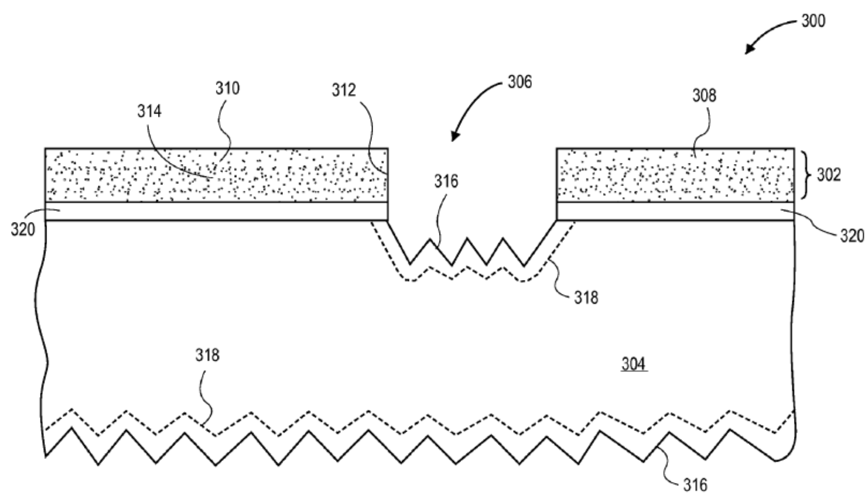

FIG. 3

Figure 3 is a cross-sectional view of a back-contact solar cell according to one embodiment described in Li. *Id.* ¶ 14. Back-contact solar cell 300 includes material layer 302 disposed above substrate 304. *Id.* ¶ 36. Trench 306 separates N-type region 308 and P-type region 310. *Id.* P-type region 310 includes dopant concentration 312 directly adjacent to trench 306 approximately equal to dopant concentration 314 in in the center of P-type region 310. *Id*. Material layer 302 is a poly-crystalline silicon layer, and substrate 304 is a single-crystalline silicon substrate. *Id*. ¶ 37. P-type region 310 includes boron dopant impurity atoms, and N-type region 308 includes phosphorous dopant impurity atoms. *Id*. Trench 306 is disposed entirely through material layer 302 and into substrate 304. *Id*. ¶ 38. Surfaces of substrate 304 not covered by material layer 302 include textured surface 316, and N-type dopants 318 are included at or near these non-covered surfaces. *Id*. Dielectric film 320 is disposed directly between material layer 302 and substrate 304 and is composed of silicon dioxide, and can be a tunnel oxide barrier layer film. *Id*. ¶ 39.

Figure 5B is reproduced below.

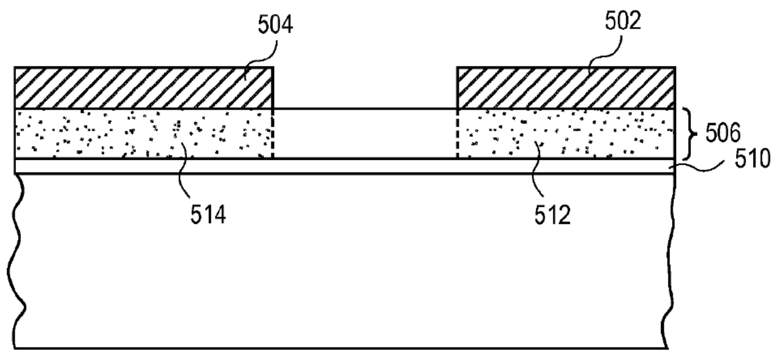

FIG. 5B

Figure 5B is a cross-sectional view of a step in the fabrication of a back-contact solar cell described in Li. Ex. 1005 ¶ 17. Dielectric film 510 is formed directly below material layer 506 and above substrate 508 (not labeled). *Id*. ¶ 43. Li teaches that "heating N-type dopant source layer 502 and P-type dopant source layer 504 includes transferring N-type dopants and P-type dopants, respectively, into portions 512 and 514, respectively, of material layer 506." *Id*. ¶ 45. Li further teaches that "heating N-type dopant source layer 502 and P-type dopant source layer 504 includes heating at a temperature of approximately 950 degrees Celsius." *Id*.

2. *Overview of King*

King reports on studies in which "[t]he surface recombination velocity *s* for silicon surfaces passivated with thermal oxide, is experimentally determined as a function of surface phosphorous concentration for a variety of oxidation, anneal, and surface conditions." Ex. 1006, 365 (emphasis omitted). King reports that, "of a back-contacted cell in which sunside diffusion is used mainly to reduce surface recombination, not to collect current, the optimum emitter is the one with the lowest" emitter saturation current density J_0. *Id*. at 369. King states that for untextured surfaces, this corresponds to an emitter with a surface phosphorous concentration $N_{D,\,\mathrm{surf}}$ of approximately "1 x 10^{18} cm^{-3} that is as thin as possible." *Id*. King also provides experimental results that show "an emitter with these specifications is probably near optimum in J_0 when it has a textured front surface, as well." *Id*.

King concludes that "*s* increases sublinearly in $N_{D,\,\mathrm{surf}}$ for the doping range from 2 x 10^{15} cm^{-3} to 1 x 10^{18} cm^{-3}" and "[b]etween 4 x 10^{18} cm^{-3} and 1 x 10^{18} cm^{-3}, *s* is linear with respect to $N_{D,\,\mathrm{surf}}$." Ex. 1006, 370. According to King, "[t]his dependence of *s* on $N_{D,\,\mathrm{surf}}$ has a profound effect on the emitter saturation current densities for passivated emitters." *Id*.

3. *Overview of Swanson-352*

Swanson-352 "relates to thermophotovoltaic conversions systems and to photovoltaic cells useful therein." Ex. 1015, 1:6–10. Swanson-352 describes the fabrication of a photovoltaic cell from the bottom side up by referring to Figures 5–10, reproduced below.

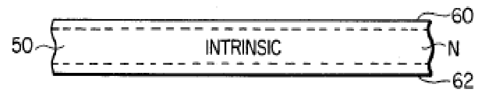

FIG_5

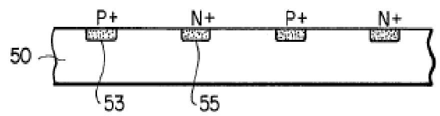

FIG_6

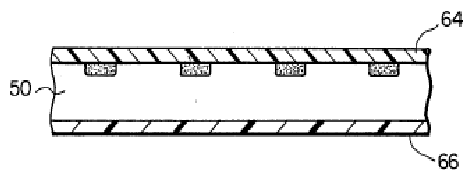

FIG_7

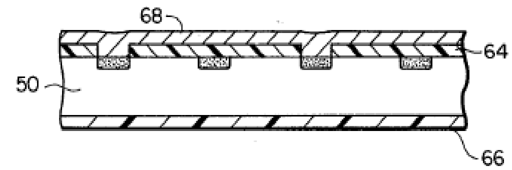

FIG_8

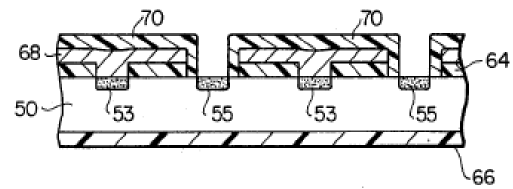

FIG_9

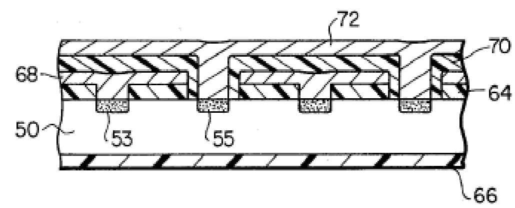

FIG_10

Figures 5–10 illustrate in cross section the steps of fabricating the photovoltaic cell described in Swanson-352. *Id*. at 2:52–54. Starting with Figure 5, intrinsic or lightly doped N-type silicon substrate 50 is provided, wherein "the doping of the bulk substrate material is 10^{14} dopant atoms per cubic centimeter or less." *Id*. at 4:42–45. Shallow diffused regions 60, 62 are formed in opposing surfaces of substrate 50 by diffusion of an N-type dopant such as phosphorous to a depth of 0.1 micron. *Id*. at 4:45–49. Swanson-352 teaches that the maximum surface dopant concentration of diffused regions 60, 62 is 10^{18} atoms per cubic centimeter. *Id*. at 4:49–51. In Figure 6, P+ regions 53 and N+ regions 55 are selectively diffused into the surface of substrate 50; the maximum doping concentration of each region is on the order of 10^{21} atoms per cubic centimeter. *Id*. at 4:52–59. Silicon oxide layers 64, 66 are then formed on the surface of substrate 50 (Figure 7), and electrical interconnect pattern 68 is deposited over silicon oxide layer 64 and P+ regions 53 (Figure 8). *Id*. at 4:60–61, 5:5–8. Silicon oxide insulating layer 70 is formed over the surface, and the silicon oxide overlying N+ regions 55 are removed as shown in Figure 9. *Id*. at 5:28–31. Second electrical interconnect pattern 72 is then formed on the surface to interconnect N+ regions 55 (Figure 10). *Id*. at 5:34–36.

4. *Overview of Marvin*

Marvin reports on studies conducted to assess the utility of Silicon Interdigitated Back Contact (IBC) solar cells for space applications. Ex. 1035, 821. Marvin explains that "[a] subset of all the possible design parameters was selected for study in order to have a manageable task," including "cell thickness, contact, width, spacing and thickness, front surface field doping and thickness, and light intensity." *Id*. at 823. Marvin reports:

> Some additional consideration was given to optimization of the front surface field region and the doped contact spacing. The previous design used a 0.5 μm thick front surface field (FSF) uniformly doped at 5E18 and 20 μm region spacing. It was found that by replacing this with a Gaussian doping profile with a characteristic width of 15 μm and a peak concentration of 1E17, the [end of life] efficiency [of the solar cell] was 12.3% with a 10 μm collector region spacing.

Id. at 826. Marvin concludes that end of life performance is maximized when "[t]he FSF is graded over 15 μm with a peak doping concentration of 1E18 cm^{-3}." *Id*. at 827.

5. *Analysis*

Petitioner contends that Li teaches most of the limitations of claim 10. Pet. 35–54. For example, Petitioner contends that Li teaches "a silicon substrate" (silicon substrate 508), "a dielectric region formed over the silicon substrate, wherein the dielectric region is formed over the back side of solar" (dielectric film 510 formed above silicon substrate 508, which may be composed of silicon dioxide), and "a first emitter region having metal impurities formed over the dielectric region" (P-type region 310 and N-type region 308). *Id*. at 36, 40–52. With respect to the claim 10 limitation "a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3}," Petitioner contends that it would have been obvious to a Skilled Artisan to use a dopant concentration within the recited range based on the teachings of King, Swanson-352, or Marvin. *Id*. at 37–40.

Patent Owner responds that Petitioner does not show that Li teaches "a first emitter region having metal impurities formed over the dielectric region" or that the proposed combinations teach "a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3}." PO Resp. 12–36, 40–56.

Claim 10 recites "a silicon substrate, wherein a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3} and wherein the portion of the silicon substrate is formed at the front side of the solar cell." Ex. 1001, 10:51–55. We focus our analysis on the "a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3}" limitation of claim 10, as it is dispositive of the controversy between the parties.

Petitioner contends that Li discloses a front portion of silicon substrate 508 that is formed by diffusing with phosphorous. Pet. 36–37 (citing Ex. 1005 ¶¶ 37, 38, 41, 49, Fig. 5E; Ex. 1003 ¶ 137). Petitioner contends that the dopant-diffused front portion of silicon substrate 508 "would naturally have a certain '*dopant concentration*' when doped." *Id.* at 37 (citing Ex. 1003 ¶ 137). Petitioner recognizes that Li does not specify the dopant concentration of the front portion of silicon substrate 508, and contends that it would have been obvious "to combine Li's back contact solar cell with the front portion doping concentration of 1x10^{18} cm^{-3} or less as disclosed in King, Swanson-352, or Marvin." *Id.* at 30–31. In particular, Petitioner contends that King teaches that a doping concentration of 1x10^{18} cm^{-3} or less "was the 'optimum' for back-contact solar cells," and Swanson-352 teaches "to use it as the maximum concentration for this portion of a back contact solar cell." *Id.* at 31 (citing Ex. 1003 ¶ 124). Petitioner also contends that Marvin teaches that "for space applications, a 'peak doping concentration of 1E18 [1 x 10^{18}] cm^{-3}' or lower with a 'Gaussian doping profile with a characteristic width of 15 [micrometers]' resulted in better efficiency metrics than higher dopant concentrations." *Id.* (citing Ex. 1035, 826–827) (alterations in original). Because Li acknowledges "that '[e]fficiency is an important characteristic of a solar cell as it is directly related to the solar cell's capability to generate power' and that '[a]ccordingly, techniques for increasing the efficiency of solar cells are generally desirable'(Ex. 1005, ¶0005)," Petitioner contends that a Skilled Artisan reviewing Li "would further have been motivated to select the efficient front doping concentrations disclosed by any of King, Swanson-352, or Marvin." Pet. 32 (citing Ex. 1003 ¶ 126).

Patent Owner responds that a Skilled Artisan would not have selected the dopant concentrations from King, Swanson-352, or Marvin when implementing Li because "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." PO Resp. 40. Patent Owner argues that "the proper dopant concentration in a solar cell is dependent upon a number of factors" and "there is no 'optimal' dopant concentration." *Id.* at 41; *see also id.* at 44–47 (arguing that Lamers,[4] Desa,[5] and Procel[6] "refute Petitioner's contention that there was an optimal dopant concentration established by 2014"). Patent Owner also argues that (1) unlike Li, King employs an oxide passivation layer, and a Skilled Artisan would have been motivated to use a higher dopant concentration than King; (2) Swanson-352 also includes a passivation layer, and is directed to a concentrator solar cell that is used in a specialized environment and requires specialized parameters, and a Skilled Artisan would have understood that Swanson-352's parameters "should not be casually used in other systems, such as Li's;" and (3) Marvin includes a passivation layer, and is directed at space applications, and if a Skilled Artisan did look to Marvin, "that person naturally would have gravitated to Marvin's terrestrial-application parameter ($5x10^{18}$ cm^{-3}) more so tha[n] Marvin's space-application parameter." *Id.* at 48–55.

Patent Owner further argues that "the trend in the industry around 2014 was to use thinner oxide layers and higher dopant concentrations," as "the industry had moved past the outdated designs with thick oxide layers such as King, Swanson, and Marvin." PO Resp. 55 (citing Ex. 2021 ¶ 146). Patent Owner asserts that Lamers, Desa, and Procel "reflect this industry trend" and "disclose dopant concentrations

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[4] M.W.P.E. Lamers, *Towards 21% Efficient N-Cz IBC Based On Screen Printing*, 26th European Photovoltaic Solar Energy Conference and Exhibition, Hamburg, Germany (2011) (Ex. 2024, "Lamers").
[5] Mohd K. Mat Desa, *Optimization of p-type Screen Printed Interdigitated Back Contact Silicon Solar Cell with Aluminum Back Surface Field*, Int'l J. of Eng'g & Tech. IJET-IJENS, Vol. 14, No. 2, 69–80 (2014) (Ex. 2025, "Desa").
[6] Paul Procel, *Analysis of the impact of doping levels on performance of back contact – back junction solar cells*, Energy Procedia 55, 128–132 (2014) (Ex. 2026, "Procel").

of $3x10^{18}$ cm^{-3}, $1x10^{19}$ cm^{-3}, and $3.47x10^{18}$ cm^{-3}, respectively." *Id.* at 55–56 (citing Ex. 2024, 2; Ex. 2025, Fig. 5(c); Ex. 2026, 132). According to Patent Owner, "because Li does not include an oxidation layer, a person of ordinary skill would have been motivated to use an even higher dopant concentration" because a Skilled Artisan "would have understood that the only guard against recombination would have been the dopants, as Li does not include a passivation layer." *Id.* at 56 (citing Ex. 2021 ¶ 147).

Having considered the complete trial record, we determine that Petitioner fails to sufficiently demonstrate that the combination of Li and King, Swanson-352, or Marvin teaches "a portion of the silicon substrate has a dopant concentration of approximately less than or equal to $2x10^{18}$ cm^{-3}" as recited in claim 10 because Petitioner fails to establish by a preponderance of the evidence that a Skilled Artisan would have been motivated to look to the dopant concentrations in King, Swanson-352, or Marvin to determine the concentration of dopants for use in Li's silicon substrate.

The record supports Patent Owner's argument that there is no "optimal" dopant concentration applicable to all back contact solar cells. PO Resp. 41–47. The prior art demonstrates a range of dopant concentrations that vary based on factors such as the structure of the solar cell and its intended use, as summarized below.

King describes studies of the surface recombination velocity for silicon surfaces passivated with thermal oxide in which "[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, 365, 366. King concludes that, for back-contacted cells where the sunside diffusion is used mainly to reduce surface recombination, the optimum emitter "is as thin as possible" and has an untextured surface with a dopant concentration of $1x10^{18}$ cm^{-3}. *Id.* at 369.

Swanson-352 describes a silicon substrate with a 0.175 micron silicon oxide layer on the doped front surface. Ex. 1015, 4:61–66. Swanson-352 teaches that the solar cell is used with a thermophotovoltaic converter that includes a parabolic cone radiation converter and a processor portion including a radiator that absorbs concentrated radiation. *Id.* at code (57); *see id*. at 2:68–3:56, Figs. 1, 2. Swanson-352 reports that, for these conditions, the maximum dopant concentration is 10^{18} cm^{-3}. *Id.* at 4:49–51.

Marvin assesses the utility of back contact solar cells for space applications. Ex. 1035, 821. Marvin reports a peak doping concentration in a high radiation environment (i.e., space) of $1x10^{18}$ cm^{-3}. *Id*. at 827. For a low radiation environment (i.e., on land), Marvin reports a higher doping concentration of $5x10^{18}$ cm^{-3}. *Id.* at 826–827.

Other prior art references provide more examples of "optimal" dopant concentrations for back contact solar cells. Lamers describes a back contact cell in which the front side is passivated using a silicon nitride coating and the back side is passivated using a silicon oxide/silicon nitride stack, and finds the "optimum doping level" to be $3x10^{18}$ cm^{-3}. Ex. 2024, 1, 2. In Desa's back contact cell that employs a silicon nitride layer for passivation and anti-reflective coating maximized efficiency at dopant concentrations of $1x10^{19}$ cm^{-3} and higher. Ex. 2025, 71, Fig. 5(c). Procel's simulated solar cell has a front surface coated by double-layer anti-reflective coating composed of silicon nitride and silicon oxide and a back side passivated using silicon oxide. Ex. 2026, 129. Procel reports that the cell's optimum peak doping concentration is $3.47x10^{18}$ cm^{-3}. *Id.* at 132.

Taken together, the prior art of record demonstrates that there is no one "optimal" doping concentration for back contact solar cells generally. On the contrary, the prior art shows that optimal doping concentration changes based on factors such as the presence (or absence) of passivation layers, the environment in which the solar cell will be employed, and how the solar cell will be used.

In light of these prior art disclosures, neither Petitioner nor Dr. Banerjee adequately explains why a Skilled Artisan would have been motivated to use the dopant concentrations reported in King, Swanson-352, and Marvin in Li's back contact solar cell. In an obviousness analysis, some kind of reason must be shown as to why a Skilled Artisan would have thought of combining or modifying the prior art to achieve the patented invention. *See Innogenetics, N.V. v. Abbott Labs.*, 512 F,2d 1363, 1374 (Fed. Cir. 2008). Here, Petitioner offers the general propositions that Li, King, Swanson-352, and Marvin are analogous art; King, Swanson-352, Marvin disclose the same $1x10^{18}$ cm^{-3} dopant concentration; and Li acknowledges that efficiency is an important solar cell characteristic, and that techniques for increasing solar cell efficiency are desirable. Pet. 30–32; Ex. 1003 ¶¶ 124, 126. Given the prior art's description of different "optimal" dopant concentrations for different solar cells, Petitioner's arguments and Dr. Banerjee's testimony leave an analytical gap that does not apprise us of why a Skilled Artisan would have employed the dopant concentration of $1x10^{18}$ cm^{-3} from King, Swanson-352, or Marvin in Li's solar cells.

In that regard, neither Petitioner nor Dr. Banerjee address whether a dopant concentration of $1x10^{18}$ cm^{-3} was an "optimal" concentration for Li's solar cell, given the differences between Li's solar cell and the solar cells described in King, Swanson-352, and Marvin. As the prior art described above demonstrates, optimal doping concentration varies based on design parameters. *See also* Ex. 2021, 103:15–17 (Dr. Banerjee testifying that "[t]he specific exact optimal [dopant] concentrations may be different for one application or the other"), 182:12–183:2 (Dr. Banerjee testifying that doping concentration depends on the solar cell structure); Ex. 1035, 823 ("Since optimization is achieved by selecting parameters which produce the results desired to meet specific performance requirements, it is necessary to first understand how each parameter affects cell performance."), 827 ("It is especially important with [Interdigitated Back Contact] cells to optimize the design to the particular mission profile. The light intensity to be used and the radiation environment affect the design to a greater extent than in conventional cells.").

The record does not establish that the design parameters of Li's silicon substrate are the same as those in King, Swanson-352, or Marvin. For example, Li's silicon substrate does not have an oxide passivation layer on the doped front side, unlike the silicon substrates in King and Swanson-352. *See* Ex. 1005 ¶¶ 40–49, Figs. 5A–5E (describing a method of fabricating the solar cell without an oxide layer on the doped front surface). And Li does not describe a particular application of its solar cells, unlike Swanson-352 and Marvin. *See* Ex. 1005. Petitioner's arguments do not address these differences.

Moreover, as discussed above, Marvin discloses different optimal dopant concentrations depending on whether the solar cell is used in a low or high radiation environment. Ex. 1035, 826–827. Petitioner relies on the high radiation dopant concentration without explaining why a Skilled Artisan would look to the dopant concentration of the high radiation environment ($1x10^{18}$ cm^{-3}) over that for the low radiation environment ($5x10^{18}$ cm^{-3}). Petitioner only argues that Marvin's focus on space applications would not have deterred the Skilled Artisan from combining Marvin with Li because Li does not limit its back contact solar cell to (low-radiation) terrestrial environments. Pet. 33 (citing Ex. 1003 ¶ 128). This argument, however, does not explain why a Skilled Artisan would disregard Marvin's findings with respect to low-radiation, terrestrial environments in favor of Marvin's findings with respect to space applications.

Petitioner further contends that

> [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."

Pet. Reply 23 (citing *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420–421 (2007)). Patent Owner argues that this is a new theory improperly raised for the first time in Petitioner's Reply and should be disregarded. PO Sur-reply 20. We agree with Patent Owner.

Our rules provide that a petitioner must include "[a] full statement of the reasons for the relief requested, including a detailed explanation of the significance of the evidence including material facts, and the governing laws, rules, and precedent." 37 C.F.R. § 42.22(a). Our rules also state that "[a] reply may only respond to arguments raised in the corresponding . . . patent owner response." *Id.* § 42.23(b). "'Respond,' in the context of 37 C.F.R. § 42.23(b), does not mean proceed in a new direction with a new approach as compared to the positions taken in a prior filing." PTAB Consolidated Trial Practice Guide, 74 (Dec. 2025) ("CTPG"). Our Trial

Practice Guide explains that "Petitioner may not submit new evidence or argument in reply that it could have presented earlier, e.g., to make out a prima facie case of unpatentability." *Id.* at 73; see also *id.* at 74 ("Examples of indications that a new issue has been raised in a reply include new evidence necessary to make out a prima facie case for the patentability or unpatentability of an original or proposed substitute claim, such as newly raised rationale to combine the prior art references that was not expressed in the petition.").

In the Petition, Petitioner argues that a Skilled Artisan would have been motivated to combine Li's back contact cell with the front portion doping concentration disclosed in King, Swanson-352, or Marvin, because Li, King, Swanson-352, and Marvin are analogous art. Pet. 30–32. Petitioner also points to Li's acknowledgement that techniques for increasing efficiency are generally desired because efficiency is an important characteristic of a solar cell. *Id.* at 32. As Patent Owner notes, however, the Petition does not include the phrase "finite number" or "obvious to try." PO Sur-reply 20. Petitioner's "obvious to try" argument is a newly raised rationale to combine the prior art references necessary to make out a *prima facie* case of unpatentability. *See* CTPG 74. Accordingly, we do not consider Petitioner's untimely new argument.

For these reasons, we determine that Petitioner does not establish by a preponderance of the evidence that independent claim 10, and claims 11, 12, 15, 16, and 19 that depend directly or indirectly therefrom, would have been obvious over the combined teachings of Li and King, Swanson-352, or Marvin.

D. Asserted Obviousness over Li and Muller

Petitioner contends that claims 10, 13–16, and 19 would have been obvious over the combined teachings of Li and Muller. Pet. 57–69; 1194IPR Pet. 63–70.

1. Overview of Muller

Muller compares *n*-type IBC solar cells with a low-dose ion-implanted front floating emitter (FFE) passivated by Al_2O_3 with low-dose ion implanted front surface field (FSF) passivated by SiO_2. Ex. 1008, 265. Muller measures doping profiles using electrochemical capacitance-voltage (ECV) profiling after ion implantation of doses of boron in the FFE and phosphorous in the FSF. *Id*. at 267. Muller's experiments included implanted doses of 1e14 cm^{-2}, 3e13 cm^{-2}, and 1e13 cm^{-2}. *Id*. Muller reports "peak doping concentrations in the range of 1e17 to 2e18 cm^{-3}" after implantation of boron or phosphorous and furnace annealing. *Id*.

Muller concludes:

> Ion implantation is suitable to form lowly doped regions acting as front surface fields (FSF) or front floating emitter (FFE) in *n*-type IBC solar cells. Very low saturation densities (J_0) in the range of 10 to 15 fA/cm^2 have been achieved for textured FSF samples passivated with a SiO_2/SiN_x stack. These profiles strongly depend on the surface recombination velocity and therefore suffer from UV-illumination degrading the SiO_2 passivation quality. For textured FFE samples J_0 values down to 5 fA/cm^2 were measured with an Al_2O_3 passivation. This configuration turned out to be quite stable against UV-irradiation.

Ex. 1008, 271. Muller reports that "[f]ully ion implantable and co-annealed IBC solar cells with an Al_2O_3 passivation on both sides featuring a weakly boron doped front floating emitter (FFE) were successfully fabricated ($\eta = 21.8\%$)." *Id*. According to Muller, under UV-illumination, "[t]he efficiency of FSF cells dropped dramatically by more than 50% while the FFE cells lost only about 1% absolute." *Id.*

2. Analysis

Relying on its arguments regarding the combination of Li with King, Swanson-352, or Marvin, Petitioner contends that "Li disclose[s] all elements of Claim 10, except for the dopant concentration of the front portion of the substrate," and "also disclose[s] the additional 'polysilicon' element of claim 15." Pet. 66 (citing *id*. at 35–54, 56); *see also* 1194IPR Pet. 68 (citing *id.* at 37–58) ("Li disclose[s] all elements of Claims 10, 16, and 19, except for the dopant concentration of the front portion of the substrate's front portion."). Petitioner contends that a Skilled Artisan would have been motivated "to replace the phosphorous diffused front portion of Li with the ion-implanted boron-doped FFE at the dopant concentration taught by Muller because such combination would result in increased solar cell efficiency and better stability under UV illumination, as taught by Muller." Pet. 67 (citing Ex. 1003 ¶¶ 192–203).

Petitioner contends that Li and Muller "are both directed to back-contact solar cells and their fabrication." Pet. 62 (citing Ex. 1003 ¶ 188). Petitioner contends that a Skilled Artisan would have looked to Muller to provide the front surface dopant concentration for Li's solar cell because 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 concentrations of $2x10^{18}$ cm^{-3} or less and then passivating the front side with 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 phosphorous-doped ion-

> implanted front surface field (FSF), passivated by SiO_x and/or SiN_x.

Id. (citing Ex. 1003 ¶ 193; Ex. 1008, Tables 1, 2). Petitioner points to Li's acknowledgement that efficiency is an important characteristic of solar cells, and that techniques for increasing solar cell efficiency are "generally desirable" and contends that a Skilled Artisan would have modified Li's solar cell with Muller's ion-implanted boron doped FFE and passivation layers due to its higher efficiency. *Id.* at 64 (citing Ex. 1005 ¶ 5; Ex. 1003 ¶ 197).

Patent Owner responds that Petitioner's proposed changes to Li "would significantly increase the cost and significantly impact the operation of Li's solar cell." PO Resp. 57. Patent Owner argues that "Petitioner fails to identify any benefit in modifying Li much less sufficient benefits to outweigh" such drawbacks. *Id.* Patent Owner also argues that Petitioner does not establish that modifying Li in view of Muller would have resulted in a more efficient solar cell. *Id.* at 57–59. As a result, Patent Owner argues, "Petitioner fails to provide a sufficient motivation to modify Li in the drastic fashion proposed." *Id.* at 56.

Having considered the complete trial record, we are not persuaded that Petitioner sufficiently demonstrates that a Skilled Artisan would have been motivated to modify Li with Muller as proposed. Petitioner asserts that "Li did not specify the concentration of dopants that should be utilized at the front surface" and that "Muller supplies that information" by showing that using a boron-doped FFE passivated with Al_2O_3 and SiN_x with a front dopant concentration of $2x10^{18}$ cm^{-3} or less "resulted in better resistance to surface recombination (J_o) and UV degradation, and overall efficiency of the solar cell" than using a phosphorous-doped FFS that also has a front dopant concentration of $2x10^{18}$ cm^{-3} or less. *See* Pet. 61–62; Ex. 1003 ¶¶ 192–197; Ex. 1008, Tables 1, 2; *see also* Ex. 1008, 267 (Muller explaining that the ion implantation of boron and phosphorous resulted "in extremely weak doping profiles with peak doping concentrations in the range of 1e17 to 2e18 cm^{-3}"). Neither Petitioner nor Dr. Banerjee, however, adequately explain why a Skilled Artisan would have employed Muller's front dopant concentration of $2x10^{18}$ cm^{-3} or less with Li in the first instance. In particular, Petitioner and Dr. Banerjee do not sufficiently explain why a Skilled Artisan seeking to determine the front dopant concentration for Li's solar cell would have looked to Muller's showing that a solar cell with a boron-doped FFE is more efficient than a solar cell with a phosphorous-doped FFS at a front dopant concentration of $2x10^{18}$ cm^{-3} or less.

In an obviousness determination, we must avoid analyzing the prior art through the prism of hindsight. *See* PO Resp. 2 ("[T]he combination [of Li and Muller] appears to have been driven by hindsight."). Instead, we must "cast the mind back to the time the invention was made" and "occupy the mind of one skilled in the art who is presented with only the references, and who is normally guided by then-accepted wisdom in the art." *W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1554 (Fed. Cir. 1983); *see also Kinetic Concepts, Inc. v. Smith & Nephew, Inc.*, 688 F.3d 1342, 1368 (Fed. Cir. 2012) (quoting *Innogenetics*, 521 F.3d at 1374 n.3 ("We must still be careful not to allow hindsight reconstruction of the references to reach the claimed invention without any explanation as to how or why the references would be combined to produce the claimed invention.")). Here, Petitioner attempts to imbue a Skilled Artisan with the knowledge of the claimed invention, when no prior art reference, references of record, or other evidence conveys or suggests that knowledge. Petitioner's argument that a

Skilled Artisan would have modified Li with Muller in this way appears to be premised on Petitioner's knowledge of the '315 patent disclosure. This is improper hindsight reasoning. Petitioner needed to explain what would have led a Skilled Artisan at the time of the invention to consider modifying Li to use a boron-doped FFE with a front dopant concentration of $2x10^{18}$ cm^{-3} or less. Petitioner fails to provide such an explanation.

We also note that Petitioner states that, in the proposed combination of Li and Muller, "Muller (instead of King, Swanson-352, or Marvin) is used for its disclosure of the front dopant concentration." Pet. 57. With respect to the combination of Li with King, Swanson-352, or Marvin, Petitioner contends that "the optimal concentration for this front doped region was well known and would have been obvious in view of the teachings of King, Swanson-352, or Marvin." *Id.* at 30 (citing Ex. 1003 ¶ 123). To the extent that Petitioner is contending that its arguments with respect to the combination of Li with King, Swanson-352, or Marvin establish the optimal front dopant concentration to use in Li, that argument also fails for the reasons set forth in Section II.C.5, *supra*.

For these reasons, we determine that Petitioner does not establish by a preponderance of the evidence that independent claim 10, and claims 13–16 and 19 that depend directly or indirectly therefrom, would have been obvious over the combined teachings of Li and Muller.

E. Asserted Obviousness over Li, King, Swanson-352, Marvin, Hu, and Ramappa, and Li, Muller, Hu, and Ramappa

Petitioner contends that claims 10–12, 15, 16, and 19 would have been obvious over the combined teachings of Li, Hu, Ramappa, and King, Swanson-352, or Marvin, and claims 10, 13–16, and 19 would have been obvious over the combined teachings of Li, Muller, Hu, and Ramappa.

Pet. 69–74; 1194IPR Pet. 70–75. Petitioner argues that, to the extent Patent Owner disputes that Li inherently discloses the claimed "emitter region having metal impurities," "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." Pet. 69. Petitioner argues that a Skilled Artisan would have been motivated to combine Li with Hu and Ramappa, but does not discuss, in its arguments for these grounds, the further combination with Muller, King, Swanson-352, or Marvin. *Id.* at 71–74. Petitioner's arguments do not remedy the deficiencies identified above with respect to the combinations of Li and King, Swanson-352, or Marvin or Li and Muller. *See* §§ II.C.5, II.D.2, *supra*. Accordingly, we determine that Petitioner does not establish by a preponderance of the evidence that claims 10–12, 15, 16, and 19 would have been obvious over the combination of Li, Hu, Ramappa, and King, Swanson-352, or Marvin, or that claims 10, 13–16, and 19 would have been obvious over the combined teachings of Li, Muller, Hu, and Ramappa.

III. CONCLUSION

After reviewing the parties' arguments and weighing the evidence offered by both parties, we determine that Petitioner does not show, by a preponderance of the evidence, that claims 10–16 and 19 of the '315 patent are unpatentable.

In summary:

Claim(s)	35 U.S.C. §	Reference(s)/Basis	Claim(s) Shown Unpatentable	Claim(s) Not Shown Unpatentable
10–12, 15, 16, 19	103	Li, King, Swanson-352, Marvin		10–12, 15, 16, 19
10, 13–16, 19	103	Li, Muller		10, 13–16, 19
10–12, 15, 16, 19	103	Li, King, Swanson-352, Marvin, Hu, Ramappa		10–12, 15, 16, 19
10, 13–16, 19	103	Li, Muller, Hu, Ramappa		10, 13–16, 19
Overall Outcome				10–16, 19

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has not established by a preponderance of the evidence that claims 10–16 and 19 of the ’315 patent are unpatentable; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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