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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/452,175	03/16/2010	Lars Samuelson	7742-121	3720

22208 7590 11/14/2016
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EXAMINER
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ART UNIT	PAPER NUMBER
1758	

NOTIFICATION DATE	DELIVERY MODE
11/14/2016	ELECTRONIC

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte LARS SAMUELSON, MARTIN MAGNUSSON, and FEDERICO CAPASSO[1]

Appeal 2015-006846
Application 12/452,175
Technology Center 1700

Before CHUNG K. PAK, CHRISTOPHER C. KENNEDY, and AVELYN M. ROSS, *Administrative Patent Judges*.

KENNEDY, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134(a) from the Examiner's decision to reject claims 22, 23, 25–30, 32–38, 44, and 45. We have jurisdiction under 35 U.S.C. § 6(b). We AFFIRM.

BACKGROUND

The subject matter on appeal relates to a solar cell structure comprising a nanowire as an active component. *E.g.*, Spec. 1:4–5; Claim 22.

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[1] According to the Appellants, the real party in interest is Qunano AB. App. Br. 2.

Claim 22 is reproduced below from page 12 (Claims Appendix) of the Appeal Brief:

22. A solar cell structure comprising:

a plurality of nanowires which are positioned with a maximum spacing between adjacent nanowires which is shorter than the wavelength of the light which the solar cell structure is intended to absorb, wherein the nanowires constitute a light absorbing part of the solar cell structure; and

a light guiding shell that encloses at least a portion of the nanowires and is adapted to direct incoming light along the nanowires and through the light absorbing part of the solar cell structure;

wherein the light guiding shell is made of a material with a higher bandgap than the nanowires.

REJECTIONS ON APPEAL

1. Claims 22, 23, 25–28, 34–38, 44, and 45 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Majumdar et al. (US 2008/0092938 A1, filed Dec. 22, 2006) in view of Tsakalakos et al. (US 2006/0207647 A1, filed Mar. 16, 2005) and Habib et al. (US 2009/0266411 A1, filed June 16, 2006), as evidenced by Wang et al. (US 2004/0144416 A1, published July 29, 2004).

2. Claims 29 and 30 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Majumdar, Tsakalakos, and Habib, further in view of Kim et al. (US 2008/0156366 A1, filed Dec. 29, 2006), as evidenced by Bhat et al. (US 2005/0253164 A1, published Nov. 17, 2005).

3. Claims 32 and 33 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Majumdar, Tsakalakos, and Habib, further in view of Spivack et al. (US 2004/0115858 A1, published June 17, 2004).

ANALYSIS

The Appellants present separate arguments only for claims 22 and 44. We limit our discussion to those claims. The remaining claims on appeal depend, directly or indirectly, from claim 22 and will stand or fall with claim 22.

After review of the cited evidence in the appeal record and the opposing positions of the Appellants and the Examiner, we determine that the Appellants have not identified reversible error in the Examiner's rejections. Accordingly, we affirm the rejections for reasons set forth below, in the Final Action, and in the Examiner's Answer. *See generally* Final Act. 2–17; Ans. 2–24.

Claim 22.

The Examiner finds, *inter alia*, that Majumdar teaches a photonic device comprising a plurality of nanowires comprising a shell that encloses at least a portion of the nanowire. Ans. 3. The Examiner finds that Majumdar "does not specifically teach the photonic device is a solar cell." *Id.*

The Examiner finds that Tsakalakos teaches solar cells comprising nanowires, including embodiments comprising an amorphous silicon coating or passivating layer over the nanowires. *See id.* at 4; Tsakalakos ¶¶ 89–90. The Examiner finds that Tsakalakos "does not specifically teach these coatings as a shell." Ans. 4.

The Examiner finds that Habib teaches nanowires used in solar cells wherein additional coatings, such as a transparent conductive oxide of indium tix oxide, is applied as a sheath or shell. *Id.* The Examiner finds that "the nanowire coating of transparent conductive oxide and/or dielectric and

surface passivation layers as a coating filling between nanowires as taught by Tsakalakos . . . or as a shell as taught by Habib" is an obvious "change of shape that have the same function." *Id.*

The Examiner further finds that Tsakalakos and Habib "teach that nanowires are a technology used in photovoltaics such that higher than average efficiency may be obtained." *Id.* at 5. The Examiner determines that "it would be obvious to a person having ordinary skill in the art to modify the photonic device of Majumdar . . . to be a solar cell because the solar cell is a known photonic device where the nanowires of Majumdar . . . can be used to increase efficiency of the cell." *Id.*

Concerning the requirement of claim 22 that the nanowires be "positioned with a maximum spacing between adjacent nanowires which is shorter than the wavelength of the light which the solar cell structure is intended to absorb," the Examiner finds that Tsakalakos teaches that "the range in density of the nanowires can vary between 5% of the volume and 100% of the volume," that "the diameter of the nanowire can vary between 1 nm and 300 nm," and that the nanowire "density is chosen based on requirements of the design." *Id.* at 5. The Examiner finds that nanowire density range disclosed by Tsakalakos overlaps the density range recited by claim 22 (i.e., "spacing . . . shorter than the wavelength of the light . . ."), thereby creating a prima facie case of obviousness. *Id.* at 5. Alternatively, the Examiner finds that Tsakalakos discloses that nanowire density is a result-effective variable, and that it would have been obvious to optimize nanowire spacing "for light transmission and current generated." *Id.* at 6.

In view of those and other findings, the Examiner concludes that the solar cell structure of claim 22 would have been obvious to a person of ordinary skill in the art. *See id.* at 3–7.

In opposition to the rejection, the Appellants first argue that "Majumdar does not even teach a solar cell," and that "it is unclear why it would have been obvious to optimize the nanowire spacing of the device of Majumdar for 'current generated' since Majumdar is directed to a phonon device, not a solar cell." App. Br. 6–7. The Appellants also argue that, "even if it were obvious to optimize the nanowire spacing of the generic nanowire device of Majumdar, the Examiner has not explained why optimizing the spacing of the ***photonic device*** of Majumdar '***for light transmission***' would necessarily lead to the same nanowire spacing as the optimized spacing of the nanowires in a solar cell to optimize the ***current generated*** in the ***solar cell***." *Id.* at 7 (emphasis in original); *see also* Reply Br. 2.

Those arguments are not persuasive of reversible error in the rejection. Although the Appellants are correct that Majumdar does not explicitly teach the use of nanowires in a solar cell, the Examiner's rejection does not rely on Majumdar alone. *See In re Keller*, 642 F.2d 413, 426 (CCPA 1981) ("[O]ne cannot show non-obviousness by attacking references individually where, as here, the rejections are based on combinations of references."). As explained above, the Examiner determines that, further in view of Tsakalakos and Habib, "it would be obvious to a person having ordinary skill in the art to modify the photonic device of Majumdar . . . to be a solar cell because the solar cell is a known photonic device where the

nanowires of Majumdar . . . can be used to increase efficiency of the cell." Ans. 5. The Appellants do not persuasively challenge that determination.

Light transmission and generation of current are important considerations in the design of a solar cell. *See, e.g.*, Tsakalakos ¶ 77; Habib ¶ 56. The Appellants' argument suggests that the Examiner proposes optimizing light transmission and current generation independent from each other. *See* App. Br. 7. However, we understand the Examiner's rejection to suggest that a person of ordinary skill in the art would have optimized light transmission and current generation, in combination, to maximize efficiency of a solar cell. *See, e.g.*, Ans. 5–6. The Appellants do not challenge the Examiner's finding that nanowire spacing is a result-effective variable, and they provide no persuasive basis to conclude that routine optimization of nanowire spacing would not result in nanowire spacing that falls within the scope of claim 22. *Cf. In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990) ("The law is replete with cases in which the difference between the claimed invention and the prior art is some range or other variable within the claims . . . . [and] in such a situation, the applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range." (citations omitted)).

The Examiner's determination is supported by the Examiner's analysis concerning the nanowire spacing disclosed by Tsakalakos, which appears to overlap the range of claim 22. *See* Ans. 5, 17–19. Although the Appellants argue that the range of Tsakalakos (nanowire density of 5% to 100%) is too broad to support a prima facie case of obviousness of the claimed range, *see* App. Br. 7–8, the Examiner persuasively argues that the Appellants' claim 22 encompasses a range of similar breadth, *see* Ans. 17–

19 (finding that nanowire density of claim 22 could be as broad as 1.86% to 100%). In the Reply Brief, the Appellants do not dispute the accuracy of the Examiner's calculation, but instead state that "the Examiner has selected an outlier combination of nanowire diameter and wavelength." Reply Br. 5. However, the Appellants concede that the nanowire diameter used in the Examiner's calculation (100 nm) is disclosed by the Appellants' Specification, they provide no explanation as to why the Examiner's selected wavelength was inappropriate, and they provide no calculation to counter the Examiner's calculation. *Id.*; *see also* Spec. at 14:17–18 ("The width of the nanowires in this embodiment is typically in the order of 100 nm."). On this record, and in view of the arguments presented, a preponderance of the evidence supports the Examiner's finding that the breadth of the range of claim 22 fully encompasses, or at least substantially overlaps, the breadth of the range of Tsakalakos. Accordingly, we are not persuaded that the breadth of the range of Tsakalakos weighs against the Examiner's conclusion of obviousness. *See also In re Peterson*, 315 F.3d 1325, 1329–30 (Fed. Cir. 2003) ("In cases involving overlapping ranges, we and our predecessor court have consistently held that even a slight overlap in range establishes a *prima facie* case of obviousness.").

The Appellants argue that Tsakalakos's disclosure of "shading," discussed by the Examiner in the Answer, *see* Ans. 22 (citing Tsakalakos ¶ 65), "teaches away" from the nanowire spacing of claim 22. *See* Reply Br. 3–4. However, Tsakalakos teaches that optimization of shading applies only to "some embodiments." *See* Tsakalakos ¶ 65. In any event, the Appellants do not persuasively explain why optimization of shading necessarily is inconsistent with the nanowire spacing of claim 22, particularly in light of

the fact that, as discussed above, Tsakalakos discloses a range of nanowire spacing that is largely if not fully encompassed by the range of claim 22. Thus, we are not persuaded that Tsakalakos discourages, discredits, or otherwise teaches away from claim 22.

The Appellants also argue that "[t]he device of claim 22 is structurally different and operates differently from the devices disclosed by Majumdar and Tsakalakos." App. Br. 8; *see also* Reply Br. 3. That argument is based on the disclosure in ¶ 21 of the Specification that, "[b]y placing the nanowires sufficiently close together on the substrate . . . the advantage of using nanowires is combined with an effective absorption of the light, as the incoming light 'sees' the closely packed nanowires as a continuous effective medium." *Id.* at 7–8 (emphases omitted) (citing Spec. ¶ 21, which appears to be equivalent to page 4, lines 20–24, of the PCT version of the Specification to which this Decision cites). However, as set forth above, the claimed range of nanowire spacing encompasses the range disclosed by Tsakalakos. The Appellants provide no basis to find that the solar cell of Majumdar as modified by Tsakalakos and Habib is somehow "structurally different" from the claimed solar cell, or that it would not result in a "continuous effective medium." *See* App. Br. 8; *cf. In re Gershon*, 372 F.2d 535, 537–39 (CCPA 1967) ("We think it is sufficient that the prior art clearly suggests doing what appellants have done, although an underlying explanation of exactly why this should be done, other than to obtain the expected superior beneficial results, is not taught or suggested in the cited references."); *Ex parte Obiaya*, 227 USPQ 58, 60 (BPAI 1985) ("The fact that appellant has recognized another advantage which would flow naturally

from following the suggestion of the prior art cannot be the basis for patentability when the difference would otherwise have been obvious.")

On this record, we are not persuaded of reversible error in the Examiner's rejection of claim 22. We affirm the rejection.

Claim 44.

Claim 44 depends from claim 22 and further recites "wherein the plurality of nanowires are positioned to present a continuous effective medium to incoming photons."

The Appellants argue that the prior art references "are silent as to a plurality of nanowires are positioned to present a continuous effective medium to incoming photons." App. Br. 10 (emphasis omitted).

That argument is not persuasive. As the Examiner explains, the Appellants' Specification teaches that the "continuous effective medium" property results from the spacing of the nanowires. Ans. 11; Spec. at 3:15–19, 4:20–23. For reasons explained above, the Examiner's rationale provides a reasonable basis for finding that solar cells having the claimed nanowire spacing would have been obvious to a person of ordinary skill in the art, and that a person of ordinary skill in the art would have expected such solar cells to possess the claimed "continuous effective medium" property. The Appellants' limited argument fails to show otherwise.

We affirm the rejection of claim 44.

CONCLUSION

We AFFIRM the Examiner's rejections of claims 22, 23, 25–30, 32–38, 44, and 45.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

AFFIRMED