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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/695,670	04/24/2015	Hirotada INOUE	YKI0489US	1037

23413 7590 09/01/2020
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ART UNIT	PAPER NUMBER
1726	

NOTIFICATION DATE	DELIVERY MODE
09/01/2020	ELECTRONIC

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte HIROTADA INOUE, KAZUNORI FUJITA, and YASUKO HIRAYAMA

Appeal 2019-005638
Application 14/695,670
Technology Center 1700

Before LINDA M. GAUDETTE, JAMES C. HOUSEL, and BRIAN D. RANGE, *Administrative Patent Judges.*

HOUSEL, *Administrative Patent Judge.*

DECISION ON APPEAL

STATEMENT OF THE CASE

Pursuant to 35 U.S.C. § 134(a), Appellant[1] appeals from the Examiner's decision to reject claims 1, 4–7, and 9–11 under 35 U.S.C. § 103(a) as unpatentable over Geerligs (US 2012/0181667 A1, pub. July 19, 2012) in view of Nakai (US 6,207,890 B1, iss. Mar. 27, 2001). We have jurisdiction under 35 U.S.C. § 6(b).

[1] We use the word "Appellant" to refer to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies the real party in interest as Panasonic Intellectual Property Management Co., Ltd. Appeal Brief ("Appeal Br.") filed July 27, 2018, 2.

We AFFIRM.[2]

CLAIMED SUBJECT MATTER

The invention relates to a solar cell having plurality of texture elements comprising square pyramids. Spec. ¶ 5. Appellant discloses that such texture elements reduce the reflection of light incident on the solar cell, but are easily broken, risking power generation efficiency. *Id.* ¶¶ 2, 5. The claimed invention is said to solve this problem by providing texture elements with a curvature radius at their vertices larger than a curvature radius of the valleys between adjacent pyramids. *Id.* ¶ 5.

Claim 1, reproduced below from the Claims Appendix to the Appeal Brief, is illustrative of the claimed subject matter:

1. A solar cell comprising:

a crystalline semiconductor substrate;

an amorphous semiconductor layer formed on a first principal face on the crystalline semiconductor substrate; and

an electrode formed on the amorphous semiconductor layer;

wherein the first principal face of the amorphous semiconductor layer comprises a plurality of texture elements formed adjacent to each other,

the plurality of texture elements comprises a plurality of first texture elements;

[2] This Decision also cites to the Specification ("Spec.") filed April 24, 2015, the Final Office Action ("Final Act.") dated January 30, 2018, the Examiner's Answer ("Ans.") dated May 16, 2019, and the Reply Brief ("Reply Br.") filed July 15, 2019.

> each of the plurality of first texture elements is an approximate rectangular pyramid having a vertex P,
>
> rectangular pyramids of adjacent first texture elements share a base edge;
>
> a valley having a lowest point V is formed between inclined planes of adjacent first texture elements;
>
> wherein the approximate rectangular pyramid forming each of the plurality of first texture elements comprises a plurality of inclined planes;
>
> wherein a cross section of each inclined plane comprises a first point proximate to the vertex P where a slope of the inclined plane changes and a second point proximate to the lowest point V between the inclined plane and an adjacent inclined plane where a slope of the inclined plane changes;
>
> wherein a curvature radius of a first arc including a vertex P and the first points of inclined planes facing each other across the vertex P is larger than a curvature radius of a second arc including lowest point V and the second points of adjacent inclined planes facing each other across the lowest point V;
>
> wherein a number of vertexes of the plurality of the first texture elements is 50% or more of a total number of vertexes of the plurality of texture elements.

Independent claim 7 recites a solar cell having pyramidal texture elements, at least 50% of which have a cross section of an inclined plane with a first point proximate the vertex where a slope of the plane changes.

OPINION

We review the appealed rejection for error based upon the issues Appellant identifies, and in light of the arguments and evidence produced thereon. *Ex parte Frye*, 94 USPQ2d 1072, 1075 (BPAI 2010) (precedential) (cited with approval in *In re Jung*, 637 F.3d 1356, 1365 (Fed. Cir. 2011) ("[I]t has long been the Board's practice to require an applicant to identify the alleged error in the examiner's rejections."). After considering the argued claims and each of Appellant's arguments, we are not persuaded of reversible error in the pending rejection. We offer the following for emphasis only.

Appellant argues the rejected claims as a group. For purposes of this appeal, claims 1 and 7 will be treated separately as explained below. In accordance with 37 C.F.R. § 41.37(c)(1)(vi), claims 4–6 and 9–11 stand or fall with claim 1.

Claim 1

The Examiner finds that Geerligs teaches a solar cell substantially as recited in claim 1, but fails to expressly disclose that the textured semiconductor layer is an amorphous silicon layer with electrodes formed thereon. Ans. 4–7. However, the Examiner finds Geerligs teaches the use of electrodes with an amorphous silicon layer. *Id.* at 4. In addition, the Examiner finds that Geerligs teaches that at least 50% of the pyramidal peaks and the valleys between adjacent pyramids are rounded such that the curvature of the peaks is larger than the curvature of the valleys. *Id.* at 5–6. The Examiner finds that Nakai also applies certain rounding to a random pyramid texture, particularly a slight rounding of the valleys between the pyramids, which enhances passivation. *Id.* at 7. The Examiner further finds that Nakai teaches an amorphous silicon layer between a crystalline silicon substrate and a transparent conductive layer, wherein the amorphous layer can reduce defects at the interface with the crystalline substrate. *Id.* The Examiner concludes that it would have been obvious to provide Geerligs' solar cell with an amorphous silicon layer over the crystalline semiconductor substrate in order to reduce defects at the interface with the crystalline substrate as Nakai teaches. *Id.*

Appellant argues that Geerligs and Nakai fail to teach or suggest that the number of vertices of the plurality of first texture elements is at least 50% of the total number of vertices of the plurality of texture elements. Appeal Br. 4–5. Appellant asserts that “Figures 21c–d of Geerligs respectfully provide no information whatsoever regarding the total number of vertexes of the plurality of texture elements, or what percentage of these vertexes are vertexes of the specifically claimed first texture elements.” *Id.* at 4 (emphasis omitted). Appellant contends that the Examiner relies on personal knowledge in interpreting Geerligs because this reference fails to teach or suggest this feature. *Id.* Appellant also contends that the Examiner misinterprets Geerligs, Figure 19a, in that the valleys and vertices correspond to the portions labeled as P and V respectively, wherein the valleys are rounded. *Id.* at 4–5. Appellant asserts that Geerligs actually appears to show that the vertices in most of the texture elements are sharp. *Id.* at 5.

Appellant further argues that Geerligs and Nakai also fail to teach or suggest that the first arc curvature at the vertices is larger than the second arc curvature at the valleys. Appeal Br. 6–8. Appellant asserts that “Figures [21c and 21d] of Geerligs merely show perspective views and therefore it is respectfully not possible to determine a relationship between curvatures of the vertices and valleys.” *Id.* at 6 (emphasis omitted). Appellant also contends that because Geerligs, Figure 21c, merely shows an intermediate step, an ordinary artisan would not have combined Geerligs and Nakai as the

Examiner proposes. *Id.* at 6–7. In this regard, Appellant asserts that Figure 7 shows a BSF layer stacked on surface 30 which has the same shape as those shown in Figures 21c and 21d. *Id.*

Appellant's arguments are not persuasive of reversible error. To begin, we note that claim 1 does not recite that the vertices and valleys are rounded and, therefore, have a radius of curvature. Rather, claim 1 recites that the first texture elements are approximate rectangular pyramids having a plurality of inclined planes,

> wherein a cross section of each inclined plane comprises a first point proximate to the vertex P where a slope of the inclined plane changes and a second point proximate to the lowest point V between the inclined plane and an adjacent inclined plane where a slope of the inclined plane changes.

Claim 1. In other words, the slope of the pyramid changes at two points—a first point proximate the vertex and a second point proximate the lowest point in the valley. This limitation does not require that the pyramid be rounded, but instead that the slope changes to be either steeper or shallower.[3]

There is no dispute that Geerligs teaches a solar cell whose surface includes a plurality of adjacent, approximately pyramidal texture elements. Nor is there any dispute that Geerligs teaches etching these texture elements so as to partially smooth them which, at least, imparts rounded valleys

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[3] Although we agree with Appellant that the Examiner misinterprets Geerligs, Figure 19a, by labeling the valleys and vertices incorrectly (Geerligs teaches that this figure "may equally display the textured front surface 2a after partly smoothening" thus indicating that there is no difference between the front and back surfaces (Geerligs ¶ 204)), we need not rely on this erroneous interpretation in order to sustain the Examiner's rejection. Accordingly, we hold the Examiner's misinterpretation of Figure 19a to be harmless error.

between the texture elements. Instead, Appellant contests the Examiner's findings that Geerligs teaches that the vertices of the texture elements are also rounded, that any rounding of the vertices yields a larger arc of curvature than at the valleys, and that such rounded texture elements number 50% or more of the total number of texture elements.

Appellant discloses that isotropic etching, i.e., the etchant is in a high temperature state such as 85°C, produces "texture elements 10a and 10b formed on the substrate 10 [that] assume the shape of a substantially square pyramid whose vertexes and valleys are sharp." Spec. ¶ 25. Conversely, Appellant teaches that the etching of the texture elements is performed using anisotropic etching, i.e., the etchant is in a low temperature state such as 40°C, such that "the etching proceeds more at the vertexes of the texture elements 10a and 10b that have been formed on the substrate 10 than at the valleys." *Id.* Appellant further discloses that this anisotropic etching results in "the curvature radius of the vertexes may be made larger than the curvature radius of the valleys." *Id.* Appellant does not disclose any further details with regard to how this anisotropic etching is performed so as to produce this relationship between the arc curvatures at the vertices and the arc curvatures at the valleys.

Geerligs likewise discloses that pyramidal texture elements, which may be isotropic, may be formed by etching, such as a wet-chemical alkaline etch or a masked alkaline etch. Geerligs ¶¶ 11, 62. Geerligs also discloses that it was known to apply a certain rounding to a random pyramid texture, particularly a slight rounding of the valleys between the pyramids, to enhance passivation. *Id.* ¶¶ 14–16. Geerligs further teaches that the textured surface may be partly smoothened by wet-chemical or dry etching, which is preferably very light to avoid increasing reflectance by an unacceptable amount. *Id.* ¶¶ 27, 31, 32, 56, 59.

A skilled artisan would reasonably have expected that Geerligs' etching process for forming the texture elements is different from Geerligs' etching process for partly smoothening these elements, because Geerligs teaches that the pyramidal texture elements are formed by etching and that these elements then may be rounded, particularly in the valleys, by partly smoothening via etching. Moreover, as the Examiner finds, Geerligs shows the pyramidal texture elements after partly smoothening have rounded vertices and broadened valleys (Figures 21c, 21d). Also, although Geerligs does not teach what percentage of the texture elements are partly smoothened, Geerligs teaches that the entire textured surface is partly smoothened. Thus, those skilled in the art would have reasonably concluded that a substantial portion, if not all, of the texture elements have been etched to provide rounded vertices and valleys.

With regard to the requirement that the arc of curvature at the vertices is larger than the arc of curvature at the valleys, both Appellant's anisotropic etching and Geerligs' partial smoothening process are etching processes designed to retain the overall surface texture, i.e., preserve the pyramidal texture elements, but "round" the texture elements. Although Geerligs focuses on ensuring that the valleys are "rounded," Geerligs suggests that other features of the surface texture are also "rounded." Geerligs ¶ 14 ("applying a certain rounding to a random pyramid texture, particularly a slight rounding (increasing the radius of curvature) of the valleys between pyramids"). Thus, those skilled in the art would have reasonably expected that both processes would have produced the same "rounding" of the pyramidal texture elements, including the same or similar amount of "rounding" of both the vertices and valleys. Further, although Appellant urges that the Examiner has misinterpreted Geerligs, Figures 21c and 21d, as showing "rounded" vertices, we disagree. In particular, Appellant fails to show any difference between Geerligs' scanning electron micrographs ("SEMs") of Figures 21c and 21d and Appellant's SEMs of Figures 4 and 5, nor do we perceive any.

Therefore, a preponderance of the record evidence supports the Examiner's position that Geerligs' partly smoothening process performed on the pyramidal texture elements produces at least 50% of the texture elements having the same "rounded" vertices with arc curvatures that are larger than the arc curvatures of the "rounded" valleys as recited in claim 1.

Furthermore, we note that Nakai teaches a similar solar cell having an amorphous silicon layer 2 formed over a plurality of pyramidal texture elements on the surface of a crystalline semiconductor substrate 1. Nakai, Figs. 1, 4. As shown in Nakai, the amorphous silicon layer formed over the substrate's pyramidal texture elements produces pyramidal texture elements that have both rounded vertices and valleys, wherein the arc of curvature of at the vertices is larger than the arc of curvature at the valleys. *Id.* Therefore, modifying Geerligs' panel to include an amorphous silicon layer in view of Nakai as the Examiner proposes would result in a solar panel having approximately rectangular pyramids with vertices whose curvature radius is greater than that of the valleys between the pyramids as recited in claim 1.

Accordingly, we sustain the Examiner's obviousness rejection of claim 1, and dependent claims 4–6 and 9–11 over the combination of Geerligs and Nakai.

Claim 7

Appellant's arguments are also not persuasive of reversible error with regard to the Examiner's obviousness rejection of claim 7. Initially, we note that claim 7 does not recite the limitation that the first texture elements each have a first arc curvature at the vertex that is larger than a second arc curvature at the valleys of adjacent texture elements. As such, Appellant's second argument is inapplicable to the Examiner's rejection of claim 7. *See In re Van Geuns*, 988 F.2d 1181, 1184 (Fed. Cir. 1993) (rejecting appellants' nonobviousness argument as based on limitation not recited in claim); *In re Self*, 671 F.2d 1344, 1348 (CCPA 1982) ("Many of appellant's arguments fail from the outset because, as the solicitor has pointed out, they are not based on limitations appearing in the claims.").

Appellant's remaining argument relevant to claim 7 is that Geerligs fails to teach or suggest that the number of vertices of the plurality of first texture elements, i.e., those having pyramidal shapes with changes in slope near their vertices, is 50% or more of the total number of vertices of the plurality of texture elements.[4] For the same reasons given above with regard

[4] Like claim 1, claim 7 does not require that the vertices of the first texture elements be rounded so as to have a radius of curvature. Also, claim 7 does not include any recitation with respect to the valleys between adjacent texture elements. Instead, claim 7 requires that each first texture element is an approximate rectangular pyramid having a plurality of inclined planes, "[wherein] a cross section of each inclined plane comprises a first point proximate to a vertex P of the rectangular pyramid where a slope of the inclined plane changes." Claim 7. This limitation merely requires that the slope of each of the pyramid's inclined planes or faces changes at a point proximate the vertex, which encompasses both the possibility that the inclined plane has a steeper slope at the vertex (i.e., pointier tip), and the

to this argument against the rejection applied to claim 1, a preponderance of the evidence supports the Examiner's position that at least 50% of Geerligs' pyramidal texture elements as modified in view of Nakai would have vertices that have changes in slope, either directly due to Geerligs' partly smoothening process or upon formation of the amorphous silicon layer as shown in Nakai.

Accordingly, we sustain the Examiner's obviousness rejection of claim 7 over the combination of Geerligs and Nakai.

CONCLUSION

Upon consideration of the record and for the reasons set forth above and in the Examiner's Answer, the Examiner's decision to reject claims 1, 4–7, and 9–11 under 35 U.S.C. § 103(a) as unpatentable over Geerligs in view of Nakai is *affirmed*.

DECISION SUMMARY

In summary:

Claims Rejected	**35 U.S.C. §**	**Reference(s)/Basis**	**Affirmed**	**Reversed**
1, 4–7, 9–11	103(a)	Geerligs, Nakai	1, 4–7, 9–11	

TIME PERIOD FOR RESPONSE

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a). *See* 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED

possibility that the inclined plane has a shallower slope at the vertex (i.e., a blunted tip).