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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte ERIC M. REHDER, XIAOBO ZHANG, JOSEPH C. BOISVERT, and PEICHEN PIEN

Appeal 2021-003607
Application 14/877,980
Technology Center 1700

Before JAMES C. HOUSEL, N. WHITNEY. WILSON, 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, 6–10, and 12–20. *See* Non-Final Act. 1. We have jurisdiction under 35 U.S.C. § 6(b).

We REVERSE.

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[1] "Appellant" refers to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies The Boeing Company as the real party in interest. Appeal Br. 3.

CLAIMED SUBJECT MATTER

The claims are directed to semiconductor device including an electrically conductive adhesive layer and a bypass diode in a carrier.

Claim 1, reproduced below, is illustrative of the claimed subject matter:

1. A solar cell structure, comprising:
    a carrier having a front side and a P-N junction;
    a solar cell electrically coupled to the front side of the carrier; and
    an adhesive layer that bonds the front side of the carrier to the solar cell, the adhesive layer including an adhesive material and conductive carbon nanostructures that electrically couple the carrier to the solar cell, wherein the conductive carbon nanostructures within the adhesive layer do not generally contact one another, and *wherein the conductive carbon nanostructures are anisotropic conductors that confine electrical conduction within the adhesive layer to a longitudinal direction between the solar cell and carrier*.

Independent claims 12 and 19 recite, respectively, a solar cell array and a method of assembling a solar cell structure, wherein, similarly to claim 1, conductive carbon nanostructures within an adhesive layer bonding the solar cell and carrier together are anisotropic conductors that confine electrical conduction within the adhesive layer to a longitudinal direction between the solar cell and carrier.

REFERENCES

The Examiner relies on the following prior art to reject the claims:

Name	Reference	Date
Brandhorst, Jr. et al.	US 5,019,176	May 28, 1991
Zahler et al.	US 2006/0021565 A1	Feb. 2, 2006
Hsieh et al.	US 2008/0190479 A1	Aug. 14, 2008
Ho et al.	US 2011/0277820 A1	Nov. 17, 2011

Toshiyuki Sameshima, et al., *Multi Junction Solar Cells Stacked with Transparent and Conductive Adhesive*, 50 Jap. J. Applied Physics 1–4 (2011), ("Sameshima").

Y. Zemen, et al., *Comparison of New Conductive Adhesives Based on Silver and Carbon Nanotubes for Solar Cells Interconnection*, 109 Solar Energy Materials & Solar Cells 155–59 (2013) ("Zemen").

REJECTIONS

The Examiner maintains the following grounds of rejection:

Claim(s) Rejected	**35 U.S.C. §**	**Reference(s)/ Basis**
1–4, 6–10, 12–20	112(b)	Indefiniteness
1–4, 7, 8, 19, 20	103	Sameshima, Zemen, Zahler
6	103	Sameshima, Zemen, Zahler, Hsieh
9, 10	103	Sameshima, Zemen, Zahler, Ho
12, 13, 17	103	Sameshima, Zemen, Zahler, Brandhorst
14–16, 18	103	Sameshima, Zemen, Zahler, Brandhorst, Ho

OPINION

We review the appealed rejections 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 Appellant's arguments and the evidence of record, we are persuaded of reversible error in the stated rejections, essentially for the reasons set forth in the Appeal and Reply Briefs.

Rejection 1: Indefiniteness

The Examiner rejects claims 1–4, 6–10, and 12–20 under 35 U.S.C. § 112(b) as indefinite for use of the term, "generally," in the limitation, "conductive carbon nanostructures within the adhesive layer do not generally contact one another." Ans. 3. The Examiner notes that the Specification discloses a volume percentage for the carbon nanostructures—about 0.1% to about 1.0%—results in the nanostructures generally not contacting one another. *Id.* at 3–4. However, the Examiner notes that although claims are read in light of the Specification, limitations from the Specification are not imported into the claims. *Id.* at 22–23.

Appellant argues that the term, "generally," is a term of degree, which is interpreted in light of the Specification. Appeal Br. 8. Appellant asserts that the Specification teaches that the conductive particles (carbon nanostructures) are sized to have about the same size as the thickness of the adhesive layer, such that these particles are in electrical contact with both the solar cell and the carrier. *Id.* at 8–9 (citing Spec. ¶ 22; Fig. 6); *see also* Reply Br. 3 (citing Spec. ¶ 32). As such, Appellant asserts that no additional particles are needed to complete an electrical path through the adhesive layer, allowing the concentration of such particles to be relatively low. Appeal Br. 9. And because the concentration of particles is relatively low, Appellant contends that the particles do not generally make contact with one another. *Id.* Moreover, because the particles are anisotropic conductors that only conduct electricity in a direction extending between the solar cell and the carrier, Appellant contends that particles contacting each other would impede electrical conductivity. *Id.* at 10; Reply Br. 3. Therefore, if none or a negligible number of particles contact one another, there would be "no

appreciable impact on the flow of electricity" in the solar cell structure. Appeal Br. 10.

Appellant further asserts that the term, "generally," is defined as "without reference to or disregarding particular person, things, situations, etc., that may be an exception." Reply Br. 5 (citing dictionary.com, i.e., https://www.dictionary.com/browse/generally, last visited July 21, 2022). Applying this definition in the context of the limitation in question, Appellant contends that "there may be exceptions" to the restriction that the carbon nanostructures do not contact one another, especially because "it would be difficult, if not impossible, to guarantee that each and every carbon nanostructure situated in the claimed adhesive layer does not contact an adjacent nanostructure." *Id.* at 5.

"[W]e apply the approach for assessing indefiniteness approved by the Federal Circuit in *Packard*, i.e., '[a] claim is indefinite when it contains words or phrases whose meaning is unclear."' *Ex parte McAward*, No. 2015-006416, 2017 WL 3669566, at *5 (PTAB Aug. 25, 2017) (precedential) (quoting *In re Packard*, 751 F.3d 1307, 1310, 1314 (Fed. Cir. 2014)). The language in 35 U.S.C. § 112, second paragraph, "of 'particular[ity]' and 'distinct[ness]' indicates[] claims are required to be cast in clear—as opposed to ambiguous, vague, indefinite—terms." *Packard*, 751 F.3d at 1313.

Exact precision, however, is not required. The test for determining the question of indefiniteness may be formulated as whether the claims "set out and circumscribe a particular area with a reasonable degree of precision and particularity." *In re Moore*, 439 F.2d 1232, 1235 (CCPA 1971). With regard to the reasonableness standard, one must consider the language in the

context of the circumstances. *Packard*, 751 F.3d at 1313. Language is an imprecise method of drawing boundaries delineating patent rights, thus unreasonable precision cannot be demanded. *Id.* On the other hand, the claims must notify the public of what they are excluded from making and using. *Id.* For this reason, an applicant is required to use language as precise as the subject matter reasonably permits. *Id.*

The use of relative terms does not automatically render a patent claim indefinite. The Federal Circuit has approved of the use of terms such as "about," "substantially," "approximately," and "generally." *See, e.g.*, *Deere & Co. v. Bush Hog, LLC*, 703 F.3d 1349, 1359 (Fed. Cir. 2012); *Anchor Wall Systems, Inc. v. Rockwood Retaining Walls, Inc.*, 340 F.3d 1298 (Fed. Cir. 2003); *Ecolab, Inc. v. Envirochem, Inc.*, 264 F.3d 1358, 1367 (Fed. Cir. 2001); *Seattle Box Co., Inc. v. Industrial Crating & Packing, Inc.*, 731 F.2d 818 (Fed. Cir. 1984). In these cases, a relative term is used to provide some "wiggle room" around a readily ascertainable limit, such as a strict numerical limit. *E.g.*, *Deere & Co.*, 703 F.3d at 1359 (concluding "substantially planar" was definite in the context of the patent at issue); *Anchor Wall Systems*, 340 F.3d at 1310–11 (holding "generally parallel" was definite as envisioning some amount of deviation from exactly parallel); *Ecolab*, 264 F.3d at 1366–67 (concluding "substantially uniform" was definite in the context of the patent at issue); *cf. Pall Corp. v. Micron Separations, Inc.*, 66 F.3d 1211, 1217–18 (Fed. Cir. 1995) (discussing the use of "about" in the context of an infringement determination).

Here, similar to *Anchor Wall Systems*, Appellant uses the term, "generally," to provide some "wiggle room" around no carbon nanostructures contacting one another. Appellant discloses that electrical

current flows longitudinally from the solar cell to the carrier, rather than laterally, through the adhesive layer due to the carbon nanostructures' anisotropic property. Spec. ¶¶ 22, 32. Therefore, Appellant discloses that these nanostructures are spaced apart so as not to contact one another. *Id.* However, Appellant acknowledges that it may be difficult, if not impossible to guarantee no nanostructure contacts an adjacent nanostructure. Appeal Br. 8.

Although the Examiner indicates that an evidentiary showing is required to support Appellant's acknowledgement that absolute lack of contact amongst the carbon nanostructures in the adhesive layer may be difficult, if not impossible, we disagree. The Specification teaches that these nanostructures are dispersed in the adhesive material and, due to their low concentrations therein, these nanostructures "do not generally make contact with one another." Spec. ¶ 22. The Examiner does not challenge the reasonableness of this disclosure. Nor do we; its reasonableness appears on its face to be sound.

Accordingly, we hold that the phrase, "generally do not contact one another," envisions some amount of deviation from exactly no contact between the carbon nanostructures in the adhesive layer. Thus, we do not sustain the Examiner's indefiniteness rejection of the claims.

Rejection 2: Obviousness over Sameshima, Zemen, and Zahler

The Examiner rejects claims 1–4, 7, 8, 19, and 20 under 35 U.S.C. § 103 as unpatentable over Sameshima in view of Zemen and Zahler. Ans. 4. The Examiner finds that Sameshima discloses a solar cell structure substantially as recited in claim 1, except for: (1) the use of conductive carbon nanostructures that generally do not contact one another and are

anisotropic conductors that confine electrical conduction with the adhesive layer to a longitudinal direction between the solar cell and the carrier; and (2) that the carrier has a P-N junction. *Id.* at 5, 8. For feature (1), the Examiner relies on Zemen and for feature (2), the Examiner relies on Zahler. *Id.* at 6–8. Because Appellant does not dispute the Examiner's findings and reasoning regarding Zahler's teaching and its combination with Sameshima, we need not further address Zahler and feature (2).

Turning to feature (1), the Examiner finds that Zemen teaches an analogous solar cell structure to Sameshima using a conductive adhesive for interconnection, wherein Zemen's adhesive includes conductive carbon nanotubes for reduced cost and increased long-term reliability. Ans. 6. The Examiner further finds that Zemen teaches that conductivity of the adhesive layer increases with increasing concentration of the carbon nanotubes from 0.1–0.3 wt.%, while simultaneously increasing in viscosity. *Id.* The Examiner concludes that it would have been obvious to have substituted Zemen's carbon nanotubes for Sameshima's conductive nanostructures in the adhesive layer to perform the same function therein with a reasonable expectation of success. *Id.* at 6–7.

In addition, the Examiner finds that "conductive carbon nanotubes are known anisotropic conductors conducting along the length of the carbon nanotube length." Ans. 7.[2] The Examiner also finds that Zemen's Figure 1 shows the carbon nanotubes forming a vertical orientation between the

[2] In response to Appellant's challenge (Appeal Br. 15) of this finding, the Examiner cites, without further dispute, two online encyclopedia sources teaching that carbon nanotubes are one-dimensional structures with high aspect ratios of over 10^3 such that electron transport propagates along the length thereof. Thus, we accept this finding as fact.

connected elements, thereby reading on the limitation that the nanotubes are anisotropic conductors that confine electrical conduction with the adhesive layer to a longitudinal direction between the solar cell and carrier of Sameshima's modified device. *Id.* Moreover, the Examiner determines that it would have been obvious to modify the content of such carbon nanotubes in Sameshima's device "in order to optimize the amount of conductive carbon nanostructures in the conductive adhesive layer to balance the conductivity of the layer as well as balancing the viscosity of the layer" to arrive at the claimed range of 0.1–1.0 vol.% by routine experimentation. *Id.*

Appellant argues, *inter alia*, that Zemen fails to teach anisotropic conductors that confine electrical conduction within the adhesive layer to a longitudinal direction between the solar cell and the carrier, as recited in claim 1. Appeal Br. 12. Appellant asserts that Zemen's Figure 1 shows, in the background, a scanning electron microscopy picture of highly entangled carbon nanotubes and, in the foreground, a schematic view of a single solar cell structure. *Id.* Appellant further asserts that this schematic view is not representative of the arrangement of the carbon nanotubes in the conductive adhesive in Zemen's solar cell structure. *Id.* at 13. As such, Appellant contends that, contrary to the Examiner's finding, Zemen fails to teach that the carbon nanotubes form a vertical orientation between the connected elements. *Id.*

Appellant's argument is persuasive of reversible error because the Examiner fails to establish that Zemen's carbon nanotubes are inherently or necessarily arranged in a vertical orientation such that electrical conduction is confined to a longitudinal direction within the adhesive layer between connected elements. We note that there does not appear to be any dispute

that Zemen's range of concentrations of carbon nanotubes in the adhesive layer, 0.1–0.5 wt.%, at least overlaps the disclosed range of about 0.1 to about 1.0 vol.%. *Compare* Ans. 5–6 *with* Appeal Br. 14–15.[3] And because the concentration of conductive particles in Zemen, like Appellant's invention, is relatively low, it follows that an ordinary artisan would have reasonably expected that Zemen's conductive particles do not generally make contact with one another.

However, the Examiner fails to direct our attention to any disclosure within Zemen that teaches or suggests the arrangement of carbon nanotubes within the adhesive layer. As Appellant asserts, Zemen discloses use of multiwalled NC 7000 carbon nanotubes that, as received, are highly entangled as shown in Figure 1. Zemen 156, § 2, col. 1. Zemen teaches that a pure powder suitable dispersion process is necessary due to the nanotubes' highly entangled form. *Id.* Zemen further teaches that the carbon nanotube filled composites were prepared using a three roll calander, with a stepwise gap decrease to 5 μm at speeds set to 20/60/180 rpm. *Id.* at 156, § 2, col. 2. Zemen milled the nanotubes, hardener and pure resin for two minutes, and cured this milled mixture at 140°C for 20 minutes. *Id.* The carbon nanotube filled adhesive was applied by a lab scale screen printing system. *Id.* at 156, § 3, col. 2. The Examiner does not explain in any detail how this processing would result (necessarily or otherwise) in an applied dispersion of the multiwalled NC 7000 carbon nanotubes within the adhesive layer, that would confine electrical conduction longitudinally between the connected

[3] Although Appellant argues that Zemen teaches away from increasing carbon nanotube concentration above 0.5 wt.%, Appellant does not take the position that Zemen's range up to 0.5 wt.% fails to overlap the disclosed range of 0.1–1.0 vol.%. Appeal Br. 14–15.

structures. In other words, the Examiner has not adequately established that Zemen's highly entangled NC 7000 carbon nanotubes are inherently transformed into nanotube structures that are arranged not only spaced apart, but also vertically between a solar cell and a carrier, so as to confine electrical conduction longitudinally therebetween.

Accordingly, we do not sustain the Examiner's obviousness rejection of independent claims 1, 12, and 19, and their dependent claims, each of which requires that electrical conduction be confined to a longitudinal direction between the solar cell and the carrier.

CONCLUSION

Upon consideration of the record and for the reasons set forth above and in the Appeal and Reply Briefs, the Examiner's decision to reject claims 1–4, 6–10, and 12–20 is *reversed*.

DECISION SUMMARY

In summary:

Claim(s) Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1–4, 6–10, 12–20	112(b)	Indefiniteness		1–4, 6–10, 12–20
1–4, 7, 8, 19, 20	103	Sameshima, Zemen, Zahler		1–4, 7, 8, 19, 20
6	103	Sameshima, Zemen, Zahler, Hsieh		6
9, 10	103	Sameshima, Zemen, Zahler, Ho		9, 10
12, 13, 17	103	Sameshima, Zemen, Zahler, Brandhorst		12, 13, 17

14–16, 18	103	Sameshima, Zemen, Zahler, Brandhorst, Ho		14–16, 18
Overall Outcome				1–4, 6–10, 12–20

REVERSED