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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte CHRISTIAN HECHT, TOBIAS HOECHBAUER, ROLAND RUPP, and HANS-JOACHIM SCHULZE

Appeal 2018-000743
Application 13/827,253
Technology Center 2800

Before ROMULO H. DELMENDO, MARK NAGUMO, and MERRELL C. CASHION, JR., *Administrative Patent Judges*.

CASHION, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

This is an appeal under 35 U.S.C. § 134(a) from a final rejection of claims 1–5, 8, 10, 11, 13–18, 20, 23 and 24. We have jurisdiction under 35 U.S.C. § 6.

We AFFIRM-IN-PART.

Claim 1 is illustrative of the subject matter on appeal and is reproduced below:

> 1. A method for manufacturing a silicon carbide device, the method comprising:
>
> providing a silicon carbide dispenser wafer comprising a silicon face and a carbon face;
>
> depositing a silicon carbide epitaxial layer on the silicon face of the dispenser wafer, the silicon carbide epitaxial layer comprising a silicon face facing away from the dispenser wafer;
>
> implanting a designated dopant distribution into the silicon face of the silicon carbide epitaxial layer, wherein the designated dopant distribution is implanted before an acceptor wafer is bonded onto the silicon carbide epitaxial layer;
>
> implanting ions with a predefined energy characteristic to form an implant zone within the silicon carbide epitaxial layer, wherein the ions are implanted with an average depth within the silicon carbide epitaxial layer corresponding to a designated thickness of an epitaxial layer of the silicon carbide substrate being manufactured;
>
> bonding the acceptor wafer onto the silicon face of the implanted silicon carbide epitaxial layer, so that the silicon carbide epitaxial layer is arranged between the dispenser wafer and the acceptor wafer; and
>
> splitting the silicon carbide epitaxial layer along the implant zone, so that a silicon carbide substrate represented by the acceptor wafer with the epitaxial layer having the designated thickness is obtained;
>
> wherein the silicon carbide epitaxial layer is split, so that the epitaxial layer of the silicon carbide substrate with the

designated thickness has a carbon face opposite the silicon face onto which the acceptor wafer is bonded,

wherein the carbon face of the silicon carbide epitaxial layer with the designated thickness is accessible for silicon carbide device fabrication,

wherein the designated dopant distribution is disposed at a face of the silicon carbide epitaxial layer with the designated thickness opposite to the carbon face accessible for silicon carbide device fabrication.

Appellant[1] requests review of the following rejections from the Examiner's Final Office Action (App. Br. 5–6):[2, 3]

I. Claims 1–5, 8, 10, 11, 14–18, 23, and 24 rejected under 35 U.S.C. § 112, second paragraph, as indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention.

II. Claims 1–3, 8, 10, 11, 18, and 24 rejected under 35 U.S.C. § 103(a) as unpatentable over Kubota (US 2009/0221131 A1, published September 3, 2009), Berger (US 2012/0083098 A1, published April 5, 2012) and Larkin '800 (US 5,363,800, issued November 15, 1994).

III. Claims 4 and 5 rejected under 35 U.S.C. § 103(a) as unpatentable over Kubota, Berger, Larkin '800, Celler (US 7,605,055 B2, issued October 20, 2009), and Letertre (US 2003/0153163 A1, published August 14, 2003).

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[1] INFINEON TECHNOLOGIES AG is the Applicant and is also identified as the real party in interest. App. Br. 2.

[2] The effective filing date of this application is before 16 March 2013, the effective date of the America Invents Act. Accordingly, we refer to the pre-AIA version of the statute.

[3] The rejection statements listed in the opinion reflect the corrections noted by the Examiner in the Answer. Ans. 2–5. Given that Appellant does not object to the modifications in the Reply Brief of October 27, 2017, we adopt the rejections statements in the Answer as presented for review on appeal.

IV. Claims 14 and 17 rejected under 35 U.S.C. § 103(a) as unpatentable over Kubota, Berger, Larkin '800, and Uchida (US 2009/0101918 A1, published April 23, 2009).

V. Claims 15 and 16 rejected under 35 U.S.C. § 103(a) as unpatentable over Larkin '800, Kubota, Berger, Uchida, and Choi (US 2013/0175539 A1, published July 11, 2013).

VI. Claim 13 rejected under 35 U.S.C. § 103(a) as unpatentable over Larkin '978 (US 5,463,978, issued November 7, 1995), Kubota, Celler, and Letertre.

VII. Claims 23 rejected under 35 U.S.C. § 103(a) as unpatentable over Larkin '978, Kubota, Celler, Letertre, and Berger.

VIII. Claim 20 rejected under 35 U.S.C. § 103(a) as unpatentable over Letertre and Berger.

IX. Claims 1–3, 8, 10, 11, 18, and 24 rejected under 35 U.S.C. § 103(a) as unpatentable over Kubota, Kong (US 4,912,064, issued March 27, 1990), and Berger.

X. Claim 13 rejected under 35 U.S.C. § 103(a) as unpatentable over Kubota, Kong, Celler, and Letertre.

OPINION

Indefiniteness Rejection

Appellant presents arguments for claims 1, 11, and 23.[4]

We REVERSE the Examiner's rejection of claims 1–5, 8, 10, 11, 14–18, 23, and 24 under 35 U.S.C. § 112, second paragraph, for the reasons presented by Appellant. We add the following for emphasis.

The Examiner concludes that the language of the last subparagraph of claim 1 is indefinite because it is not clear if the face of the silicon carbide

[4] The Examiner withdrew the rejection of claims 1, 20, and 23 as indefinite on the grounds based on the claim language "wherein the carbon face of the silicon carbide epitaxial layer with the designated thickness is adapted accessible for silicon carbide device fabrication." Ans. 5.

on which the designated dopant distribution is disposed on is the same as the silicon face where the dopant is implanted. Final Act. 3. However, we agree with Appellant that, when reading the claim as a whole, it is sufficiently clear that the "face" refers to the silicon face of the epitaxial silicon carbide layer. App. Br. 9.

We also find the Examiner's ambiguity concern as to whether the final product of the method in claim 23 is a silicon carbide substrate, a silicon carbide device or a silicon carbide device without basis for the reasons presented by Appellant. Final Act. 3; App. Br. 9–10.

With respect to claim 11, the Examiner concludes that the language associating the predefined energy, the designated thickness, and the drift layer is indefinite because the Specification and the claims "do not provide any specific predefined energy characteristic, do not provide any specific designated thickness of the epitaxial layer as well as a corresponding thickness of a drift layer." Final Act. 3–4. According to the Examiner, the metes and bound of the claim are unclear because these limitations do not differentiate the claimed substrate from the prior art's substrate. *Id.* at 4.

We agree with Appellant that the Examiner is arguing the breadth of the claim and that the disputed language is not indefinite. App. Br. 10. That is, while the disputed language may render the scope of the claims broad, claims are not indefinite on the basis of their breadth alone. *See In re Gardner*, 427 F.2d 786, 788 (CCPA 1970) ("Breadth is not indefiniteness.").

Therefore, we reverse the Examiner's rejection of claims 1–5, 8, 10, 11, 14–18, 23, and 24 under 35 U.S.C. § 112, second paragraph, for the reasons presented by Appellants and given above.

The Prior Art Rejections

Rejections II and III: Obviousness rejection based on Kubota, Berger, and Larkin '800 (Claim 1)

Appellant presents arguments for claim 1 and relies on these arguments to address the rejection of claims 2, 3, 8, 10, 11, 18, and 24 as well as the separate rejection of claims 4 and 5, all of which depends from claim 1. *See generally* App. Br. Accordingly, we select claim 1 as representative of the subject matter presented for review on appeal for these rejections. Claims 2–5, 8, 10, 11, 18, and 24 stand or fall with claim 1.

a. Claim 1

The Examiner finds that the combined teachings of Kubota and Berger suggest a method for manufacturing a silicon carbide device that differs from the claimed invention in that the combined teachings do not disclose forming the SiC epitaxial layer on the Si face of the SiC dispenser wafer while leaving the exposed top carbon surface of the epitaxial layer accessible for silicon carbide device fabrication. Final Act. 5–8; Ans. 9. The Examiner turns to Larkin '800, directed to making semiconductor-device-quality SiC films, for the missing feature. Larkin '800 col. 1, ll. 16–18, 37–40. The Examiner finds Larkin '800 discloses that "either the Si face or the C face can be polished for growth and used for the preferred embodiment" and that "[t]he choice is determined by the intended use of the SiC film to be grown." Ans. 9 (quoting from Larkin '800 col. 6, ll. 48–63). Thus, the Examiner finds Larkin '800 suggests making semiconductor devices on either the Si face or the C face. The Examiner determined that it would have been obvious to one skilled in the art to modify the method from

the combined teachings of Kubota and Berger to make a SiC wafer where the carbon face is accessible for silicon carbide device fabrication. Final Act. 8–9; Ans. 9.

In addressing this rejection, Appellant does not dispute that Kubota's SiC wafer has a silicon side and a carbon side. Instead, Appellant argues that Larkin '800 does not teach or suggest the feature of a substrate (the claimed dispenser wafer) being bonded to another wafer (the claimed acceptor wafer) and turned around and split so that an "epitaxial layer of the silicon carbide substrate with the designated thickness" having an exposed carbon face ends up on an upper surface of the resulting acceptor wafer. App. Br. 12. Appellant also argues that Larkin '800 fails to teach or suggest an implementation of a designated doping distribution to a back side of a semiconductor device. *Id.* Appellant contends Larkin '800 merely describes the use of conventional doping techniques. *Id.* at 13. That is, Appellant argues that Larkin '800 does not teach the claimed method.

We are unpersuaded of reversible error in the Examiner's determination of obviousness. It is well-established that nonobviousness cannot be established by attacking the references individually when the rejection is predicated upon a combination of prior art disclosures. *In re Merck & Co.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986); *In re Keller*, 642 F.2d 413, 425 (CCPA 1981) ("The test [for obviousness] is what the combined teachings of the references would have suggested to those of ordinary skill in the art."). As the Examiner explains, Larkin '800 was not relied upon to teach the argued features. Ans. 6. Instead, the Examiner relied upon Kubota and Berger as teaching these features. *Id.* Larkin '800 was principally cited to teach that an SiC wafer can undergo further processing on either the

silicon face or the carbon face of an SiC wafer, as desired. *Id.* at 9. Given this disclosure, Appellant has not adequately explained why one skilled in the art would not have motivated to modify the method of the combined teachings of Kubota and Berger in view of Larkin '800 so as to produce a SiC wafer having a carbon face accessible for silicon carbide device fabrication and reasonably expect the resulting technique to provide such a SiC wafer. *In re O'Farrell*, 853 F.2d 894, 904 (Fed. Cir. 1988) ("For obviousness under § 103, all that is required is a reasonable expectation of success."). Thus, by arguing Larkin '800 separately, Appellant's arguments do not address the rejection presented by the Examiner.

Accordingly, we affirm the Examiner's rejections of claims 1–5, 8, 10, 11, 18, and 24 under 35 U.S.C. § 103(a) for the reasons presented by the Examiner and given above. We also affirm the alternate rational for the rejection of claim 1 for the same reasons. Final Act. 9–13; Ans. 10–11.

Rejection IV: Obviousness rejection based on Kubota, Berger, Larkin '800, and Uchida (Claims 14 and 17)

a. Claim 14

Claim 14 requires manufacturing the electrical silicon carbide device on the carbon face of the epitaxial layer of the silicon carbide substrate.

The Examiner finds that this feature is taught by Larkin '800's disclosure that either the Si face or the C face can be polished for growth, as determined by the intended use of the SiC film to be grown. Final Act. 26; Larkin '800, col. 6, ll. 58–63. The Examiner cites Uchida to further support the finding that this feature was known to those skilled in the art. Final Act. 26–27; Uchida Figure 1, ¶ 137.

Appellant argues that Kubota, Berger, and Larkin '800 are directed to substrate manufacturing while Uchida is directed to the fabrication of a MOSFET that minimizes the misalignment between "the actual location[s] of the source electrode 109 from the expected one due to the misalignment of the photomask with a resist film." App. Br. 26 (emphasis omitted). According to Appellant, there is no motivation for one skilled in the art to look at Uchida to improve the substrate manufacturing methods taught by Larkin '800, Berger, and Kubota given that Uchida is directed to a different fabrication process. *Id.*

We need not address Uchida because Larkin '800 teaches the disputed feature. Ans. 14.

b. Claim 17

Claim 17 requires that the electrical silicon carbide device comprises a blocking voltage above 500V.

The Examiner determines that Larkin '800's disclosure that silicon carbide possesses properties that should make it a superior semiconductor for applications that involve high temperature, high power, high radiation, and/or high frequency (Larkin '800 col. 1, ll. 25–30) and Berger's disclosure that a composite substrate including the monocrystalline semiconductor layer is used to form semiconductor devices including IGBT and power devices (Berger Figure 7F, ¶¶ 15, 42, and 130) would have rendered obvious to one of ordinary skill in the art at the time of the invention the modification of the combined teachings of the cited art to provide an electrical silicon carbide device comprising a blocking voltage above 500V. Final Act. 27.

We agree with Appellant that there is reversible error in the Examiner's determination of obviousness for this claim. App. Br. 26–27. "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (quoted with approval in *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007)). The Examiner has not provided an adequate technical explanation of why or how one skilled in the art would have modified the combined teachings of the cited art to incorporate an electrical silicon carbide device comprising a blocking voltage above 500V. The Examiner has not adequately explained why the noted portions of Larkin and Berger would have led one skilled in the art to the subject matter of claim 17. Therefore, the Examiner's articulated reason for combining the references lacks rational underpinning.

Accordingly, we affirm the prior art rejection of claim 14 for the reasons given by the Examiner and presented above. However, we reverse the rejection of claim 17 for the reasons presented by Appellant and given above.

Rejection V: Obviousness rejection based on Larkin '800, Kubota, Berger, Uchida, and Choi (Claims 15 and 16)

Appellant essentially relies on the same line of argument in addressing the rejection of claims 15 and 16. App. Br. 23–25. Accordingly, we limit our discussion to claim 15.

a. Claim 15

Claim 15 requires attaching the silicon carbide substrate with the manufactured electrical silicon carbide device to a carrier wafer facing the electrical silicon carbide device; and removing the acceptor wafer from the epitaxial layer comprising the electrical silicon carbide device attached to the carrier wafer.

The Examiner finds that this feature is taught by Choi. Final Act. 28; Choi Figures 6A–6F, ¶ 81. The Examiner determines that it would have been obvious to modify the combined teachings of Larkin '800, Kubota, Berger, and Uchida to incorporate this feature for purposes including removal of low cost, low quality substrate from the device structure or reclaiming the expensive substrate from the device structure for reuse. Final Act. 28–29.

Appellant argues that Berger's final composite wafer includes a metallization layer which is intentionally included in the wafer to provide good ohmic electrical connection between carrier wafer and semiconductor layer. App. Br. 24; Berger ¶ 124. According to Appellant, if Berger's wafer 713 were to be attached to a first substrate 100 as taught by Choi following which first substrate 100 were to be removed as taught in Choi's FIG. 6E, the resulting structure would include metallization layer 770 completely covering an upper surface of buffer layer 110. App. Br. 24. Thus, Appellant contends that this would prevent the ion implantation (subsequently carried out as shown in Choi's FIG. 6G) from reaching channel layer 120 thus resulting in a modified device that is unsuitable for its intended purposes. *Id.*

We disagree with Appellant. Here, the Examiner finds that Kubota does not include a metallization layer. Ans. 14. Moreover, the metallization layer 770 disclosed in Berger is an optional layer. Berger ¶¶ 135–137..

Accordingly, we affirm the Examiner's rejection of claims 15 and 16.

Rejections VI and VII: Obviousness rejection based on Larkin '978, Kubota, Celler, and Letertre (Claim 13)

Appellant presents arguments for independent claim 13 but does not present separate arguments for separately rejected dependent claim 23. *See generally* App. Br. Accordingly, we select claim 13 as representative of the subject matter presented for review on appeal for these rejections. Claim 23 stands or falls with claim 13.

Claim 13 is directed to a method of making a SiC substrate that includes repetition of the implantation, bonding and splitting steps to maximize the use of a silicon carbide dispensing wafer.

We refer to the Examiner's Final Action for a statement of the rejection. Final Act. 19–22. Briefly, the Examiner relies on the teachings of Celler and Letertre, both directed to semiconductor substrates, to teach as known to repeat the implantation, bonding and splitting steps to maximize the use of a silicon carbide dispensing wafer. Final Act. 21–22; Celler col. 1, ll. 5–8, col. 7, ll. 5–21; Letertre ¶¶ 2, 4, 5, and 56.

Appellants argue Celler relates to the repeated manufacture of thin diamond layers, a material completely different from silicon carbide and makes no mention of "bonding another acceptor wafer onto the remaining silicon carbide epitaxial layer" or of "splitting the remaining silicon carbide epitaxial layer along the another implant zone" while Letertre is directed to

the manufacturing of a SiC substrate from a larger SiC single crystal. App. Br. 21; Celler col. 7, ll. 5–21; Letertre ¶¶ 13, 14. Thus, Appellant contends that one skilled in the art would not be motivated to modify the method from the teachings of Larkin '978 and Kubota to incorporate the disputed additional steps from the teachings of Celler and Letertre. App. Br. 21.

We are unpersuaded by these arguments. We agree with the Examiner that Appellant's arguments do not address the rejection presented by the Examiner. Ans. 11. The Examiner relies on Celler and Letertre for their teaching of reusing donor wafers in a wafer manufacturing process where desired. Final Act. 21–22; Celler col. 1, ll. 5–8, col. 7, ll. 5–21; Letertre ¶¶ 2, 4, 5, 56. Appellant has not persuasively disputed the Examiner's stated reason for combining these references' teachings. Appellant has not adequately explained why one skilled in the art, using no more than ordinary creativity, would not have been capable of reusing the donor substrate from the combined teachings of Larkin '978 and Kubota, as taught by Celler and Letertre, to reduce manufacturing costs. Final Act. 22; Ans. 12–13. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007) ("A person of ordinary skill is also a person of ordinary creativity, not an automaton."); *see also In re Sovish*, 769 F.2d 738, 743 (Fed. Cir. 1985) (presuming skill on the part of one of ordinary skill in the art.). Appellant's arguments, thus, do not point to error in the determination of obviousness.

Accordingly, we affirm the Examiner's rejections of claims 13 and 23 under 35 U.S.C. § 103(a) for the reasons presented by the Examiner and given above. We also affirm the alternate rational for the rejection of claim 13 for the same reasons. Final Act. 22–25.

Rejections VIII: Obviousness rejection based on Letertre and Berger (Claim 20)

Claim 20 is directed to a silicon carbide device comprising a carrier wafer being a graphite wafer coated with silicon carbide.

We refer to the Examiner's Final Action for a statement of the rejection. Final Act. 29–31.

Appellant argues that the combined teachings of the cited art would not have led one skilled in the art to the claimed invention because the Examiner does not explain why the material of Letertre's carrier wafer is inadequate as it is and in need of replacement with Berger's carrier graphite wafer coated with silicon carbide material. App. Br. 22.

We are unpersuaded of error in the Examiner's determination of obviousness by this argument. It is well-established that the test [for obviousness] is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *In re Keller*, 642 F.2d 413, 425 (CCPA 1981).

The Examiner finds Letertre discloses a silicon carbide device that differs from the claimed invention in that it does not comprise a carrier wafer being a graphite wafer coated with silicon carbide. Final Act. 29–30. The Examiner finds Berger discloses the use of the claimed carrier web in the manufacturing of a composite wafer for use in semiconductor devices. *Id.* at 30. The Examiner determines that it would have been obvious to one of ordinary skill in the art to use Berger's carrier wafer as the carrier wafer in Letertre's device for the purpose of providing suitable material of carrier wafer to form a thermally and chemically stable carrier wafer as disclosed by Berger. *Id.* at 30–31. Appellant has not adequately explained why the

carrier wafer of Berger would be unsuitable for the silicon carbide device of Letertre. Appellant has not adequately explained why one skilled in the art would not have been capable of combining the teachings of Letertre and Berger, as proposed by the Examiner, and reasonably expect Berger's carrier wafer would perform adequately as a carrier web in the device of Letertre. *In re O'Farrell*, 853 F.2d 894, 904 (Fed. Cir. 1988) ("For obviousness under § 103, all that is required is a reasonable expectation of success."). Thus, Appellant's arguments do not point to reversible error.

Accordingly, we affirm the Examiner's rejection of claim 20 under 35 U.S.C. § 103(a) for the reasons presented by the Examiner and given above.

Rejections IX and X: Obviousness rejection based on Kubota and Kong

From the Final Action, the Examiner appears to rely on Kong as an alternate to the Larkin '800 and Larkin '978 references respectively cited in Rejections II and VI. *Compare* Final Act. 8–9 and 19–20 *with* Final Act 36–37 and 44–45, respectively. Appellant does not present specific arguments addressing Rejections IX and X. Therefore, to the extent that Appellant may be relying on the arguments presented for Rejections II and VI to address the rejections based on Kubota and Kong, we again find the arguments unpersuasive of Examiner error for the reasons given above.

Accordingly, we affirm the Examiner's rejections of claims 1–3, 10, 11, 13, 18, and 24 under 35 U.S.C. § 103(a) for the reasons presented by the Examiner and given above.

ORDER

The Examiner's rejection of claims 1–5, 8, 10, 11, 14–18, 23, and 24 under 35 U.S.C. § 112, second paragraph is reversed.

The Examiner's prior art rejections of claims 1–5, 8, 10, 11, 13–16 18, 20, 23, and 24 under 35 U.S.C. § 103(a) are affirmed.

The Examiner's prior art rejection of claim 17 under 35 U.S.C. § 103(a) is reversed.

Because the affirmed rejections do not reach all the claims, our decision is an affirmance-in-part.

TIME PERIOD

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

AFFIRMED-IN-PART