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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte SHIN HARADA, HIDETO TAMASO, and
TOMOAKI HATAYAMA

Appeal 2014-009633
Application 13/121,893
Technology Center 2800

Before: ELENI MANTIS MERCADER, CARL W. WHITEHEAD JR., and JOHN R. KENNY, *Administrative Patent Judges*.

KENNY, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

This is an appeal under 35 U.S.C. § 134 from a Final Rejection of claims 1–8, which constitute all pending claims. Final Act. 1; App. Br. 5. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

CLAIMED INVENTION

The claims are directed to a silicon carbide semiconductor device. Claim 1, reproduced below, is representative of the claimed subject matter:

> 1. A silicon carbide semiconductor device comprising:
>
> a substrate of a first conductive type made of silicon carbide and having a dislocation density of 5×10^3 cm^{-2} or less; and
>
> a p type impurity layer formed by ion-implantation formed on said substrate, a concentration of conductive impurities having a second conductive type different from said first conductive type being 1×10^{20} cm^{-3} or more and 5×10^{21} cm^{-3} or less.

REFERENCES

Powell '324	US 7,294,324 B2	Nov. 13, 2007
Powell '520	US 7,314,520 B2	Jan. 1, 2008
Sriram	US 7,348,612 B2	Mar. 25, 2008
Kiyama	US 7,531,889 B2	May 12, 2009

Ohmsha, *Basic and Application of SiC elements*, 100–01 (Mar. 2003) (partial English Translation in prosecution history file), App. Br. Evidence Appendix.

REJECTIONS

Claims 1, 2, and 5–8 stand rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Powell '324 and Sriram. Final Act. 3–4.

Claims 3 and 4 stand rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Powell '324, Sriram, and Powell '520. Final Act. 4.

ANALYSIS

Claims 1, 2, and 5–8

The Examiner finds Powell '324 teaches a silicon carbide semiconductor device with the substrate recited in claim 1. Final Act. 3. The Examiner finds that Sriram in combination with Powell '324 teaches or suggests the recited p type impurity layer of claim 1. *Id.* at 3–4.

Appellants argue (i) the cited prior art does not teach or suggest the recited range of conductive impurities for the p type impurity layer; (ii) unexpected reverse breakdown voltage results establish the nonobviousness of claim 1, and (iii) combining Sriram with Powell '324 would change Powell '324's principle of operation. App. Br. 9–21. In addition, Appellants argue that Kiyama cannot be combined with Powell '324 and Sriram. We are not persuaded by these arguments.

The Recited Range of Conductive Impurities

Claim 1 recites a range of conductive impurities for its p type impurity layer of 1×10^{20} cm^{-3} to 5×10^{21} cm^{-3}. Sriram discloses ". . . [f]or [its] p^+ region 14, carrier concentrations of from about 1×10^{18} cm^{-3} to about 1.0×10^{20} cm^{-3} may be suitable, but carrier concentrations as high as possible are preferred." Sriram 8:17–21 (bold omitted). Based on this disclosure, Appellants argue that Sriram does not disclose any upper limit of carrier concentrations and, therefore, does not suggest the claimed range. *Id.*; App. Br. 10; Reply Br. 7. We are not persuaded by this argument. As noted above, Sriram discloses that the range of 1×10^{18} cm^{-3} to 1×10^{20} cm^{-3} may be suitable. That disclosed range overlaps with the recited range (i.e., at 1×10^{20} cm^{-3}) and by itself would suggest the claimed range. *In re Woodruff*, 919 F.2d 1575, 1577 (Fed. Cir. 1990) (holding range of about 1–5% suggests the range of more than 5%). We do not find Sriram's additional

disclosure of "carrier concentrations as high as possible are preferred" undermines this suggestion. The additional disclosure indicates that the concentrations of just above 1 x 10^{20} cm^{-3} also would be expected to be suitable and, if anything, would be preferable to those below 1 x 10^{20} cm^{-3}. Accordingly, we agree with the Examiner that the cited prior art suggests the claimed range. Ans. 3–4.

Unexpected Results

Appellants argue that unexpected results regarding reverse breakdown voltages demonstrate the nonobviousness of claim 1. App. Br. 9–17. For instance, Appellants indicate the Specification reports significantly better reverse breakdown voltages for substrates with a dislocation density of 5 x 10^3 cm^{-2} or less than with dislocation densities exceeding 1 x 10^4 $cm.^{-2}$ App. Br. 14 (citing Spec. Fig 9). Appellants argue these results are unexpected, relying on Ohmsha's statement that "it is reported that these secondary defects do not affect the reverse characteristics of the p-n junction." App. Br. 13 (emphasis omitted).

The Examiner finds the cited results are not unexpected. Ans. 4–5. Citing Kayama, the Examiner finds that an ordinarily skilled artisan would be aware that using a lower dislocation density would improve reverse breakdown. Ans. 4–5 (citing Kiyama 1:48–51). The Examiner further discounts Ohmsha's cited statement because Ohmsha provides no support for the statement and Ohmsha also expresses a lack of clarity regarding the effects of the secondary defects. Ans. 4 (citing Ohmsha).

Appellants argue the Examiner fails to properly assess the evidence of unexpected results. App. Br. 11–15; Reply Br. 8–12. In their Reply Brief, Appellants reiterate their argument that Ohmsha establishes the unexpected nature of the results. *Id.* at 9–10. Appellants further argue that Kiyama's

teachings are not relevant because Kiyama is directed to a gallium nitride support base, and Kiyama does not teach the effect carrier concentration has on reverse breakdown voltages. *Id.* at 10–12.

We are not persuaded by Appellants' arguments. Ohmsha cites nothing to support the statement relied on by Appellants. Ohmsha. Further, Appellants present no persuasive evidence that Kiyama's teachings are irrelevant to the issue of whether dislocation is a known factor for reverse breakdown voltage merely because Kiyama is directed to a gallium nitride support base. Reply Br. 10; *In re Pearson*, 494 F.2d 1399, 1405 (CCPA 1974) ("Attorney's argument in a brief cannot take the place of evidence"). In addition, although the cited portions of Kiyama might not demonstrate the effect that carrier concentration has on reverse breakdown voltage, neither does Appellants' briefing. Appellants have not identified what effect carrier concentration, versus dislocation density, has on reverse breakdown and whether such an effect would be unexpected. Reply Br. 10–12. Appellants have not proven the existence of unexpected results. *In re Geisler*, 116 F.3d 1465, 1469 (Fed. Cir. 1997).

Combining Powell '324 and Sriram

Appellants argue that one of ordinary skill in the art would not have modified the source and drain portions of Powell '324 with the p^+ region of Sriram because that modification would change Powell '324's principle of operation. App. Br. 16–17. In particular, Appellants argue that Powell '324 seeks to reduce defects whereas Sriram's modification would increase defects due to increased implantation density. *Id.* We are not persuaded by that argument, however, because the Examiner finds that there are ways to have higher carrier concentrations without increasing defect density (Ans. 5) and Appellants do not persuasively rebut that finding. Reply Br. 6–12.

Combining Kiyama, Powell '324, and Sriram

Appellants argue that Kiyama cannot be combined with Powell '324 and Sriram. Reply Br. 11–12. We are not persuaded by this argument, however, because the Examiner does not combine Kiyama with Powell '324 and Sriram to reject claim 1. Ans. 4–5. The Examiner merely relies on Kiyama as evidence that certain phenomena were expected. *Id.*

Accordingly, we sustain the rejection of claim 1 and of claims 2 and 5–8, not separately argued. App. Br. 9–21.

Claims 3 and 4

Appellants present the same arguments for claims 3 and 4 as for claim 1. App. Br. 21; Reply Br. 12. Accordingly, we sustain the rejection of claims 3 and 4.

DECISION

We affirm the rejections of claims 1–8.

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)(iv).

AFFIRMED