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Datasheet for the decision of 26 May 2011

Case Number: T 1198/08 - 3.4.03

Application Number: 97932077.7

Publication Number: 0958610

IPC: H01L 29/24

Language of the proceedings: EN

Title of invention:
A bipolar semiconductor device having semiconductor layers of SiC and a method for producing a semiconductor device of SiC

Applicant:
CREE, INC.

Headword:
-

Relevant legal provisions:
EPC Art. 123(2)

Relevant legal provisions (EPC 1973):
EPC Art. 84, 54(1), 56

Keyword:
"Added subject-matter (no)"
"Clarity (yes) - functional feature"
"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:
T 0068/85 "Case Law" 6th Ed CH II.B.1.2.2

Catchword:
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Case Number: T 1198/08 **-** 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 26 May 2011

Appellant: CREE, INC.
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Representative: Cross, Rupert Edward Blount
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 21 January 2008 refusing European patent application No. 97932077.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: G. Eliasson
Members: T. Häusser
T. Karamanli

Summary of Facts and Submissions

I. The appeal concerns the decision of the examining division refusing the European patent application No. 97 932 077.

II. Claim 1 of the set of claims on which the decision was based comprised the following features:

(a)' "said device comprises a further layer (2, 13, 19) having such a resistance that it substantially lowers the current at which the temperature coefficient of the device shifts from negative to positive with respect to a device being identical except for a theoretical zero resistance of said further layer is arranged in series with said pn-junction",

(b)' "said further layer (2, 13, 19) having a resistance has a resistivity of 0,02 - 0,08 Ω cm".

The examining division held that feature (a)' contained added subject-matter and that features (a)' and (b)' were not clear.

III. The following documents were cited during the examination proceedings:

D1: US-A-5 385 855,

D2: US-A-4 945 394,

D3: WO 95/34915 A1,

D4: WO 96/22610 A1.

In an obiter dictum of the decision under appeal the examining division expressed the view that the claimed invention was not new in view of the documents D2-D4.

IV. At the oral proceedings before the board, the appellant requested that the decision be set aside and that a patent be granted in the following version:

- Claims 1 to 11 according to the sole request, filed at oral proceedings,
- Description pages 1 to 13, filed at oral proceedings,
- Drawings as published.

V. The wording of independent claim 1 reads as follows:

"1. A bipolar semiconductor device having semiconductor layers of SiC and at least one pn-junction with charge carrier transport thereacross in a conducting forward state of the device, characterized in that the said device comprises a further layer (2, 13, 19) arranged in series with said pn-junction, having a resistance such that it causes a temperature coefficient of on-state voltage drop to shift from negative to positive at a substantially lower current density than a device being identical except for the absence of said further layer, so that a stable operation is secured at normal working current densities."

VI. The appellant argued essentially as follows:

The indication that a stable operation was secured at normal working current densities rendered the term "substantially" clear, as it implied that the lowering of the current density at which the temperature

coefficient of on-state voltage drop had to be sufficient to ensure the stable operation.

A quantitative way to render the term "substantially" clear, e. g. an indication by how much the current density was lowered in order to allow the device to be operated in a stable manner, would not even be possible, as the operation of the device depended on the conditions under which it was operated.

Furthermore, none of the prior art documents on file provided a bipolar semiconductor device with a further layer arranged in series with the pn-junction as claimed. The layer 21 in document D2 and the n^+-layer in documents D3 and D4 were highly doped in order to form a good contact to the contact layer, whereas the n^--layer in documents D3 and D4 was part of the pn-junction. These layers could therefore not be regarded as the claimed further layer.

Reasons for the Decision

1. Admissibility

The appeal is admissible.

2. Amendments

2.1 The examining division held in the decision under appeal that the feature (a)' of claim 1 then on file (see point II. above) contained added subject-matter since the expression "with respect to a device being identical except for a theoretical zero resistance of

said further layer" was not directly and unambiguously derivable from the application as filed.

2.2 During the appeal proceedings claim 1 was amended, thereby overcoming the above objection by providing "a device being identical except for the absence of said further layer" as a reference for the substantial lowering of the current density. The board regards claim 1 in its present form to be directly and unambiguously derivable from claim 1 as originally filed and from the original description (page 2, lines 15-23; page 3, lines 18-34; page 9, lines 14-23; page 10, lines 30-34; page 11, lines 12-25; page 12, lines 32-35).

2.3 Dependent claims 2-4 and 9 are based on claim 2 as originally filed and on the original description and drawings (page 9, lines 7-14 and 19-23; page 12, lines 14-35; Figures 3 and 9) and dependent claims 5, 6, 7, 8, and 10 are based on claims 6, 3, 4, 7, and 11 as originally filed, respectively.

Dependent claim 11 is based on the original description and drawings (page 11, lines 1-12; Figure 5).

Furthermore, the description has been brought into conformity with the amended claims without introducing subject-matter which extends beyond the content of the application as filed.

2.4 Accordingly, the board is satisfied that the amendments comply with the requirements of Article 123(2) EPC.

3. Clarity

3.1 The examining division held in the decision under appeal that the feature (a)' of claim 1 then on file (see point II. above) was unclear as it was not clear what change of current would fall under the term "substantially", therefore not unambiguously allowing the distinction to be made as to which subject-matter was covered by the claim and which was not. Furthermore, the expression "with respect to a device being identical except for a theoretical zero resistance of said further layer" placed an undue burden on others seeking to establish the extent of the protection.

The examining division also held that the feature (b)' of claim 1 then on file (see point II. above) was unclear since it lacked an indication at what temperature the resistivity was measured.

3.2 During the appeal proceedings feature (b)' was deleted, thereby rendering the clarity objection concerning that feature irrelevant.

3.3 Furthermore, feature (a)' was replaced during the appeal proceedings by the feature

(a) "said device comprises a further layer (2, 13, 19) arranged in series with said pn-junction, having a resistance such that it causes a temperature coefficient of on-state voltage drop to shift from negative to positive at a substantially lower current density than a device being identical except for the absence of said further layer, so

that a stable operation is secured at normal working current densities".

Feature (a) has a functional aspect in that a stable operation at normal working current densities has to be secured. The board accepts the appellant's line of reasoning in that this aspect clarifies the term "substantially". Another functional aspect of feature (a) is the indication of a "device being identical except for the absence of said further layer" as a reference for the substantial lowering of the current density.

3.4 According to established case law (see T 68/85, OJ EPO 1987, 228, subsequently confirmed by decisions of the boards of appeal, see for further references "Case Law of the Boards of Appeal", 6th edition 2010, chapter II.B.1.2.2), functional features defining a technical result are permissible in a claim if

(i) such features cannot otherwise be defined more precisely without restricting the scope of the invention, and

(ii) these features provide instructions which are sufficiently clear for the expert to reduce them to practice without undue burden, if necessary with reasonable experiments.

In order to determine whether feature (a) - having functional aspects - is clear, the requirements (i) and (ii) have to be considered.

3.5 The incorporation of the specific structural features of the embodiments into claim 1 in order to define more precisely feature (a) would be an undue limitation of the scope of the invention. Furthermore, the desired clarification would not be achieved as it depended on the current density under which the device was operated, whether the operation was stable or not. The requirement (i) is therefore regarded to be satisfied.

3.6 From the description on page 2, line 23 to page 3, line 7, and Figures 1 and 2 it is evident for the skilled person - a semiconductor physicist - that, in order to achieve a stable operation, the temperature coefficient of the on-state voltage drop has to be positive. The skilled person would determine that coefficient by routine work, e.g. by the use of such graphs as in Figures 1 and 2. Furthermore, the skilled person would obtain the temperature coefficient by such routine work for the device with the further resistive layer as well as the reference device without that layer in order to check whether the resistive layer causes the temperature coefficient to shift from negative to positive at a lower current density.

The description also teaches (see the paragraph bridging pages 1 and 2) that in the case of silicon devices, the cross-over point where the temperature coefficient shifts from negative to positive is on the order of 50-100 A/cm^2. Beyond that cross-over point, the operation of the device is stable due to the positive temperature coefficient. The object of the invention is to reduce the cross-over point for silicon carbide devices to the same region as for silicon devices (page 3, paragraph 3). As to the value of the normal

working current densities, the skilled person receives thus the guidance from the description that the lower limit of the normal working current density is on the order of 50-100 A/cm^2 (cf. page 3, lines 27-30).

In practice, the normal working current densities can be readily determined, e. g. by the use of such standard experimentation employed for producing the data usually accompanying commercial bipolar semiconductor devices in the form of device datasheets.

The requirement (ii) is therefore also regarded to be satisfied.

3.7 For these reasons the board is satisfied that claim 1 is clear. The dependent claims are also considered to be clear so that the requirements of Article 84 EPC 1973 as to the clarity of the claims are met.

4. Novelty and inventive step

4.1 In the decision under appeal the examining division expressed in an obiter dictum the opinion that the subject-matter of claim 1 then on file was not new in view of each of the documents D2 to D4.

Document D2 discloses a silicon carbide bipolar transistor comprising an n-type doped layer 23 and a base of p-type character (column 6, lines 6-21). Document D3 discloses a silicon carbide semiconductor device comprising a highly doped p-conducting layer 1 forming a pn-junction with an n-conducting layer 3 of low doping concentration (page 5, lines 6-10). Finally, document D4 discloses a silicon carbide vertical

pn-junction comprising an n^--layer 2 with low doping concentration and a p^+-layer 4 on the n^--layer (title, page 11, lines 6-13).

Thus, using the wording of claim 1, each of the documents discloses a bipolar semiconductor device having semiconductor layers of silicon carbide and a pn-junction with charge carrier transport thereacross in a conducting forward state of the device. However, none of these documents discloses a further layer arranged in series with the pn-junction, having a resistance such that it causes a temperature coefficient of on-state voltage drop to shift from negative to positive at a substantially lower current density than a device being identical except for the absence of said further layer, so that a stable operation is secured at normal working current densities (feature (a) of claim 1, see point 3.3 above).

The disclosure of document D1 on file is not closer to the subject-matter of claim 1 than the disclosure of documents D2 to D4. Claims 2 to 11 are dependent on claim 1 providing further limitations.

Accordingly, the subject-matter of claims 1 to 11 is new (Article 52(1) EPC and Article 54(1) EPC 1973).

4.2 Feature (a) has the advantage of ensuring a stable operation at normal working current densities (see the description, page 2, line 15 - page 3, line 16). None of the documents on file contains any teaching which would lead the skilled person to the subject-matter of

claim 1, which is therefore not regarded to be obvious for the skilled person.

The subject-matter of claims 2 to 11 is also not considered obvious as these claims are dependent on claim 1.

Accordingly, the subject-matter of claims 1 to 11 involves an inventive step (Article 52(1) EPC and Article 56 EPC 1973).

5. Other requirements of the EPC and conclusion

The description has been brought into conformity with the amended claims in order to comply with the requirements of Article 84 EPC 1973. These requirements of the EPC are therefore also satisfied.

In view of the above the sole request is allowable.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent in the following version:

   Claims: 1 to 11, filed at oral proceedings of 26 May 2011.

   Description: Pages 1 to 13 filed at oral proceedings of 26 May 2011.

   Drawings: Sheets 1/3 to 3/3 as published.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson