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Datasheet for the decision of 31 March 2022

Case Number: T 1869/18 - 3.4.03

Application Number: 05803665.8

Publication Number: 1774577

IPC: H01L21/04, H01L29/16, H01L29/45

Language of the proceedings: EN

Title of invention:
METHOD OF PRODUCING SILICON-RICH NICKEL-SILICIDE OHMIC CONTACTS FOR SIC SEMICONDUCTOR DEVICES

Applicant:
Wolfspeed, Inc.

Headword:

Relevant legal provisions:
EPC 1973 Art. 84, 113(1)
RPBA 2020 Art. 13(1), 13(2), 15(1)

Keyword:
Main request - amendment after summons - admitted into the proceedings (no)
Right to be heard - opportunity to comment (yes)
Claims - clarity - auxiliary requests (no)

Decisions cited:

Catchword:
While objections raised by the Board for the first time in a communication under Article 15(1) RPBA 2020 may be considered to give rise to exceptional circumstances within the meaning of Article 13(2) RPBA 2020, and may possibly justify the filing of amendments which specifically respond to the new objections, this does not open the door to additional amendments which are unrelated to the new objections, and for which no exceptional circumstances exist (Reasons, point 3.10).

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Case Number: T 1869/18 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 31 March 2022

Appellant: (Applicant)	Wolfspeed, Inc. 4600 Silicon Drive Durham NC 27703-8475 (US)
Representative:	FRKelly 27 Clyde Road Dublin D04 F838 (IE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 26 February 2018 refusing European patent application No. 05803665.8 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	M. Stenger
Members:	S. Ward
	C. Heath

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division to refuse European patent application No. 05 803 665 on the grounds that the claimed subject-matter was not new within the meaning of Articles 52(1) and 54 EPC.

II. The Board understands the requests of the appellant to be as follows:

- that the decision under appeal be set aside and that a patent be granted on the basis of the main request filed with the letter dated 3 February 2022 (see said letter, page 1, first paragraph of the section "Amended Claims"); or
- that the decision under appeal be set aside and that a patent be granted on the basis of the first auxiliary request or the second auxiliary request filed with the statement of grounds of appeal (see the statement of grounds of appeal, page 1, third paragraph, and page 6, first paragraph of the section "Conclusion"); or
- "that the decision be set aside and that the application be remitted to the Examination Division for further examination" (see the the statement of grounds of appeal; page 6, first paragraph of the section "Conclusion").

III. The following document is referred to:

D5: YANG S J ET AL: "Study of Co- and Ni-based ohmic contacts to n-type 4H-SiC", DIAMOND AND RELATED MATERIALS, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL, vol. 13, 2004, pages 1149-1153, XP004507935, ISSN: 0925-9635, doi:10.1016/j.diamond.2003.10.067

IV. Claim 1 of the main request reads as follows:

"A method of producing an ohmic contact to silicon carbide comprising:
i) depositing a layer of nickel and a layer of silicon on a silicon carbide surface at a temperature of up to 500°C, wherein the layers of nickel and silicon are deposited in a ratio of silicon layer thickness to nickel layer thickness of between 1.81:1 and 3.65:1;
ii) heating the deposited layer of nickel and the deposited layer of silicon to a temperature in a range of between 200 and 500°C at which a nickel-silicon compound will form having the formula $Ni_{1-x}Si_x$ *where* $0.5 < x < 0.67$*, but below the temperature at which either element will react with silicon carbide; and*
iii) annealing the nickel-silicon compound to a temperature of about 850°C, the composition of the nickel-silicon compound and the annealing temperature being within a region of a phase diagram at which free carbon does not exist."

Claim 1 of the first auxiliary request reads as follows:

A method of producing an ohmic contact to silicon carbide comprising:
i) forming a deposited film of nickel and silicon on a silicon carbide surface at a temperature below a temperature at which either element will react with silicon carbide with an atomic fraction of silicon that is 0.52;
ii) heating the deposited film of nickel and silicon to a temperature at which a nickel-silicon compound will form having the formula $Ni_{1-x}Si_x$ *where* $0.5 < x < 0.67$*,*

but below the temperature at which either element will react with silicon carbide; and
iii) annealing the nickel-silicon compound to a temperature higher than the heating temperature for the deposited film, the composition of the nickel-silicon compound and the annealing temperature being within a region of a phase diagram at which free carbon does not exist."

Claim 1 of the second auxiliary request is the same as claim 1 of the first auxiliary request, except "where $0.5 < x < 0.67$" is replaced by "where $x=0.52$".

V. The Examining Division found that the subject-matter of claim 1 of the then main request was not new within the meaning of Article 54 EPC in view of document D5.

VI. Following a summons to oral proceedings, the Board sent the appellant a communication under Article 15(1) RPBA 2020 setting out its provisional views. The Board expressed doubts whether claim 1 of the main request met the clarity requirement of Article 84 EPC 1973, and found that the subject-matter of claim 1 of the main request was not new over D5. Brief comments were made on inventive step. The comments on clarity and inventive step also applied to the auxiliary requests, and it could also be questioned whether the auxiliary requests met the requirements of Article 123(2) EPC.

VII. The appellant's arguments, insofar as they are relevant to the present decision, may be summarised as follows:

Regarding the clarity issues raised by the Board, claim 1 of the main request had been amended to define the claimed temperatures numerically, thereby complying with the requirements of Article 84 EPC.

Regarding novelty and inventive step, D5 did not include the features of (i) annealing at about 850°C and (ii) layers of nickel and silicon being deposited in a ratio of silicon layer thickness to nickel layer thickness of between 1.81:1 and 3.65:1.

The interactions of these individual features produced the synergistic effect outlined in paragraph 32 of the application as filed, namely precluding the presence of carbon, thereby eliminating a number of carbon-based problems associated with conventional metal-silicide contacts on silicon carbide. Neither D5 nor the other cited prior art would lead the skilled person to the claimed solution.

In claim 1 of the first auxiliary request the atomic fraction of silicon had been specified as 0.52. The cited references did not disclose or suggest such a specific atomic fraction.

Claim 1 of the second auxiliary request, which incorporated the subject-matter of previous claim 12, had been deemed allowable by the Examining Division.

Reasons for the Decision

1. The appeal is admissible.

2. *Cancellation of oral proceedings*

2.1 In a communication dated 7 March 2022, the appellant stated (only) the following: "The Appellant's

representative will not be attending the Oral Proceedings scheduled for 8 March 2022". Such a statement is normally treated as equivalent to a withdrawal of the request for oral proceedings. Since the Board saw no point in holding oral proceedings in the absence of the appellant, it exercised its discretion to cancel the oral proceedings and to issue the present decision based on the written proceedings (see *Case Law of the Boards of Appeal*, 9th edition 2019, III.C.4.3.2).

2.2 Since the main request was filed with the letter dated 3 February 2022, just over one month before the scheduled oral proceedings, the appellant, in view of the requirements of Article 13(2) RPBA 2020, could not have been in any doubt that the oral proceedings would have included a discussion on whether this request would be admitted into the proceedings. The oral proceedings therefore represented the appellant's opportunity to hear the Board's views on this matter and to present its comments according to Article 113(1) EPC 1973. By electing not to be represented at the oral proceedings, the appellant chose not to make use of this opportunity.

3. *Main request: Admission into the proceedings*

3.1 Article 13(2) RPBA 2020 reads as follows:

"Any amendment to a party's appeal case made after the expiry of a period specified by the Board in a communication under Rule 100, paragraph 2, EPC or, where such a communication is not issued, after notification of a summons to oral proceedings shall, in principle, not be taken into account unless there are

exceptional circumstances, which have been justified with cogent reasons by the party concerned."

The present main request was filed with letter dated 3 February 2022, which was after notification of the summons to oral proceedings (dated 14 July 2021), hence the conditions stipulated in Article 13(2) RPBA 2020 apply.

3.2 Under point 7.3, second paragraph of the Board's communication, the following was stated:

"It is accepted that some of the objections raised by the Board (e.g. under Article 84 EPC) were not present in the contested decision, and that this might be considered to constitute "exceptional circumstances" within the meaning of Article 13(2) RPBA 2020, justifying a response, possibly including amended claims."

3.3 In section 3 of the communication, the Board raised objections of lack of clarity (Article 84 EPC) against the feature appearing in paragraphs i) and ii) of claim 1 whereby an upper temperature limit was defined as a "temperature at which either element [nickel or silicon] will react with silicon carbide" (point 3.2), and against the feature appearing in paragraph iii) which referred to "the composition of the nickel-silicon compound and the annealing temperature being within a region of a phase diagram at which free carbon does not exist" (point 3.9).

3.4 In addition, the Board noted (points 5.4, 5.5) that it could be inferred from the description that the heating stage was actually carried out at a temperature in the range of 200 to 500°C and the annealing stage was

actually carried out at a higher temperature in the range of 500 to 900°C. While including such numerical ranges in claim 1 might resolve the clarity issues, it was difficult to see how the resulting subject-matter could involve an inventive step. Such a claim would include embodiments in which both the heating and the annealing steps might take place very close to 500°C, hence effectively at the same temperature. It was unlikely that this would achieve the desired characteristics.

3.5 In claim 1 of the current main request, the following numerical temperatures or ranges have been specified; "up to 500°C" (point i)), "in a range between 200 and 500°C" (point ii)), and "of about 850°C" (point iii)).

The Board does not dispute that these amendments can be seen as a response to the above points raised for the first time in the communication under Article 15(1) RPBA 2020, and may therefore be considered justifiable in the light of the requirements of Article 13(2) RPBA 2020.

3.6 However, claim 1 of the main request has been further amended as follows:

"i) depositing a layer of nickel and a layer of silicon ... wherein the layers of nickel and silicon are deposited in a ratio of silicon layer thickness to nickel layer thickness of between 1.81:1 and 3.65:1".

3.7 This amendment cannot be considered to be a response to any objection raised by the Board for the first time in its communication under Article 15(1) RPBA 2020, nor does the appellant assert this to be the case.

According to the letter dated 3 February 2022, this feature is seen by the appellant as establishing a difference over D5 (page 2, fourth paragraph from the end), in other words it has been included to overcome the objection of lack of novelty over D5. Moreover, in the same letter it is presented as contributing to inventive step (page 2, fourth paragraph from the end).

3.8 However, the objection that the subject-matter of claim 1 lacked novelty over D5 was not raised for the first time in the Board's communication, but was the reason for the refusal of the application. Any amendments aimed at overcoming this objection should have been filed with the statement of grounds of appeal as part of the appellant's "complete appeal case" (Article 12(3) RPBA 2020).

3.9 Moreover, it would have been apparent to the appellant at the time of filing the statement of grounds of appeal that any amendment aimed at establishing novelty over D5 should, if it were to have any chance of leading to the grant of a patent, also serve (at least arguably) to establish an inventive step. Hence, no "exceptional circumstances" can be seen for introducing amendments aimed at establishing either novelty or inventive step after notification of the summons to oral proceedings, nor have any "cogent reasons" been advanced by the appellant for so doing.

3.10 While objections raised by the Board for the first time in a communication under Article 15(1) RPBA 2020 may be considered to give rise to exceptional circumstances within the meaning of Article 13(2) RPBA 2020, and may possibly justify the filing of amendments which specifically respond to the new objections, this does not open the door to additional amendments which are

unrelated to the new objections, and for which no exceptional circumstances exist.

3.11 In the present case, the main request was filed after notification of the summons to oral proceedings, and has been amended by the inclusion of *inter alia* the features cited above under point 3.6. This amendment is not related to any objection raised by the Board for the first time, and is not justified by any exceptional circumstances. The main request is therefore not admitted into the proceedings pursuant to Article 13(2) RPBA 2020.

3.12 Moreover, in applying Article 13(2) RPBA 2020, the Board may also rely on the criteria set out in Article 13(1) RPBA 2020 (see Supplementary publication 2 of the Official Journal EPO 2020, explanatory notes to Article 13(2), page 60, fourth paragraph; see also T 2429/17, Reasons for the Decision, point 2.2).

3.13 According to Article 13(1) RPBA 2020, any amendment to a party's appeal case after it has filed its grounds of appeal or reply may be admitted only at the discretion of the Board, and in exercising its discretion the Board shall take into account inter alia:

"whether the party has demonstrated that any such amendment, prima facie, overcomes the issues raised by ... the Board and does not give rise to new objections."

3.14 In claim 1 of the main request the feature "annealing the nickel-silicon compound to a temperature of about 850°C" is introduced. The Board doubts whether it would be clear to the skilled person which range of annealing temperatures would fall within the definition "about

850°C". Hence, even if this amendment overcomes the specific objections under Article 84 EPC 1973 raised in relation to point iii) of the claim under points 3.9 to 3.12 of the Board's communication, it gives rise *prima facie* to a new clarity objection.

3.15 The main request is therefore not admitted into the proceedings also pursuant to Article 13(2) RPBA 2020 in combination with Article 13(1) RPBA 2020.

4. *First auxiliary request*

4.1 Paragraphs i) and ii) of claim 1 set out method steps involving forming and heating a deposited film of nickel and silicon, both of which are to be carried out below a "temperature at which either element will react with silicon carbide". The Board interprets this to mean that there is a unique temperature above which nickel will react with silicon carbide, and a unique temperature above which silicon will react with silicon carbide, and that the claimed steps are to be carried out below the lower of these temperatures.

4.2 Assuming such unique onset temperatures exist, the Board does not see why the temperature below which the method steps of paragraphs i) and ii) are to be carried out could not have been claimed numerically. The definition in terms of a "temperature at which either element will react with silicon carbide" appears merely to place an obstacle in the path of a skilled person attempting to understand the meaning of the claim.

4.3 Moreover, a feature defining subject-matter in terms of an onset temperature of a chemical reaction appears to the Board to be open to more than one interpretation. It might be understood in terms of a temperature at

which the reaction would commence to some measurable extent. But if this is the case, it is not clear from the claim, or even from the description, by what means this is to be measured.

4.4 Alternatively, the claimed feature may be intended to mean a temperature at which the reaction would occur to a significant extent, an interpretation which would appear to have some support in the description. In the embodiment described in paragraph [0047] of the description, the suggested range for the low temperature heat treatment is 200 to 500°C, and in paragraph [0048] the following is stated:

"The temperature range of between about 200 and 500°C is high enough to provide significant diffusion between the silicon and the nickel films, but below temperatures at which any significant reaction occurs between the nickel or the silicon and the silicon carbide surface".

This implies that what is intended is to work at temperatures at which silicon or nickel may indeed react with silicon carbide, but not to a "significant" degree. However, the term "any significant reaction" is not further defined.

4.5 Furthermore, the Board doubts that there exists an unambiguous "temperature at which either element will react with silicon carbide", and which is independent of other unspecified parameters. In paragraph [0025] of the description, the following is stated:

"At temperatures above about 500°C, nickel or silicon or both will begin to react with silicon carbide."

The formulation "nickel or silicon" appears to imply that there are temperatures above about 500°C at which nickel (but not silicon) will begin to react with silicon carbide, and also temperatures above about 500°C at which silicon (but not nickel) will begin to react with silicon carbide. This in turn implies that the onset of the respective reactions does not just depend on temperature, but on other unspecified conditions, and hence no clear numerical temperature can be derived from the feature referred to above under point 4.1.

It was also the view of the Examining Division (reasons, page 8, final paragraph, page 9, first paragraph) that the onset of the reaction would depend on other conditions such as the nature of the Ni/Si film (co-sputtered, layered) and the type of SiC (4H, 6H), and would not be purely determined by a temperature, and the Board finds this to be a plausible position.

4.6 For these reasons, the Board judges that the feature defined above under point 4.1 would not convey to the skilled person a single unambiguous numerical temperature representing the upper limit of the range, and represents an unclear definition of the claimed subject-matter (Article 84 EPC 1973).

4.7 Paragraph iii) defines the following feature:

"annealing the nickel-silicon compound to a temperature higher than the heating temperature for the deposited film, the composition of the nickel-silicon compound and the annealing temperature being within a region of a phase diagram at which free carbon does not exist."

4.8 Here again, claim 1 of the auxiliary request attempts to define the subject-matter in terms of parameters (composition, annealing temperature) which would produce a physical effect (non-existence of free carbon). Issues similar to those mentioned above in connection with paragraphs i) and ii) arise, and there is no need for the Board to set them out at length. It is again not certain whether the intention is that free carbon is not present to any measurable extent (if so, it is not clear from the claim, or even from the description, how this would be measured), or merely not to any significant extent (in which case it it is not clear in the claim, or in the description, how much would be significant).

4.9 Furthermore, the "composition of the nickel-silicon compound" appears to be defined as one of two variable parameters, the values of which can be chosen so that the resulting compound lies within a region of a phase diagram at which free carbon does not exist. This is in contradiction with the rest of the claim, from which it may be derived that the composition of the nickel-silicon compound is fixed.

4.10 In paragraph i) of claim 1, the deposited film is defined to have "an atomic fraction of silicon that is 0.52", and in paragraph ii) of claim 1 the stoichiometric formula of the nickel-silicon compound formed by heating is given as $Ni_{1-x}Si_x$. The Board understands this to mean that the claimed film would have a composition given by $Ni_{0.48}Si_{0.52}$. This understanding is further confirmed by the following passage from paragraph [0047] in which the atomic fraction in the compound formed by heating and the atomic fraction (or ratio) during deposition are equated:

"After an initial heating (the low temperature heat treatment of 200 to 500°C), this film thickness ratio range will form a film having an atomic fraction of silicon in the resulting homogeneous film of between about 0.50 and 0.67, with 0.52 being preferred. As noted elsewhere, this atomic ratio may also be obtained by a sputter deposition technique or any other PVD or CVD technique that does not otherwise adversely affect the resulting contact".

It is not clear to the Board why, in claim 1, the general stoichiometric range of $0.5 < x < 0.67$ is retained, when the preferred value of $x=0.52$ is now defined, however, the main point is that, according to paragraphs i) and ii) of claim 1, the composition of the nickel-silicon compound is fixed, and the implication in paragraph iii) that it is a variable parameter renders the claim unclear (Article 84 EPC).

4.11 Finally, the Board notes that paragraph [0019] defines a "silicon-rich" composition to be one in which the atomic fraction of silicon is greater than the atomic fraction of nickel; hence the composition of claim 1 of the first auxiliary request ($x=0.52$) is silicon-rich.

According to paragraph [0050], carbon formation can be precluded in silicon rich silicon-nickel films "when the annealing step is carried out over a temperature range of 500 to 900°C". Hence, the meaning of paragraph iii) of claim 1 would appear to amount to the following: annealing the nickel-silicon compound [with stoichiometric formula $Ni_{0.48}Si_{0.52}$] to a temperature higher than the heating temperature for the deposited film at a temperature in the range of 500 to 900°C.

Given the apparent availability of this simple numerical definition of the subject-matter, the parametric definition used in paragraph iii) merely obscures the underlying meaning, and is therefore unclear.

4.12 For the above reasons, the Board judges that claim 1 of the first auxiliary request does not meet the requirements of Article 84 EPC 1973.

5. *Second auxiliary request*

5.1 Claim 1 of the second auxiliary request differs from claim 1 of the first auxiliary request only in that "where $0.5 < x < 0.67$" is replaced by "where $x=0.52$". The significance of the additional feature was questioned in the Board's communication (point 6.3) in relation to Article 123(2) EPC. The appellant made no further comment on this matter.

5.2 The Board has already expressed its view above under point 4.10 that where the deposited film has "an atomic fraction of silicon that is 0.52", and where the stoichiometric formula of the nickel-silicon compound formed by heating expressed as $Ni_{1-x}Si_x$, the implication is that $x=0.52$, and hence the additional feature of claim 1 of the second auxiliary request does not further limit the claimed subject-matter.

5.3 The Board therefore judges that claim 1 of the second auxiliary request does not meet the requirements of Article 84 EPC 1973 for the reasons already given in relation to the first auxiliary request.

6. In summary, the main request is not admitted into the proceedings pursuant to Article 13(2) RPBA 2020, and

the first and second auxiliary requests do not meet the requirements of Article 84 EPC 1973.

The appellant's alternative request was that "the decision be set aside and that the application be remitted to the Examination Division for further examination". In view of the conclusion of the previous paragraph, no further examination on the part of the Examining Division is required, and this request is rejected.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero M. Stenger

Decision electronically authenticated