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Datasheet for the decision of 14 March 2023

Case Number: T 2907/19 - 3.4.03

Application Number: 12181385.1

Publication Number: 2546865

IPC: H01L21/04, H01L29/66

Language of the proceedings: EN

Title of invention:
Methods of processing semiconductor wafers having silicon carbide power devices thereon

Applicant:
Wolfspeed, Inc.

Relevant legal provisions:
EPC Art. 52(1), 97(2), 123(2)
EPC 1973 Art. 56, 76(1), 84, 111(1)
RPBA 2020 Art. 13(1), 13(2)

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Keyword:
Amendments - main, first to third auxiliary requests - added subject-matter (yes)
Claims - main, first to third auxiliary requests - clarity (no) - fifth auxiliary request - clarity (yes)
Inventive step - main, second auxiliary request (no) - fifth auxiliary request (yes)
Amendment after summons - fourth auxiliary request - taken into account (no) - fifth auxiliary request - taken into account (yes)
Double patenting - same subject-matter (no)

Decisions cited:
G 0004/19

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Beschwerdekammern

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Case Number: T 2907/19 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 14 March 2023

Appellant: (Applicant)	Wolfspeed, Inc. 4600 Silicon Drive Durham, NC 27703 (US)
Representative:	Boult Wade Tennant LLP Salisbury Square House 8 Salisbury Square London EC4Y 8AP (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 6 June 2019 refusing European patent application No. 12181385.1 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	T. Häusser
Members:	M. Ley
	E. Mille

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division to refuse European patent application No. 12 181 385 pursuant to Article 97(2) EPC.

II. The examining division decided that the claims of the main request lacked clarity (Article 84 EPC 1973) and that the subject-matter of claims 1 and 11 according to the main request and claims 1 and 9 according to the former auxiliary request did not involve an inventive step (Article 56 EPC 1973).

III. The following documents are cited in this decision:

D1 WO 01/86727 A2
D4 WO 2005/048363 A2
D5 US 2005/104072 A1

IV. The appellant requests that the contested decision be set aside and European patent be granted on the basis of the set of claims of a main request or alternatively of any one of first to sixth auxiliary requests. The main request and the first to third auxiliary requests were filed with the statement setting out the grounds of appeal and the fourth to sixth auxiliary requests were filed with the letter dated 14 February 2023.

The claims according to the main request and the second auxiliary request are identical to those of the main request and the auxiliary request underlying the decision, respectively.

V. In its communication pursuant to Article 15(1) RPBA 2020 the board raised a further clarity objection

against claim 1 of the main request and added subject-matter objections against claims 1, 7 to 9 and 11 of the main request. It also expressed the preliminary opinion that claim 11 of the main request did not involve an inventive step when starting from document D4 as closest state of the art and that the claims of the first to third auxiliary requests did not overcome all objections raised against the claims of the main request.

VI. Claim 1 according to the **main request** has the following wording :

A method of forming a silicon carbide semiconductor device, comprising:
forming an epitaxial layer (140) on a surface of a silicon carbide substrate (100),
the epitaxial layer having a thickness greater than 3 microns;
forming a semiconductor device (110) at a first surface of the epitaxial layer (140) opposite the silicon carbide, SiC, substrate (100);
mounting a carrier substrate (105) to the first surface of the epitaxial layer (140);
removing the silicon carbide substrate (100) to expose a second surface of the epitaxial layer (140) opposite the first surface while the carrier substrate (105) and the epitaxial layer (140) are providing mechanical support;
forming a metal layer on the second surface of the epitaxial layer (140);
locally annealing the metal layer to form an ohmic contact (107) on the second surface of the epitaxial layer (140); and
separating the epitaxial layer (140) from the carrier substrate (105); and

wherein locally annealing the metal layer comprises locally heating the deposited metal layer to a temperature that is sufficient to cause the metal layer to form an ohmic contact (107) to the surface of the epitaxial layer (140) opposite the first surface but that is lower than a temperature at which the carrier substrate (105) will detach from the epitaxial layer (140).

Claim 11 of the **main request** has the following wording:

A method of forming a silicon carbide power semiconductor device, comprising:
forming an epitaxial layer (140) on a surface of a silicon carbide substrate (100), the epitaxial layer having a thickness greater than 3 microns;
forming a semiconductor device (110) at a first surface of the epitaxial layer (140) opposite the silicon carbide substrate (100) having a first thickness greater than 300 microns;
mounting a carrier substrate (105) to the first surface of the epitaxial layer (140);
thinning the silicon carbide substrate (100) to a second thickness of less than 150 microns while the carrier substrate (105) and the epitaxial layer (140) are providing mechanical support;
forming a metal layer on the thinned silicon carbide substrate (100’) opposite the first surface of the silicon carbide substrate;
locally annealing the metal layer to form an ohmic contact (107) on the thinned silicon carbide substrate (100’) opposite the first surface of the silicon carbide substrate; and
wherein locally annealing the metal layer comprises locally heating the deposited metal layer to a temperature that is sufficient to cause the metal layer

to form an ohmic contact (107) to the surface of the silicon carbide substrate (100’) opposite the first surface but that is lower than a temperature at which the carrier substrate (105) will detach from the silicon carbide substrate (100’).

Claim 1 according to the **first auxiliary request** is identical to claim 1 according to the main request.

Claims 1 and 9 according to the **second auxiliary request** correspond to the claims 1 and 11 according to the main request, respectively, with the following feature inserted before the last feature:

wherein locally annealing the metal layer comprises locally heating the metal layer by laser annealing the metal layer and/or directing an electron beam at the metal layer; and

Claim 1 according to the **third auxiliary request** is identical to claim 1 according to the second auxiliary request.

Claim 8 according to the **fourth auxiliary request** has the following wording (amendments made with respect to claim 11 of the main request indicated by the board):

A method of forming a silicon carbide power semiconductor device, comprising:
forming an epitaxial layer (140) on a surface of a silicon carbide substrate (100), the epitaxial layer having a thickness greater than 3 µm ~~microns~~;
forming a semiconductor device (110) at a first surface of the epitaxial layer (140) opposite the silicon carbide substrate (100) having a first thickness greater than 300 µm ~~microns~~;

mounting a carrier substrate (105) to the first surface of the epitaxial layer (140);
thinning the silicon carbide substrate (100) to a second thickness of less than 150 µm ~~microns~~ while the carrier substrate (105) ~~and the epitaxial layer 140 are~~ is providing mechanical support to the silicon carbide substrate (100);
forming a metal layer on the thinned silicon carbide substrate (100’) opposite the first surface of the silicon carbide substrate;
locally annealing the metal layer to form an ohmic contact (107) on the thinned silicon carbide substrate (100’) opposite the first surface of the silicon carbide substrate; and
wherein locally annealing the metal layer comprises locally heating the deposited metal layer to a temperature that is sufficient to cause the metal layer to form an ohmic contact (107) to the surface of the silicon carbide substrate (100’) opposite the first surface but that is lower than a temperature at which the carrier substrate (105) will detach from the silicon carbide substrate (100’).

Claim 1 according to the **fifth auxiliary request** has the following wording (amendments made with respect to claim 1 of the main request indicated by the board):

A method of forming a silicon carbide semiconductor device, comprising:
forming ~~an~~ silicon carbide epitaxial layer (140) on a surface of a silicon carbide substrate (100), the epitaxial layer having a thickness greater than 3 µm ~~microns~~;
forming a semiconductor device (110) at a first surface of the epitaxial layer (140) opposite the silicon carbide, SiC, substrate (100);

mounting a carrier substrate (105) to the first surface of the epitaxial layer (140);
removing the silicon carbide substrate (100) to expose a second surface of the epitaxial layer (140) opposite the first surface while the carrier substrate (105) ~~and the epitaxial layer (140) are~~ <u>is</u> providing mechanical support <u>to the epitaxial layer (140)</u>;
forming a metal layer on the second surface of the epitaxial layer (140);
locally annealing the metal layer to form an ohmic contact (107) on the second surface of the epitaxial layer (140); and
separating the epitaxial layer (140) from the carrier substrate (105); and
wherein locally annealing the metal layer comprises locally heating the deposited metal layer to a temperature that is sufficient to cause the metal layer to form an ohmic contact (107) to the surface of the epitaxial layer (140) opposite the first surface but that is lower than a temperature at which the carrier substrate (105) will detach from the epitaxial layer (140).

The wording of the claims according to the **sixth auxiliary request** is not relevant for the present decision.

VII. The appellant argued essentially as follows:

The subject-matter of claim 11 of the main request involved an inventive step.

The fourth auxiliary request should be admitted into the proceedings as it attempted to overcome the clarity and added subject-matter objections raised by the board

in its communication pursuant to Article 15(1) RPBA 2020.

No arguments were advanced in relation to the substance of the objections raised by the board in this communication.

Reasons for the Decision

1. The invention concerns a method of manufacturing a semiconductor device on a silicon carbide substrate.

The application as originally filed describes two main embodiments.

In the first main embodiment, the method has a step of thinning the silicon carbide substrate from a first to a second thickness and forming an ohmic contact on the silicon carbide substrate. Prior to the thinning, a carrier substrate is mounted. Methods according to the first main embodiment are shown in Figures 1A to 1F for the semiconductor device directly formed at a surface of the silicon carbide substrate and in Figures 3A to 3J for the semiconductor device formed at the surface of an epitaxial layer grown on the silicon carbide substrate.

In the second main embodiment, the method has a step of completely removing the silicon carbide substrate and forming an ohmic contact on an exposed second surface of an epitaxial layer, the semiconductor device being at the opposite first surface of the epitaxial layer, see Figures 2A to 2D.

2. State of the art cited by the examining division

Document D1 discloses a method for fabricating SiC MESFETs, which is similar to the first main embodiment of the application. D1 discusses forming epitaxial layers on a silicon carbide substrate and forming a semiconductor device within the epitaxial layers. The substrate is then partially mechanically thinned using processes such as grinding or lapping (as described on page 16, lines 28 to 30). The thinning process exposes a back surface of the substrate opposite the surface on which the epitaxial layers are formed. A metal layer is formed on the exposed back surface of the thinned substrate and annealed to form an ohmic contact. The thinned substrate forms an integral part of the final device (see Figure 6I of D1).

Document D4 describes a method of processing the back-side of a semiconductor wafer for the fabrication of light emitting diodes (LEDs); the method including thinning (e.g. by grinding or polishing) a silicon carbide substrate in order to change the forward operating voltage of the light emitting device. In relation to Figures 1 to 7, D4 describes forming devices 110 (e.g. GaN-based epitaxial layers) on a silicon carbide substrate 100, and connecting a wafer carrier 105 to the substrate so that the back side of the substrate 100 can be accessed. The wafer carrier 105 is attached via an adhesive layer 120. The back side of the substrate is then processed to form a thinned wafer 100’, see e.g. Figure 3. The silicon carbide substrate may be thinned using an in-feed or creep-feed grinder. The wafer carrier 105 can then be removed, in order to perform subsequent processing of the devices. However, in every described embodiment the

thinned substrate forms the basis for the final devices.

Document D5 discloses a process of forming ohmic contacts by locally annealing a metal layer on a silicon carbide substrate by laser annealing or electron beam annealing.

Main request

3. Amendments - Article 123(2) EPC and Article 76(1) EPC 1973

3.1 The present application is a divisional application within the meaning of Article 76 EPC 1973 of parent European application No. 06 803 439.

Claim 1 does not meet the requirements of Articles 76(1) EPC 1973 for the following reasons:

Claim 1 of the main request relates to the embodiment shown in Figures 2A to 2D, defined in claims 21 to 26 and described in paragraphs [0015] to [0018] and [0050] to [0054] of the parent application as originally filed. In particular, claim 1 is partly based on claims 21 and 26 as well as paragraphs [0015], [0018] and [0051] of the parent application as originally filed.

However, no basis can be found in the parent application as originally filed for a step of removing the silicon carbide substrate while the carrier substrate (105) and the epitaxial layer (140) are providing mechanical support.

Paragraph [0015] of the parent application as originally filed discloses merely that the carrier

substrate provides "mechanical support to the epitaxial layer", see also original claims 22 to 24 and paragraph [0016]. An epitaxial layer providing mechanical support cannot be derived by the skilled person from paragraph [0051], either.

In other words, the parent application as originally filed discloses a step of removing the silicon carbide substrate to expose a second surface of the epitaxial layer opposite the first surface, while the carrier substrate is providing mechanical support to the epitaxial layer.

Therefore, the subject-matter of claim 1 of the main request extends beyond the parent application as filed, contrary to the requirements of Article 76(1) EPC 1973.

3.2 For corresponding reasons the subject-matter of claim 1 of the main request extends beyond the application as filed, contrary to the requirements of Article 123(2) EPC.

4. Clarity - Article 84 EPC 1973

Claim 1 of the main request is not clear (Article 84 EPC 1973) because it is related a method of manufacturing a silicon carbide semiconductor device, wherein the only element explicitly made of silicon carbide (i.e. the substrate) is removed. The board understands that the claimed epitaxial layer 140 must be made of silicon carbide.

5. Inventive step - Article 56 EPC 1973

5.1 Claim 11 corresponds to the example shown in Figures 1A to 1F, 3A to 3J and described in paragraphs [0036] to

[0049] and [0055] to [0064] of the parent application as originally filed. From paragraphs [0006] and [0039], the board understands that the carrier substrate is providing mechanical support to the silicon carbide substrate, when the silicon carbide substrate is thinned to a second thickness. The board uses this interpretation for the feature "the carrier substrate (105) and the epitaxial layer (140) are providing mechanical support" during the thinning in claim 11.

5.2 Document D4 discloses subject-matter that is conceived for the same purpose as the invention, namely for providing a method of forming a silicon carbide semiconductor device, and has the most relevant technical features in common with it, as detailed below. Document D4 is therefore considered the closest state of the art.

5.3 Document D4 discloses (in the wording of claim 11 of the main request) a method of forming a silicon carbide power semiconductor device (Figures 1 to 5), comprising:
forming an epitaxial layer (page 8, lines 16 to 20, GaN-based epitaxial layers 110) on a (first) surface of a silicon carbide substrate (100, page 8, lines 20 to 22), ~~the epitaxial layer having a thickness greater than 3 microns~~;
forming a semiconductor device (GaN-based epitaxial layers 110, "active region", page 8, lines 19 and 20) at a first surface of the epitaxial layer (Figure 1) opposite the silicon carbide substrate (100) having a first thickness greater than 300 microns (page 8, lines 13 and 14, 400 µm);
mounting a carrier substrate (105) to the first surface of the epitaxial layer (110) (Figure 2; page 8, lines 23 to 27);

thinning (Figure 3; page 9, lines 3 to 17) the silicon carbide substrate (100) to a second thickness of less than 150 microns (page 9, lines 29 to 31, 120 µm) while the carrier substrate is providing mechanical support to the silicon carbide substrate (implicit);
forming a metal layer (107) on the thinned silicon carbide substrate opposite the first surface of the silicon carbide substrate (Figure 5; page 10, lines 12 to 17); and
locally annealing the metal layer to form an ohmic contact (page 10, lines 12 to 17) on the thinned silicon carbide substrate (Figure 5); and
wherein locally annealing the metal layer comprises locally heating (page 10, line 13, "laser annealing"; page 10, line 12 to 16 mentions document D5 treating "localized annealing") the metal layer to a temperature that is sufficient to cause the metal layer to form an ohmic contact (107) to the surface of the silicon carbide substrate opposite the first surface (Figure 5) ~~but that is lower than a temperature at which the carrier substrate will detach from the silicon carbide substrate~~.

5.4 The subject-matter of claim 11 of the main request differs from D4 by the following two distinguishing features:

(i) the epitaxial layer has a thickness greater than 3 µm;
(ii) the annealing is done at a temperature that is lower than a temperature at which the carrier substrate will detach from the silicon carbide substrate.

This is not contested by the appellant (see the statement of grounds of appeal, section 3.2, page 7).

5.5 The two distinguishing features are unrelated to each other. It is therefore appropriate to formulate partial objective technical problems in relation to them.

5.5.1 Regarding (i), a thickness of 3 µm does not provide any substantial mechanical support when the substrate is thinned to a second thickness of slightly lower than 150 µm. Thus, the objective technical problem related to feature (i) is to select a suitable thickness for epitaxial layer 110 in D4.

The board is of the opinion that a thickness of 3 µm is typical for epitaxial layers used to form LEDs and would be selected by the skilled person without exercising any inventive skills.

5.5.2 Regarding feature (ii), the objective technical problem is to select a suitable annealing temperature.

In the board's opinion, a skilled person using its common general knowledge would perform the heating of the metal layer at a temperature sufficiently high to achieve the desired ohmic contact and sufficiently low not to damage the device. In the example of D4, it would wish to avoid a premature detaching of the SiC substrate layer from a carrier substrate, i.e. in the case that the carrier substrate should be removed only after the formation of the ohmic contacts (D4, page 10, lines 17 to 18).

5.6 In view of the above, the subject-matter of claim 11 of the main request does not involve an inventive step within the meaning of Article 56 EPC 1973, contrary to the requirements of Article 52(1) EPC.

First to third auxiliary requests

6. Claim 1 according to the first to third auxiliary requests do not meet the requirements of Article 76(1) EPC 1973 for the reasons given for the main request.

The subject-matter of claim 9 of the second auxiliary request does not involve an inventive step (Article 52(1) EPC and Article 56 EPC 1973) for the reasons given for the main request.

In addition, claim 1 of the first to third auxiliary requests lack clarity (Article 84 EPC 1973) for the reasons given for the main request.

Fourth auxiliary request

7. Admission - Articles 13(1) and (2) RPBA 2020

7.1 According to Article 13(2) RPBA 2020, which is to be applied in view of Article 25(1) RPBA 2020, any amendment to a party's appeal case made 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.

Several decisions have held that, at the third level of the convergent approach, the boards of appeal are free to use the criteria set out in Article 13(1) RPBA 2020 when deciding, in the exercise of their discretion in accordance with Article 13(2) RPBA 2020, whether to admit an amendment made at this stage of the proceedings, see the Case Law of the Boards of Appeal of the European patent office, 10th Edition, July 2022, V.A.4.5.1. The board agrees to this approach.

7.2 The fourth auxiliary request was filed after notification of the summons to attend oral proceedings. The amendments made to claim 8 of the fourth auxiliary request address the added subject-matter objections raised for the first time in the board's communication pursuant to Article 15(1) RPBA 2020. This might be considered as exceptional circumstances.

However, the subject-matter of claim 8 clearly does not involve an inventive step (Article 56 EPC) for the reasons already given for the main request. Hence, the fourth auxiliary request does not overcome all raised objections.

Therefore, the board does not admit the fourth auxiliary request into the appeal proceedings (Articles 13(1) and (2) RPBA 2020).

Fifth auxiliary request

8. Admission - Article 13(2) RPBA 2020

The fifth auxiliary request was filed after notification of the summons to attend oral proceedings.

Since it overcomes all objections raised by the board in its communication under Article 15(1) RPBA 2020 and the objections raised by the examining division in the impugned decision, as detailed below, the board admits the fifth auxiliary request into the appeal proceedings.

9. Amendments - Article 76(1) EPC 1973 and Article 123(2) EPC

Claim 1 is based on claims 21 and 26 as well as paragraphs [0015], [0018] and [0051] of the parent application as originally filed. From paragraph [0037], first sentence and the wording "silicon carbide semiconductor device" in original claim 1, a skilled person understands that a silicon carbide epitaxial layer is used.

Dependent claims 2 to 7 are disclosed in claims 22 to 25 and paragraphs [0022] and [0053] of the parent application as originally filed.

Similarly, claims 1 to 7 are based on clauses 21 to 26 on pages 5d and 5e as well as paragraphs [0015], [0018], [0022], [0037], [0051] and [0053] of the application as originally filed.

Therefore, claims 1 to 7 of the fifth auxiliary request meet the requirements of both Article 76(1) EPC 1973 and Article 123(2) EPC.

10. Clarity - Article 84 EPC 1973

10.1 The examining division argued that the expression "locally annealing" was considered "somewhat vague in that it remains unspecified in what respect the annealing should be local", see the contested decision, "Grounds for the decision", section 1.2.

10.2 The appellant disagreed and argued that the skilled person understood the meaning of the terms "locally annealing" and "locally heating" as a local annealing process that was applied only within a specific area or portion of the device rather than across the whole device, see also paragraph [0060] of the description of the application.

10.3 The board does not share the examining division's view.

The skilled person reading the application and using its common general knowledge understands what is meant by "locally annealing" or "locally heating" a metal layer to form an ohmic contact. The term "locally" implies that the metal layer/epitaxial layer interface is heated without heating e.g. the first surface of the epitaxial layer, see also paragraph [0060] of the description of the application: "Localized annealing may be employed to anneal the ohmic contact 255 on the backside of the thinned wafer 210' without substantially heating the front side of the thinned wafer and the associated device structures". The skilled person would know how to distinguish the claimed annealing from other annealing processes. For example, it would understand that heating the entire device (including the carrier substrate, the epitaxial layer and the metal layer) in an oven is excluded by the wording of claim 1, because in this way the whole device would be subjected to the same temperature. The application gives two examples for local annealing (i.e. laser annealing and electron beam annealing) and refers to prior art using localized annealing, see paragraph [0045] of the application as filed. In other words, the skilled person understands the technical meaning of "locally annealing".

Therefore, the term "locally annealing" in claim 1 of the fifth auxiliary request is clear.

10.4 By specifying that the epitaxial layer is a *silicon carbide* epitaxial layer, the board's clarity objection raised against claim 1 of the main request is overcome.

10.5 The board is therefore satisfied that claim 1 of the fifth auxiliary request is clear (Article 84 EPC 1973).

11. Inventive step - Article 52(1) EPC, Article 56 EPC 1973

11.1 In the statement of grounds of appeal, the appellant argued that D1 failed to disclose six features of claim 1 of the main request underlying the impugned decision.

11.2 In the board's view, D1 discloses (in the wording of claim 1 of the fifth auxiliary request) a method of forming a silicon carbide semiconductor device (Figures 5 and 6), comprising:
forming an silicon carbide epitaxial layer (13, 14; page 19, lines 30 to 32; page 20, line 33 to page 21, line 2) on a [first] surface of a silicon carbide substrate (10; page 19, lines 30 to 32), ~~the epitaxial layer having a thickness greater than 3 µm~~;
forming a semiconductor device at a first surface of the epitaxial layer (Figures 6C to 6G) opposite the silicon carbide substrate (10);
~~mounting a carrier substrate to the first surface of the epitaxial layer~~;
~~removing~~ thinning (Figures 6G, 6H; page 16, lines 28 to 30; page 22, lines 3 to 5) the silicon carbide substrate (10) to expose a second surface of the thinned silicon carbide substrate ~~of the epitaxial layer opposite the first surface while the carrier substrate is providing mechanical support to the epitaxial layer~~;
forming a metal layer (32; Figure 6I) on the second surface of the thinned silicon carbide substrate ~~of the epitaxial layer~~; and
~~locally~~ annealing the metal layer to form an ohmic contact (32; Figures 5 and 6I; page 16, lines 26 to 33; page 22, lines 15 to 17) on the second surface of the

thinned silicon carbide substrate ~~of the epitaxial layer~~),
~~separating the epitaxial layer from the carrier substrate;~~
wherein ~~locally~~ annealing the metal layer comprises ~~locally~~ heating the metal layer to a temperature that is sufficient to cause the metal layer to form the ohmic contact on the second surface of the thinned silicon carbide substrate (page 22, lines 15 to 17) ~~of the epitaxial layer but that is lower than a temperature at which the carrier substrate will detach from the epitaxial layer~~.

11.3 The method according to claim 1 differs from the one of D1 by the following distinguishing features :

(i) the epitaxial layer has a thickness greater than 3 μm
(ii) a carrier substrate is mounted to the first surface of the epitaxial layer,
(iii) the silicon carbide substrate is removed to expose a second surface of the epitaxial layer opposite the first surface while the carrier substrate is providing mechanical support to the epitaxial layer
(iv) the metal layer is formed on the second surface of the epitaxial layer
(v) the ohmic contact is formed by locally heating the metal layer to a temperature that is sufficient to cause the metal layer to form the ohmic contact on the second surface of the epitaxial layer opposite to the first surface but that is lower than a temperature at which the carrier substrate will detach from the epitaxial layer.
(vi) the epitaxial layer is separated from the carrier substrate

These six distinguishing features substantively correspond to those identified by the appellant.

11.4 For reasons corresponding to those provided above under point 5.5.1 above, distinguishing feature (i) is not considered to be inventive.

A thickness of 3 µm does not provide any substantial mechanical support when the substrate of D1 is thinned. Thus, the objective technical problem related to feature (i) is to select a suitable thickness for epitaxial layer 13, 14 in D1, which is composed of first and second epitaxial sub-layers 13 and 14.

The thickness of the first epitaxial layer is 0.5 to 2 µm according to page 17, lines 8 to 15 of D1. The thickness of the second epitaxial layer 14 is not explicitly disclosed in D1, but it is stated that it is selected according to the desired pinch-off voltage, see D1, page 18, lines 1 to 8. It is obvious for the skilled person to select a thickness of epitaxial layer 14 of greater than 1 µm so that a total thickness of the epitaxial layer 13, 14 of greater than 3 µm would be achieved.

11.5 Regarding features (ii) to (vi), the objective technical problem associated thereto is to improve the thermal performance of the device known from D1.

11.5.1 The board agrees with the examining division that it might be obvious for the skilled person to connect a temporary carrier substrate providing a mechanical support, when thinning silicon carbide substrate 10 of D1 as shown in Figures 6G and 6H. As pointed out by the examining division, this aspect is also known from D4, see Figures 1 to 3, wherein a support substrate 105 is

used when thinning a semiconductor wafer 100. D4 also discloses the removal of the carrier substrate 105, see page 10, line 5. Hence, distinguishing features (ii) and (vi) alone might be considered obvious for the skilled person.

11.5.2 Page 17, lines 1 to 2 of D1 states that the thermal performance of the device known from D1 is improved by thinning the wafers before metallization, as shown for silicon carbide substrate 10 in Figures 6G and 6H. The skilled person wishing to solve the objective technical problem would hence have a motivation to further reduce the thickness of substrate 10. It would, however, not get an incentive to completely remove substrate 10 and provide metallisation 32 directly on an exposed backside of epitaxial layer 32. Neither one of the prior art documents at hand nor document D1 itself disclose or suggest that the silicon carbide substrate 10 could be completely removed to expose a second surface of the epitaxial layer 13, 14 opposite the first surface.

11.5.3 Even if the skilled person would know from its common general knowledge that a silicon carbide substrate could be completely removed from an epitaxial layer, it would not apply this knowledge to the method of D1. In D1, the epitaxial layer 13 and 14 as well as the substrate 10 are etched to form an isolation mesa, on which a passivation layer 60 is formed (see Figure 6B; page 20, line 33 to page 21, line 3). In other words, after the step shown in Figure 6B, the plurality of mesas are in mechanical contact through substrate 10. In Figure 6I, metallization layer 32 is formed on the (thinned) substrate 10' and functions as conducting plane (page 15, lines 16 to 19; page 22, lines 5 and 6) to improve the device packaging by permitting easier

attachment of the device to a circuit board (page 16, lines 32 to 33). The skilled person understands from D1 that metallization layer 32 is a conducting plane common to a plurality of mesas, each forming one MESFET, if not to all. Hence, in order to provide the function of metallization layer 32 as common conducting plane, thinned substrate 10' supporting metallization layer 32 cannot be completely removed.

Moreover, in D1, the thinned substrate 10' has a thickness of 25 to 100 µm (page 16, lines 28 to 30) and layer 13 is 0.5 to 2 µm thick (page 17, lines 8 to 15). The thickness of layer 14 is not disclosed. In order to completely remove substrate 10 and at the same time maintain the mechanical stability of the device, the skilled person would have to grow layers 13 and 14 thicker than 25 µm and thus make the transistors much larger. Furthermore, it would have to form the mesa structure in layers 13 and 14 alone and find other ways to laterally isolate the transistor shown in Figure 6I. The board is of the opinion that the skilled person would not consider this arrangement.

For the board, feature (iii) is therefore not obvious in view of the state of the art documents at hand and the common general knowledge of the skilled person.

11.5.4 Regarding (iv) and (v), the board agrees with the examining division that a skilled person using its common general knowledge would perform the heating of the metal layer at a temperature sufficiently high to achieve the desired ohmic contact and sufficiently low in a way to not damage the device, regardless whether the ohmic contact is formed on the silicon carbide substrate as in D1 or on the epitaxial layer. In particular, in view of documents D4 (page 10, lines 12

to 21) and D5 (claims 1, 2, 4 and 5, [0083]) it would be obvious for the skilled person to apply laser annealing or electron beam annealing in order to form metallization 32 in D1.

However, as the board considers that feature (iii) is not rendered obvious, the skilled person would not provide the metal layer on an exposed second surface of the epitaxial layer in D1 in order to form the ohmic contact (feature (iv)), either.

11.5.5 Therefore, the subject-matter of claim 1 would not be obvious for the skilled person when starting from document D1 as closest state of the art.

11.6 The subject-matter of claim 1 does also involve an inventive step when considering D4 as the starting point for the assessment of inventive step. From Figures 7 to 16 of D4, the skilled person understands that the thinned substrate 100' is foreseen as an integral part of the finished device and cannot be removed. Moreover, document D4 uses a gallium nitride epitaxial layer, and not a silicon carbide epitaxial layer as claimed.

11.7 In view of the above, the board is convinced that the subject-matter of claim 1 according to the fifth auxiliary request involves an inventive step (Article 52(1) and Article 56 EPC 1973) over the state of the art documents at hand.

12. Double patenting

12.1 According to the headnotes of G 4/19, a European patent application can be refused under Articles 97(2) and 125 EPC if it claims the same subject-matter as a European

patent which has been granted to the same applicant and does not form part of the state of the art pursuant to Article 54(2) and (3) EPC. The application can be refused on that legal basis, irrespective of whether it a) was filed on the same date as, or b) is an earlier application or a divisional application (Article 76(1) EPC) in respect of, or c) claims the same priority (Article 88 EPC) as the European patent application leading to the European patent already granted.

The definition of "the same subject-matter was not subject of the referral and of decision G 4/19, see Reasons, points 3, 15 and 16.

12.2 As pointed out before, the present application is a divisional application of parent European application No. 06 803 439. European patent EP 1 935 007 B1 was granted for the parent application.

Claim 1 of according to the fifth auxiliary request differs from claim 1 of patent EP 1 935 007 by the step of separating the epitaxial layer from the carrier substrate.

Hence, independent claim 1 of the fifth auxiliary request is different from independent claim 1 of the granted parent application and thus does not define the same subject-matter. Hence, the prohibition of double patenting is not pertinent to the claims of the fifth auxiliary request. This is not precluded by the fact that claim 1 of the fifth auxiliary request corresponds to dependent claim 2 of the granted parent application.

13. Conclusion

For the above reasons the board is of the opinion that the application and the invention to which it relates, in the version according to the appellant's fifth auxiliary request, meet the requirements of the EPC. Hence, a patent is to be granted on the basis of that version (Articles 97(1) EPC and 111(1) EPC 1973). The sixth auxiliary request does not need to be examined.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division with the order to grant a patent in the following version:

   Claims:
   No. 1 to 7 of the fifth auxiliary request filed with the letter dated 14 February 2023;

   Description:
   Pages 1, 2, 2a, 3 to 5, 5h, 7 to 12 and 14 to 17 of the fifth auxiliary request filed with the letter dated 14 February 2023 and pages 6 and 13 of this fifth auxiliary request filed during the oral proceedings of 14 March 2023;

   Drawings:
   Sheets 1/7 to 7/7 as originally filed.

The Registrar: The Chairman:

S. Sánchez Chiquero T. Häusser

Decision electronically authenticated