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Datasheet for the decision of 18 October 2021

Case Number: T 1827/16 - 3.4.03

Application Number: 09151203.8

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Language of the proceedings: EN

Title of invention:
Device for Controlling Electrical Conduction Across a Semiconductor Body

Applicant:
Cree, Inc.

Relevant legal provisions:
EPC Art. 52(1), 54(1), 54(2)
RPBA 2020 Art. 13(2), 25(1)

Keyword:
Novelty - main request (no)
Amendment after summons - auxiliary request - taken into account (no)

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Beschwerdekammern

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Case Number: T 1827/16 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 18 October 2021

Appellant: (Applicant)	Cree, Inc. 4600 Silicon Drive Durham, NC 27703 (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 15 March 2016 refusing European patent application No. 09151203.8 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	M. Ley
	C. Heath

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division to refuse European patent application No. EP 09 151 203 pursuant to Article 97(2) EPC.

The following documents were cited:

D1 JP 2001 094097 A

D4 US 2004/079989 A1

D5 US 2005/280004 A1

D6 US 2006/270103 A1

The examining division decided that claims 1 and 9 according to a main request did not fulfil the requirements of Article 123(2) EPC and that the subject-matter of the same claims did not involve an inventive step (Article 52(1) EPC, Article 56 EPC) in view of D1 as closest prior art in combination with D5 or D6 for claims 1 and 9 or in view of D1 combined with D5 or D6 "in the light of e.g. D4" for claim 9.

Regarding the first and second auxiliary requests, the examining division held that claims 1 and 9 did not meet the requirements of Article 123(2) EPC and were not allowable in view of a lack of novelty (Article 52(1) EPC, Article 54(1) and (2) EPC) for claim 1 and in view of a lack of inventive step (Article 52(1) EPC, Article 56 EPC) for claims 1 and 9.

II. In a communication pursuant to Article 15(1) RPBA dated 6 April 2020, the Board informed the appellant that neither the main request nor the auxiliary request - both filed with the statement setting out the grounds of appeal - met the requirements of the EPC.

III. With its letter dated 22 October 2020, the appellant filed modified main and auxiliary requests.

IV. With a short letter dated 28 September 2021, the appellant informed the Board that it would not attend the oral proceedings scheduled for 22 October 2021.

The Board then cancelled the oral proceedings.

V. The appellant requests that the impugned decision be set aside and a European patent be granted on the basis of either a main request or an auxiliary request filed with the letter dated 22 October 2020. In the alternative, the appellant requests the application be remitted to the examining division for further prosecution.

VI. Claim 1 according to the main request has the following wording (Board's labelling):

A device for controlling electrical conduction across a semiconductor body, comprising:
(a) *a source region (38) having a first conductivity type within the semiconductor body;*
(b) *at least one well region (33, 34) having a second conductivity type and positioned adjacent said source region (38) to control carrier flow from said source region (38);*
(c) *a drift region (54) adjacent a side of said at least one well region (33, 34) opposite said source region (38), said drift region (54) having said first conductivity type for providing a conductive path for carriers from said source region (38);*
characterized in that the device further comprises:
(d) *an epitaxial channel layer (46) on at least a portion of said source region (38) and at least one*

well region to provide a conductive path across said at least one well region (33, 34) to said drift region (54),
(d1) *wherein said channel layer (46) comprises a first channel layer region (56) of said first conductivity type on said source region (38),*
(d2) *a second channel layer region (58) that is epitaxially grown with said second conductivity type on said at least one well region (33, 34); and*
(d3) *a third channel layer region (60) of the first conductivity type adjacent the second channel layer region (58) opposite the first channel layer region (56),*
(d4) *the third channel layer region (60) extending on a portion of a JFET region (61); and*
(e) *a control contact (45) on said channel layer (46) for controlling current from said source region (38) across said drift region (54),*
(f) *wherein the at least one well region (33, 34) includes at least two well sections (33) at a first doping level on either side of the source region (38) and*
(g) *a well (34) at a second doping level that is higher than the first doping level below the source region (38) and between the well sections (33).*

Claim 1 according to the auxiliary request corresponds to claim 1 according to the main request, wherein the following feature is added at its end:

(h) and *wherein an inversion channel region is formed in both the second channel layer region (58) and a top region (31) of the well sections (33) when a voltage is applied to the control contact (45).*

VII. The appellant's arguments can be summarized as follows:

(a) Main request

In the statement setting out the grounds of appeal, the appellant argued that the independent claims differed from D1 by a third channel layer region that extended only on a JFET region (i.e. the upper portion (61) of the drift region 54). Since the channel layer (46) was divided into sections, or regions, it allowed a better control over a threshold voltage that regulated current from source to drain. In the channel layer (46), the n+ source (38) provided carriers for conduction from the source (38), through the N-type first channel layer region (56) to the channel zone (50) of the P type second channel layer region (58). The carriers then moved across the drift region (54) towards the collector (42). The first channel layer region (56) along with the second channel layer region (58) added additional levels of control that allowed the voltage on the gate or control contact (45) to manipulate accurately the magnitude of the current conducting through the device (30). The first channel layer region (56) extended on at least a portion of the source (38) while the threshold voltage regulating region (58) extended on the well region (33) to provide additional carriers across the conductive channel (50). As the second channel layer region (58) was completely on the well region (33), a threshold voltage inverted the second channel layer region (58) to create the conductive channel (50). By having a third channel layer region (60) only on a JFET region, this allowed the second channel layer region (58) to provide a better control of the threshold voltage that

regulated current. Therefore, the objective technical problem to be solved was how to control conduction in a semiconductor device.

In its letter dated 22 October 2021, the appellant argued that D1 did not disclose a second channel layer that was "epitaxially grown with said second conductivity type" on said at least one well region, said second conductivity type being opposite to the first conductivity of the drift region. In D1, channel layer 5a was grown with the same conductivity type as the drift region and then submitted to a step of ion implantation to form region 5b, see figures 5(a) and 5(b) of D1. Such configuration might suffer from fluctuations in the threshold voltage that turned ON the device, at least partly due to temperatures variations. The technical effect would be to provide a higher threshold voltage than the prior art devices of D1. The higher threshold voltage provided greater assurance that the device would be normally OFF at a gate bias of zero volts for all operating temperatures.

(b) Auxiliary request

D1 did not disclose feature (h). The technical effect would be a thicker inversion channel region and thus a reduction in device channel resistance, see paragraph [0037] of the application. Paragraphs [0078] to [0081] of D1 described that the depletion region was formed at the interface between channel layer 5b and gate oxide 7. It did not extend into the underlying p-type region 41.

Reasons for the Decision

1. The appeal is admissible.

2. The appellant's declaration of non-attendance at the oral proceedings is considered by the Board as equivalent to a withdrawal of its request for oral proceedings (see Case Law of the Boards of Appeal of the European Patent Office, 9th Edition, 2019, III.C. 4.3.2).

Taking into account the appellant's arguments provided in its letter dated 22 October 2020, the Board concludes that the case is ready for decision without oral proceedings.

3. The invention concerns a device for controlling electrical conduction across a semiconductor body, like e.g. a power transistor. The device has an epitaxial channel layer (46, 56, 57, 58, 60) divided into sections of varying conductivity type and doping level (see figures 2 and 3). The epitaxial channel layer provides a conductive path from a source region (38) across a well region (33, 34) to a drift region (54), see figures 2 and 3.

4. Main request

4.1 Added subject-matter - Article 123(2) EPC

In the impugned decision, the examining division objected that the device of claim 1 according to the main request and its manufacturing method according to claim 9 lacked a third channel layer region (60) on the drift portion (54, 61), see points 1.1 and 1.3 of the decision. The examining division further stated that

the omission that the well 34 below source region was at a higher doping level than wells 33 was an "inadmissible intermediate generalisation" and that an arbitrary high number of wells 33 encompassed by the wording of claims 1 and 9 was not disclosed in the application as originally filed, see points 1.2 and 1.3 of the decision.

The Board is of the opinion that the amendments made to claim 1 overcome the examining division's objections under Article 123(2) EPC.

The Board is also satisfied that the amendments made to claim 1 overcome the Board's objections under Article 123(2) EPC raised in sections 4.3.1 and 4.3.2 of the communication according to Article 15(1) RPBA 2020.

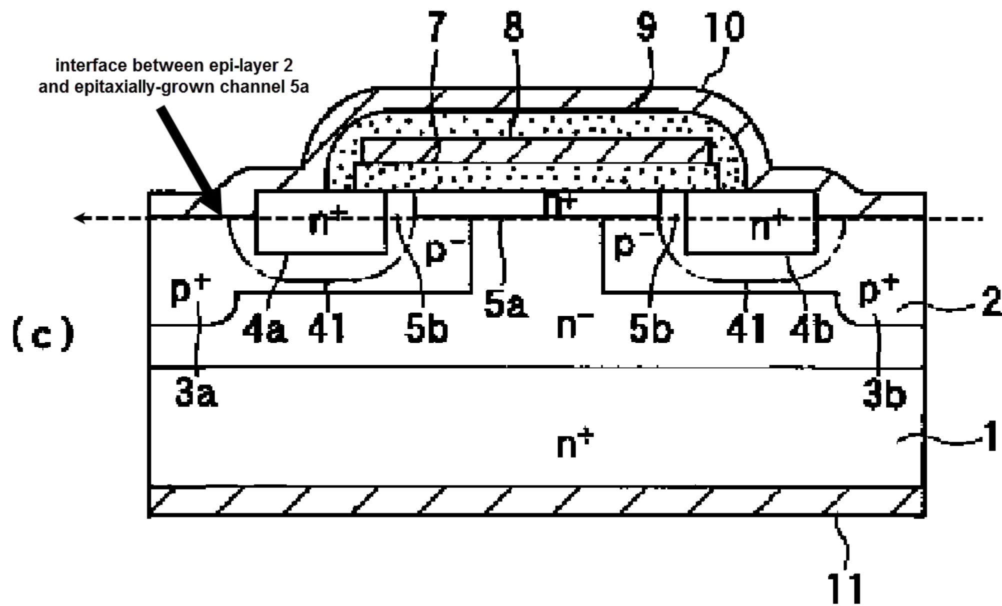
4.2 Novelty - Articles 52(1), 54(1) and (2) EPC

4.2.1 The Board agrees with the examining division that the example shown in figures 1 or 7(c) of document D1 is a suitable closest prior art. This is not contested by the appellant.

In D1, the basic structure of the device of figure 1 or 7(c) is a silicon carbide substrate 1 with an epi-layer 2, onto which an epitaxial channel 5a is grown, see figure 4(c) or see the annotated figure 7(c) provided by the Board with an indication of the position of the interface the epi-layer 2 and the epitaxially-regrown channel 5a.

The Board therefore agrees with the examining division that region 4a can be divided into two parts: an upper part within epitaxial channel 5a, which corresponds to the first channel layer region, and a lower part within

epi-layer 2, which corresponds to the source region. Analogously, the steps shown in figures 5(a) and (5b) form a p-type second channel layer region 5b within the epitaxial channel 5a and a p-type doped region 41 within epi-layer 2.



Contrary to the examining division's assumption, claim 1 does not stipulate that the two well sections have a uniform and constant first doping level, see e.g. present claim 4 or paragraph [0035]. Neither does claim 1 require that the second doping level is uniform and constant over the entirety of the well below the source region. In other words, in the Board's view, claim 1 merely requires that <u>one sub-part</u> of the "well below the source region" has a second doping level higher than the first doping level of a <u>sub-part</u> of the well sections. In D1, this condition is fulfilled, because the doping level in region 41 immediately below the source region 4a is necessarily higher than the doping level of regions 3a (close to the interface with the drift region) at each side of the source drain region

in view of the way how these regions are formed by dopant implantation.

Hence, D1 discloses a device for controlling electrical conduction across a semiconductor body (figures 1, 4 - 7), comprising:
a source region (lower part of 4a within epi-layer 2, figures 1, 5(c) and 7(c)) having a first conductivity type (n, [0047], [0067]) within the semiconductor body (2, figure 5(c));
at least one well region (3a, 41 within epi-layer 2) having a second conductivity type (p, [0046], [0064]) and positioned adjacent said source region (lower part of 4a within epi-layer 2) to control carrier flow from said source region (figure 1);
a drift region (2) adjacent a side of said at least one well region (3a, 41 within epi-layer 2) opposite said source region (lower part of 4a within epi-layer 2), said drift region (2) having said first conductivity type (n, [0064]) for providing a conductive path for carriers from said source region (lower part of 4a);
wherein the device further comprises:
an epitaxial channel layer (5a, figure 4c) on at least a portion of said source region (lower part of 4a within epi-layer 2) and [said] at least one well region (41, 3a) to provide a conductive path across said at least one well region (41, 3a) to said drift region (2),
wherein said channel layer comprises a first channel layer region (upper part of 4a within channel 5a) of said first conductivity type (figure 6a) on said source region (lower part of 4a within 2),
a second channel layer region (part of 5b within 5a) that is epitaxially grown "with" said second conductivity type (p) on said at least one well region (41, 3a within 2); and

a third channel layer region (5a) of the first conductivity type (n) adjacent the second channel layer region (5b within 5a) opposite the first channel layer region (upper part of 4a within 5a),
the third channel layer region (5a) extending on a portion of a JFET region (figure 1, the upper portion of the drift region, i.e. the part of 2 between 3a and 3b, constitutes a JFET region); and
a control contact (8) on said channel layer (upper part of 4a, 5b, 5a) for controlling current from said source region (lower part of 4a) across said drift region (2),
wherein the at least one well region (3a, 41) includes a two well sections (portions 3a, 41 on each side of source region) at a first doping level (doping level of 3a, p^-) on either side of the source region (upper part of 4a within 2) and
a well (portion of 41 below the lower part of 4a within epi-layer 2) at a second doping level that is higher than the first doping level (doping level in 41 > doping level in 3a, see figures 5(a) and 5(b)) below the source region (lower part of 4a within 2) and between the two well sections (portions 3a, 41 on each side of source region).

4.2.2 Claim 1 according to the main request has been amended after the Board's objection under Article 123(2) EPC, see the communication, section 4.3.1. The feature that the third channel region extends <u>only</u> on a JFET region (see VII.(a), first paragraph), said JFET region being the upper portion of the drift region, is not longer in claim 1.

Regarding the other alleged distinguishing feature, i.e. a second channel layer region "that is epitaxially grown with said conductivity type" (see VII.(a), second paragraph), the appellant's arguments relate to the way

the channel including the second channel layer region (58) is made compared to the manufacturing known from D1. However, claim 1 does not concern a manufacturing method, but a device for controlling electrical conduction across a semiconductor body. Feature (d2) of device claim 1 merely requires that the second channel layer region is part of an epitaxially grown channel layer and has the second conductivity type. Both aspects are clearly disclosed in D1: the second channel layer region is a part of epitaxially grown channel layer 5a (see D1, figure 4(c)) and is doped with the second conductivity type (see D1, figures 5(a) and 5(b)). The fact that D1 uses a different manufacturing method to obtain the same structural features is not relevant.

Moreover, the Board is not convinced that feature (d2) would improve the threshold voltage compared to the device of D1. The application as originally filed describes that the threshold voltage for a n-type grown channel layer, i.e. the one known in the art according to paragraphs [0003] and [0008] of the application and lacking any p-type second channel layer region, is improved by adding said p-type second channel layer region acting as a threshold voltage regulating region, see paragraphs [0008], [0012] to [0015], [0032], [0037] and [0038] and see also the appellant's argumentation in the statement setting out the grounds of appeal. As the device of D1 comprises a channel layer divided at least into three sections as claimed, it cannot be concluded that its threshold voltage is different from the claimed device. No indication can be found in the application that a further improvement of the threshold voltage compared to the device of D1 would be obtained.

From the above it follows that D1 discloses a second channel layer region "that is epitaxially grown with said second conductivity type".

4.2.3 Therefore, a device having all the claimed features is known from D1. The subject-matter of claim 1 lacks novelty over D1 (Article 54(1) and (2) EPC).

5. Auxiliary request

According to Article 13(2) RPBA 2020 in combination with 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.

The auxiliary request was filed after notification of the Board's summons to oral proceedings. The appellant did not indicate any reasons justifying exceptional circumstances that would have prevented it to file the auxiliary request with the statement setting out the grounds of appeal or during the examination procedure.

Moreover, feature (h) is disclosed in paragraph [0036] of the application as originally filed. However, this part of the description makes it clear that the claimed "inversion channel region" is formed when using a retrograde profile that includes decreasing p-type carrier levels from the bottom of the P+ well (33) toward the top of the P+ well (33). Claim 1, however, is not limited to this specific type of dopant profile. According to paragraph [0037], in a device having the features mentioned in claim 1, the inversion channel region is formed only in the second channel layer

region 58, see figure 2, "channel zone (50)". Thus, *prima facie*, claim 1 according to the auxiliary request does not meet the requirements of Article 123(2) EPC.

After the above considerations, the Board did not admit the auxiliary request into the proceedings (Articles 13(2) and 25(1) RPBA 2020).

6. In the present decision, the Board focused on the embodiment of figure 1 of D1 and its manufacturing shown in figures 4(a) to 7(c). The Board maintains its provisional view (see its communication, sections 5.5.1 to 5.5.5) that the subject-matter of claim 1 lacks an inventive step over the alternative embodiment shown in figure 9 of D1.

7. As no allowable request is on file, the appeal must fail.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated