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**Datasheet for the decision
of 3 June 2020**

Case Number: T 2279/16 - 3.4.03

Application Number: 11756731.3

Publication Number: 2548230

IPC: H01L29/78, H01L29/739,
H01L29/872, H01L29/06,
H01L29/40

Language of the proceedings: EN

Title of invention:

TRENCH DMOS DEVICE WITH IMPROVED TERMINATION STRUCTURE FOR HIGH VOLTAGE APPLICATIONS

Applicant:

Vishay General Semiconductor LLC

Headword:

Relevant legal provisions:

EPC Art. 52(1), 56, 113(1), 116(1)
RPBA 2020 Art. 13(1), 13(2)

Keyword:

Inventive step - main request (no)
Late-filed auxiliary requests - admitted (no)

Decisions cited:

Catchword:



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Case Number: T 2279/16 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 3 June 2020

Appellant: Vishay General Semiconductor LLC
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Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 3 May 2016
refusing European patent application No.
11756731.3 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman T. Häusser
Members: S. Ward
G. Decker

Summary of Facts and Submissions

- I. The appeal is against the decision of the Examining Division to refuse European patent application No. 11 756 731 on the grounds that the claimed subject-matter did not involve an inventive step within the meaning of Articles 52(1) and 56 EPC in the light of documents D6 and D3.
- II. In the statement of grounds of appeal the appellant requested that the decision under appeal be set aside and that a patent be granted "based on the claims filed on March 22, 2016".

The statement of grounds of appeal also contained a request for oral proceedings, and in a summons to oral proceedings pursuant to Rule 115(1) EPC dated 17 February 2020, the appellant was duly summoned to oral proceedings to be held on 4 June 2020.

The Board sent a communication pursuant to Article 15(1) RPBA 2020 dated 21 April 2020 containing the provisional opinion that independent claims 1 and 6 did not appear to involve an inventive step over the combination of documents D6 and D3. Under point 5.2 the Board stated the following: "The appellant is reminded of the provisions of Article 13 RPBA 2020."

In a letter dated 29 April 2020 the appellant stated that "nobody will be present for the applicant at the oral proceedings". The Board therefore sent a communication dated 6 May 2020 cancelling the oral proceedings.

By letter dated 18 May 2020 the appellant requested that the decision under appeal be set aside and that a patent be granted based on the claims filed on 22 March 2016 (main request), or alternatively based on one of auxiliary requests 1 and 2, both newly filed with the letter.

III. The following documents are referred to:

D3: US 6 396 090 B1

D6: US 2005/0230744 A1

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

"A termination structure for a trench MOS device, said termination structure comprising:

- a semiconductor substrate (100B) having an active region and a termination region, the substrate having a first type of conductivity;*
- a termination trench (120) located in the termination region and extending from a boundary (112) of the active region toward an edge of the semiconductor substrate (100B);*
- a doped region (152) having a second type of conductivity disposed in the substrate below the termination trench (120);*
- a MOS gate (122) formed on a sidewall adjacent the boundary (112), wherein the doped region (152) extends from below a portion of the MOS gate (122) toward the edge of the semiconductor substrate (100B);*
- a termination structure oxide layer (150) formed on the termination trench (120) covering a portion of the MOS gate (122) and extending toward the edge of the substrate (100B), the termination structure oxide layer (150) being located exclusively on the*

termination trench (120) and not extending into the active region, the termination structure oxide layer (150) and the doped region (152) being in contact with one another and defining an interface therebetween such that the whole doped region (152) is located in the termination region and an entirety of a laterally extending surface of the doped region (152) is in contact with the termination structure oxide layer (150);

- *a first conductive layer formed on a backside surface of the semiconductor substrate (100B); and*
- *a second conductive layer (160, 165) formed atop the active region and in contact with an exposed portion of the MOS gate (122), and extending to cover a portion of the termination structure oxide layer (150)."*

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

D6 was the closest prior art, and claim 1 comprised seven features (A)-(G) distinguishing the claimed subject-matter from D6 [listed under point 2.2, below].

These differences resulted in lowering the electric fields in the active region by pushing the electric field further into the bulk, thereby reducing its presence at the trench surface. The achievement of this effect was the objective technical problem.

The skilled person would have considered D3, as it also showed a termination structure for a power trench MOS device.

However, there was no hint in D3 regarding distinguishing features F) and G), and the skilled

person would not be enabled by D3 to arrive at features F) and G), hence the termination structure according to claim 1 involved an inventive step over the combination of D6 and D3.

Auxiliary requests 1 and 2 were filed in reply to the preliminary opinion of the Board, and incorporated further distinguishing features over the cited prior art.

Reasons for the Decision

1. The appeal is admissible.

In relation to the main request, the sole issue to be decided is whether the claimed subject-matter involves an inventive step.

2. *Main Request: Closest Prior Art and Distinguishing Features*

- 2.1 Both the Examining Division and the appellant took D6 to be the closest prior art. D6 discloses a first embodiment in the form of a Schottky diode (Figs. 2A-2G; paragraphs [0032]-[0038]), and a second embodiment being a modification of the first (Fig. 2H; paragraph [0039]). The Board considers the second embodiment to be the most suitable starting point for the discussion of inventive step.

- 2.2 The appellant identifies the following differences in claim 1 of the main request over D6:

(A) a MOS gate (122) formed on a sidewall adjacent the boundary (112), wherein the doped region (152) extends from below a portion of the MOS gate (122);

(B) the termination structure oxide layer (150) is formed on the termination trench (120) covering a portion of the MOS gate (122);

(C) a second conductive layer (160, 165) is formed atop the active region and an exposed portion of the MOS gate (122), and extends to cover a portion of the termination structure oxide layer (150);

(D) the second conductive layer (160, 165) is in contact with an exposed portion of the MOS gate (122);

(E) the termination structure oxide layer (150) is located exclusively on the termination trench (120) and does not extend into the active region;

(F) the whole doped region (152) is located in the termination region;

(G) an entirety of a laterally extending surface of the doped region (152) is in contact with the termination structure oxide layer (150).

2.3 Features (A)-(D) are defined in relation to a "MOS gate (122)". Since D6 does not disclose a MOS gate, at least these four features can be accepted as distinguishing the claimed subject-matter from D6.

2.4 Regarding other potential distinguishing features, it is, in the opinion of the Board, firstly necessary to have a clear understanding of the meaning of the terms used in the application, in particular the terms

"active region", "termination region" and "termination trench". The Board's understanding of these terms is given in the following.

- 2.5 An "active region" is a region in which the active effect (e.g. Schottky rectification) takes place. In Fig. 2 of the present application the active effect is provided by the Schottky contact formed at the interface between the metal layer 160 and the first layer 100A, hence the active region is to the left of the dotted line (as indicated).
- 2.6 A "termination region" is, according to the Board's interpretation, a region in which the active effect does not take place, and which lies immediately adjacent to the "active region" (indicated as "TERMINATION" in Fig. 2 of the present application). In other words, *by definition*, there is no intermediate region between the active and termination regions.
- 2.7 A "termination trench", where present, is located in the termination region. However, it may or may not extend over the entire termination region, i.e. right up to the boundary with the active region. For example, in the finished embodiments of the present invention (Figs. 2 and 12) the termination trench extends up to the boundary with the active region, whereas in the embodiments of D6 (Fig. 2H, for example), there is a small intermediate region or gap between the end of the active region (the region covered with metal silicide layer 165) and the beginning of the termination trench (135A, as best seen in Fig. 2B). This intermediate region (which will be referred to in the following as the "gap region") is in the termination region but not part of the termination trench.

2.8 According to the above understanding, there is a further difference between present claim 1 and D6, which may be given the reference sign (H):

(H) *"a termination trench (120) located in the termination region and extending from a boundary (112) of the active region toward an edge of the semiconductor substrate (100B)"* (underlining added by the Board).

2.9 Concerning feature (E), the termination structure oxide layer 150 in Fig. 2H of D6 is *not* located exclusively on the termination trench, as it also covers the small gap region between the termination trench and the active layer. Feature (E) therefore represents a difference over D6.

2.10 Regarding feature (F), however, while the whole doped region (i.e. either the leftmost or rightmost P-doped region 140 in Fig. 2H of D6) may be considered to extend slightly beyond the termination *trench* (see paragraph [0035] of D6), it does not extend beyond the termination *region* (i.e. it ends in the gap region). The whole doped region is therefore entirely "located in the termination region", and feature (F) is therefore disclosed in D6.

2.11 In Fig. 2H of D6, the entirety of a laterally extending surface of the doped region (the planar upper surface of the leftmost or rightmost P-doped region 140) is depicted as being in contact with the termination structure oxide layer (150). Hence feature (G) is disclosed in D6.

2.12 In summary, the Board finds that claim 1 differs from D6 in features (A)-(D), and also in features (E) and

(H). Features (F) and (G), however, are disclosed in D6.

3. *Technical problem solved*

3.1 Referring to paragraph [0025] of the description of the application, the appellant argues that the technical effect achieved is to lower the electric fields in the active region. This paragraph refers to Fig. 4, "which shows the electric field at different positions along the device both with and without the implantation region 152." Hence, this paragraph is focused on the effects of the implantation region 152, and does not explicitly refer to the effects of any of the distinguishing features (A)-(D), (E) and (H).

3.2 A more accurate statement of the problem solved by the distinguishing features can be derived from paragraph [0008]: "to reduce the crowding of the electric field at the edge of the device (near the active region)". The Board regards this as the technical problem.

4. *The Combination of D6 with D3*

4.1 The appellant accepted that, starting from D6 and seeking a solution to the above problem, the skilled person would consider D3, which discloses a trench termination structure for an MOS device, which may be a Schottky diode, whereby the "novel trench termination structure is to overcome problems of electric field crowding issues" (column 3, lines 35-37).

4.2 With particular reference to Fig. 5A, D3 discloses a MOS gate 122, which, in the terminology of the present application, has the following characteristics (column 4, line 35 - column 5, line 3):

The MOS gate (122) is formed on a sidewall adjacent the boundary (of the active and termination regions); the termination structure oxide layer (150) is formed on the termination trench covering a portion of the MOS gate (122); a second conductive layer (160A) is formed atop the active region and an exposed portion of the MOS gate (122), and extends to cover a portion of the termination structure oxide layer (150); the second conductive layer (160A) is in contact with an exposed portion of the MOS gate (122).

Hence, all of features (A)-(D) are disclosed in D3, except for the second part of feature (A): "wherein the doped region (152) extends from below a portion of the MOS gate (122)".

- 4.3 Concerning the two other distinguishing features recognised by the Board (E and H):

D3 discloses that the termination structure oxide layer (150) is located exclusively on the termination trench and does not extend into the active region (Fig. 5A), hence feature (E) is disclosed.

D3 also discloses that the termination trench (120) is located in the termination region and extending from a boundary of the active region toward an edge of the semiconductor substrate, hence feature (H) is disclosed.

- 4.4 The skilled person would therefore find in D3 a known solution to the objective problem, and would be motivated to incorporate the disclosed MOS gate arrangement into the closest prior art. By directly following the teaching of D3 (as depicted in Fig. 5A),

the skilled person would be led to a device having all the distinguishing features listed above with the exception of the second part of feature (A):

"wherein the doped region (152) extends from below a portion of the MOS gate (122)".

The Board's understanding is that the term "extends from" implies that the *lateral end point* of the doped region is located below a portion of the MOS gate, as depicted in Fig. 2 of the present application (i.e. the doped region extends under part of the MOS gate, but not under the entire MOS gate).

4.5 Neither D6 nor D3 discloses an embodiment having both a doped region and a MOS gate, and hence, in incorporating an MOS gate into the arrangement of D6, the skilled person would not find any explicit teaching on the positional relationship which these two features should have.

4.6 In Fig. 2H of D6 the left and right P-doped regions 140 are shown in the termination region extending under the entire trench and (just) into the gap region between the edges of the trench and the active region. The skilled person could not persist with this exact arrangement, since, in incorporating the MOS gate of D3, the gap region would have to be eliminated so that only a thin oxide layer would separate the MOS gate and the active region, as shown in Fig. 5A of D3.

One possible solution would be to maintain the P-doped layer in the form shown in Fig. 2H, so that in the modified arrangement it would extend up to, or even into, the active layer. Alternatively, the skilled person could reduce the lateral extent of the P layer

so that it would continue to lie exclusively in the termination region (as it does in Fig. 2H), in which case an obvious possibility would be to locate the lateral end of the P-doped layer under the MOS gate.

- 4.7 In the opinion of the Board, the salient question is whether there is any technical significance in such a choice. In other words, would a doped region extending from a point below a portion of the MOS gate achieve any particular technical effect, which would not be achieved by a doped region existing below the entire MOS gate, or is this merely an arbitrary choice? According to paragraph [0022] of the description of the present application, the answer would appear to be the latter:

"The implantation region 152 is located beneath a portion of the MOS gate 122 and the termination oxide layer 150. In some implementations the edge of the implantation region 152 may extend to the boundary 112 and surrounds the corner of the MOS gate 122."

Hence, the implantation (doped) region may extend below a portion of the MOS gate or it may extend under the entire MOS gate, with no indication of any particular technical significance being attached to either choice.

- 4.8 The only feature which does not flow directly from the combination of D6 and D3 is that the doped region extends from below a portion of the MOS gate. However, this feature is not associated in the application with any specific technical effect, and hence it can only be regarded as defining one of a limited number of equally possible alternative lateral end points of the doped region, the selection of which does not involve an inventive step.

5. *Arguments of the Appellant*

5.1 The appellant's arguments on inventive step are focused on the contention that the skilled person would not arrive at the features (F) and (G), based on the combination of D6 and D3.

5.2 For the reasons given above, the Board is of the opinion that features (F) and (G) are, in fact, disclosed in D6.

6. The Board therefore concludes that the subject-matter of claim 1 of the main request does not involve an inventive step within the meaning of Articles 52(1) and 56 EPC.

7. *Auxiliary Requests*

7.1 In its communication pursuant to Article 15(1) RPBA 2020, the Board stated: "The appellant is reminded of the provisions of Article 13 RPBA 2020" (point 5.2). Article 13(2) RPBA 2020 states the following:

"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."

In the present case, a summons to oral proceedings pursuant to Rule 115(1) EPC dated 17 February 2020 was sent. Receipt of the summons was acknowledged by the

appellant by means of a fax dated 18 February 2020. Auxiliary requests 1 and 2 were filed with the letter dated 18 May 2020, hence "after notification of a summons to oral proceedings".

- 7.2 It is not explicitly stated in Article 13(2) RPBA 2020 whether this provision still applies if, following notification of a summons to oral proceedings, the oral proceedings are subsequently cancelled. In the Board's opinion, at least in the case where the cancellation of oral proceedings has been occasioned by an appellant's statement that it will not be represented at the oral proceedings, Article 13(2) RPBA 2020 is applicable.

The provisions of Article 13(2) RPBA 2020 take effect either after the expiry of a period specified in a communication under Rule 100(2) EPC or "after notification of a summons to oral proceedings", and there is nothing in the wording of the article to indicate any exceptions to this, or that the effects of Article 13(2) RPBA 2020 are dependent on the subsequent procedural history of the case.

Moreover, the purpose of oral proceedings is to allow a party to state its case before the Board. Where an appellant decides that it will not be represented at oral proceedings, a Board may decide to cancel the oral proceedings on the ground that it sees no point conducting oral proceedings with an absent appellant. To conclude that such a purely practical decision by the Board should have the effect of returning the appellant to a more favourable position regarding the admission of new requests than that of an appellant who elected to attend the oral proceedings would be, in the view of the Board, inconsistent with the aim and purpose of Article 13 RPBA 2020, which is to provide a

convergent approach to limiting the possibilities for a party to amend its appeal case. Hence, the Board judges that Article 13(2) RPBA 2020 applies to the present case.

- 7.3 The appellant's letter dated 18 May 2020 contains no attempt to justify why the auxiliary requests should be admitted into the procedure; the appellant merely states the following:

"According to the preliminary opinion of the Board of Appeal, the termination structure according to claim 1 does not involve an inventive step over D6 in view of D3. In reply to this preliminary opinion, two auxiliary requests are filed."

The combination of D6 and D3 is exactly the same combination which led to the refusal of the application for lack of inventive step, and hence this was not a new objection from the Board (even if the Board's reasoning differed in certain details from that of the Examining Division). It should be apparent to any appellant that its arguments may fail to convince the Board, and the fact that the Board in this case issued a preliminary opinion in which it came to the same conclusion as the Examining Division does not constitute "exceptional circumstances" within the meaning of Article 13(2) RPBA 2020.

- 7.4 Moreover, the appellant's submission does not contain "cogent reasons" (or indeed any reasons) why the auxiliary requests should be admitted.

Auxiliary requests 1 and 2 filed with the letter dated 18 May 2020 are therefore not admitted into the procedure pursuant to Article 13(2) RPBA 2020.

7.5 For completeness the Board notes that even if it had come to a different conclusion about the applicability of Article 13(2) RPBA 2020, there can be no doubt that at least Article 13(1) RPBA 2020 applies, and auxiliary requests 1 and 2 also fail to meet the requirements for admission into the proceedings pursuant to that article.

Article 13(1) RPBA 2020 requires that:

"Any amendment to a party's appeal case after it has filed its grounds of appeal or reply is subject to the party's justification for its amendment and may be admitted only at the discretion of the Board ... The party shall provide reasons for submitting the amendment at this stage of the appeal proceedings."

The appellant provided no reasons why auxiliary requests 1 and 2 were submitted at a late stage in appeal proceedings. In its provisional opinion the Board raised no new objections, and the appellant does not argue that new objections were raised. As noted above, a provisional opinion in which the Board merely concurs with the conclusion of the department of first instance does not justify the filing of new requests at a late stage in the proceedings. Hence, and in addition to the conclusion reached above under point 7.4, auxiliary requests 1 and 2 are also not admitted into the proceedings pursuant to Article 13(1) RPBA 2020.

8. *Articles 116(1) and 113(1) EPC*

8.1 Following the request for oral proceedings in the statement of grounds of appeal, the appellant stated in its letter dated 29 April 2020 that "nobody will be

present for the applicant at the oral proceedings". Such a statement is normally treated as equivalent to a withdrawal of the request for oral proceedings (see *Case Law of the Boards of Appeal, 9th Edition, 2019, III.C.4.3.2*). No further request for oral proceedings was made in the subsequent submissions of the appellant. Hence, there is no current request for oral proceedings pursuant to Article 116(1) EPC on file.

8.2 Concerning the appellant's right to be heard according to Article 113(1) EPC, in the communication pursuant to Article 15(1) RPBA 2020 the appellant's attention was drawn to the provisions of Article 13 RPBA 2020. This clearly indicated to the appellant the Board's intention to apply the provisions of this article to the admission of any new requests, including the requirement (under both Article 13(1) and Article 13(2) RPBA 2020) that a party must provide reasons why such requests should be admitted. The appellant therefore had an opportunity to be heard on this issue in the letter accompanying the newly filed requests, but chose not to provide any reasons why they should be admitted into the procedure.

Moreover, oral proceedings pursuant to Article 116(1) EPC to be held on 4 June 2020 and to which the appellant had been duly summoned would have provided the appellant with a further opportunity to be heard pursuant to Article 113(1) EPC on all issues, including the admission of any new requests. It was the appellant's own decision to forgo that right by announcing that it would not be represented at oral proceedings.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:



S. Sánchez Chiquero

T. Häusser

Decision electronically authenticated