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Case Number: T 2278/08 - 3.4.03

Application Number: 00300391.0

Publication Number: 1096574

IPC: H01L 29/78, H01L 29/10, H01L 21/336

Language of the proceedings: EN

Title of invention:
Power MOSFET having a trench gate electrode and method of making the same

Applicant:
SILICONIX Incorporated

Opponent:
-

Headword:
-

Relevant legal provisions (EPC 1973):
EPC Art. 56
RPBA Art. 12(4)

Keyword:
"Main request not admitted"
"Inventive step (no) - first and second auxiliary request"

Decisions cited:
-

Catchword:
-

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Case Number: T 2278/08 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 20 March 2012

Appellant: (Applicant)
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 16 July 2008 refusing European patent application No. 00300391.0 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: G. Eliasson
Members: R. Q. Bekkering
P. Mühlens

Summary of Facts and Submissions

I. This is an appeal against the refusal of application 00 300 391 for lack of an inventive step, Article 56 EPC 1973.

II. With the statement setting out the grounds of appeal dated 24 November 2008, the appellant requested that the decision under appeal be set aside and a patent granted on the basis of the following:

Main request: claims 1 to 15 filed with the statement setting out the grounds of appeal, or

First auxiliary request: claims 1 to 15 filed with the statement setting out the grounds of appeal, or

Second auxiliary request: claims 1 to 15 filed with the statement setting out the grounds of appeal.

III. The summons to oral proceedings requested by the appellant were provided with an annex in which a provisional opinion of the board on the matter was given. In particular, doubts were expressed as to whether the appellant's main request should be admitted into the proceedings having regard to Article 12(4) of the Rules of Procedure of the Boards of Appeal (RPBA). Moreover, the subject-matter of claim 1 of the main request, as well as of both the first and second auxiliary request appeared to lack an inventive step in the sense of Article 56 EPC 1973.

No arguments were provided by the appellant in response to the board's observations. The appellant merely

informed the board that neither the appellant nor its representative would attend the scheduled oral proceedings and requested that the procedure be continued in writing.

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

"*A method of fabricating a power MOSFET comprising the sequential steps of:*
providing a semiconductor substrate of a first conductivity type;
growing an epitaxial layer of the first conductivity on a surface of the substrate;
forming a trench in the epitaxial layer, the trench defining a cell of the MOSFET;
forming a first insulating layer on a wall of the trench;
forming a gate in the trench, the gate being separated from the epitaxial layer by the insulating layer;
implanting dopant of a second conductivity type into the epitaxial layer to form a body, a lower boundary of the body forming a first portion of a substantially planar horizontal PN junction with a portion of the epitaxial layer of the first conductivity type;
implanting a single dopant of the first conductivity type at a single dose and a single energy into the epitaxial layer to form a source region;
depositing a second insulating layer over the epitaxial layer;
forming an opening in the second insulating layer to expose at least a portion of the source region;
implanting additional dopant of the second conductivity type through the second insulating layer opening into a central region of the cell to form a heavily doped

region, the heavily doped region being spaced apart from the wall of the trench and forming a second portion of the substantially planar horizontal PN junction with the portion of the epitaxial layer of the first conductivity type, and such that the heavily doped region extends all the way between the source region and the substantially planar horizontal PN junction;
depositing a metal layer over the second insulating layer such that the metal layer contacts the portion of the source region and the entire PN junction remains above a level of a bottom of the trenches after the deposition of the metal layer; and
limiting the thermal energy to which the power MOSFET is exposed following the implantation of the body such that the body does not diffuse substantially."

V. Claim 1 of the first auxiliary request corresponds to claim 1 of the main request in which the feature:

"implanting a single dopant of the first conductivity type at a single dose and a single energy into the epitaxial layer to form a source region"

is replaced by:

"using a single mask for blocking areas where the body is to be contacted, implanting dopant of the first conductivity type into the epitaxial layer to form a source region".

VI. Claim 1 of the second auxiliary request corresponds to claim 1 of the first auxiliary request in which the feature:

"using a single mask for blocking areas where the body is to be contacted, implanting dopant of the first conductivity type into the epitaxial layer to form a source region".

is replaced by:

"*implanting an arsenic dopant of the first conductivity type at a single dose of 8E15 cm^{-2} and a single energy of 80 KeV into the epitaxial layer to form a source region*".

VII. Reference is made to the following documents:

D1: EP 0 923 137 A

D3: US 5 629 543 A

D4: US 5 689 128 A.

VIII. The appellant submitted with the statement setting out the grounds of appeal in substance the following arguments:

The subject-matter of claim 1 of all requests involved an inventive step in view of documents D4, D1 and D3, and any of the remaining cited documents. In particular, all documents failed to disclose or suggest a succession of steps as recited in claim 1 for implanting, through a source region implanted using a single mask for blocking areas where the body was to be contacted, a heavily doped region extending all the way down from the source region.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

As noted in the annex to the summons to the oral proceedings, the appellant's main request filed in the appeal proceedings corresponds to the main request withdrawn in the oral proceedings before the examining division following an objection under Article 123(2) EPC.

By withdrawing the above request, the appellant has prevented a decision from being taken on it by the examining division, forming the basis for the appeal, thereby depriving the appeal proceedings of its main function of providing a review of the decision of the department of first instance.

No arguments were submitted by the appellant on this point in response to the board's observations provided in the annex to the summons to oral proceedings referred to above.

The board, therefore, exercises its discretion not to admit the appellant's main request into the appeal proceedings in accordance with Article 12(4) of the Rules of Procedure of the Boards of Appeal (RPBA).

3. *First and second auxiliary request*

3.1 The appellant's second auxiliary request corresponds to the main request as refused in the decision under appeal. It is considered expedient to deal with this request first.

3.2 *Novelty, inventive step*

3.2.1 *Document D4*

Document D4 discloses a method of forming a high density trenched DMOS (Diffused Metal Oxide Semiconductor) transistor (cf figure 2 and corresponding description).

In particular, D4 discloses, in the terms of claim 1, a method of fabricating a power MOSFET (DMOS) comprising the sequential steps of:
providing a semiconductor substrate (10) of a first conductivity type (n) (column 4, lines 41 to 42);
growing an epitaxial layer (12, 34) of the first conductivity (type) (n) on a surface of the substrate (column 4, lines 42 to 50);
forming a trench in the epitaxial layer, the trench defining a cell of the MOSFET (column 4, lines 60 to 62);
forming a first insulating layer (24) on a wall of the trench (column 4, lines 62 to 65);
forming a gate (22) in the trench, the gate being separated from the epitaxial layer by the insulating layer (column 4, line 65 to column 5, line 8);
implanting dopant of a second conductivity type (p) into the epitaxial layer to form a body (14), a lower

boundary of the body forming a first portion of a substantially planar horizontal PN junction with a portion of the epitaxial layer (34) of the first conductivity type (column 5, lines 13 to 23);
implanting an arsenic dopant of the first conductivity type (n) at a single dose and a single energy of 80 keV into the epitaxial layer to form a source region (column 5, lines 31 to 33);
depositing a second insulating layer (28) over the epitaxial layer (column 5, lines 36 to 41);
forming an opening in the second insulating layer to expose at least a portion of the source region (column 5, lines 38 to 41);
depositing a metal layer (30) over the second insulating layer such that the metal layer contacts the portion of the source region and the entire PN junction remains above a level of a bottom of the trenches after the deposition of the metal layer (see figure 2); and
limiting the thermal energy to which the power MOSFET is exposed following the implantation of the body such that the body does not diffuse substantially (column 3, lines 52 to 54).

3.2.2 The following differences of the subject-matter of claim 1 over D4 are provided:

(i) the dose of the implant for forming the source regions is $8x10^{15}$ cm^{-2};

(ii) a step of implanting additional dopant carried out after said forming step of the opening in the second insulating layer and through said opening in the second insulating layer to form a heavily doped region; and

(iii)the heavily doped region extending all the way between the source region and the substantially planar horizontal PN junction.

The subject-matter of claim 1 is, thus, new over document D4 (Article 54(1) and (2) EPC 1973).

3.2.3 Based on the above differences, the following respective partial objective problems to be solved can be defined:

(i) find suitable implantation parameters;
(ii) reduce cost and process time;
(iii)find an alternative source region shape.

3.2.4 Regarding (i), the selection of appropriate implant parameters is a matter of routine experimental practice for a person skilled in the art. This is all the more so as the claimed dose lies within the range of $5x10^{15}$ to $8x10^{18}$ $/cm^2$ used in D4 (column 5, line 31 to 33).

3.2.5 Regarding (ii), an alternative processing sequence involving implanting the source regions first and then implanting the deep body region through an opening in a second insulating layer is known from D1 (see paragraphs [0034], [0042] and figure 4K). It would be obvious to a person skilled in the art to use this alternative processing sequence in the method of D4.

In D1 the source region is implanted by a double implant process of phosphorous and arsenic (cf paragraph [0038], figures 4I, 4K and figures 5, 5A, 5B). Phosphorus ions will penetrate deeper into the substrate during implant and also during later

diffusion steps. Advantageously, the n+ source regions will have a depth of about 0.4 to 0.8 µm after diffusion. The arsenic implant extends the n+ source to the substrate surface, and also forms the n+ contacts 16 (see figures 1 and 1a) by compensating (converting) the p-type surface of the p+ heavy body to n-type in the desired contact area. The preferred sheet resistance profiles for the n+ source along the edge of the trench, and the n+ contact are shown in figures 5a and 5b, respectively. Subsequently, the deep body region is implanted through an opening in a second insulating layer (see paragraphs [0035], [0041], [0042] and figure 4k).

In as far as the claim wording excludes a further (second) implant to form the source region, the solution provided in D1, eliminating the need for a mask and thus reducing cost and process time (cf paragraph [0042]) differs in the use of the double implant.

No inventive merit is seen in replacing the double implant of D1, providing a more refined doping profile, by a single implant.

It is noted that contrary to what is argued by the appellant, in D1 the n+ source region (32a, 32b) including the n+ source contact region (16) is formed by the double implant using a single mask (n+ blocking mask)(cf paragraph [0037], figure 4I).

3.2.6 Finally, regarding (iii) it is noted that the alleged difference in the shape of the source region between figure 2A of the application and figure 2 of D4 would

appear to only stem from the fact that cross-sections at different locations are compared. Figure 2 of D4 shows a cross section at the location where a contact is formed to the body region, whereas figure 2a of the application shows a cross section where no such contact is present (ie in a plane parallel to the plane of the drawing but offset in the direction perpendicular to the plane of the drawing). As indicated in the application, the source implant is actually blocked in areas where the body is to be contacted (page 8, second paragraph). Conversely, in D4 in areas other than shown in figure 2A, the source region will extend along the substrate's surface.

Accordingly, the only aspect remaining regarding (iii) is that the heavily doped region extends all the way to the PN junction.

In as far as this is not already the case in the figure 2 embodiment of D4, it is considered to be a design option readily available to the skilled person, known for instance from a similar device as provided in document D3 (see figure 3F).

3.2.7 No arguments were submitted by the appellant in response to the board's observations provided in the annex to the summons to oral proceedings, which essentially correspond to the above.

3.2.8 Accordingly, the subject-matter of claim 1 according to the second auxiliary request is obvious to a person skilled in the art and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

3.2.9 Claim 1 of the first auxiliary request differs from that of the second auxiliary request in that the feature:

"*implanting an arsenic dopant of the first conductivity type at a single dose of 8E15 cm^{-2} and a single energy of 80 KeV into the epitaxial layer to form a source region*"

reads instead:

"using a single mask for blocking areas where the body is to be contacted, implanting dopant of the first conductivity type into the epitaxial layer to form a source region".

The use of a single mask for blocking areas where the body is to be contacted when forming the source region is known from document D4 (column 5, lines 29 to 33). The implant dose and energy of the source implant is not specified in claim 1 according to the first auxiliary request, so that the claim is broader in this respect having regard to claim 1 of the second auxiliary request discussed above.

Accordingly, the subject-matter of claim 1 of the first auxiliary request also lacks an inventive step in the sense of Article 56 EPC 1973.

3.2.10 Hence, both the appellant's first and second auxiliary requests are not allowable.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar Chair

S. Sánchez Chiquero G. Eliasson