BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS	**BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE**	**CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS**

Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [ ] To Chairmen
(D) [X] No distribution

Datasheet for the decision of 24 September 2013

Case Number: T 0774/10 - 3.4.03

Application Number: 00930012.0

Publication Number: 1192664

IPC: H01L 29/08, H01L 29/735, H01L 29/78

Language of the proceedings: EN

Title of invention:
A SEMICONDUCTOR ELEMENT

Applicant:
Eklund, Klas-Håkan

Headword:
-

Relevant legal provisions:
EPC Art. 123(2)

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Added subject-matter (yes) - main request"
"Inventive step (no) - auxiliary request"

Decisions cited:
-

Catchword:
-

Case Number: T 0774/10 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 24 September 2013

Appellant: (Applicant)
Eklund, Klas—Håkan
Manhemsvägen 20 B
SE-191 43 Sollentuna (SE)

Representative:
Karlström, Lennart
Noréns Patentbyrå AB
Box 10198
SE-100 55 Stockholm (SE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 30 September 2009 refusing European patent application No. 00930012.0 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: G. Eliasson
Members: R. Q. Bekkering
T. Bokor

Summary of Facts and Submissions

I. This is an appeal against the refusal of application 00 930 012 for lack of an inventive step, Article 56 EPC 1973, over documents

D1: US 5 146 298 A

D2: Arnold E. et al., "High-Temperature Performance of SOI and Bulk-Silicon RESURF LDMOS Transistors", Proceedings of the 8th International Symposium on Power Semiconductor Devices and ICs (ISPSC'96), 20-23 May 1996, Maui, HI, USA, pages 93-96.

II. Oral proceedings were arranged as requested by the appellant. The summons to these oral proceedings was provided with an annex in which a provisional opinion of the board on the matter was given.

Reference was made to the following further documents:

D4: Arnold E., "Silicon-on-Insulator Devices for High Voltage and Power IC Applications", Journal of the Electrochemical Society, Vol. 141, No. 7, July 1994, pages 1983 to 1988

D5: Lu Q. et al. "High voltage silicon-on-insulator (SOI) MOSFETs", Proceedings of the 3rd International Symposium on Power Semiconductor Devices and ICs. ISPSD '91, 22-24 April 1991, IEEE, New York, NY, USA, pages 36 to 39.

In the annex, it was noted *inter alia* that the subject-matter of claim 1 appeared to lack an inventive step, Article 56 EPC 1973, with respect to the documents D1 and D5.

III. In a letter dated 22 August 2013, in response to these summons, the appellant announced that neither the applicant nor the representative would come to the oral proceedings.

Moreover, in this letter the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following:

Main request:

Claims 1 to 4 filed with the letter of 22 August 2013,

Auxiliary request:

Claims 1 to 4 filed with the statement setting out the grounds of appeal of 28 January 2010.

IV. Oral proceedings took place in the absence of the appellant.

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

"*A semiconductor element comprising an insulating surface layer (1) in which electric contact connections are provided, said connections being connected to contact areas (5, 6) situated beneath the insulating surface layer (1), of which contact areas at least one is a first conductive type, wherein at least one of the* *contact areas (5, 6) and a further area (9, 10) formed by two layers of mutually different conductive types disposed between the contact areas (5, 6) are surrounded by a layer (8) of a second conductive type of material, **characterised** in that the second layer (8) has a thickness in the order of 1 µm or less, has a doping ratio of $3x10^{16}$ to 10^{17} atoms per cm^3, and is covered with an insulating layer (11) comprised of silicon dioxide at least on that side of said layer which lies distal from the surface layer.*"

VI. Claim 1 of the auxiliary request corresponds to claim 1 of the main request, with the characterising portion reading as follows (difference highlighted):

"***characterised** in that the second layer (8) has a thickness in the order of 1 µm or less, has a doping ratio of **10^{16}** to 10^{17} atoms per cm^3, and is covered with an insulating layer (11) comprised of silicon dioxide at least on that side of said layer which lies distal from the surface layer.*"

VII. The appellant submitted in substance the following arguments:

Regarding the doping ratio defined in claim 1 according to the main request, in the description it was stated that the doping ratio should be 10^{16} to 10^{17}. However, the doping ratio mathematically was defined as total charge per area unit divided by the thickness of the layer. In the original description, it was defined that the total charge should be $3x10^{12}/cm^2$. With the maximal thickness of 1 µm this mathematically led to a doping ratio of $3x10^{16}$, as defined in claim 1 of the main request.

The object of the invention, as stated on page 1 of the application as filed, was to improve a semiconductor element of the type defined in document D1 so that the dimensions of the semiconductor element could be reduced substantially without detracting from its performance. The problem was not solved by only adding an isolating layer, but an insulating layer would be necessary to avoid deteriorating the performance of the semiconductor device if the doping was increased and the thickness reduced of the second layer in the semiconductor device. It did not seem that the skilled person earlier had realised when such an insulating layer would be needed, and what influences of the performance of the semiconductor element it would have. This was however what the inventor/applicant of the present application had realised, and found that by providing the insulating layer and by reducing the thickness, an increased doping concentration in the second conductive type material would have the effect that the full depletion of the second conductive type layer under layers 9 and 10 was possible, thereby increasing the breakthrough voltage in vertical direction.

Document D2 did not contain any information leading a person skilled in the art in this direction.

Document D5 did not either contain any information leading in the way towards the invention as defined in claim 1. On the contrary, for obtaining the increased breakdown voltage the device described and shown in

Fig. 1b, was not provided with an insulation covering that side of the layer which lay distal from the surface layer, but had an opening on the buried oxide under the drain contact and through that hole a diffusion into the substrate. The increased breakdown voltage was consequently made in another way than in the present invention, a way that was more complicated, and consequently also more expensive. For this reason document D5 did not lead a man skilled in the art towards the invention, which therefore was believed to have an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Procedural issues*

The amended new claims according to the appellant's main request were filed after oral proceedings before the board were arranged.

In view of the fact that the amendments were filed in advance of the oral proceedings, constitute an attempt to overcome the objections raised and are provided with reasons in support thereof, and as the board is able to deal with the requests in substance, without adjournment of the oral proceedings, the new requests are admitted into the proceedings (Article 13(1) and (3) RPBA).

However, an appellant filing amendments, but renouncing to come to oral proceedings before the board to which it was duly summoned, must be taken to waive its right to present comments on any ground for an adverse decision which may arise (Article 113(1) EPC 1973, Article 15(3) RPBA).

3. *Main request*

3.1 *Amendments*

3.1.1 Claim 1 of the main request defines that the second layer (8) "*has a doping ratio of $3x10^{16}$ to 10^{17} atoms per cm^3*".

A doping ratio of $3x10^{16}$ atoms per cm^3 is not explicitly disclosed anywhere in the application as originally filed.

3.1.2 According to the appellant, though, this doping ratio is derivable from the application as originally filed. In the description it was stated that the doping ratio should be 10^{16} to 10^{17}. However, the doping ratio mathematically was defined as total charge per area unit divided by the thickness of the layer. In the original description, page 2, line 26, was defined that the total charge should be $3x10^{12}/cm^2$. With the maximal thickness of 1 µm this mathematically lead to a doping ratio of $3x10^{16}$, as defined in claim 1. With the preferred thickness of 0.3 µm, as also stated on page 2, line 26, of the original description, the preferred doping ratio became 10^{17}, as already included in the description and in claim 1.

3.1.3 First of all it is noted that, although the value and unit of the total charge is not clearly legible in the application (cf page 2, line 26) and the appellant actually requested in the statement setting out the grounds of appeal that the expression "*cm^2*" on page 1, line 19 be corrected to "*cm^3*", it is believed to be clear that the specification on page 1, line 19 of $3x10^{12}$ atoms per cm^2 is actually correct, and that the total charge referred to on page 2, line 26 corresponds to this value.

According to the application as originally filed "*By providing an insulating layer on the opposite side of the second conductive type of material in relation to the insulating surface layer, the layer of second conductive type material can be made thinner, in the order of magnitude of 1 µm or less, as distinct to present-day thicknesses of 4-5 µm. This enables the charge carrier concentration, doping, to be increased from about 10^{15} to about 10^{17}*" (cf page 2, lines 6 to 12) and "*This layer or plate has a thickness in the order of 1 µm or less, and has a doping ratio of 10^{16} to 10^{17} atoms per cm^2*" (cf page 4, lines 15 to 17).

In the passage referred to by the appellant it is stated that a significant improvement is achieved compared to the prior art provided by document D1 when layer 8 is about 0.3 µm thick, ie thinner compared to 4-5 µm in the prior art (cf application, page 2, lines 6 to 10), while retaining a total charge of $3x10^{12}/cm^2$.

Indeed, according to the description, "*According to this prior publication, the first type of conductive material is normally p-type silicon doped with about* $5x10^{14}$ *atoms per* cm^3*, whereas the second conductive material is n-type silicon doped with about* $3x10^{12}$ *atoms per* cm^2" (cf page 1, lines 15 to 19).

However, the application as originally filed does not disclose that a total charge of $3x10^{12}/cm^2$, used in the prior art, should be used in all cases and for all thickness of layer 8. Indeed such a pre-condition is nowhere mentioned in the application, neither are any technical reasons evident for which this should be implicit to a skilled reader.

The statement referred to by the appellant, that the total charge of $3x10^{12}/cm^2$ should be retained (page 2, line 26), is rather understood to merely concern a particularly advantageous embodiment with a 0.3 µm thick layer.

Accordingly, the doping ratio of $3x10^{16}$ per cm^3 is not directly and unambiguously derivable from the application as originally filed.

3.1.4 Hence, with the introduction of a doping ratio of $3x10^{16}$ per cm^3, the application has been amended in such a way that it contains subject-matter, which extends beyond the content of the application as filed, contrary to the requirement of Article 123(2) EPC.

The appellant's main request is, therefore, not allowable.

4. *Auxiliary request*

4.1 As noted in the summons to the oral proceedings, a semiconductor element according to the pre-characterising portion of claim 1 is known from document D1, cited as prior art in the application as originally filed (page 1, lines 7 to 26).

The features in the characterising portion of claim 1 provide a distinction over D1.

Accordingly, the subject-matter of claim 1 is new over document D1, Article 54(1) EPC 1973.

4.2 As indicated in the application and argued by the appellant, the distinguishing features provide an increase in the breakdown voltage of the device. In particular, "*when the p-area is replaced with an insulating layer in accordance with the invention, the breakdown voltage will, instead, be determined by the doping and the critical field in the layer comprising said second type of conductive material surrounded by the insulating layer*" (ie layer 8) (cf application page 2, lines 17 to 22; figure 1).

The objective problem to be solved relative to D1, accordingly, is to increase the breakdown voltage.

4.3 Document D5 is concerned with increasing the breakdown voltage of transistors of this type. To this end the device includes a silicon-on-insulator (SOI) structure, ie the silicon layer providing the drift region (the second layer (8) in claim 1) has an underlying insulating layer of silicon dioxide (is "*covered*" with an insulating layer comprised of silicon dioxide at least on that side of said layer which lies distal from the surface layer, as per claim 1). Moreover, using the conventional Reduced Surface Field (RESURF) technique, which, as is well known, requires higher dopant concentrations for thinner layers in order to control the extension of the depletion layer, the device is optimised for a high breakdown voltage. The silicon layer has a thickness of 1 µm and a dopant concentration of 1.1 x 10^{16} atoms per cm^3 (ie falling within the ranges specified in claim 1)(cf section "*Device Structures and Optimization*" and figures 1, 2).

It would be obvious to the skilled person entrusted with solving the above problem to apply this teaching of D5 to the device of D1, thereby arriving at the subject-matter of claim 1.

Incidentally it is noted that higher dopant concentration levels and thinner layers (cf eg document D2 showing a 0.2 µm layer in a SOI device (cf figure 1(b)) would be readily arrived at, following the above considerations, by straightforward experimentation and thus also be obvious to the skilled person.

4.4 The appellant argued that in document D5, for obtaining the increased breakdown voltage, the device described and shown in Fig. 1b, was not provided with an insulation covering that side of the layer which lay distal from the surface layer, but had an opening on the buried oxide under the drain contact and through that hole a diffusion into the substrate. The increased breakdown voltage was consequently made in another way than in the invention, a way that was more complicated, and consequently also more expensive. For this reason document D5 did not lead a man skilled in the art towards the invention.

It is however noted that document D5 discloses a standard SOI structure with an insulating layer covering the side of the n^- drift layer (ie the second layer 8 in claim 1) which lies distal from the surface layer (cf figure 1(a)) as per claim 1. Moreover, even in the modified SOI structure (cf figure 1(b)) referred to by the appellant, the insulating layer covers the side of the n^- drift layer (ie the second layer 8 in claim 1) which lies distal from the surface layer as defined in claim 1. The opening under the drain contact is not on the side of the n^- drift layer which lies distal from the surface layer but under the drain contact area (ie contact area 6 in claim 1). Accordingly, in fact both solutions offered in document D5 fall under the terms of claim 1.

Moreover, the appellant argued that it did not seem that the skilled person had realised earlier when such an insulating layer would be needed, and what influences on the performance of the semiconductor element it would have. The inventor/applicant of the application found that by providing the insulating layer and by reducing the thickness, an increased doping concentration in the second conductive type material would have the effect that the full depletion of the second conductive type layer under layers 9 and 10 became possible, thereby increasing the breakthrough voltage in the vertical direction.

It is, however, noted that, as discussed above, the provision of an insulating layer for this purpose is already suggested in document D5 and, thus, obvious to the skilled person. Furthermore, it would be readily apparent to the skilled person that by reducing the thickness and increasing the doping concentration of the second layer, full depletion of the second layer is assured, thereby achieving a high breakdown voltage, as this corresponds to the underlying principle of the conventional RESURF technique applied in document D5 (see eg document D4, page 1985, section "*RESURF principle*").

Accordingly, the subject-matter of claim 1 of the auxiliary request, having regard to the state of the art, is obvious to a person skilled in the art and, thus, lacks an inventive step in the sense of Article 56 EPC 1973.

4.5 The appellant's auxiliary request is, therefore, not allowable.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar:	Chair:
S. Sánchez Chiquero	G. Eliasson