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Datasheet for the decision of 5 June 2018

Case Number: T 2074/13 - 3.4.03

Application Number: 05709452.6

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Language of the proceedings: EN

Title of invention:
METHOD FOR MANUFACTURING SOI WAFER

Applicant:
SUMCO Corporation

Headword:

Relevant legal provisions:
EPC 1973 Art. 56, 84
EPC Art. 52(1), 123(2)
RPBA Art. 13(3), 15(1)

Keyword:
Inventive step - (no)
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Catchword:

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Case Number: T 2074/13 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 5 June 2018

Appellant: (Applicant)	SUMCO Corporation 2-1, Shibaura 1-chome, Minato-ku Tokyo 105-8634 (JP)
Representative:	Beckmann, Claus Kraus & Weisert Patentanwälte PartGmbB Thomas-Wimmer-Ring 15 80539 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 28 February 2013 refusing European patent application No. 05709452.6 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	S. Ward
	W. Van der Eijk

Summary of Facts and Submissions

I. The appeal is against the decision of the Examining Division refusing European patent application No. 05 709 452 on the ground that the claimed subject-matter did not involve an inventive step within the meaning of Article 56 EPC.

II. At the end of the oral proceedings held before the Board the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request filed during the oral proceedings before the Board or alternatively on the basis of the first or second auxiliary request, filed with letter of 4 May 2018.

III. The following documents are referred to:

D1: JP 2 228061 A
D2: WO 2004/010505 A1

Computer generated translations of documents D1 and D2 were annexed to the Board's communication under Article 15(1) RPBA and are referred to in this decision.

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

"A method for manufacturing SOI wafers in which a laminated wafer (10) is formed by laminating an active layer wafer (21) to a base wafer (22) with an insulating film (12) interposed therebetween, followed by reducing the thickness of the active layer wafer side to produce an SOI wafer (11), comprising the steps of:

implanting oxygen ions into the active layer wafer (21) to form an oxygen ion implanted layer (13) in the active layer wafer under a condition of dose within a range of 5.0E16 to 3.0E17 atoms/cm^2;
reducing the oxygen in the vicinity of the surface layer of the active layer wafer (21) by out diffusion by heat treating the active layer wafer (21) on which the oxygen ion implanted layer (13) has been formed in a reducing atmosphere;
forming a laminated wafer (10) by laminating the active layer wafer (21) onto a base wafer (22) with an insulating film (12) interposed therebetween;
allowing a portion of the active layer wafer (21) to remain on the surface side of the oxygen ion implanted layer (13) by grinding the active layer wafer portion of the laminated wafer (10);
exposing the oxygen ion implanted layer (13) by polishing or etching a portion of the remaining active layer wafer (21);
forming an oxide film (15) of a predetermined thickness on the exposed surface of the oxygen ion implanted layer (13) by oxidation treatment of the laminated wafer (10); and
removing the oxide film (15) together with the oxygen ion implanted layer (13) to expose an SOI layer (16) having a reduced thickness; and
repeating steps of forming an oxide film by oxidation treatment and removing the oxide film several times to further reduce a thickness of the SOI layer (16)."

Claim 1 of auxiliary request 1 is identical to claim 1 of the main request except that the final feature ("repeating steps ...") has been omitted, and the two preceding steps have been amended as follows:

"forming an oxide film (15) of a predetermined thickness on the exposed surface of the oxygen ion implanted layer (13) by oxidation treatment using a wet heat treatment of the laminated wafer (10); and removing the oxide film (15) together with the oxygen ion implanted layer (13) by using HF etching."

Claim 1 of auxiliary request 2 is identical to claim 1 of the main request except that the final three features read as follows:

"forming an oxide film (15) of a predetermined thickness on the exposed surface of the oxygen ion implanted layer (13) by oxidation treatment using a wet heat treatment of the laminated wafer (10); and removing the oxide film (15) together with the oxygen ion implanted layer (13) by using HF etching to expose an SOI layer (16); and
repeating steps of forming an oxide film by oxidation treatment using a wet heat treatment and removing the oxide film by HF etching several times to reduce a thickness of the SOI layer (16)."

In all of the above requests, claim 1 is directed to the manufacturing method of the first embodiment (Fig. 1). All requests also comprise a second independent claim directed to the second embodiment (Fig. 2).

V. With the summons to oral proceedings, the Board sent the appellant a communication under Article 15(1) RPBA setting out its provisional views. In this communication, the Board expressed doubts whether the claimed subject-matter met the clarity requirements of Article 84 EPC 1973. In particular, the final feature required *inter alia* the repetition of the step of forming an oxide film on the oxygen ion implanted

layer. Since, at this point in the process, the oxygen ion implanted layer had been completely removed, it was not seen how this was possible.

The Board also questioned how the invention achieved the results ascribed to it in the description. In particular, according to the passage describing the transition from stage H to stage I in Fig. 1 (page 13, first paragraph) the removal of the oxide film 15 "by, for example, HF etching" achieved the result that "the thickness of an SOI layer 16 exposed following removal of the oxide film is decreased and uniform within the plane." Since HF etching is well known to be effective for removing silicon oxide, but has no effect on silicon, it was difficult to see how this step reduced the thickness of the SOI layer 16.

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

(a) The invention defined by claim 1 was clear, and was to be understood as follows: The step of forming an oxide film 15 on the exposed surface of the oxygen ion implanted layer 13 by oxidation treatment was described in the final paragraph on page 12 of the description as originally filed. The skilled reader would understand that the resulting oxidation would not be limited only to the layer 15 depicted in Fig. 1(H), but that residual silicon in the oxygen ion implanted layer 13, and silicon at the surface of SOI layer 16 would also be oxidised.

The subsequent step of removing the oxide film together with the oxygen ion implanted layer would therefore not only expose the SOI layer but would reduce its thickness (as stated in the first paragraph on page 13,

and the paragraph bridging pages 13 and 14) in the sense that the portion of the SOI layer which had been oxidised would be removed.

The repetition mentioned in the final feature of claim 1 therefore referred to additional cycles of oxidising the SOI layer and removing the oxide film to further reduce the thickness of the SOI layer, as explained in the second paragraph of page 13.

The claimed subject-matter was therefore clear and consistent with the description.

(b) Regarding inventive step, the implanted oxide layer enabled an SOI layer to be produced with a smooth and uniform surface.

A damaged layer formed by a step of polishing the laminated wafer could be removed by performing (for the first time) the steps of forming an oxide film and removing the oxide film.

However, since the implanted oxide layer could not be produced arbitrarily close to the surface of the wafer (step B in Fig. 1), the final exposed SOI layer (step I in Fig. 1) might be too thick. This problem was solved by further reducing the thickness of the SOI layer by repeating several times the steps of forming an oxide film by oxidation treatment and removing the oxide film, while maintaining the smoothness and uniform thickness of the SOI wafer.

The defect portion did not remain on the thin SOI layer, since a step of forming an oxide film and a step of removing the oxide film were repeated several times.

The problem was therefore to provide an SOI layer which was both thin and smooth.

The prior art on file gave no hint to a person skilled in the art to repeat the step of forming the oxide film and the step of removing the oxide film several times, as now claimed. D2 disclosed an alternative method of removing defects in the upper surface of the SOI layer, but did not teach the claimed repetition of steps.

According to auxiliary request 1, the oxidation treatment for forming the oxide film was performed using a wet heat treatment, which enabled a large amount of the SOI layer to be removed. Oxidation using the wet heat treatment could be performed under a low temperature and for a short time, and was not disclosed in D1 and D2.

The arguments for inventive step for auxiliary request 2 were essentially a combination of the arguments for the main request and auxiliary request 1.

Reasons for the Decision

1. The appeal is admissible.

2. *Main Request: Article 84 EPC 1973 and Article 123(2) EPC*

In view of the amendments made and arguments submitted at oral proceedings, the Board is satisfied that claim 1 of the main request meets the requirements of the above provisions.

3. *Main Request: Inventive step*

3.1 Document D1 is the closest prior art for the subject-matter of claim 1 of the main request. The Examining Division found that claim 1 as then on file differed from D1 only in the feature "implanting oxygen ions ... under a condition of dose within a range of 5.0E16 to 3.0E17 atoms/cm2". In document D1 the implantation dose is 4.0E17 atoms/cm2, and the Examining Division concluded that this difference did not involve an inventive step.

In the communication under Article 15(1) RPBA, the Board noted that it saw no reason to disagree with the conclusion of the Examining Division, and that, in the statement of grounds of appeal, the appellant had not provided any reasons why this conclusion was wrong beyond stating that "arguments already submitted in the examination procedure" were "fully maintained".

Since no arguments were submitted, either in the subsequent letter dated 4 May 2018 or at oral proceedings, that the claimed implantation dose was inventive, the Board sees no reason to change its view on this matter.

3.2 Another difference over D1 arises from the features:

"forming an oxide film (15) of a predetermined thickness on the exposed surface of the oxygen ion implanted layer (13) by oxidation treatment of the laminated wafer (10); and
removing the oxide film (15) together with the oxygen ion implanted layer (13) to expose an SOI layer (16) having a reduced thickness".

The corresponding feature in D1 (page 2 of the translation, final three lines) is:

"Finally, the oxygen ion implanted layer 12 is completely transformed into oxide ... in dry etching, wet etching or oxidizing atmosphere and then removed by etching to obtain a substrate".

3.3 In the oral proceedings the appellant accepted that Fig. 1(H) was a simplified and schematic representation of a more complex process, which would result not only in the creation of oxide film 15, but also in at least partial oxidation of the remainder of layer 13 and a region of the surface of SOI layer 16. Subsequent treatment (e.g. HF etching) would remove the oxide film, the remaining oxygen ion implanted layer and the oxidised top surface of the SOI layer, thereby providing the "SOI layer (16) having a reduced thickness".

3.4 This analysis appears plausible, and the Board sees no reason to question it. However, on the basis of this understanding, it is, in the opinion of the Board, implicit that the process in D1 by which "the oxygen ion implanted layer 12 is completely transformed into oxide" would also result in some oxidisation of the upper surface of the SOI layer 13, such that the subsequent removal of the oxide portions would also result in an SOI layer "having a reduced thickness", as defined in claim 1 of the main request.

3.5 Hence, the only difference is that, prior to its removal, the oxygen ion implanted layer of the present invention is (according to the appellant) partially oxidised, whereas in D1 it is "completely transformed into oxide". The Board sees no reason to consider this

difference inventive, nor was this argued by the appellant in the appeal procedure.

3.6 The remaining distinguishing feature of claim 1, which has been the focus of essentially all of the appellant's arguments on inventive step in relation to the main request, is the following:

"repeating steps of forming an oxide film by oxidation treatment and removing the oxide film several times to further reduce a thickness of the SOI layer (16)."

3.7 As noted above, D1 discloses forming an oxide film by oxidation treatment and removing the oxide film, which, for the reasons given above under point 3.4, the Board considers would reduce the thickness of the SOI layer.

D1 does not, however, disclose the subsequent repetition of such steps "several times".

3.8 It was argued by the appellant that the principal technical effect of forming and removing the oxide film *for the first time* (as shown in Fig. 1, steps H and I) was to remove damage to the surface of the SOI layer caused by prior manufacturing steps (polishing), whereas the principal technical effect of *repeating* the steps of forming and removing the oxide film several times was to further reduce the thickness of the SOI layer, as stated in the final feature of the claim.

3.9 The problem may therefore be seen as further reducing the thickness of the SOI layer, while not detracting from its smoothness and uniform thickness (see page 13, second paragraph).

3.10 The distinguishing feature in question concerns the modification of an already existing SOI wafer structure, and hence the starting point for evaluating inventive step is the SOI wafer structure of Fig. 1(f) in D1. The question before the Board is whether it would be obvious to the skilled person, in the light of the prior art, to solve the problem of further reducing the thickness of an SOI layer by repeatedly forming and removing an oxide film.

3.11 Document D2 discloses a manufacturing method which results in the SOI wafer shown in step (7) of Fig 1. A method for further processing this SOI wafer is shown in Fig. 4 and described on page "17 of 33" of the English translation of D2 (lines 21-33). According to this method, "a sacrificial oxidation treatment is performed to thermally oxidize the outermost layer portion of the SOI layer 15 after the thickness decreasing step and then etch away the formed thermal oxide film 15s with hydrofluoric acid or the like".

This further processing may be performed either to remove a damaged layer 15a or "for the purpose of finely adjusting the final thickness of the SOI layer 15."

Hence, document D2 teaches the skilled person a method for adjusting (i.e. reducing) the final thickness of an SOI layer by forming an oxide film and removing the oxide film.

3.12 The Board accepts that D2 does not teach explicitly that this step may be repeated several times. However, according to D2, the sacrificial thermal oxide film 15s is "very thin", in particular "about 5 nm or more and 100 nm or less", so that "the influence of formation/

removal of the thermal oxide film 15s on the film thickness distribution of the SOI layer 15 can be small."

The skilled person therefore learns that in reducing the final thickness of an SOI layer by forming and removing an oxide film, the thickness of the sacrificial oxide film to be removed should be less than 100 nm, otherwise the process may have a detrimental effect on the film thickness distribution (i.e. smoothness and uniformity) of the SOI layer.

This would, in the opinion of the Board, immediately suggest to the skilled person that, where it is desired to reduce the thickness of the SOI layer by more than 100 nm, this reduction should be carried out in two or more stages, whereby the thickness of the SOI layer is reduced by no more than 100 nm at each stage.

3.13 In this way the skilled person would be led, in an obvious manner, to the claimed feature mentioned above to solve the posed problem.

3.14 For completeness, the Board is of the opinion that the problem solved by the final feature of claim 1 could alternatively be posed as further reducing defects in the SOI layer.

3.15 Contrary to the view of the appellant (see point 3.8, above), the Board does not believe that it is plausible to draw a rigid distinction between the technical effects of the first formation and removal of an oxide film and those of subsequent repetitions. It seems to the Board inevitable that cases would exist where the first cycle of forming and removing an oxide film would not be sufficient to remove all of the deformations

(for example, where the deformations were large and/or the amount of the SOI surface removed was small).

D2 teaches that such damage may be removed by forming and removing a very thin oxide layer on the outermost layer portion of the SOI layer. If the removal of this very thin layer proved insufficient to remove all the damage, it would be obvious to repeat the steps until the damage was eliminated.

3.16 The distinguishing features of the claimed subject-matter are therefore considered to be obvious in the light of the prior art, and the subject-matter of claim 1 of the main request does not, therefore, involve an inventive step within the meaning of Article 52(1) EPC and Article 56 EPC 1973. In view of this conclusion, it is unnecessary for the Board to examine independent claim 2.

4. *Auxiliary requests 1 and 2*

4.1 The appellant argued that, even if the Board took the view that the subject-matter of claim 1 of the main request was not inventive, the added feature of forming the oxide film on the exposed surface of the oxygen ion implanted layer "by oxidation treatment using a wet heat treatment of the laminated wafer (10)" was sufficient by itself (auxiliary request 1) or at least in combination with the repetition of the steps of forming and removing the oxide film (auxiliary request 2) to render the claimed subject-matter inventive.

4.2 According to Article 13(1) RPBA:

"Any amendment to a party's case after it has filed its grounds of appeal or reply may be admitted and

considered at the Board's discretion. The discretion shall be exercised in view of inter alia the complexity of the new subject matter submitted, the current state of the proceedings and the need for procedural economy."

4.3 Auxiliary requests 1 and 2 were filed with the appellant's letter dated 4 May 2018, approximately one month before the oral proceedings. The newly-added feature of forming the oxide film by a wet heat treatment was not present in any of the claims submitted with the statement of grounds of appeal, and hence auxiliary requests 1 and 2 constitute amendments to the appellant's case after it has filed its grounds of appeal within the meaning of Article 13(1) RPBA. As such, they may be admitted and considered only at the Board's discretion.

4.4 Forming the oxide film by a wet heat treatment was also not present in any of the originally filed claims, nor was it present in any version of the claims submitted for consideration by the Examining Division. Consequently, it cannot be assumed that this feature was covered by the search report or that it was the subject of an additional search during examination.

4.5 Even if the appellant's arguments regarding the auxiliary requests were considered plausible, the Board would still not be in a position to order the grant of a patent, since there is no guarantee that there has ever been an attempt to identify the most suitable prior art for this feature. Hence, the case would have to be remitted to the department of first instance pursuant to Article 111(1) EPC 1973 for further prosecution, possibly including an additional search,

which would not be in keeping with the need for procedural economy stipulated in Article 13(1) RPBA.

4.6 Auxiliary requests 1 and 2 are therefore not admitted into the proceedings pursuant to Article 13(1) RPBA.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated