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D E C I S I O N
of 30 October 2001

Case Number: T 0078/98 - 3.4.3

Application Number: 93101422.9

Publication Number: 0553861

IPC: H01L 21/306

Language of the proceedings: EN

Title of invention:
Semiconductor wafer with low surface roughness and semiconductor device

Applicant:
CANON KABUSHIKI KAISHA

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 108, 84, 56, 54

Keyword:
"Inventive step - auxiliary request (yes)"
"Amendment- main request (not allowable)"

Decisions cited:
-

Catchword:
-

Case Number: T 0078/98 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 30 October 2001

Appellant: CANON KABUSHIKI KAISHA
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 12 August 1997 refusing European patent application No. 93 101 422.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
J. H. Van Moer

Summary of Facts and Submissions

I. European patent application No. 93 101 422.9 was refused in a decision of the examining division dated 12 August 1997. The ground for the refusal was that no text existed that was agreed to by the applicant, contrary to Article 113(2) EPC, since the examining division did not give consent under Rule 86(3) EPC to the amended claims filed with the letter dated 10 June 1997.

The reason for denying the consent to the amendments was that the amended claims did not meet the requirements of Rule 86(4) and Article 84 EPC for the following reasons:

(a) Claim 1 filed with the letter dated 10 June 1997 contains in addition to all the features of claim 1 as filed, a further step of hydrogenation treatment which constitutes unsearched subject matter. Since the subject matter of claim 1 as filed does not involve an inventive step having regard to the prior art document

D1: 1991 Symposium on VLSI Technology, IEEE Cat. no. 91 CH 3017-1, 28 March 1991, Oiso JP, pages 45 to 46,

and the additional features of claim 2 as filed are not interrelated with those of claim 1 as amended, the subject matter of claim 1 as amended does not combine with the originally claimed invention to form a single general inventive concept, contrary to the requirements of Rule 86(4) EPC.

(b) Claim 1 as amended shows the same deficiencies under Article 84 EPC which were previously raised against claim 1 as filed: A product was defined in terms of a process to be used to fabricate it, thereby rendering the category of the claim unclear.

II. The appellant (applicant) lodged an appeal on 10 October 1997, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 17 December 1997 together with amended claims.

III. At the oral proceedings held on 30 October 2001, the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of one of the following requests:

Main request:

Claims: claim 1 according to the main request filed during the oral proceedings, claims 2 to 4 filed during the oral proceedings;

Description: pages 2 to 9 filed during the oral proceedings;

Drawings: Figures 1 to 5 filed during the oral proceedings;

Auxiliary request:

Claims: claim 1 according to the auxiliary request filed during the oral proceedings, claims 2 to 4 as for the main request;

Description and **Drawings** as for the main request.

IV. Claim 1 according to the appellant's main request reads as follows:

"1. A method of preparing a semiconductor member comprising a monocrystalline silicon layer (13) on an insulating layer (12), comprising the steps:

forming a porous silicon layer (15) on a surface of a monocrystalline silicon substrate (14);

flattening a surface of the porous silicon layer; and forming a monocrystalline silicon layer (13) on the flattened surface of the porous silicon layer by epitaxial growth,

bonding a second silicon substrate (11) provided on its surface with an insulating layer (12) to the surface of the monocrystalline silicon layer (13) so as to contact the latter with the surface of said silicon oxide layer, removing the monocrystalline silicon substrate (14), and removing the porous silicon layer (15) by selective etching,

wherein the surface of the thus obtained monocrystalline silicon layer (13) is a surface having characteristics of a center line average surface roughness Ra of not more than 0.4 nm after washing with an aqueous ammonia-hydrogen peroxide solution (APM) in a composition ratio of $NH_4OH:H_2O_2:H_2O$ of 1:1:5 by volume at 85°C for 10 minutes."

V. Claim 1 according to the auxiliary request differs from that of the main request in that the step "flattening a surface of the porous silicon layer;" is replaced by:

"forming oxide layers inside pores and on a surface of the porous silicon layer and remove the oxide film formed on the surface of the porous silicon layer, and flattening the surface of the porous silicon layer by heat treatment under a hydrogen atmosphere;".

VI. The appellant presented essentially the following arguments in support of his requests:

(a) The present invention relates to providing a silicon on insulator (SOI) structure having a monocrystalline silicon which retains a low surface roughness even after washing the semiconductor member in a conventional aqueous ammonia-hydrogen peroxide solution conventionally known as "RCA wash". The appellant has discovered that a monocrystalline silicon layer grown on a flattened, porous silicon layer has superior crystalline properties which, after bonding to an insulating layer, will result in a silicon layer having a very small surface roughness when washed with the conventional RCA wash.

(b) In the decision under appeal, and throughout the examining procedure, the examining division erroneously concluded that the decisive features for attaining the low surface roughness were the parameters of the washing step. On the contrary, the washing step recited in claim 1 merely constitutes a manner of defining the surface quality of the semiconductor layer, and therefore

the washing step as such has no significance in assessing novelty or inventive step.

(c) The claimed method is not obvious having regard to the prior art, since none of the prior art methods suggests the growth of a monocrystalline silicon layer on a flattened porous silicon layer in order to improve the surface quality. Instead, document D1 suggests changing the composition of the washing solution in order that the surface roughness does not increase.

Reasons for the Decision

1. *Admissibility*

The statement of the grounds of appeal does not explicitly challenge the ground for refusing the application in suit, but instead contains arguments that the examining division based their findings on an incorrect evaluation of the application in suit (cf. items VI(a) and (b) above). Thus, the statement of the grounds of appeal contains arguments challenging the reasoning in the decision regarding lack of clarity and lack of inventive step which formed the basis for not admitting the last set of claims under Rule 86(3) EPC. Therefore, the reasoning in the statement of the grounds of appeal can be construed as challenging the decision on the question of admissibility under Rule 86(3) EPC. The statement of the grounds of appeal therefore complies with Article 108, third sentence EPC.

2. *Amendments*

2.1 Main request

Claim 1 according to the main request contains the step of "flattening a surface of the porous silicon layer" which was not claimed in the application as filed but only disclosed in conjunction with Figures 3A to 3F. According to the description of the embodiment described with reference to Figures 3A to 3F, however, the porous layer is flattened by a heat treatment under a hydrogen atmosphere after the pores of the porous layer are subjected to oxidation, and oxide on the surface of the porous layer is removed (cf. page 16, lines 6 to 17).

Thus, there is no general disclosure in the application as filed which would provide a basis for the step of flattening the surface of the porous silicon layer without any reference to the preceding process steps of oxidizing the pores of the porous silicon layer and the removal of the oxide on the surface of the porous silicon layer. It is also not evident that the step of flattening of the surface without the preceding steps of oxidation and removal of oxide would provide the required high quality surface. Moreover, there is also no evidence that alternative methods for flattening the porous layer exist which would immediately be taken into consideration by the skilled person as suitable substitutes for the method disclosed in the application as filed. On the contrary, the above-mentioned process of flattening the surface of the porous layer is described in the application as filed as being the crucial factor for obtaining the desired high quality of the surface of the epitaxial layer (cf. page 17, lines 17 to 19).

Therefore, claim 1 according to the main request contains subject matter which extends beyond that of the application as filed, contrary to the requirements of Article 123(2) EPC.

2.2 Auxiliary request

2.2.1 Claim 1 according to the auxiliary request specifies that the step of flattening the surface of the porous silicon layer is carried out by heat treatment under a hydrogen atmosphere after forming oxide layers inside the pores of the porous layer and removing an oxide layer on the surface of the porous layer. Thus, the objection raised against claim 1 according to the main request is overcome by claim 1 of the auxiliary request.

2.2.2 Claim 2 is based on claim 2 as filed. Claims 3 and 4 are based on page 24, line 1 to page 25, line 26 and page 1, lines 5 to 10, respectively, of the application as filed.

2.2.3 Therefore, in the Board's judgement, the claims according to the auxiliary request meet the requirements of Article 123(2) EPC.

3. *Clarity - auxiliary request*

The Board is of the opinion that the claims according to the auxiliary request meet the requirements of Article 84 EPC. The objections raised in the examination proceedings and referred to in the decision under appeal were based on the fact that the independent claims were directed to a device but contained method steps in terms of a washing treatment

of the claimed device. Since the claims according to the auxiliary request are directed to a method of preparing a semiconductor member, these objections are now overcome.

4. *Novelty and inventive step - auxiliary request*

4.1 The present invention relates to silicon on insulator (SOI) structures used for substrates of integrated circuits. The technical problem addressed by the application in suit relates to maintaining a small surface roughness after the semiconductor member has been subjected to the various washing treatments which are required in any process of producing integrated circuits. The method as claimed produces an SOI semiconductor member having a monocrystalline silicon layer with improved surface flatness and crystallinity compared to those produced by conventional methods. The improved crystallinity and surface roughness have the effect of making the silicon surface less prone to damage when washed in conventional washing solutions of aqueous ammonia hydrogen peroxide ($NH_4OH:N_2O_2:H_2O$).

4.2 Document D1 is considered to be the closest prior art, since it concerns the effect on the surface roughness of silicon wafers after washing the wafers in aqueous ammonia hydrogen peroxide solutions, i.e. the same problem as addressed in the application in suit. The surface roughness of the wafers which were subjected to the same washing treatment as defined in claim 1 are in the range from about 0.25 nm to about 0.85 nm (cf. page 45 "Experimental", Figure 1), i.e. a range overlapping with that of claim 1. Document D1 however does not disclose any silicon on insulator structures, let alone those produced by growing a monocrystalline

silicon layer on a flattened silicon porous layer.

Therefore, the subject matter of claim 1 is new within the meaning of Article 54 EPC.

4.3 The subject matter of claim 1 according to the auxiliary request involves an inventive step within the meaning of Article 56 EPC, since none of the cited prior art documents discloses the steps of growing a monocrystalline silicon layer on a flattened silicon porous layer in order to improve the surface properties of a silicon on insulator structure.

4.4 Therefore, in the Board's judgement, claims 1 to 4 according to the auxiliary request meet the requirements of Article 52(1) EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of the first instance with the order to grant the patent with the following documents:

   - claims 1 to 4 according to the auxiliary request submitted at the oral proceedings;

   - description and figures submitted at the oral proceedings.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla