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D E C I S I O N
of 3 December 1994

Case Number: T 0846/91 - 3.4.1

Application Number: 85402574.9

Publication Number: 0187596

IPC: H01L 27/10

Language of the proceedings: EN

Title of invention:
Semiconductor memory device and method for producing the same

Applicant:
FUJITSU LIMITED

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes, after amendment)"

Decisions cited:
-

Catchword:

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 846/91

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 3 December 1994

Appellant: FUJITSU LIMITED
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Decision under appeal: **Decision of the Examining Division 048 of the European Patent Office dated 17 May 1991 refusing European patent application No. 85 402 574.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G.D Paterson
Members: Y. van Henden
R. Shukla

Summary of Facts and Submissions

I. European patent application No. 85 402 574.9 (publication No. 187 596) was refused by decision of the Examining Division.

II. The reason given for the refusal was that, having regard to the state of the art which can be derived from documents:

D1: GB-A-2 138 207, and
D2: Patent Abstracts of Japan, vol 8, No. 167 (E-258) (1604), 2 August 1984 and JP-A-59 63757,

a person skilled in the art of making dynamic random access memories (DRAM) with trench capacitors would not have to display inventiveness to arrive at the subject-matter of independent Claims 1 and 3 filed on 20 February 1991.

III. The Applicant lodged an appeal against the decision of the Examining Division and submitted new claims annexed to its Statement of Grounds of appeal, Claim 1 being directed to a semiconductor memory device and Claim 3 being an independent claim relating to a method for making such a memory device.

IV. In a communication issued on 3 December 1992 in pursuance of Article 110(2) EPC, the Board explained that, having regard to the teachings of (D1) and (D2), the new Claim 1 lacked an inventive step. Nevertheless, the Board took the view that, under the proviso of suitable amendments to Claim 3, protection might be granted for a method of making a semiconductor memory device. The Board also took the view that document (D2) is the most relevant prior art for the purpose of assessing both novelty and inventive step.

V. Following further communications from the Board, the Appellant filed on 12 September 1994 a new Claim 1 which reads as follows:

"A method for producing a semiconductor memory device, comprising the steps of:

selectively forming, on the surface of a semiconductor substrate (1), a field oxide layer (10) having an edge portion in the form of a bird's beak;

etching simultaneously the edge portion of the field oxide layer and the semiconductor substrate to remove the bird's beak and to form a trench (46) having some of its side walls almost perpendicular to the surface of the substrate;

forming an insulating layer (7) in the trench (46); and

forming, in the trench, a capacitor including a conductive layer (8) formed on the insulating layer (7), a dielectric layer (9) formed on the conductive layer (8) and an electrode (11) formed on the dielectric layer (9),

characterized in that the etching is performed at substantially the same etching rate through said field oxide layer and said semiconductor substrate to form under the region of bird's beak a side wall of the trench (46) which is almost perpendicular to the surface of the substrate."

To this claim is appended Claim 2.

VI. With a letter dated 27 October 1994, the Appellant requested that a European patent be granted on the basis of the following documents:

description: page 1, as originally filed;
pages 2, 2a and 4 to 9 as filed on 14 June 1993;

page 3 corresponding to the "second subsidiary request" filed on 9 June 1994;

claims: Claims 1 and 2 filed on 12 September 1994;

drawings: sheets 1/8 to 6/8 and 8/8 as originally filed;
sheet 7/8 (no. corrected) filed on 9 June 1994.

Reasons for the Decision

1. The Board is satisfied that the application has not been amended in such a way that it contains subject-matter which extends beyond the content of the application as filed - Article 123(2) EPC. The Board is furthermore satisfied that the claims are clear, concise and that they define the invention for which protection is sought - Article 84 EPC.

Finally, the application in suit discloses etching techniques and the etchant gases by means of which silicon and silicon dioxide are etched at substantially the same rate - see page 7 of the application as filed, lines 32 to 37. The Board, therefore, is also satisfied that said application discloses the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

2. *State of the art*

2.1 In the wording of Claim 1, document (D1) discloses a method for producing a semiconductor memory device - see page 4, lines 30 to 33 -, comprising the steps of

- selectively forming a field oxide layer (2) on the surface of a semiconductor substrate (1) - see page 4, lines 37 to 49;

- forming a trench (6) with side walls almost perpendicular to the surface of the substrate (1) - see Figure 5b and page 4, lines 75 to 89;

- forming an insulating layer (3) on the surface of the trench (6) - see Figure 6b and page 4, lines 94 to 102 - and

- forming, in the trench, a capacitor including a conductive layer (9) formed on the insulating layer (3) - see Figure 7b and page 4, lines 111 to 118 -, a dielectric layer (11) formed on the conductive layer (9) - see from page 4, line 124, to page 5, line 17 - and an electrode (12) formed on the dielectric layer (11) - see Figure 8 and page 5, lines 17 to 21.

In a semiconductor memory device manufactured according to the method disclosed in (D1), the field oxide layer (2) is formed between the adjacent memory cells and the trenches (6) are not formed by removing any portion of the field oxide - see: Figure 5b; page 3, lines 20 to 23; page 4, lines 78 to 83.

2.2 Document (D2) discloses a method of producing a trench capacitor in the silicon substrate of a semiconductor memory device, which method comprises the step of forming a trench (24) by simultaneously etching a bird's beak portion (21) of a Si02 field oxide layer (20) and an adjacent portion of the substrate. As can be seen on Figure 8, the sidewall (25) of the trench (24) located on the same side as the field oxide layer (20) is not vertical and, furthermore, ends directly below the

extremity of the bird's beak (21). Besides, no capacitor including a conductive layer formed on an insulating layer coating the walls and bottom of the trench (24), a dielectric layer formed on said conductive layer and an electrode formed on the dielectric layer is provided.

2.3 The task which the application in suit sets out to meet is that of increasing the degree of integration in a dynamic random access memory such as disclosed in document (D2). Starting from this device and bearing in mind that the width of the trench's bottom may not be reduced at will if a capacitor has to be formed in the trench, this purpose can only be achieved through a reduction of the trench's width at the surface of the substrate, what in turn requires that both sidewalls of the trench be almost vertical. Starting now from the prior art disclosed in (D1), the same purpose can be achieved by reducing the thickness of the substrate's portion separating adjacent memory cells, whereby a beak portion of the field oxide layer will have to be removed, thus leading to the same problem of providing an almost vertical sidewall on the beak's side. For this reason, as well as those explained in Section 2.2 of the present decision, the Board does not hold the prior art known from (D1) to come as close to the invention as does the prior art disclosed in (D2). Furthermore, since the removal of an edge portion of the field oxide layer (10) and the equality of etching rates through said layer and through the substrate (1) features the etching process to be carried out in order to form the trench(46), the Board does not raise objections against Claim 1 on the basis of Rule 29(1) EPC.

3. *Inventive Step*

While carrying out the method known from document (D2), the formation of a sidewall (25) which is not vertical obviously results from the fact that the etching rate of the material forming the beak, i.e. silicon dioxide, is less than that of silicon. Thereby, the width of the opening through which the silicon of the substrate is exposed to the action of the etchant increases progressively as the trench becomes deeper, whereas the width of the trench's bottom remains equal to the initial width of said opening.

With consideration to Figure 8 of document (D2), it is clear that the trench wall (25) will come the nearer to the vertical as the etching rate of silicon becomes higher with respect to that of silicon dioxide. Contrary thereto, however, the patent application in suit teaches to reduce to unity the ratio of the respective etching rates of silicon and silicon dioxide. Furthermore, whereas document (D2) leads the skilled person away from a complete removal of the field oxide layer edge portion, as evidenced by the existence of a "bird beak residual section (202)", such removal is necessarily achieved when carrying out the method of Claim 1. Finally, as mentioned earlier, document (D1) is not concerned with providing a trench underneath a bird's beak portion of a field oxide.

Therefore, in the Board's view, the prior art methods according to documents (D1) and (D2) taken individually or in combination would not lead a skilled person to the method as claimed without the benefit of hindsight.

In the Board's judgment, therefore, Claim 1 involves an inventive step.

4. Claim 1 is allowable and, with it, Claim 2 since it is a dependent claim and, therefore, covers a particular embodiment of the invention defined by Claim 1.

Order

For these reasons it is decided that:

1. The decision of the Examining Division is set aside.

2. The case is remitted to the first instance with the mission to grant a European patent on the basis of the file documents recited in Section VI above.

The Registrar: The Chairman:

M. Beer G.D Paterson