BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

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File Number: T 301/90 - 3.4.1

Application No.: 80 304 232.4

Publication No.: 0 030 116

Title of invention: Method of manufacturing a semiconductor device having a patterned multi-layer structure

Classification: H01L 21790

D E C I S I O N
of 23 July 1990

Proprietor of the patent: FUJITSU LIMITED

Opponent (01): Deutsche ITT Industries GmbH, Freiburg
(02): Telefunken electronic GmbH
(03): Siemens Akteigesellschaft

Headword:

EPC

Keyword: Inventive step (yes)
Non-obvious use of a known effect of a known measure for a new technical purpose

Headnote

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number : T 301/90 - 3.4.1 EP- 80304 232.4

D E C I S I O N
of 30 September 1991
correcting errors in the decision
of the Technical Board of Appeal 3.4.1
of 23 July 1991

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Decision under appeal :	**Interlocutory decision of the Opposition Division of the European Patent Office dated 26 March 1990 conerning maintenance of European patent No. 0 030 116 in amended form.**

Composition of the Board :

Chairman : G.D. Paterson
Members : H.J. Reich
U.G. Himmler

Summary of Facts and Submissions

I. The Respondent is owner of European patent No. 0 030 116.

II. The patent was separately opposed by the Appellants "Deutsche ITT Industries GmbH", "TELEFUNKEN electronic GmbH" and "Siemens AG" on the ground that its subject-matter did not involve an inventive step in view of the prior art disclosed in a series of documents, among which, inter alia, were documents:

D1 : "Electronics", 31 August 1978, pages 117-121, (former DI-4 and DS-8);
D2 : "IBM Technical Disclosure Bulletin", Vol. 20, No. 4, September 1977, page 1388 (former DT-1);
D3 : Patent Abstracts of Japan of JP-A-52-40 978 (former DS-2);
D4 : DE-A-2 727 788 (former DI-3);
D5 : "Extended Abstracts of the Journal of the Electrochemical Society", October 1978, Abstract No. 193, pages 515-517 (former DI-8);
D6 : DE-A-2 632 093 (former DT-6 and DS-3);
D7 : "IBM Technical Disclosure Bulletin", Vol. 19, No. 9, February 1977, pages 3415 and 3416 (former DI-2); and
D8 : DE-A-2 340 442 (former DI-11).

III. By an interlocutory decision within the meaning of Article 106(3) EPC dated 26 March 1990 the Opposition Division decided on the amended form in which the European patent could be maintained as requested by the Respondent.

The set of claims on which the decision was based comprises 12 claims, of which Claim 1, the sole independent claim, reads as follows:

"1. A method of manufacturing a semiconductor device having a multi-layer structure, in which a first layer is formed to a predetermined pattern over a second layer, which second layer is to be etched and is formed above a semiconductor substrate of the device, and the second layer is etched through using the first layer as a mask, characterised in that the second layer is etched part way through by isotropic etching, and then the remainder of the second layer is etched through by anisotropic etching in the direction of thickness of the second layer, using the first layer as a mask, to form an opening therethrough, the first layer is then removed and a third layer is formed on the second layer."

IV. All three Appellants independently lodged an appeal against the interlocutory decision.

V. Oral proceedings were held, at the end of which the three Appellants requested that the decision under appeal be set aside and that the European patent No. 0 030 116 be revoked.

The Respondent requested that the appeal be dismissed and that the patent be maintained on the basis of the documents mentioned in the interlocutory decision within the meaning of Article 106(3) EPC, dated 26 March 1990.

VI. In support of their requests, the three Appellants jointly submitted that Claim 1 would not be allowable under Article 56 EPC in view of the prior art disclosed in document D1 and a skilled person's general knowledge as evidenced by document D2, essentially for the following reasons:

(a) The problem of the patent under appeal is to create an edge-free etch profile for fine patterns which are a true copy of their etch mask. In document D1, the Figure 2b teaches a skilled person that anisotropic etching results in fine patterns and Figure 2a shows that isotropic etching avoids edges.

(b) A person skilled in the semiconductor art would be able to derive from document D1 a hint to use the claimed sequence of an isotropic and a subsequent anisotropic etching step for the production of contact holes when interpreting the statement in document D1, page 121, right column, last sentence "... anisotropic plus isotropic ..." in the light of the complete content of this document, in particular in the light of the following explicit indications: The described processes are set to etch finer lines with less undercutting (the title); it allows to etch thin films anisotropically as well as isotropically with an improvement of the dimensional control leading to higher circuit densities (page 117, left column, paragraph 3); it is used to produce contact windows (Figure 3 and page 119, right column, paragraph 1); and it enables to produce both tapers and straight walls (page 121, right column, paragraph 3). Furthermore it would be self-evident to a skilled person to start with the isotropic etching and to apply the anisotropic etching as the second method step in view of the evident needs for no edges on the upper surface of a contact hole and a fine structure for the contacting area on its bottom.

(c) Document D1, Figure 5 and page 120, right column, paragraph 4, as well as document D2, lines 7-11, hint to a skilled person to use the same mask for two subsequent etching steps which each produce a

different etch profile. Moreover, a skilled person would have no doubt that an isotropic etching step followed by an anisotropic one can be realised in practice. Figure 2a of document D1 shows that during an isotropic etching step the mask surface is not attacked.

(d) The claimed two etching steps, via the tapered form of the isotropic etch profile, transfer the sharp edge of the anisotropic etch profile from the upper surface of the contact hole deeper into the insulating material but produce no smooth-off effect on the edge as for instance the final isotropic etch step without mask in document D3. This results in a reduction of the depth of the contact hole part with vertical walls. A person skilled in the semiconductor art would know that the contact layer thickness and the contact hole depth have to be matched in order to avoid a thinning of the deposited contact layer part next to the horizontal hole walls causing breaks. Hence, a skilled person would be able to foresee the advantages produced by the measures claimed in Claim 1 of the patent under appeal.

(e) The further method steps claimed in Claim 1, i.e. a replacement of the first layer (mask) by a third layer (contact layer) are self-evident and obvious in view of documents D2 and D3.

VII. The above submissions were contested by the Respondent, who argued essentially as follows:

(a) Document D1 - in particular on page 118, left column, paragraph 5 to right column, paragraph 2, and with regard to Figures 2a and 2b - discusses generally the virtues of anisotropic etching due to directional bombardment in reproducing faithfully the dimensions

of a mask for the manufacture of highly resolved patterns. Document D1 is silent about the problem underlying the patent under appeal, i.e. how to avoid the sharp edge on the upper end of such an anisotropically etched opening.

(b) Document D1, page 121, right column, paragraphs 3 and 4, expresses pure speculations about possible future abilities of plasma assisted etching. All practically realised contact holes described in this document -see Figure 3 and page 121, left column, paragraph 2 -have been produced by anisotropic etching alone. Figure 5 of document D1 represents a laboratory measure for demonstrating the individual properties of isotropic and anisotropic etching within the same opening and thus would provide no help with regard to a manufacturing method in a production line. Document D1 would thus give no hint to combine isotropic and anisotropic etch techniques in the production of one and the same opening, and does not teach that such a measure solves said edge problem. Any combination of the etch profiles in Figures 2a and 2b of document D1 would, therefore, be wishful thinking leaving open why a skilled person should do so.

(c) Moreover, in the documents cited by the Appellants, all prior art solutions of the known sharp edge problem in anisotropic etching point away from the one claimed in Claim 1 of the patent under appeal:

In documents D2, D4 and D5 the anisotropic etching simultaneously varies the mask opening (resist erosion). The resulting continuous form changes of the mask are immediately transferred to the etched opening causing thus its tapered profile. In documents D2 and D3 the upper edge of the taper is additionally rounded

off in a further etching step without mask. Document D6 realises a partly tapered, partly vertical, etch profile in an anisotropic etching process by using variable delaying means (etching a pattern of variable size into a thermal protection layer on the rear side of the substrate) for the temperature rise in the etch mask, i.e. by retardation of the resist erosion.

In the method of document D7 first a mask with a tapered opening is produced and subsequently the taper is transferred by an anisotropic etching to the etched opening.

Document D8 achieves a taper by etching a heterogenous multi-layer structure wherein each deeper lying layer is more etch-resistent than the neighbouring upper one.

The above solutions of the edge problem would be efficient and therefore discourage a skilled person to look for a further one.

Reasons for the Decision

1. There is no formal objection under Articles 123(2) or (3) EPC to the current version of the claims, description and drawings.

2. The Board agrees with the finding of the Opposition Division that Claim 1 is novel over the prior art derivable from the adduced evidence. None of the cited documents describes a method of manufacturing a semiconductor device, wherein a second layer under the patterned first mask layer is first isotropically etched only part way

through and then the remainder, using the same mask, is etched through anisotropically.

3. Inventive Step

3.1 The Appellants concede implicitly that Claim 1 is novel; see paragraph VI above. The only substantive issue raised in this appeal is whether a first partial isotropic etching step (creating a top position with a tapered edge profile) followed by an anisotropic etching step for the remaining layer part (creating a lower portion with a vertical edge profile) would be obvious to a skilled person.

3.2 The Board agrees with the Appellants' view in paragraph VI-a above and regards the "plasma-assisted etching techniques" represented in document D1, in particular Figure 2b with the corresponding description, as the nearest prior art. Document D1 discloses thus in the wording of Claim 1:

"A method of manufacturing a semiconductor device having a multi-layer structure, in which a first layer ("mask" in Figure 2b) is formed to a predetermined pattern over a second layer ("film" in Figure 2b), which second layer is to be etched and is formed above a semiconductor substrate of the device, and the second layer is etched through using the first layer as a mask, characterised in that ... the second layer is etched through by anisotropic etching in the direction of the thickness of the second layer, using the first layer as a mask, to form an opening therethrough."

This method results in an overall vertical etch profile.

3.3 Starting from this nearest prior art as disclosed in document D1, the objective problem underlying the present

invention is to provide a method of forming minute and fine openings in the second layer without a sharp edge at the upper end of the opening in order to be able to admit a given thickness of the second layer (for an insulation without short-circuits) without the danger of breaks in an overlying relatively thin third layer (as a wiring; see the patent under appeal, page 4, lines 1 and 2 in combination with page 3, lines 16 to 26.

3.4 The solution of this problem is characterised according to Claim 1 in that:

"the second layer is etched part way through by isotropic etching, and then the remainder is etched through by anisotropic etching."

The further measures distinguishing the subject-matter of Claim 1 from the method of document D1:

that after formation of the opening "the first layer is removed and a third layer is formed on the second layer"

are a natural consequence of the intended use of the manufactured semiconductor device and do not contribute to the solution of the objective problem. They are, therefore, not to be considered in the evaluation of inventive step, see decision T 37/82, OJ EPO 1984, 71.

Hence, the issue of inventive step reduces to the question whether it would be obvious to replace a first part of an overall anisotropic etching process in the method described in document D1 by an isotropic one in order to avoid layer breaks caused by profile edges. All other facts and evidence submitted during the opposition procedure are less relevant.

3.5 The crucial text in document D1, page 121, right column, last sentence, on which the Appellants base their main argument of lack of inventive step in paragraph VI-b above, reads as follows:

"However, the ability of plasma assisted etching to produce anisotropic plus isotropic etch profiles should lead to the fabrication of device structures impossible with wet chemical etching."

In the Board's view, the mentioned "isotropic etch profile" defines the form of a taper and the "anisotropic" one represents a vertical wall form of the opening. It is, therefore, admitted that the text cited above clearly hints a skilled person at producing an etch profile for one and the same opening which profile starts on the surface to be etched with a taper and continues in a vertical side wall. The combination of these two structural elements is clearly proposed in document D1 and moreover known from document D6, Figure 5a in combination with page 1 to page 2, paragraph 2, to avoid edge-caused breaks in a metallisation layer. In the Board's view, it has to be stressed that the text cited above teaches to produce the combination of a tapered plus a vertical wall part of the opening exclusively by "plasma assisted etching", i.e. by one and the same etch mechanism. In the Board's view - contrary to the Appellants' opinion in paragraph VI-b - no deviating interpretation is possible within the frame of the technical disclosure of document D1 for the following reasons:

A "plasma-assisted etching" is clearly defined to be based - in addition to the production of volatile particles by a chemical process - on the physical phenomenon of sputtering by a directional bombardment of the etched surface with

accelerated ions (see D1, page 117, left column, last paragraph, and right column, paragraphs 1 and 4). Independent from the chemical or physical character of the ion-substrate interaction, the charged particles always have a trajectory perpendicular to the surface of the substrate (D1, page 118, right column, paragraph 2). The indication in document D1, page 121, right column, paragraph 3, i.e. that the production of "variable tapers as well as straight walls" may be possible "after a better understanding of the influence of the charged particle on the profile", in the Board's opinion, proposes a skilled person to develop plasma parameters which allow to diminish the quantitative influence of said perpendicular ion trajectories on the profile in order to make it deviate from its vertical form; see also document D1, page 117, Figure 1.

The profile represented in Figure 5 of document D1 is not only produced for a different purpose (demonstration) but also does not show a continuation of both etching mechanisms for producing an opening in one and the same layer.

There is no explicit or implicit hint in document D1 to completely dispense with perpendicular ion trajectories in the production of tapers and to produce a taper - alone or in combination with a vertical wall part - by an interaction between substrate and etchant particles (ions) which only show a nondirectional thermal Brownian movement, i.e. by an isotropic etch mechanism in the sense of Claim 1. Whenever in the text of document D1 the isotropically etched taper according to Figure 2a is mentioned, this is exclusively done in the light of a disadvantageous horizontal undercutting of an etch mask which enlarges the reproduction of the mask pattern on the substrate.

3.6 In order to avoid sharp-edge caused breaks in a metalisation layer within an anisotropically etched contact hole, the actual technical development according to the cited prior art documents went into directions differing technically from the present invention, despite the known physical effects of an isotropic etch mechanism. In documents D2, D4, D5, D6 and D7 the taper is caused by the geometrical form of the mask and its variation during the etch process with a throughout anisotropical character of the etch mechanism. Document D8 produces a tapered etch profile by decreasing the etchability of the material to be etched with increasing depth of the opening; see in detail chapter VII-c above.

3.7 In particular, in view of the fact that in the formation of minute and fine openings undercutting was always regarded as an undesirable side-effect and that the prior art stuck to an anisotropical etch mechanism and realised tapers in fine openings (contact holes) by maintaining the anisotropical effect of the etchant and by varying the properties of the mask or the material to be etched instead, the Board finds that a skilled person could not be expected to be able to transform the negative effect of undercutting into a positive manufacturing step for a taper-formation, which transfers said sharp edge nearer to the substrate surface. This new technical purpose, in the Board's view, has to be regarded as not obvious to a skilled person.

It is a generally accepted principle in the assessment of inventive step that whereas the use of a known measure to achieve a known result on the basis of the expected inherent effect of such measure is not normally inventive, nevertheless the indication of a new and non-obvious technical result, which can be achieved by these known

effects (whether chemical - see decision T 4/83, OJ EPO 1983, 493, point 7, or physical - see decision T 39/82, OJ EPO 1982, 419, point 7.2.3) may convert the use of this known measure into a new and non-obvious tool for the solution of a new technical problem, and may thus represent an enrichment of the art and imply an inventive step.

3.8 For the above reasons, the Board finds that the subject-matter of Claim 1 involves an inventive step within the meaning of Article 56 EPC.

4. Hence, it follows that amended Claim 1 is allowable. Dependent Claims 2 to 12 concern particular embodiments of the method according to Claim 1 and are, therefore, likewise allowable.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar The Chairman

M. Beer G.D. Paterson