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D E C I S I O N
of 4 September 1997

Case Number: T 0312/94 - 3.4.1

Application Number: 89201777.3

Publication Number: 0350997

IPC: H01L 21/306

Language of the proceedings: EN

Title of invention:
Reactive ion etching of a silicon-bearing material with hydrobromic acid

Applicant:
Philips Electronics N.V.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Interpretation of part of a document in the context of the remainder"
"A combination of zero values in a table not a realistic technical teaching in its context"
"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:
-

Catchword:
It is a general legal rule for the interpretation of any document, in particular a patent application or patent, in order to determine its true meaning and thus its content and disclosure, that no part of such a document should be construed in isolation from the remainder of the document: on the contrary, each part of such a document must be construed in the context of the contents of the document as a whole. Thus, even though a part of a document appears to have a particular meaning when interpreted literally and in isolation from the remainder of the document, the true meaning of that part of the document may be different having regard to the remainder of the document.

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0312/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 4 September 1997

Appellant: Philips Electronics N.V
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Decision under appeal: Decision of the Examining Division of the European Patent Office posted 17 January 1994 refusing European patent application No. 89 201 777.3 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: G. D. Paterson
Members: H. J. Reich
R. K. Shukla

Summary of Facts and Submissions

I. European patent application No. 89 201 777.3, including claims 1 to 15 as originally filed, was refused by a decision of the Examining Division.

II. The reason given for the refusal was that the subject-matter of original claim 1 is not novel with respect to the disclosure of document

D1: EP-A-0 272 143,

contrary to the requirements of Articles 52(1) and 54(1) and (2) EPC, and that the subject-matter of independent original claim 6 did not satisfy the requirements of Articles 52(1) and 56 EPC having regard to D1. The Examining Division took the view that the subject-matter of claim 1 is fully anticipated by D1, which in particular was considered to disclose the claimed step of:

"exposing said silicon-bearing layer to a hydrogen bromide plasma to selectively etch said silicon-bearing layer relative to photoresist and silicon oxide."

As to the lack of novelty of claim 1, the Examining Division considered that the definition of the invention given in claim 1 does not exclude that further gases beside hydrogen bromide may be present. On the other hand, document D1 does not prescribe the presence of any of silicon tetrafluoride, chlorine or oxygen, in addition to the main etching gas hydrogen bromide; this follows from the description at page 12, lines 1 to 17 and Table 4. In Table 4 gas flows of each of these gases are given in the range of 0 sccm up to a

respective maximum value, thereby envisaging the possible use of a gas with zero content for each of these gases, and thus only containing HBr.

As to the lack of inventive step in claim 6, which differs from the method disclosed in D1 in that it includes the further step of "removing any surface oxides from said polysilicon layer with an oxide etching plasma", it would readily occur to a skilled person that any initial oxide on polysilicon surfaces should be removed prior to the hydrogen bromide plasma etch in order to allow the etch of the polysilicon to proceed.

III. The applicant lodged an appeal against this decision, and filed with the statement of grounds of appeal an amended set of claims 1 to 3 to replace the original claims 1 to 15, wherein claim 1 comprised the subject-matter of original claims 1, 3 and 4 and claims 2 and 3 correspond to original claims 2 and 5 respectively. Original claims 6 to 15 were deleted. The applicant requested that the decision under appeal be set aside and that a patent be granted on the basis of said amended claims 1 to 3. Auxiliarily he requested oral proceedings.

The amended claim 1 reads as follows:

"1 A method of manufacturing semiconductor devices by selectively etching a layer of silicon-bearing material, comprising the steps of

providing a patterned photoresist mask over a layer of silicon-bearing material to expose only areas to be etched,

removing any surface oxides from said silicon-bearing layer with an oxide etching plasma and then

exposing said silicon-bearing layer to a plasma formed in an atmosphere of hydrogen bromide alone or

hydrogen bromide mixed with an inert gas such as helium, argon or nitrogen, to selectively etch said silicon-bearing layer relative to photoresist and silicon oxide."

This amended claim was intended to define the invention more clearly, by stating that the plasma is formed in an atmosphere of "hydrogen bromide alone", or "hydrogen bromide mixed with an inert gas".

Claims 2 and 3 are dependent on claim 1.

IV. In support of this request the applicant made essentially the following submissions:

(a) According to claim 1 of D1 the silicon body is exposed to a plasma which is formed "by communicating into said chamber a reactive gas **mixture** comprising...hydrogen bromide." Furthermore the skilled reader learns from D1, page 6, lines 25 to 26 that "one presently preferred gas chemistry composition which was used for etching silicon comprises HBr (hydrogen bromide), SiF_4 (silicon tetrafluoride), O_2 and He". Hence, a skilled person would conclude from the given ranges from 0 sccm up to a maximum value, that in some cases a small quantity of some gases would be satisfactory or that in some cases one of the reactive components would be superfluous. The supposition, that he would choose **a plasma formed in hydrogen bromide alone** for etching a silicon-bearing layer has to be considered as inadmissible hindsight.

(b) In the method of the present invention the plasma is formed in an atmosphere of hydrogen bromide alone or mixed with an inert gas, the only

chemically active constituent being hydrogen bromide. From the example in the original description page 6, lines 17 to 27 it is clear that with the present invention polysilicon can be etched with a selectivity to silicon oxide of 100:1 and a selectivity to photoresist of 60:1. Using the method of document D1 polysilicon can be etched with a selectivity to silicon oxide of more than 50:1 and with a selectivity to photoresist of only 4-8:1, see D1, page 13 lines 25 to 27. With regard to the selectivity of etching polysilicon to photoresist the inventive method is superior to the method of D1, wherein the additionally present reactive components obviously worsen the selectivity of etching to photoresist.

Reasons for the Decision

1. *Allowability of amendments*

The subject-matter of claim 1 of the above request is disclosed in original claims 1, 3 and 4. Claims 2 and 3 correspond to original claims 2 and 5. There is, therefore, no objection to such amended claims under Article 123(2) EPC. In the Board's view, the wording in the original claim 1: "exposing said silicon-bearing layer to a hydrogen bromide plasma" and the corresponding wording in the amended claim 1: "exposing said silicon-bearing layer to a plasma formed in an atmosphere of hydrogen bromide **alone**" both define the identical technical requirement; i.e. that the sole active gas is hydrogen bromide. This definition is consistent with the overall disclosure of the original application, which contains no suggestion to the effect that additional chemically reactive constituents may be

included in the plasma. A mixture of hydrogen bromide with one or more inert gases is clearly disclosed as an alternative; see page 4, lines 4 to 6.

Thus the amended claims clarify and emphasise an essential feature of the invention, that hydrogen bromide is the sole active ingredient of the plasma, which, as explained in the original description, provides the advantage of highly selective plasma etching of silicon.

2. *Novelty of amended claim 1*

2.1 Document D1 discloses in the wording of claim 1:

"A method for manufacturing semiconductor devices (see D1, page 2, lines 8 to 18) by selectively etching a layer of silicon-bearing material (D1, page 12, lines 35), comprising the steps of

(a) providing a patterned photoresist mask over a layer of silicon-bearing material (page 13, line 20) to expose only areas to be etched,

(b) removing any surface oxides from said silicon-bearing layer with an oxide etching plasma (page 6, lines 29, 30), and then

(c) exposing said silicon-bearing layer to a plasma...to selectively etch said silicon-bearing layer relative to photoresist and silicon oxide (page 13, lines 20 to 27)."

2.2 In relation to the question of novelty of claim 1, the crucial issue is whether or not D1 also discloses exposing said silicon-bearing layer to "a plasma formed in an atmosphere of hydrogen bromide alone or hydrogen bromide mixed with an inert gas such as helium, argon

or nitrogen ..."; that is, does D1 disclose the use of a plasma in which hydrogen bromide is the **only** active etchant gas?

The subject-matter of D1 is concerned with the provision of a silicon etch process for forming deep, narrow silicon trenches. The "Summary" of the invention at page 4, lines 11 to 26 explains that the invention involves the use of a plasma formed from a "reactive gas mixture", and this Summary corresponds to the definition of the invention in the two independent claims 1 and 5, both of which require the use of a "reactive gas mixture". The Summary explains that such mixtures are brominate - or iodinate - based. The description of the invention which follows the Summary consistently implies that a reactive gas mixture should always be used. For example, under the headings "Hydrogen bromide" and "Hydrogen iodide" on page 6 of D1, reference is made respectively to the "hydrogen bromide main etchant gas" and the "hydrogen iodide main etchant gas" (see page 6, lines 26 and 46), and reference is made to the advantages of using other reactive gases in the mixture (i.e. that SF_4 makes the reaction more volatile, O_2 controls the taper, and He dilutes and reduces black silicon - see page 6, lines 28 to 36).

The example of a "Total Gas Flow" in Table 4 of D1 at pages 12 and 13 discloses "HBr, sccm:10-75"; "SiF_4, sccm:0-10; Cl_2, sccm:0-15;" and "O_2, sccm:0-10". If read literally and in isolation, this example could be said to disclose as one possibility the use of HBr alone (that is, if the zero value for each of SiF_4, Cl_2 and O_2 is taken). On a similar basis, Table 1 of D1 at pages 7 and 8 could also be said to disclose the use of

HBr alone. As indicated in paragraph II above, the Examining Division in its decision interpreted Table 4 of D1 in this way, i.e. "as envisaging for each of these gases the complete omission thereof".

However, it is a general legal rule for the interpretation of any document, in particular a patent application or patent, in order to determine its true meaning and thus its content and disclosure, that no part of such a document should be construed in isolation from the remainder of the document: on the contrary, each part of such a document must be construed in the context of the contents of the document as a whole. Thus, even though a part of a document appears to have a particular meaning when interpreted literally and in isolation from the remainder of the document, the true meaning of that part of the document may be different having regard to the remainder of the document.

In the present case, Tables 1 and 4 of D1 must be interpreted in the context of the remainder of D1, in particular in the context of the passages discussed above which consistently suggest that a mixture of reactive gases is to be used. When so interpreted, in the Board's view it is clear that the combination of zero values for the gases SiF_4 and O_2 in Table 1, and for the gases SiF_4, Cl_2 and O_2 in Table 4 is in reality **not** part of the technical teaching of D1. In other words, on its true meaning D1 does not disclose the use of a plasma either formed in an atmosphere of hydrogen bromide alone, or hydrogen bromide mixed with an inert gas.

2.3 Consequently D1 does not deprive amended claim 1 of novelty.

2.4 Document D2 (US-A-4 502 915) discloses a method wherein after removal of surface oxides, a silicon-bearing layer is etched in a plasma formed in an atmosphere of HCl, HBr and He; see D2, column 3, lines 20 to 29 and therefore similarly does not deprive amended claim 1 of novelty.

3. *Inventive step*

3.1 Starting from the closest prior art disclosed in D1, the objective problem underlying the present invention is to provide a method for etching a silicon-bearing surface with a high selectivity to silicon oxide, wherein the selectivity to photoresist is improved. This problem is solved by using a plasma for selectively etching the silicon-bearing layer relative to photoresist and silicon oxide which is "formed in an atmosphere of hydrogen bromide alone or hydrogen bromide mixed with an inert gas such as helium, argon or nitrogen".

3.2 D1 at page 12, lines 15 to 18, suggests increasing the selectivity to photoresist by using high pressure and/or low power. Document D2 and all further documents cited in the European Search Report are totally silent about the problem of improving the etch selectively to photoresist. Hence, such prior art would not make it obvious to a skilled person that using HBr as the single reactive constituent of the plasma in place of the reactive gas mixture taught by D1 would maintain the high selectivity to the (underlying) silicon oxide and would increase the selectivity of the etching of polysilicon with regard to photoresist by a factor of more than five (see IV-(b) above).

3.3 For these reasons, the subject-matter of claim 1 is considered to involve an inventive step in the sense of Article 56 EPC.

4. Thus, claim 1 is allowable under Article 52(1) EPC. Dependent claims 2 and 3 concern particular embodiments of the method claimed in claim 1 and are, therefore, likewise allowable.

5. The case is remitted to the Examining Division in order that the description should be adapted to the above set of claims and to the cited prior art in particular as disclosed in D1 (see paragraph 2.1 above).

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 Examining Division with the order to grant a patent on the basis of claims 1 to 3 filed on 24 March 1994 with a description to be adapted accordingly.

The Registrar: The Chairman:

M. Beer G. D. Paterson