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D E C I S I O N
of 1 August 2000

Case Number: T 0659/96 - 3.4.3

Application Number: 90307877.2

Publication Number: 0414372

IPC: H01L 21/306

Language of the proceedings: EN

Title of invention:
Dry etching methods

Applicant:
SONY CORPORATION

Opponent:
-

Headword:
Chlorine trifluoride/SONY

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no) - "problem-solution" approach"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0659/96 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 1 August 2000

Appellant: SONY CORPORATION
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 27 February 1996 refusing European patent application No. 90 307 877.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
A. C. G. Lindqvist

Summary of Facts and Submissions

I. European patent application No. 90 307 877.2 was refused in a decision of the examining division dated 27 February 1996. The ground for the refusal was that the subject matter of claims 1 to 4 lacked an inventive step with respect to the prior art documents

D3: US-A-4 784 720; and

D4: WO-A-81 02 947.

II. The reasoning in the decision for the finding of lack of inventive step can be summarized as follows:

Document D4 is the closest prior art, since it discloses the use of a gas mixture including ClF_3 as a first component for etching silicon. In order to obtain anisotropic etching, however, according to the teaching of document D4, it is necessary to decrease the amount of ClF_3, and instead use almost pure Cl_2, which however would slow down the etching rate to almost zero.

Since the claimed composite gas differed from that of document D4 in that the second component was also for forming a protective coating on the side walls of the trench, the technical problem to be solved was to protect the side walls of the trench from etching.

The solution to the problem, as set out in the claimed invention, was rendered obvious by document D3 which discloses the use of a composite gas including a combination of $SiCl_4$ and N_2 for forming a protective layer on the side walls of a trench during etching of silicon.

III. The appellant (applicant) lodged an appeal on 26 April 1996, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 5 July 1996. Oral proceedings were requested in case the Board intended to dismiss the appeal.

IV. In response to a communication annexed to summons to oral proceedings, the appellant filed with the letter dated 30 June 2000 new claims 1 to 3 and amended pages 2 and 3 of the description.

V. At the oral proceedings held on 1 August 2000, the appellant requested that the decision under appeal be set aside and a patent be granted on the following documents:

Claims: 1 to 3 filed with the letter dated 30 June 2000

Description: page 1 filed with the letter dated 12 December 1994
pages 2 and 3 filed with the letter dated 30 June 2000

Drawings: Figures 1(A) to 1(C) as originally filed.

VI. Independent claims 1 and 3 read as follows:

"1. A composite gas for anisotropic dry etching to form a desired configuration of trench (14) in monocrystalline silicon, the composite gas comprising:

$SiCl_4/N_2$ based gas for etching the monocrystalline silicon and for forming a

protective layer (15) on the side wall of said trench (14) while the etching is performed;
characterised in that
said composite gas further comprises ClF_3 gas."

"3. An anisotropic dry etching process for forming a trench (14) in monocrystalline silicon, the process comprising the steps of:
forming an opening (11a) in an SiO_2 layer (11) formed on a monocrystalline silicon substrate (10);
performing etching utilizing the residual SiO_2 layer (11) as a masking layer and with an etching gas as claimed in any preceding claim."

VII. The appellant presented essentially the following arguments in support of his request:

(a) Contrary to the opinion of the examining division, document D3, and not document D4, should be considered as the closest prior art, since it relates to anisotropic etching using protective sidewalls in the trenches, whereas document D4 is concerned with isotropic etching of silicon using a gas mixture including chlorine trifluoride (ClF_3).

(b) In the decision under appeal, the technical problem is formulated in relation to document D4 as the closest prior art, and is considered as protecting the sidewalls of the trench from etching. This problem is not derivable from the closest prior art, as it should be, and is based upon the knowledge of the invention as claimed. Thus, the formulation of the problem involves an

ex post facto analysis, which is not permissible in the consideration of inventive step.

In the appellant's view document D3 reflects the closest prior art and the technical problem addressed by the invention is to increase the etch rate in the formation of a trench in silicon, as stated in the application as filed.

(c) The skilled person, regardless of starting point, would not consider combining the teaching of the two documents D3 and D4, since document D4 emphasizes isotropic etching using ClF_3 (cf. D4, page 12, lines 6 to 15), whereas document D3 is related to anisotropic etching. It is furthermore taught in document D4 that when anisotropic etching is desired, Cl_2 should be the major component of the gas mixture and not ClF_3 (cf. D4, page 12, lines 11 to 15).

Secondly, the skilled person is discouraged from using ClF_3 as etchant in the method of document D3, since document D3 discloses that chlorine liberating sources (etchants) are less preferred for silicon etching in view of the high volatility of Si_xCl_y (cf. column 8, lines 24 to 30). Thus, fluorine radicals, which would result from the use of ClF_3, would be even less suited to such a system.

(d) As documents D3 and D4 point in opposite directions, the skilled person faced with the task of increasing the etch rate of the method of document D3 would rather resort to the commonly known measure of changing the process parameters

such as the gas pressure and microwave power, in order to obtain the desired increase in etch rate.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. *Amendments and clarity*

Claim 1 contains the features of originally filed claims 1 and 2 and further specifies that the gas is for "anisotropic dry etching". This last feature is disclosed on page 1, lines 3 to 5 of the application as filed. Claim 2 corresponds to claim 3 as filed, and claim 3 corresponds to claim 7 as filed and includes the above-mentioned feature that the etching is dry and anisotropic.

Therefore, in the Board's judgment, the requirements of Article 123(2) EPC are met. The Board furthermore considers the claims to be clear, as required by Article 84 EPC.

3. *Novelty*

3.1 Document D3 discloses an anisotropic plasma dry etching process for etching trenches. The anisotropic etching is obtained by forming passivation layers on the side walls of the trenches during the etching process (cf. abstract). Among the different methods for forming the passivation layer on the side walls, it is suggested to include in the plasma, in addition to an etchant gas, species which cause a precipitation onto the side walls

of the trench (cf. column 6, lines 30 to 38; column 8, line 31 to column 9, line 12). As a specific example, HBr is used as etchant gas, and a mixture of $SiCl_4$ and N_2 is present to form the protective sidewall layer (cf. column 8, 46 to 46; column 11, line 27).

3.2 The subject matter of claim 1 differs from the composite gas disclosed in document D3 in that the composite gas comprises ClF_3 together with $SiCl_4$ and N_2, whereas in document D3 the combination HBr, $SiCl_4$ and N_2 is mentioned.

3.3 Document D4 discloses the use of ClF_3 as an etchant gas for dry etching of silicon, either alone or in mixture with e.g. Cl_2 (cf. abstract). The use of ClF_3 in a dry etching process is found to give a relatively high etch rate and high uniformity of etch rate across each work piece, as well as an absence of any proximity effects (cf. page 13, lines 28 to 35). Pure ClF_3 produces isotropic dry etching, but by adding Cl_2 to the etchant gas, the dry etching becomes increasingly anisotropic (cf. page 11, lines 14 to 34; Figures 5 and 6). A complete anisotropic etching process, i.e. without any lateral etching under the mask, is only obtained by using 100% Cl_2. It is however observed that an increased amount of Cl_2 will slow down the etching rate with respect to that for pure ClF_3. There is no disclosure as to the mechanism involved in anisotropic etching when adding Cl_2 to ClF_3.

3.4 The subject matter of claim 1 thus differs from composite gas of document D3 in that it discloses a mixture of ClF_3 together with $SiCl_4$ and N_2, where the two latter gases contribute to form a protective side wall on the trench, whereas in document D3 the mixture of

ClF_3 and Cl_2 is disclosed without mentioning any formation of protective sidewalls.

3.5 The subject matter of claim 1 is therefore new within the meaning of Article 54 EPC. As independent claim 3 contains all features of claim 1, the subject matter of claim 3 is new as well.

4. *Inventive step*

4.1 The Board agrees with the appellant that document D3, in contrast to document D4 as in the decision under appeal, represents the closest prior art: Document D3 concerns the formation of a trench in silicon by anisotropic dry etching employing the same base mixture of gases as in the application in suit, i.e. $SiCl_4/N_2$ base mixture, the mixture forming a protective layer on the sidewalls of the trench during the etching. In contrast, document D4 discloses ClF_3 primarily as an etchant gas for *isotropic* dry etching. It should however also be mentioned that the claims considered in the decision under appeal specified "dry etching" and were not limited to "anisotropic" dry etching.

4.2 The objective technical problem addressed by the present invention is thus to increase the etch rate of an anisotropic dry etching process for silicon. This problem is also addressed in the application as filed when discussing the prior art discussed therein (cf. page 1, lines 6 to 25).

Although the Board agrees with the appellant on both the choice of the closest prior art and the formulation of the technical problem addressed by the present invention, it does not agree with the appellant that

the technical problem should be either disclosed in or immediately apparent from the closest prior art without any reference to the claimed subject matter. On the contrary, for the application of the problem-and-solution approach, it is essential to carry out a comparison between the features of the claimed subject matter with the features of the closest prior art so as to determine the features which distinguish the invention from the closest prior art and which in combination with the features known from the closest prior art provide the solution to the problem. In order to avoid an ex post facto analysis, however, according to the established case law of the boards of appeal, such a formulation of the technical problem must not be so narrow as to include a hint to the solution to the problem.

4.3 In document D4, the use of ClF_3 gas for dry etching of silicon is disclosed, where ClF_3 is described as having several favourable properties such as high etch rate, high selectivity with respect to silicon dioxide, and excellent uniformity (cf. abstract and page 13, line 28 to page 14, line 9). Moreover, the etch process using ClF_3 could be carried out at low power levels. It is also shown in document D4 that pure ClF_3 produces isotropic etching of silicon.

4.4 Thus, a skilled person seeking an alternative to HBr used in document D3 in order to further improve the etch rate would in the Board's opinion consider the choice of ClF_3 known from document D4.

4.5 The appellant argued that ClF_3 was disclosed in document D4 as an etchant for *isotropic* dry etching. When anisotropic etching was desired, document D4 taught to

use pure Cl_2 instead. Thus, according to the appellant, document D4 was not only teaching away from using ClF_3 for *anisotropic* dry etching, but also provided a solution for obtaining anisotropic etching (use of pure Cl_2).

The Board agrees with the appellant's observation that pure ClF_3 is reported in document D4 to be an isotropic etchant. In the present case, however, starting with the composite gas known from document D3, the components $SiCl_4$ and N_2 are present in order to produce sidewalls in the etched trenches, so as to prevent any lateral etching, i.e. to cause the etching process to be anisotropic. Therefore, in the Board's judgment, the skilled person would not be dissuaded by the observations in document D4 that pure ClF_3 is an isotropic etchant, since it is not essential whether ClF_3 is isotropic etchant or not, as long as protective sidewalls are present.

As to the argument that document D4 teaches to use pure Cl_2 when anisotropic etching was desired, the Board finds that Cl_2 would not be a viable alternative to the skilled person seeking to increase the etch rate, since it is known from D4 that the overall etch rate for Cl_2 is lower than for ClF_3 (cf. D4, page 11, lines 19 to 22).

4.6 The appellant further argued that document D3 was teaching away from using a chlorine-based etchant, since its compounds with silicon would be highly volatile compared to bromine compounds (cf. D3, column 8, lines 24 to 27). This argument would be even stronger against the use of fluorine. Therefore, the skilled person following the teaching of document D3

would not consider the use of ClF_3.

The Board finds that document D3 teaches that anisotropic dry etching can be obtained by using a process where protective sidewalls are formed in the etched trenches. There are a number of ways described in document D3 for forming the protective sidewalls. As discussed under point 3.1 above, one alternative is to include additional gas components to the etchant which form the protective sidewall. In addition, there is also described the possibility of choosing an etchant gas where the reaction products of the etchant with silicon form the protective sidewalls. The statement on column 8, lines 24 to 27 describing chlorine liberating sources as less preferred etchant is therefore in the context of discussing which properties an etchant gas must have, in order that the reaction products of the etchant gas itself may form protective sidewalls. It is also apparent that this statement is not applicable to the embodiments where, in addition to an etchant gas, species which cause a precipitation onto the side walls of the trench are included in the composite gas, since the chlorine-containing gas $SiCl_4$ is in particular mentioned to be suitable for such applications (cf. D3, column 8, lines 46 to 49; column 9, lines 6 to 12; column 10, line 50; column 11, line 27). Thus, in the light of the above considerations, the Board finds that the skilled person would not be discouraged to use ClF_3 as an etchant gas, as long as other species, which cause the formation of protective sidewalls, are also included in the composite gas used for the dry etching.

4.7 Regarding the argument made by the appellant that the skilled person would rather be inclined to change the process parameters such as gas pressure and microwave

power in order to increase the etch rate, the Board agrees that it is well-known in the art that e.g. increased gas pressure leads to a correspondingly higher etch rate. This, however, is possible only to a limited extent, since as disclosed in document D3, the etch process is less anisotropic with higher gas pressure (cf. D3, column 7, lines 37 to 51). Therefore, in the light of the limited prospects of obtaining a considerably higher etch rate by varying only the process parameters, the skilled person would have to consider other means, such as the etchant gases as well.

4.8 For the above reasons, in the Board's judgment, the subject matter of claim 1 does not involve an inventive step within the meaning of Article 56 EPC. The patent application therefore does not meet the requirements of Article 52(1) EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla