

Publication in the Official Journal ~~Yes~~ / No

File Number: T 424/90 - 3.4.1

Application No.: 83 300 333.8

Publication No.: 0 084 970

Title of invention: Magnetically enhanced plasma process and apparatus

Classification: H01J 37/34

**D E C I S I O N**  
of 11 December 1991

Proprietor of the patent: MATERIALS RESEARCH CORPORATION

Opponent: LEYBOLD AKTIENGESELLSCHAFT

Headword:

**EPC** Article 56

Keyword: "Inventive step (no)" - "competent skilled person is qualified in the technical field of the claimed solution" - "use of means disclosed in a neighbouring technical field where the competent skilled person expects identical problems"

**Headnote**



Case Number : T 424/90 - 3.4.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.1  
of 11 December 1991

**Appellant :**  
(Opponent)

LEYBOLD AKTIENGESELLSCHAFT  
Wilhelm-Rohn-Strasse 25  
Postfach 15 55  
W - 6450 Hanau am Main 1 (DE)

**Representative :**

Zapfe, Hans, Dipl.-Ing.  
Am Eichwald 7  
W - 6056 Heusenstamm - 2 (Rembrücken) (DE)

**Respondent :**  
(Proprietor of the patent)

MATERIALS RESEARCH CORPORATION  
Route 303  
Orangeburg  
New York 10962 (US)

**Representative :**

Fysh, Michael, Q.C.,  
Francis Taylor Building  
Temple  
London EC4Y 7BY (GB)

Moon, Donald Keith  
BREWER & SON  
Quality House  
Quality Court  
Chancery Lane  
London WC2A 1HT (GB)

**Decision under appeal :**

Interlocutory decision of the Opposition Division  
of the European Patent Office dated  
20 April 1990 concerning maintenance of European  
patent No. 0 084 970 in amended form.

**Composition of the Board :**

**Chairman :** G.D. Paterson  
**Members :** H.J. Reich  
Y. van Henden

**Summary of Facts and Submissions**

I. The Respondent is owner of European patent No. 0 084 970.

II. This patent was opposed by the Appellant on the grounds mentioned in Article 100(a) EPC; relying with regard to Claim 1 as granted inter alia on the paper of H.Okano et al. "High Rate Reactive Ion-Etching Using a Magnetron Discharge" presented at the ET Electrotech Seminar, Honolulu, Hawaii, in January 1981. The technical content of this oral state of the art was evidenced by document:

D1: Solid State Technology, April 1982, pages 166 to 170.

During the proceedings before the Opposition Division the Respondent requested to maintain the patent on the basis of an amended Claim 1. With regard to this amended claim, the Appellant relied additionally on a further prior art document referred to in the European Search Report:

D2: US-A-4 194 962.

The Appellant submitted that a skilled person would arrive at the apparatus according to amended Claim 1 without requiring an inventive step by making use of the magnetic pole means known from document D2 in the apparatus known from document D1.

III. By an interlocutory decision within the meaning of Article 106(3) EPC the Opposition Division decided that the patent could be maintained in amended form.

The independent claims on which the decision was based read as follows:

- "1. A plasma processing apparatus for the selective etching of a workpiece, the apparatus including an evacuable chamber (11), means (16) for evacuating the chamber, at least one source (17) of reactant gas, means (19, 21) for introducing said at least one reactant gas at low pressure into the chamber, an electrode (24) in the chamber having at least one workpiece support surface (34) electrically insulated from the chamber, means (28) for applying a voltage to the workpiece support surface, and means for generating an electron-trapping magnetic field, whose lines of magnetic force co-operate with the electrode surfaces to form a completely enclosed region, the apparatus being characterised in that: the means for providing an electron trapping magnetic field comprise first magnetic pole means (40, 103) at one end of the workpiece support surface and second magnetic pole means (43, 104) at the other end of the workpiece support surface, with the workpiece support surface being located between the first and second magnetic pole means, which project outwardly therefrom, the first and second magnetic pole means being of opposite polarity, thereby to provide lines of force (45) which leave said electrode at the first pole means, extend across the workpiece support surface in the gap between the first and second pole means, and re-enter said electrode at the second pole means to enclose the workpiece support surface in an electron trapping magnetic field."
10. A method of operating a plasma processing device according to claim 1, which method includes the steps of placing at least one workpiece (27) on said workpiece support (34), evacuating the chamber, introducing a reactant gas into the chamber, and applying a voltage to the workpiece

support, characterized by: adjusting the voltage applied to the workpiece support to the minimum value necessary to produce a dense glow discharge in the magnetic electron-trapping field closely adjacent to said workpiece support surface."

Claims 2 to 9 are dependent on Claim 1.

The Opposition Division took the view that the competent skilled person would know of document D2 and would learn that the magnetic pole piece means described therein allows a uniform sputtering of material from each point of a large target surface without any relative movement between magnetic field and target. However, a skilled person would not consider this document concerning sputter coating with an inert working gas, for guidance in reducing undercutting caused by the "loading effect", in reactive ion etching of a masked surface.

IV. The Appellant lodged an appeal against the decision of the Opposition Division. He requested that the decision under appeal be set aside and that the patent be revoked. In support of his request, the Appellant essentially submitted that:

- (a) a transfer of constructional elements from a sputtering apparatus to an apparatus for reactive ion etching would belong to the average knowledge of a physicist, due to the fact that both these processes are often carried out in the same apparatus by only changing the composition of the working gas.
- (b) The homogenising effect of the expanded magnetic field (plasma belt) of document D2 on the interacting ions would be independent from their inert or

reactive properties and would thus be a well known equivalent to the relative target movement in document D1.

(c) Hence, Claim 1 would mainly teach to use the apparatus of document D2 for reactive ion etching. The fact that for this purpose its gas inlet only has to be supplied with a chemical reactive working gas would be natural.

V. In preparing for the oral proceedings which were initially auxiliarily requested by both parties, the Board informed the parties that in view of the disclosures of documents D1 and D2, it appeared that the main question in connection with the assessment of inventive step was whether it would have been obvious to a skilled person to use the magnetic pole means known from document D2 in the apparatus according to document D1. Its provisional view in this respect was that the competent skilled person, a specialist concerning plasma produced ions for a target interaction, could be expected to further improve the efficiency of the reactive species generation in the apparatus described in document D1 by expanding the ion source laterally above all parts of the workpiece surface and etching all these parts simultaneously as taught by document D2, since the reduction of the ion kinetic energy, of the loading effect induced undercutting and of the scattering collisions were already present and observable during use of the apparatus of document D1. Any compensation of the lower average velocity of the ionising electrons in the reactive etching apparatus of document D1 with regard to the sputtering apparatus of document D2 by an increase of the magnetic field strength would be regarded as a mere routine adaptation in the analogous use of the teaching of document D2.

VI. In response to the Board's communication, the Appellant withdrew his request for oral proceedings, and stated that he would not attend oral proceedings appointed for 11 December 1991.

VII. Oral proceedings were duly held, at which the Appellant was not represented and at the end of which the Respondent requested that the appeal be dismissed and that the patent be maintained on the basis of his main request (see paragraph III above), or on the basis of the auxiliary request as filed during the oral proceedings.

Claim 1 of the auxiliary request as filed during oral proceedings reads as follows:

"1. In a reactive ion etching process for the selective chemical etching of a masked surface of a workpiece, an evacuable chamber (11), .... (followed by the corresponding remaining features of Claim 1 of the main request, wherein the words "the apparatus being" before "characterised" are excluded).....with the magnetic field lines of force extending substantially parallel to and closely adjacent the workpiece support surface and further characterised in that the process comprises the steps of mounting the workpiece to be etched on the workpiece support surface with the masked surface exposed; introducing at least one reactant gas at low pressure into the chamber; applying a voltage to the workpiece support surface to produce a uniform plasma of reactive species and ions in the electron-trapping magnetic field closely adjacent the workpiece support surface and spaced therefrom by a plasma sheath electric field having lines of force perpendicular to the masked surface of the workpiece."

VIII: In support of his requests, the Respondent made essentially the following submissions:

- (a) The contents of the patent in suit show that the competent skilled person is a semiconductor specialist in the field of very large scale integrated (VLSI) circuits (col. 1, lines 15-25).
- (b) Document D1 concerns chemically reactive etching but this was an experimental proposal, and document D2 concerns chemically inert sputtering. Neither of these documents was part of the common general knowledge in the field of the claimed invention. Furthermore, the documents contain no cross-references to each other, so that to mosaic them would be the result of an unallowable ex post facto analysis.
- (c) The problem underlying the patent in suit clearly comprises not only improving the efficiency of reactive species generation but also - as follows from the contents of columns 3 and 4 of the patent - to avoid the disadvantages of the prior art such as a mask undercutting caused by the loading effect, and high kinetic energy of the incident ions which destroys the etch mask.
- (d) A skilled person would not think of using means derived from a sputtering apparatus in a device for reactive ion etching, because the large kinetic energy of the sputtering ions would heat and thus destroy an etch mask, and the known ion sputtering which is comparable with sand blasting, would not impinge perpendicularly on the target surface as necessary for an anisotropic etching process. Hence, the uniformity of erosion which is mentioned in



document D2 would not teach that uniformity would also be obtained in an unisotropic etching process.

- (e) Document D1 is silent about mask undercutting. A skilled person would not be able to adapt the process parameters of document D2 to a reactive ion etching process. Moreover, a simple replacement of the plasma loop in document D1 by the plasma belt of document D2, i.e. a simple change of the local extension of the ion producing plasma, would not solve the problems indicated in paragraph VIII c above, in particularly the mask undercutting.

IX. At the conclusion of the oral proceedings the decision was announced that the patent is revoked.

#### Reasons for the Decision

##### 1. Inventive Step - Claim 1 - Main Request

- 1.1 It was not contested by the Respondent that document D1 is accurate evidence of the technical contents of the corresponding paper which was orally presented in January 1981. From the oral disclosure evidenced by document D1 there is known, in accordance with the wording of Claim 1:

"A plasma processing apparatus for the selective etching of a workpiece (D1, Figure 5), the apparatus including an evacuable chamber (D1, Figure 1), means for evacuating the chamber ("Roots Blower" and "Diffusion Pump" in Figure 1), at least one source of reactant gas ("Gas inlet"), means for introducing said at least one radiant gas at low pressure into the chamber (D1, page 166, left column, last line, in combination with the indication CHF<sub>3</sub> Pressure:

0.05 Torr in Figure 3), an electrode ("Cathode" in Figure 1) in the chamber having at least one workpiece support surface (the "wafer" in Figure 1) electrically insulated from the chamber (see "Teflon" in Figure 1), means for applying a voltage to the workpiece support surface (1.3 KV in Figure 1), and means for generating an electron-trapping magnetic field ("Sm-Co Permanent Magnet Assembly" in Figure 1), whose lines of magnetic force cooperate with the electrode surfaces to form a completely enclosed region (Figure 2)."

- 1.2.1 Starting from document D1 as the closest prior art, the objective problem underlying the subject-matter as claimed in Claim 1 is, in the Board's view, restricted to avoiding the disadvantages of this known apparatus, such as relative movement between the plasma loop and the wafer in order to cover the complete wafer surface, and a sloped etch profile in regions along the side edges of the known plasma loop, and to improve thereby the efficiency of the reactive species generation.
- 1.2.2 The reducing of the kinetic energy of the reactive ions impinging on the substrate surface, as a result of increasing the magnetic field for trapping plasma generating electrons is known from curve "V<sub>DC</sub>" in Figure 3 and the corresponding description of document D1.
- 1.2.3 As is admitted in the introductory part of the patent in suit, when evaluating the relevant prior art -in particular in column 3, lines 15, 16, 27, 28 and 38 to 40 - it is known in the art to reduce the loading effect and resulting mask undercutting by increasing the reactive species generation rate, for instance by increasing the plasma density. Document D1, page 168, lines 6 and 7, indicates explicitly that the electron trapping magnetic

field increases the ionisation efficiency - i.e. the reactive species generation rate by a factor of ten. Therefore, due to the known critical importance of the quality of the edge profile in VLSI-circuits, a skilled person working according to the teaching of document D1, in the Board's view, would both expect and be able to observe, concomittantly with the increase of the reactive species generation rate, a reduction of the mask undercutting caused by the loading effect.

1.2.4 Hence, the reduction of the kinetic energy of the reactive ions and that of the loading-effect-induced mask undercutting are qualitatively known and foreseeable expectations which are inherent in the closest prior art. Moreover, the Respondent has submitted no evidence of a quantitative improvement in these two effects when replacing the plasma loop of document D1 by the plasma belt of document D2. For these reasons - contrary to the Respondent's view in paragraph VIII (c) and (e) - and following the established jurisprudence of the Boards of Appeal, these two effects cannot be included into the formulation of the objective problem when assessing the question of inventive step.

1.3 Though the claimed apparatus is no doubt intended to be used in the reactive ion etching of VLSI circuits, the Board does not accept the Respondent's submission set out in paragraph VIII (a) above that, for the evaluation of inventive step, the competent skilled person is merely a semiconductor specialist. The Board considers that in real life, a semiconductor specialist would consult a plasma specialist, if his problem concerns providing a technical improvement of an ion generating plasma apparatus as in the present case. The semiconductor specialist would be expected to form a team with the plasma specialist and to entrust him with the task of increasing the efficiency of

the reactive species generation. Thus, in the Board's view, it is appropriate in the present case to follow Decision T 32/81, OJ EPO 1982, 225, and to base the assessment of whether the claimed solution involves an inventive step on the knowledge and abilities of the specialist in that technical field in which the objective problem prompts the person skilled in the art to seek its solution. Hence, for the above reasons in the present case the competent skilled person is held to be a plasma specialist.

- 1.4 The Board considers that a plasma specialist would have been aware that the objective problem of increasing the efficiency of the reactive species generation meant the task of enlarging the plasma source area which emits ions for an interaction with a target and of homogenising the density of the emitted ions. It was clearly part of the general knowledge of the plasma specialist that any later use of the emitted ions for a chemical etch process or for a physical sputter process would not technically influence the generation process of the ions. Thus, the plasma specialist would look for advice in each special technical field, where he would expect to find or where he knows of the existence of his own problem, i.e. to produce ions for a homogenous interaction with a large target surface. According to the established jurisprudence of the Boards of Appeal such technical fields are considered as neighbouring fields and are considered as part of the relevant state of the art when assessing inventive step; see in particular Decision T 176/84, OJ EPO 1986, 50, paragraph 5.3.1. In the Board's view, the Appellant is right in his submission set out in paragraph IV (a) and (c) above, that sputtering processes and reactive ion etching processes are often carried out in the same apparatus. Hence, a plasma specialist has a realistic practical motivation to be aware of technical developments

in the field of sputtering devices and thus to know of the existence in this field of problems which are similar to his own, as well as how such problems have been solved. For the above reasons, the Board does not accept the Respondent's submission as set out in paragraph VIII (b) above, and holds that the competent skilled person would indeed take into account the teaching of document D2 when seeking to solve problems arising in the apparatus disclosed in document D1.

- 1.5 Moreover, the explicit teaching in document D2, column 2, line 67, and column 3, lines 39,40, that the plasma belt produced by the magnetic pole means disclosed in this document, extends over broad target areas and produces a relatively even sputtering - i.e. ion impingement - across the target, in the Board's view makes it obvious that these means solve the objective problem as defined in paragraph 1.2.1 above. This teaching of document D2 would therefore actively suggest to the skilled person the replacement of the magnet assembly and its scanning mechanism in the reactive ion etching apparatus according to Figure 1 of document D1 by the magnetic pole means disclosed in document D2. Thus the teaching of document D2 would suggest a solution to the objective problem, which solution is characterised according to the wording of Claim 1 in that:

"... the means for providing an electron trapping magnetic field (see D2, column 3, lines 30 to 37) comprise first magnetic pole means (D2, Figure 3, 104, upper parts 106, 108) at one end of the workpiece support surface (between 62 and 72 in Figure 3) and second magnetic pole means (102, lower parts 106, 108 in Fig. 3) at the other end of the workpiece support surface, with the workpiece support surface being located between the first and second

magnetic pole means (see Figures 3 and 4), which project outwardly therefrom (108 versus 72 in Figure 3), the first and second magnetic pole means being of opposite polarity (column 7, lines 59 to 62) thereby to provide lines of force which leave said electrode at the first pole means, extend across the workpiece support surface in the gap between the first and second pole means and re-enter said electrode at the second pole means (see dashed curves in Figures 3 and 4, and column 7, lines 37 to 40) to enclose the workpiece support surface in an electron-trapping magnetic field (column 7, lines 10 to 15)."

- 1.6 The technical facts submitted by the Respondent according to paragraph VIII (d) represent - as shown below - no technical hindrance which would prevent a skilled person from making use of the above-described known advantages of the magnetic pole means of document D2 in the closely analogous situation of the apparatus of document D1. Document D1 teaches particularly on page 167, lines 15-18, to keep the kinetic energy of the ions as small as possible in order to preserve the mask pattern. Furthermore, from the direction of the field lines in Figure 3 of document D2 a skilled person would easily derive the parallel relationship between the equipotential lines of the border area of the enclosed plasma and the neighbouring target surface, and would thus also derive the movement of the impinging ions which is throughout perpendicular to the target surface.
- 1.7 The Respondent's submission in paragraph VIII (e) that a skilled person would not be able to adapt the process parameters when transferring magnetic pole means from a sputtering to a reactive ion etching apparatus was not supported by any technical fact. The Board does not accept this submission for the following reasons: in the reactive ion etching apparatus of document D1, the electron

trapping magnetic field of the pole means disclosed in document D2 would be confronted mainly with two different experimental conditions: a different working gas to be ionised (see also paragraph IV (a)) and a lower acceleration (diode) voltage in order to produce ions with a lower kinetic energy (see D1, page 167, lines 15 to 18). It is regarded as generally known expert knowledge that a possible lower average velocity of ionising electrons - such as in a reactive ion etching apparatus as compared to a sputtering apparatus as a consequence of the lower ion acceleration voltage to be supplied - can easily be compensated by an increase of the magnetic field strength in order to achieve a comparable degree of electron deflection, hence of electron confinement. Moreover, in the Board's view, Figure 3 of document D1 gives a skilled person sufficient advice in particular with regard to what strength of magnetic field and what radio frequency power is needed in order to achieve an appropriate kinetic ion energy for reactive etching, and to compensate for resulting differences in the ionisation energy between inert atoms for sputtering and molecules for reactive etching. This view is also supported by the fact that the range of magnetic field strength in Figure 3 of document D1 is identical with the one indicated in the patent in suit, column 7, lines 21-24.

1.8 For the reasons stated above, in the Board's judgment Claim 1 of the Respondent's main request therefore lacks an inventive step within the meaning of Article 56 EPC.

2. Inventive Step - Claim 1 - Auxiliary Request

2.1 The wording of Claim 1 according to the Respondent's auxiliary request adds to the subject-matter of Claim 1 of the main request only features which are known either from document D1 or from document D2.

- 2.2 From document D1 the following features are known: "in a reactive ion etching process for the selective chemical etching of a masked surface (see D1, Figure 6) of a workpiece ... mounting the workpiece to be etched on the workpiece support surface with the masked surface exposed (see "wafer" in Figure 1); introducing at least one reactant gas at low pressure into the chamber (Figure 1 and Figure 3); and applying a voltage to the workpiece support surface (Figure 1) to produce a uniform plasma of reactive species and ions in the electron trapping magnetic field closely adjacent the workpiece support surface (Figure 4 with the corresponding description)."
- 2.3 It is also known from document D2 that "the magnetic field lines (of the electron trapping magnetic field) extend substantially parallel to and closely adjacent the workpiece support surface .... and spaced therefrom by a plasma sheath electric field having lines of force perpendicular to the masked surface of the workpiece (see Figures 3 and 4 in D2 and note that the plasma is equipotential)."
- 2.4 Hence, a skilled person arrives at the subject-matter of Claim 1 of the auxiliary request by making use of the magnetic pole means disclosed in document D2 in the closest prior art according to document D1. Such a use has to be regarded as obvious for the reasons set out above. Therefore, in the Board's judgment the subject-matter of Claim 1 according to the Respondent's auxiliary request also does not involve an inventive step within the meaning of Article 56 EPC.
3. Claims 2 to 9 of both requests fall because of their dependency on the respective Claims 1.




4. Method Claim 10 exclusively comprises measures which are completely self evident in view of the prior art according to document D1. In particular, the claimed step of "adjusting the voltage applied to the workpiece support to the minimum value necessary to produce a dense glow discharge" represents the adjustment of an optimum between two conflicting parameters, reactive ion generation rate and target temperature, which is regarded to fall within a skilled person's normal abilities. For these reasons, Claim 10 is not allowable under Article 56 EPC.

**Order**

**For these reasons, it is decided that:**

1. The decision of the Opposition Division is set aside.
2. The patent is revoked.

**The Registrar:**



**M. Beer**

**The Chairman:**



**G. D. Paterson**