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D E C I S I O N
of 13 June 2003

Case Number: T 1097/00 - 3.4.3

Application Number: 92304964.7

Publication Number: 0516480

IPC: H01L 21/26

Language of the proceedings: EN

Title of invention:
Method for surface treatment with extra-low-speed ion beam

Patentee:
RESEARCH DEVELOPMENT CORPORATION OF JAPAN

Opponent:
-

Headword:
Surface cleaning/RESEARCH DEVELOPMENT CORPORATION

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 1097/00 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 13 June 2003

Appellant: RESEARCH DEVELOPMENT CORPORATION OF JAPAN
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 5 June 1998 refusing European application No. 92304964.7 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
J. P. B. Seitz

Summary of Facts and Submissions

I. European patent application No. 92 304 964.7 was refused in a decision of the examining division dated 20 June 2000. The ground for the refusal was that the application did not meet the requirement of inventive step having regard to the prior art documents

D1: WO 88 06 194 A;

D2: US 4 217 855 A; and

D3: WO 88 02 790 A.

II. The appellant (applicant) lodged an appeal on 29 August 2000, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 30 October 2000 together with new claims forming the basis of the appellant's requests.

III. In response to a communication accompanying summons to oral proceedings, the appellant filed on 11 June 2003 a new main request and new first and second auxiliary requests.

IV. At the oral proceedings held on 13 June 2003 following a brief discussion about the admissibility of the late filed requests, the appellant withdrew the main and first auxiliary requests filed on 11 June 2003 and requested that the decision under appeal be set aside and that a patent be granted on the basis of a main request or an auxiliary request as follows:

Main request:

Claims 1 to 8 of the main request filed on 30 October 2000 together with the grounds of appeal;

Auxiliary request:

Claims 1 to 8 of the second auxiliary request filed on 11 June 2003.

V. Claim 1 according to the appellant's main request reads as follows:

"1. A method for non-damage surface cleaning a solid, said method consisting of irradiating a surface of said solid with an ion beam accelerated by an acceleration voltage, said ion beam consisting of ions generated by ionising a cluster of atoms and/or molecules of a substance which is gaseous at ambient temperature and which is chemically unreactive under the conditions of said irradiation."

VI. Claim 1 according to the appellant's auxiliary request reads as follows:

"1. A method for non-damage surface cleaning a solid, said method consisting of irradiating a surface of said solid with an ion beam accelerated by an acceleration voltage; the method comprising the steps of:

a) forming a cluster being a lump-shaped group of atoms or molecules of a gaseous substance which is gaseous at ambient temperature;

b) directing electrons onto said cluster to form cluster ions;

c) accelerating the thus generated cluster ions by acceleration voltage;

d) subjecting the ions to mass separation by use of an electric field or a magnetic field; and

e) irradiating said ions onto said surface of the solid causing said surface to be made available as a clean surface for subsequent use."

VII. The reasoning in the decision under appeal can be summarized as follows:

(a) Document D3 discloses a method of depositing a film onto a substrate wherein a beam of ionized clusters of atoms is directed towards the substrate during deposition. The beam of ionized clusters cleans the substrate as the film is deposited. The claimed method thus differs from that of document D3 in that only cleaning of a substrate surface is carried out.

(b) The technical problem thus relates to providing a damage free cleaning of a substrate surface. It is disclosed in document D3 when discussing prior art, that cleaning can be carried out by ion bombardment of a surface prior to deposition. This indication, together with the fact that the cleaning by the ion clusters in document D3 is clearly independent of the deposition process, provide a sufficient incentive to a skilled person to test a method where the cleaning is carried out

without simultaneous deposition of a film. It is furthermore known from document D2 to perform a cleaning step prior to deposition. The modification of the process of document D3 would only entail routine measures.

(c) Although the applicant correctly observed that the teaching of document D3 is directed towards carrying out cleaning and deposition at the same time, the skilled person would understand that prior to the use of the process of document D3 for the deposition of a film, a first step of cleaning the substrate surface is indispensable.

VIII. The appellant presented essentially the following arguments in support of his requests:

(a) The application in suit is concerned with the problem of providing a clean surface without damaging it, so that the surface is available for subsequent use. Document D3, on the other hand, is concerned with a method of vapor deposition of a thin film, where the substrate is cleaned simultaneously with deposition, and is not concerned with cleaning of the substrate surface as such. On the contrary, document D3 teaches against having a cleaning step prior to deposition, since, according to document D3, a clean and defect-free substrate surface prior to growth is not required (cf. page 14, line 29 to page 15, line 7). This is also indicated by the fact that document D3 in its discussion of prior art touches on the same problem as addressed by the present invention, but proposes a different solution to

the one provided by the present invention (cf. D3, page 1, line 1 to page 2, line 14). Therefore, the skilled person would not expect that an additional cleaning step would have to be added in order to clean the substrate surface before depositing the thin film, since the method of document D3 already contains a cleaning step.

(b) In the method of document D3, the cleaning and deposition processes are interlinked and they affect each other. A separate cleaning process independent from the deposition process cannot be derived from document D3. Consequently, it is only possible to arrive at the claimed process by picking features from the process of document D3 out of the context in which they were disclosed, in other words, with the benefit of hindsight.

(c) Since, in the method of document D3, cleaning and deposition occur simultaneously, the method does not clean the substrate surface, but the film as it is deposited.

Reasons for the Decision

1. The appeal is admissible.

2. *Inventive step - Main request*

The only issue in the present appeal is that of inventive step.

2.1 Document D3 was considered the closest prior art in the decision under appeal. It discloses a method of depositing a thin film on a substrate 12 by directing a beam 28 of ionized clusters 30 of "volatile species", e.g. noble gas atoms, against the surface 16 of the substrate at the same time that the thin film is being deposited on the substrate (cf. abstract; Figure 1 with accompanying text). The clusters of the volatile species disintegrate into individual atoms or molecules upon striking the surface of the substrate and drive contaminants off the surface. The atoms of the disintegrated clusters also have sufficient energy to move the atoms of the thin film around which improves the uniformity of the deposited thin film (cf. page 2, lines 15 to 17 and 5, lines 8 to 28). Due to the high mass of the cluster, typically 1000 times that of a single atom, each atom has a small kinetic energy, so that little damage is done to the surface when a strikes the surface (cf. page 5, lines 8 to 28).

It is also pointed out in document D3 that, generally, a surface has to be cleaned carefully before deposition takes place on it in order to obtain a high quality thin film (cf. D3, page 1, line 20 to page 2, line 14). A cleaning step carried out during deposition, on the other hand, as in the method of document D3, is disclosed to be beneficial as it prevents formation of *in situ* contamination (cf. page 2, lines 15 to 21).

2.2 The method of claim 1 according to the main request differs from that of document D3 in that in the claimed method, the surface is cleaned without any simultaneous deposition of a film, whereas in document D3, there is no cleaning of the substrate surface prior to

deposition, and cleaning and deposition take place simultaneously.

2.3 The problem addressed by the invention as claimed is disclosed in the application in suit as providing a method of cleaning a surface which does not damage the surface in order to prepare the surface for subsequent use, such as deposition of a film onto the surface (cf. item VIII(a) above; the application as published, column 1, lines 43 to 49).

This formulation of the technical problem is also valid having regard to the closest prior art document D3, since as submitted by the appellant, document D3 is primarily concerned with the deposition of a defect-free uniform film on a substrate and to this end employs a beam of ionized clusters of a volatile species to provide *in situ* cleaning of the surface during the simultaneous deposition of the film.

It is generally recognized in the art of thin film deposition that the provision of a clean and defect-free substrate surface is a prerequisite for the *subsequent* growth of a high-quality thin film (cf. D3, page 1, lines 25 to 31).

A skilled person would therefore be routinely confronted with the problem of providing a clean and defect-free surface for the subsequent growth thereon of a high-quality film.

2.4 As held in the decision under appeal, a skilled person reading the disclosure of document D3 would readily understand that the cleaning provided by ionized

clusters is independent from the process of the film deposition. In particular, the beam of the ionized clusters 30 and beam of the specimen 24 to be deposited are independently controllable, and therefore, it would be apparent to the skilled person that the cleaning provided by ion clusters could as well be carried out without simultaneously depositing a film. Therefore, the skilled person faced with the task of ensuring that the surface to be deposited is clean before the film deposition takes place, would consider using the beam of ionized clusters for this purpose, and thereby arrive at the method of claim 1 according to the main request and the first auxiliary request without employing inventive skills.

2.5 The appellant argued in this context that document D3 is solely concerned with a process of depositing a thin film and not with the problem of providing a clean surface for subsequent use, and therefore, a skilled person seeking a find a process of cleaning a surface would not consider document D3 at all (cf. item VIII(a) above).

As also admitted by the appellant, the process of cleaning a substrate surface is not an end in itself, but must be seen in the context of preparing the substrate surface for a subsequent process step, such as forming a thin film on the substrate surface. In the case of depositing a thin film, the quality of the thin film depends crucially on how free from defects and contaminants the surface is prior to the thin film deposition. Therefore, the skilled person seeking an appropriate method of cleaning a surface prior to depositing a thin film would also consider prior art

documents, such as document D3, which discuss the issue of surface cleaning with a view to preparing the surface for the deposition of thin films.

2.6 The appellant contended that document D3 teaches against cleaning the substrate surface prior to deposition. In this connection, the appellant relied upon the passage on 14, line 29 to page 15, line 7 of document D3 which discloses that the beam of ionized clusters aids in removing defects in the surface, and therefore, according to the appellant, it would infer that the method of document D3 would not depend on having a defect-free substrate surface prior to deposition.

The Board finds, however, that the above-mentioned passages describes how a beam of ionized clusters removes *defects in the thin film* as the thin film is deposited. Therefore, the above passage fails to support the appellant's contention, since it does not disclose that the method of carrying out deposition and cleaning simultaneously would be able to remove *defects in the substrate surface.*

Furthermore, document D3 discloses that cleaning prior to deposition has a different purpose from that of cleaning during deposition (cf. page 2, lines 2 to 21). In the former case, contaminants which are already present on the substrate surface are removed, while in the latter case, *in situ* contaminants, i.e. contaminants which appear during deposition, are removed.

Thus, the Board does not find any passages in document D3 which would support the appellant's contention that cleaning during deposition may be regarded as a replacement for cleaning the substrate surface prior to deposition.

2.7 The appellant argued furthermore that document D3 consistently teaches that cleaning is effected simultaneously with layer deposition. The complicated interplay between the substances of the cluster and those of the thin film would make it impossible to deduce that clusters of chemically unreactive gases may be used to effect non-damage surface cleaning of surfaces. Therefore, the appellant argued, the separation of the deposition and cleaning processes in the method of document D3 would only be possible using hindsight (cf. item VIII(b) above).

Document D3 discloses that the interplay in form of exchange of kinetic energy between the volatile and nonvolatile species improves the uniformity of the deposited film (cf. D3, page 5, lines 17 to 28; page 8, lines 10 to 14; page 14, line 24 to page 15, line 7). Contrary to the appellant's submissions, however, the Board cannot find any indication in document D3 suggesting that a beam of ionized clusters would only be effective for cleaning a surface when it is used simultaneously with depositing a thin film. As disclosed on page 2, lines 2 to 14 of document D3, it was well-known in the art to use a beam of ions of inert species for cleaning surfaces. Therefore, the Board sees no reason why a skilled person would doubt that a beam of ionized *clusters* of inert (chemically unreactive) species would also be effective for

cleaning surfaces. On the contrary, document D3 explains in detail how a beam of ionized clusters creates less damage to the surface to be cleaned than a conventional beam of ions and yet remains effective in cleaning the surface (cf. e.g. D3, page 5, lines 8 to 17; page 14, lines 11 to 23).

2.8 For the above reasons, therefore, the subject matter of claim 1 according to the main request does not involve an inventive step within the meaning of Article 56 EPC.

3. *Inventive step - Auxiliary request*

3.1 Claim 1 according to the auxiliary request differs from claim 1 of the main request in that (i) the clusters are specified to be "a lump-shaped group of atoms or molecules"; (ii) a process step is added whereby ions are subject to mass separation by use of an electric field or a magnetic field (step d)); and (iii) the requirement that the atoms or molecules of the clusters have to be chemically unreactive under the conditions of the irradiation has been deleted.

3.2 Feature (i) is merely intended as a further specification of the term "cluster". Since however both the method described in the application in suit and the method disclosed in document D3 both use the principle of adiabatic expansion through a nozzle for producing clusters, feature (i) is necessarily known from document D3, and is therefore not a distinguishing feature (cf. application as published, column 3, lines 8 to 45; Figure 2; document D3, page 10, lines 7 to 26). This was also not contested by the appellant.

3.3 Thus, in addition to the difference discussed with respect to the main request in item 2.2 above, the method of claim 1 according to the auxiliary request further differs from the method of document D3 in that the ionized clusters are subject to mass separation by use of an electric field or a magnetic field, whereas in document D3, no mass separation of the ionized clusters takes place.

3.4 The mass separation step has the advantage of preventing a spread in size and number of atoms of the cluster, thereby preventing damage in the substrate surface caused by the impact of smaller clusters. This problem is also briefly discussed in document D3, however without offering any solution (cf. D3, page 10, line 37 to page 11, line 9).

3.5 Document D1 discloses a method of depositing a thin film on a substrate where in analogy to the method of document D3 a beam of ionized clusters is directed to the substrate surface to clean the surface during the deposition of the thin film (cf. D1, abstract). As a solution to the problem of having a spread in size of the clusters produced, document D1 suggests to use a mass separator 28 employing an electric or a magnetic field (cf. D1, page 11, lines 24 to 33).

3.6 Thus, the skilled person faced with the task of ensuring that the size of the ionized clusters is uniform would use a mass separator as suggested in document D1 for this purpose.

Therefore, in the Board's judgement, the subject matter of claim 1 according to the auxiliary request does not involve an inventive step within the meaning of Article 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Fabiani R. K. Shukla