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D E C I S I O N
of 26 August 2003

Case Number: T 0758/02 - 3.4.2

Application Number: 95909401.2

Publication Number: 0804638

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Language of the proceedings: EN

Title of invention:
Polishing diamond surface

Patentee:
THE GOVERNMENT OF THE UNITED STATES OF AMERICA, as represented by THE SECRETARY OF THE NAVY

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step after amendments - yes"

Decisions cited:
-

Catchword:
-

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Case Number: T 0758/02 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 26 August 2003

Appellant: THE GOVERNEMENT OF THE UNITED STATES OF AMERICA, as represented by THE SECRETARY OF THE NAVY
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 6 February 2002 refusing European application No. 95909401.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: A. G. Klein
Members: A. G. M. Maaswinkel
G. E. Weiss

Summary of Facts and Submissions

I. The appellant lodged an appeal, received on 15 April 2002, against the decision of the examining division, dispatched on 6 February 2002, refusing the European patent application 95909401.2. The fee for the appeal was paid on 15 April 2002 and the statement setting out the grounds of appeal was received on 13 June 2002.

The examining division objected that the application did not meet the requirements of Article 52(1) EPC because the subject-matter of the second independent process claim 10 then on file was not allowable under Article 56 EPC having regard to the teaching of document

(D1) US-A-5 269 890.

II. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: 1 to 15 ("Main request - Annex A2") filed on 11 July 2003 with letter of 10 July 2003;
Description: pages 1, 2, 2a, 3 to 12 filed on 11 July 2003 with letter of 10 July 2003;
Drawings: sheets 1/2 and 2/2 filed on 11 July 2003 with letter of 10 July 2003.

III. The wording of independent claim 1 reads as follows:

"A process for smoothing a diamond surface containing asperities thereon comprising the steps of:

(a) implanting ions in the diamond surface to form non-diamond carbon on the diamond surface and the asperities, and

(b) removing the non-diamond by electrochemical etching,

wherein said step of implanting ions is done by directing an ion beam at an angle of less than 90° from the diamond surface, and is accomplished with ion beam at an energy level of about 1×10^4 to about 1×10^7 electron volts."

The wording of independent claim 11 reads as follows:

"A process for polishing a diamond containing asperities thereon comprising the steps of:

(a) forming non-diamond carbon in the diamond and the asperities;

(b) dissolving the non-diamond carbon disposed on the diamond and the asperities; and

(c) turning the diamond to form non-diamond carbon around the asperities;

wherein the step of forming the non-diamond carbon is accomplished by directing an ion beam having an energy of about 1×10^4 to about 1×10^7 electron volts at the diamond at an angle of less than 90° with respect to the diamond, and wherein the step of dissolving the non-diamond carbon is accomplished by submerging the non-diamond carbon in a liquid having an electric field of sufficient strength to remove the non-diamond carbon."

Claims 2 to 10 and claims 12 to 15 are dependent claims.

IV. The appellant's arguments may be summarised as follows:

Claim 1 is a combination of claims 1, 2 and 4 as originally filed. Claim 11 is a combination of claims 15 and 16 as originally filed. Newly filed claims 9, 10, 14 and 15 are supported by the passage in page 4, line 37 to page 5, line 2 of the original description. The further dependent claims find their support in the originally filed dependent claims. The amendments in the description include an acknowledgement of the closest prior art, an amendment of the summary of invention and the correction of some minor clerical errors which should be admissible under Article 123(2) EPC.

The novelty of the subject-matter of the claims was not disputed by the examining division. In the impugned decision document D1 was cited as the closest prior art. The independent process claims differ commonly from the teaching of document D1 by the use of an ion beam incident at an angle of less than 90° from the diamond surface and in that this ion beam has an energy level of about 1×10^4 to about 1×10^7 electron volts. These technical features entail the smoothing or polishing of a diamond surface without effecting irreversible and non-annealable damages on its surface. For the issue of inventive step the question has to be answered whether the prior art as a whole *would* prompt the skilled person to modify the teaching of document D1 in a straightforward way. Document D1, however, fails to provide a guidance to use an ion implantation angle different from 90°. In fact, it is noted that an implantation angle of 90° on an asperity leads to damaging the asperities but also -at the same time- the

planar surfaces of the diamond around the asperities, which results in new undesirable damages around the asperities. The inventors have recognised that by applying ion implantation under an oblique angle the new and unexpected effect results that the asperity is damaged, but not the planar surface. There is no disclosure or hint in the prior art suggesting this process step.

As to the further prior art, document US-A-5 154 023 cited in the Supplementary European Search Report and in the following referred to as document D2, this document discloses a process for polishing refractory materials including CVD diamond films by softening the operative surface to a predetermined depth by forming a soft ion-implanted layer therein and mechanical polishing and repeating. The process utilises ion implantation *normal* to the surface to be polished to repeatedly create a damaged, softened ion implanted region whose asperities are removed by *mechanical* polishing. Therefore since neither document D1 nor D2 disclose applying the ion beam under an oblique angle and since this feature solves the technical problem of softening the asperities so that these may be removed without at the same time damaging the planar diamond surface the claimed process of claims 1 and 11 involves an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The board is satisfied that the amendments in the claims are fairly supported by the passages in the original application documents referred to by the appellant. The adaptation of the description and the acknowledgement of the prior art are equally admissible.

3. *Patentability*

3.1 Novelty

3.1.1 Document D1

Document D1 discloses a process for the removal of non-diamond carbon from a surface on a substrate by submerging it in an electrochemical apparatus, (Figure 1). The main application of the process lies in the definition of patterns of non-diamond carbon on a substrate, see column 8, lines 22 and 23. As shown in Figure 1 and disclosed in column 6, lines 32 to 45, photoresist patterns 28 are placed on the non-diamond carbon layer and the non-exposed parts of this layer are etched away in the electrolytic bath. In a subsequent step the photoresist is stripped off leaving the patterned non-diamond carbon layer. In lines 29 to 31 of column 6 it is disclosed that the non-diamond carbon layer may be formed in the surface of a diamond substrate by ion implantation at a typical energy of

40 KeV (*see Examples 1 to 4*). Document D1 does not refer to the smoothing of a diamond surface containing asperities, furthermore the document is silent with respect to the angular direction of the applied ion beam to the diamond surface.

3.1.2 Document D2

This document discloses a process for polishing or smoothing a refractory material which may be diamond with a surface containing asperities, see Figure 3 and column 4, lines 48 to 50. In the process ions having an energy of 5000 KeV are implanted in the diamond surface (Figure 4 and column 4, lines 58 to 60) to form non-diamond carbon on the diamond surface and in the asperities (column 5, lines 26 to 49). The non-diamond material is removed by mechanical polishing (Figure 5; column 5, lines 52 and 53). Document D2 does not disclose the removing of the non-diamond material by electrochemical etching. The document does also not include any disclosure with respect to the angular direction of the ion beam in the ion-implantation step.

3.1.3 The further documents are less relevant.

3.1.4 Therefore the subject-matter of claims 1 and 11 is novel (Articles 52(1) and 54 EPC).

3.2 Inventive step

3.2.1 Closest prior art

Independent claims 1 and 11 relate to a process for *smoothing* (Claim 1), respectively for *polishing*

(Claim 11) a diamond containing asperities. In accordance with the problem and solution approach, the closest prior art for assessing inventive step should be a prior art document disclosing subject-matter conceived for the same purpose or aiming at the same objective as the claimed invention and having the most relevant technical features in common, see Case law of the Boards of Appeal of the European Patent Office. 4th edition 2001, Chapter I.D.3.1.

3.2.2 Although document D1 discloses a process for "removal of non-diamond carbon from a diamond surface" (*see Abstract*) the aim of this process is to enable the *patterning* of the surface (*see Figures 1 to 3*) which is carried out by applying a photoresist pattern onto the non-diamond carbon surface and electrochemically etching the unprotected part of this layer. Therefore the object pursued in document D1 is not smoothing a diamond surface, but the inverse. Since the purpose in document D1 is to *pattern* the non-diamond carbon surface and is silent about roughness or asperities of the original diamond surface, the skilled person wishing to *smooth* or *polish* a diamond surface would not have consulted document D1 as a suitable starting point.

In the decision under appeal the examining division had made reference to the passage in D1 in column 2, lines 27 to 29, "*Removal of non-diamond carbon from a surface can be used to polish and clean the surface*" and had argued that the use of the method known from D1 for polishing inherently implied the presence of asperities on the diamond surfaces. To the board's understanding the cited phrase must be read in the context of the passage following this sentence

"*Surprisingly, it can also be applied to patterning a substrate by selectively removing the non-diamond carbon from the surface of a substrate without any direct or physical electrical contact between the substrate and the electrodes*" which is the actual purpose aimed at in this disclosure. Since the problem of surface roughness or asperities is not referred to in D1 at all, the use of this document as a starting point for the problem and solution approach would appear to be based on hindsight.

3.2.3 Document D2 pursues the same purpose as the process in the patent application under appeal and is therefore considered as the closest prior art.

3.2.4 Document D2

The subject-mater of independent claims 1 and 11 differs from the smoothing or polishing process disclosed in D2 (*see Section 3.1.2 supra*) in the features:

(a) the non-diamond is removed by *electrochemical etching*, whereas in the process disclosed in document D2 the softened material is removed by mechanical polishing; and

(b) the ion beam is applied at an angle of *less than 90°* from the diamond surface.

3.2.5 The objective problem addressed by these differences could be seen in offering an alternative smoothing/polishing process. The formulation of this technical problem is, as such, not regarded as

inventive. Therefore it should be discussed whether the skilled person, starting from the disclosure in document D2, would have an incentive to modify the prior art polishing process by the features (a) and (b).

3.2.6 With respect to feature (a) the modification of the *mechanical* material removing step to an *electrochemical* step would be a possible alternative. The skilled person knows, for instance from document D1, that non-diamond carbon may be removed by disposing the object in an electrochemical bath. However, as can be seen from Figures 5 and 7 in document D2, it is intrinsic to the *mechanical* removal of the upper peaks (22 in Figure 5; 42 in Figure 7) that in the "valleys" (38 in Figure 6) the non-diamond material is not removed and that -during the next cycle of ion beam implantation of the substrate surface(see Figure 8)- the beam will be absorbed in these filled valleys. Therefore by the repetitive application of ion beam implantation and mechanical polishing gradually all peaks are removed and a polished surface results (Figure 10). In contrast, if the irradiated and softened material were removed electrochemically, *all* non-diamond material would be etched away and the resulting surface would still show the original roughness pattern or asperities. Therefore a modification of the polishing technique disclosed in document D2 by replacing the mechanical polishing step by an electrochemical removal of the softened layer would be detrimental to the result of the process and the skilled person would consequently reject such a measure.

3.2.7 As to feature (b), document D2 only discloses the application of an ion implantation step as such and is

silent about the angle of incidence of the ion beam with respect to the diamond surface. According to column 5, lines 43 to 53, the ion implantation affects the orientation of the crystal lattice structure and causes a transformation of the structure to a quasi-amorphous and mechanically softened state. Tilting the direction of the ion beam incident to the diamond surface would not have an effect on this transformation, therefore it is not obvious why a skilled person *would* contemplate introducing feature (b) in the process disclosed in document D2.

3.2.8 Document D1

As explained in Section 3.2.2 *supra*, the board is not convinced that document D1 represents the closest prior art, because apart from the teaching that non-carbon disposed on a surface may be removed by electrochemical means and that this removal can be used to polish and clean the surface this document does not address the polishing process. Therefore at most the skilled person would learn from this document that an ion beam may be used for implantation and softening of the surface and that the softened and electrically conductive surface may be etched in an electrochemical bath. Neither document D1 nor the further available documents disclose or hint at a beneficial influence on removal of surface roughness or asperities by tilting the direction of the ion beam. Therefore, in the opinion of the board, the process defined in claims 1 and 11 is not obtainable in an obvious way from the prior art documents and the subject-matter of these claims involves an inventive step within the meaning of Article 56 EPC.

3.2.9 The further claims 2 to 10 and 12 to 15 are dependent on the independent claims and are therefore equally allowable.

4. For the above reasons, the board finds that the request of the appellant meets the requirements of the EPC and that a patent can be granted on the basis thereof.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of the first instance with the order to grant a patent on the basis of the following documents:

Claims: 1 to 15 ("Main request - Annex A2") filed on 11 July 2003 with letter of 10 July 2003;

Description: pages 1, 2, 2a, 3 to 12 filed on 11 July 2003 with letter of 10 July 2003;

Drawings: sheets 1/2 and 2/2 filed on 11 July 2003 with letter of 10 July 2003.

The Registrar: The Chairman:

P. Martorana A. Klein