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Datasheet for the decision of 20 October 2011

Case Number: T 0606/08 - 3.2.07

Application Number: 95917098.6

Publication Number: 0757615

IPC: B26B 21/60, C23C 14/06

Language of the proceedings: EN

Title of invention:
Process of coating a layer of amorphous diamond on blades

Patent Proprietor:
The Gillette Company

Opponent:
Eveready Battery Company, Inc.

Headword:
-

Relevant legal provisions:
EPC Art. 56, 84, 123(2)
RPBA Art. 13(1), 13(3)

Keyword:
"Allowability of amendments (main and second auxiliary requests - no)"
"Admissibility of fourth auxiliary request filed at oral proceedings (yes)"
"Inventive step (all remaining requests - no)"

Decisions cited:
T 0172/82

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0606/08 **-** 3.2.07

D E C I S I O N
of the Technical Board of Appeal 3.2.07
of 20 October 2011

Appellant: (Patent Proprietor)
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Decision under appeal:
Decision of the Opposition Division of the European Patent Office posted 24 January 2008 revoking European patent No. 0757615 pursuant to Article 101(3)(b) EPC.

Composition of the Board:

Chairman: H. Meinders
Members: H. Hahn
E. Dufrasne

Summary of Facts and Submissions

I. The appellant (patent proprietor) lodged an appeal against the decision of the Opposition Division to revoke the European patent EP-B-0 757 615.

II. The following documents are cited in the present decision:

Of the opposition proceedings:
D1 = US-A-5 295 305
D2 = "The cathodic Arc Plasma Deposition of Thin Films", Philip C. Johnson, Physics of Thin Films, Vol. 14, Academic Press Inc., 1998 (ISBN 0-12-533014-6), pages 129-199
D4 = "Diamond-like Carbon films synthesized by cathodic arc evaporation", B.F. COLL et al., Thin Solid Films, 209 (1992), pages 165-173
D5 = WO-A-95/29044 (corresponding to the application as originally filed underlying the patent in suit)
D6 = S. Aisenberg et al., "Ion-Beam Deposition of Thin Films of Diamondlike Carbon", Journal of Applied Physics, Vol. 42, No. 7, June 1971, pages 2953-2958
D7 = P.J. Fallon et al., "Properties of filtered-ion-beam-deposited diamondlike carbon as a function of ion energy", Physical Review, Vol. 48, No. 7, 15/8/1993, pages 4777-4782

Filed in the appeal proceedings:
Gillette's Technical Report No. 4449, title page and pages 1, 17 and 18
Gillette's Technical Report No. 4421, pages i, ii, iii, 8 and 14

III. The opposition had been filed against the patent in its entirety under Article 100(a) EPC, for lack of inventive step. After the Opposition Division had raised *ex officio* an objection under Article 100(c) EPC, that the patent extends beyond the content of the application as originally filed, the opponent adopted this objection with its letter dated 19 October 2007.

The Opposition Division considered D6 and D7, although being late filed, *prima facie* relevant and therefore introduced them into the proceedings. It further held that the subject-matter of claim 1 as granted according to the main request represented an unallowable intermediate generalisation and therefore contravened Article 123(2) EPC. It further considered that the subject-matter of claim 1 of auxiliary request I filed with Fax dated 22 October 2007 complied with Articles 123(2) and 84 EPC, but lacked an inventive step in view of an obvious combination of the teachings of D1 and D6, the latter in association with the background knowledge of D7. Auxiliary request II filed during the oral proceedings before the Opposition Division was considered not to be admissible, according to Rule 71a EPC 1973, for being filed too late and since the additional features were taken from the description and designated therein as being "conventionally known". As a result the patent was revoked.

IV. With a communication dated 22 July 2011 and annexed to the summons to oral proceedings the Board presented its preliminary opinion with respect to the claims of the main request and first auxiliary request as filed with the grounds of appeal and the second to fifteenth

auxiliary requests as filed with letter dated 12 October 2010.

None of the sixteen requests appeared to be formally allowable under Article 123(2) and/or Article 84 EPC.

With respect to the issue of inventive step the Board remarked amongst others that D1 appeared to represent the uncontested closest prior art and that it should be discussed whether or not D7 belonged to the common general knowledge.

It appeared that Gilette's Technical Report No. 4449, and particularly its figure 10, did not support the alleged criticality of the maximum duration of 2 minutes for applying the high bias according to claim 1 of the main request (see point VIII) for the adhesion of the amorphous diamond coating.

Furthermore, it appeared that by applying the cathodic arc deposition process known from the text book D2 according to the more up to date knowledge as evidenced by D7, in the process for producing diamond coated razor blades of D1, while applying ordinary skills the person skilled in the art arrives in an obvious manner at the subject-matter of claim 1 of the main request.

The Board further remarked that if claim 1 of the main request were to be understood as excluding an intermediate layer it would be discussed whether or not the skilled person would try to omit this intermediate layer.

V. With letter dated 20 September 2011 the appellant replaced the sixteen requests by a new main request and new first to third auxiliary requests accompanied by arguments concerning the allowability of the amendments made as well as the patentability of the subject-matter of their claims, basically taking account of the Board's comments in the annex to the summons.

VI. With letter dated 22 September 2011 faxed on 23 September 2011 the appellant submitted adapted description pages for the first to third auxiliary requests.

VII. Oral Proceedings before the Board were held on 20 October 2011. To start, the allowability of the amendments made to claim 1 of the main request was discussed. The negative conclusion thereto likewise applied to the second auxiliary request which comprised the identical amendment. Thereafter the allowability of the amendments made to claim 1 of the first auxiliary request was discussed which discussion resulted in the filing of amended new first and third auxiliary requests. Subsequently, inventive step of the subject-matter of claim 1 of the first auxiliary request was discussed, particularly in view of D1, D2, D4 and D7 and the two Gillette technical reports. This was followed by the issue of inventive step of claim 1 of the new third auxiliary request which resulted in the filing of a further, fourth, auxiliary request, of which the admissibility was discussed.

(a) The appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of: the main request,

filed with letter dated 20 September 2011; or in the alternative, the first auxiliary request, filed during the oral proceedings; or the second auxiliary request, filed with letter dated 20 September 2011; or one of the third and fourth auxiliary requests, filed during the oral proceedings.

(b) The respondent requested that the appeal be dismissed.

At the end of the oral proceedings the Board announced its decision.

VIII. Independent claim 1 of the main request reads as follows (amendments compared to claim 1 as granted are in bold; emphasis added by the Board):

"1. A process for forming a razor blade wherein a layer of amorphous diamond (60) is deposited on a substrate (50) **using a cathodic arc source**, comprising the steps of:
(a) providing a substrate;
(b) forming a wedge-shaped sharpened edge on said substrate that has an included angle of less than thirty degrees and a tip (52) radius of less than 1,200 angstroms; and
characterized by
(c) depositing a layer (60) of amorphous diamond on said sharpened edge; applying an initial high bias **in the range of 200 to 2,000 Volts** to the substrate (50) during deposition **for up to two minutes to establish adhesion**, and then applying a second lower bias **in the range of 10 to 200 Volts** to the substrate during

deposition **to optimize the structure of the amorphous diamond coating**."

IX. Claim 1 of the first auxiliary request differs from that of the main request in that step (b) has been amended to read "forming a wedge-shaped sharpened edge **having a tip (52)** on said substrate that has an included angle of less than thirty degrees and a tip ~~(52)~~ radius of less than 1200 angstroms; and" while in step (c) the first feature "**at an equal rate or simultaneously on both sides of the substrate**" was incorporated between the passages "… sharpened edge" and "; applying an …" while the second feature "**, wherein the angle of presentation is greater than 20° but less than 90°, the angle being measured from the line bisecting the angle enclosed by the tip and first and second inclined surfaces of the sharpened edge**" was added as the last feature of claim 1.

X. Claim 1 of the second auxiliary request is based on claim 1 of the main request but defines in step (a) a "**steel**" substrate.

XI. Claim 1 of the third auxiliary request is based on claim 1 of the first auxiliary request and defines also in step (a) a "**steel**" substrate.

XII. Claim 1 of the fourth auxiliary request differs from that of the third auxiliary request in that in step (c) the feature "on said sharpened edge" was replaced by the feature "**directly on said sharpened edge of said steel substrate**".

XIII. The appellant argued essentially as follows:

Claim 1 of the main request is based on original claims 1 and 6 in combination with the deposition steps taken from page 13, lines 25 to 32 of the application as originally filed (corresponding to the published D5). It is clear to the person skilled in the art that said bias voltage values are negative. The omission of the feature "to establish the desired **crystal** structure" which the Board in its communication considered to be inconsistent with the definition "amorphous diamond" is in line with decision T 172/82 (see OJ EPO 1983, 493). There is no need to incorporate the term "hard carbon" after the expression "amorphous diamond" as disclosed at page 13, lines 30 and 31 of D5 (the application as originally filed) since it is clear that the resulting amorphous diamond coating is a particularly hard carbon (see patent, paragraph [0007]).

It is disagreed with the Board that the features of equal deposition on both sides of the blade and the angle of presentation represent essential features of the claimed process. Even a razor blade which is coated only on one side or unevenly coated (see e.g. D5, page 15, lines 8 to 11) is suitable for the intended purpose. The passage at page 13, lines 21 to 24 of D5 does not imply that all these features have to be combined. These two features only result in the deposition of amorphous diamond on the sharpened edge which, according to the other features of claim 1, already takes place there. Hence the omission of these two features is not considered to contravene Articles 84 and 123(2) EPC.

In order to overcome the objection under Article 123(2) EPC the two omitted features have been incorporated into claim 1 of the new first auxiliary request and the definition of the angle of presentation is based on the second alternative disclosed on page 15, lines 18 to 21 of D5.

D1 is considered as the closest prior art for disclosing a method for coating a razor blade with a diamond-like carbon (DLC) coating after cleaning the substrate with argon plasma for 5 minutes and depositing an intermediate niobium layer on which the DLC layer is then deposited by sputtering (see column 4, lines 43 to 67). Figure 5 of D1 shows a Raman spectrum with two overlapping peaks at about 1331 cm^{-1} and 1550 cm^{-1}, corresponding to sp^3 bonding and sp^2 bonding, respectively (see figure 5 and column 1, lines 37 to 40). This spectrum cannot be interpreted as indicating the presence of 50% of each since it would need to be calibrated for such an analysis.

The objective technical problem has been set out in the grounds of appeal (see page 3, paragraph 4). The amorphous diamond coatings according to the patent in suit comprise at least 40% sp^3 bonding (see patent paragraph [0007]) and thus have a higher degree of sp^3 bonding than the DLC coating of D1, which has been identified as prior art in the patent from the outset, the coating of this prior art using sputtering not being entirely successful and resulting in a lower hardness (see patent, paragraphs [0004] and [0005]). The key point is to have a coating with improved mechanical properties which adheres well to the underlying steel substrate. This problem is solved by

the subject-matter of claim 1 and results in improvements with respect to the hardness of the coating and in an aspect ratio of greater than 2:1 which is responsible for the improved sharpness of the coated razor blade (see patent, column 5, line 51).

The Opposition Division relied on D6 in its decision but its sputtering process cannot suggest the cathodic arc plasma deposition (CAPD) process as claimed and as forming part of D2 or D7.

It is admitted that D2 teaches that the adhesion is improved but D2 does not teach the person skilled in the art that the CAPD process results in a harder coating since it only speculates about its future potential for the deposition of diamond-like carbon (see page 194). D2 discloses two alternatives for the cleaning: either with noble gas ions or with ions from the target material of the arc source but does not mention that the latter one should be done to improve the hardness (see pages 171 and 173). Even if there would be no difference with respect to the hardness of the claimed amorphous diamond coating then D2 would not allow to arrive at the claimed solution since D1 shows that a good adhesion can already be obtained by plasma cleaning the surface with argon ions for 5 minutes, i.e. there is no need to change the cleaning step.

D7 shows that the content of sp^3 bonding is attributed to the bias voltage and according to its process an amorphous diamond coating is deposited containing a high amount of sp^3 bonding on flat Si-substrates. It does not describe any cleaning step or bombardment with high energy ions. Razor blades have a complex shape and

are different from the flat Si wafers according to D7. In view of the disclosure of D7 the skilled person would not expect a higher hardness and even if he would, he would still end up with a process having the 5 minute plasma cleaning step with argon ions according to D1. The two step deposition as set out in claim 1 is not disclosed in D7 but is essential for a proper adhesion.

The importance of the two step deposition with the high bias in the first step can be derived from the two Gillette technical reports (see Report No. 4421, page 8, last paragraph; Report No. 4449, figure 10). Particularly figure 10 shows that the first step is critical for the adhesion. Report no. 4421 also discloses that adhesion on flat substrates is insensitive to all process variables while adhesion on blade edges depends on a number of parameters (see page 14, second paragraph). The two reports show the tendency of adhesion in view of the length of the first high bias step but do not reveal values higher than 120 seconds for this step.

D4 teaches replacement of sputtering by CAPD and deposits the DLC coating on steel or Si-substrates. D4 obtains a DLC layer with relatively high sp^2 bonding (see the Raman spectrum of figure 9: the peak at 1500 cm^{-1} corresponds to the sp^2 bonding). According to an example of D4 the CADP process, which applied a cleaning step with hydrogen or argon plasma at a bias voltage of -1000 volts for 10 minutes, resulted in a powdery coating on an HSS substrate (see page 167, right hand column). Therefore there exists a prejudice for the person skilled in the art to use CAPD for

obtaining well adhering DLC films. If D7 belongs to the common general knowledge then this conclusion should also apply to D4.

Therefore the subject-matter of claim 1 of the first auxiliary request is not rendered obvious by the teachings of the discussed prior art.

Claim 1 of the new third auxiliary request has been amended in line with the first auxiliary request but additionally specifies the "steel" substrate which has a basis at page 4, lines 35 and 36 of D5.

The formation of an intermediate layer, e.g. niobium, according to D1 is essential and the DLC layer is deposited thereon. It argued that according to claim 1 of the third auxiliary request the deposition takes place directly on the steel substrate and results in a simplification of the process by omitting this intermediate layer. It is clear from the wording of claim 1: "providing a steel substrate", "… forming a wedge-shaped sharpened edge on said substrate" and "depositing a layer (60) of amorphous diamond on said sharpened edge" that the coating is directly applied.

The other documents cannot suggest this solution since D7 only discloses coating of Si-substrates and D2 does not provide any information in this respect, at least not with an amorphous diamond coating. D4 on the other hand obtains only a poor adhesion by the low degree of sp^3 bonding in the coating on a steel substrate while D6 does not relate to a CAPD process.

Process claim 1 of the new fourth auxiliary request overcomes the objections raised with respect to claim 1 of the third auxiliary request and now clearly specifies that the coating is "directly" applied to the steel substrate. Claim 1 of this request is based on claims 1 and 12 of the third auxiliary request, the latter being derivable from page 2, lines 30 to 35 of D5.

The new fourth auxiliary request should be admitted into the procedure because the appellant has always argued that the amorphous diamond coating is directly applied to the steel substrate, i.e. no new issue requiring an additional discussion is created. The arguments presented for the third auxiliary request fully apply for this new request.

XIV. The respondent argued, insofar as relevant for the present decision, essentially as follows:

Since claim 1 is directed to a process claim any functional or purpose terms disclosed in the description in the context of the amendments made should be incorporated into claim 1 in order to ensure that the result is actually achieved. Further, the claimed two bias voltages should be negative voltages. Feature (c) of claim 1 of the main request represents an intermediate generalisation of the two passages disclosed in D5 at page 13, lines 21 to 24 and at page 13, lines 25 to 32 since a two-step bias deposition without an equal deposition on both sides of the blade and without the angle of presentation is not directly and unambiguously derivable from the

disclosure of D5. Therefore claim 1 of the main request contravenes Article 123(2) EPC.

No further objections under Articles 84 and/or 123(2) EPC are raised against claim 1 of the new first auxiliary request.

There appears to be confusion what is a DLC coating and what is an amorphous diamond coating. According to D4 amorphous carbon films comprise sp^3 bonding and have a diamond-like structure (DLC) (see page 165, left hand column, first sentence; abstract). According to D7 amorphous carbon contains significant tetrahedral sp^3 bonding, which is responsible for the high hardness, and it is often referred to as "diamondlike carbon" (DLC) (see page 4777, left hand column, first two sentences). Taking account of the definitions in these two scientific documents which do not distinguish between DLC and amorphous diamond, one cannot see the difference between the DLC coating according to D1, which has substantial sp^3 bonding (see column 1, lines 25 and 36 to 40 and figure 5), and the amorphous diamond coating according to the patent in suit, since the latter "may be characterized as having at least 40% sp^3 bonding" (see patent, paragraph [0007]). There exists also no evidence supplied by the appellant which would allow distinguishing between these two definitions. According to figure 5 of D1, which shows two peaks of the same height in the Raman spectrum, the content of sp^3 bonding appears to be 50%, and even if a calibration would be needed to derive the exact value from this Raman spectrum, an error of more than 20% would be necessary to prevent arriving at the disclosed minimum value of 40% sp^3 bonding according to the patent

in suit. Hence any improvement of the hardness as compared to the DLC coating of D1 cannot be seen. Furthermore, claim 1 of the first auxiliary request does not contain any corresponding restriction with respect to parameters of the amorphous diamond coating e.g. the hardness or the amount of the sp^3 bonding, the aspect ratio or the sharpness.

No detailed information with respect to the Raman spectrum of figure 9(b) of D4 is available but D4 itself mentions that it is odd (see page 170, right hand column, last paragraph to page 171, left hand column).

D1 is undisputedly considered as the closest prior art, and presents as such for claim 1 of the first auxiliary request its preamble. D1 relates thus to the same technical problem as the patent in suit. The distinguishing features are comprised in feature (c) of claim 1. D1 aims to improve the hardness and corrosion resistance of the shaving edge by depositing a DLC coating (see column 1, lines 19 to 25). Although the sharpness is not defined in claim 1 of the first auxiliary request the disclosed aspect ratio of 2:1 to 4:1 of the amorphous diamond coating according to the patent in suit (see patent, paragraph [0011]) overlaps with the range of 1:1 to 3:1 according to D1 (see column 2, line 62). Hence there exists no improvement with respect to the sharpness nor for the hardness of the coating according to the patent in suit when compared with D1. There is also no evidence on file showing any improvement of the adhesion of the amorphous diamond coating according to the patent in suit in comparison with that of D1. Consequently, all

these unproven alleged effects need not be considered for the definition of the technical problem underlying claim 1 of the first auxiliary request. The objective problem is therefore considered to merely represent the provision of an alternative deposition process starting from the teaching of D1.

Textbook D2 is generally concerned with CAPD of thin films. It mentions that with this method DLC films exceeding the microhardness of diamond have been produced (see page 176, fourth paragraph), that the potential of this method for the deposition of DLC has been demonstrated and that such DLC coating will be a major application thereof (see page 194, second and fourth paragraphs). D2 further discloses that good cleaning is of vital importance for the adhesion and that the substrates have to be cleaned by high-energy ion bombardment with a high negative bias and that the deposition then takes place at a reduced bias voltage (see pages 171 to 172, paragraph "Coating Cycle"). The outstanding adhesion of the films of the CAPD process results from the high deposition energies involved and said cleaning of the substrate at high bias of -500 to -2000 volts results in a bombardment with either noble gas ions or ions from the arc source itself and additionally heats the substrate which further promotes good coating adhesion (see page 173, paragraph "Adhesion"). The voltage range of D2 thus broadly overlaps with that of 200-2000 volts of claim 1 of the first auxiliary request. The process is further simplified when the ions from the arc source itself are taken for the cleaning step since no further gas or reactant is needed.

D7 teaches that a higher content of sp^3 bonding results in higher hardness of the amorphous carbon coating and that the optimum is obtained at a bias of about -100 volts (see figure 5 and page 4777, left hand column, first paragraph). The amorphous DLC coatings of D7 were deposited from a filtered beam of carbon ions produced by CAPD (see page 4777, paragraph "Experimental Details"). If the skilled person wants to have a hard coating he would select the conditions of bias voltage where he gets the maximum of sp^3 bonding. The incentive for doing so was provided in D2.

D1 teaches that sp^3 bonding is essential to obtain a hard coating and that a substantial amount thereof is necessary and D7 teaches in its figure 5 how to achieve this result. Consequently, claim 1 of the first auxiliary request lacks inventive step.

No effect of the claimed measures has been shown with respect to the prior art. D4 does not represent a prejudice since it is a single statement in the prior art and actually discloses that the DLC films exhibited good hardness and an excellent adhesion level on high speed steel (HSS) substrates (see abstract).

No formal objections are raised with respect to claim 1 of the third auxiliary request.

However, the wording of claim 1 of this request still does not exclude any intermediate layer, particularly when considering dependent claim 12 of this request which explicitly defines the direct deposition of the amorphous diamond coating onto the substrate, so that the arguments with respect to lack of inventive step of

claim 1 of the first auxiliary request fully apply to this request.

Furthermore, D2 mentions the deposition onto metal parts (see page 171, paragraph "5 Coating Cycle") while D4 mentions the promising mechanical results on HSS substrates (see abstract). Hence claim 1 of the third auxiliary request lacks inventive step for this reason as well.

Claim 1 of the fourth auxiliary request is not objected to under Articles 123(2) and/or 84 EPC but this request could have been presented much earlier than in the final stage of the oral proceedings before the Board, in view of the comments made by the Board in its communication annexed to the summons to oral proceedings (see points 5.2 and 5.7). This late filed request should therefore not be admitted.

D1 is still considered as closest prior art document which mentions that the DLC coating can delaminate from a Mo intermediate layer due to electrochemical reaction. On the other hand, if the skilled person follows the arc cleaning and deposition bias voltage conditions as set out in D2 (see pages 171 and 173) he would expect to obtain a well adhering coating. The skilled person would therefore at least try to provide the DLC layer directly onto the substrate. The more so in view of the disclosure of D4, reporting an excellent adhesion (see abstract). Therefore claim 1 of the fourth auxiliary request lacks inventive step as well.

Reasons for the Decision

1. *Allowability of amendments (Articles 84 and 123(2) EPC)*

Claim 1 of the main request

1.1 Process claim 1 of the main request has been restricted to the use of a cathodic arc source (see point VIII above); it is based on original claims 1 and 6 in combination with the bias voltage ranges of the two deposition steps taken from page 13, lines 25 to 32 of the application as originally filed (corresponding to the published D5). The deposition steps are disclosed as: "An initial high bias in the range of 200-2000 volts is applied to the substrate during deposition for up to two minutes to establish adhesion. A second stage lower bias in the range of 10-200 volts is then applied to optimize the structure of the amorphous diamond hard carbon coating and to establish the desired crystal structure" (emphasis added by the Board).

1.1.1 It goes without saying that said bias voltage values are negative so that the missing minus signs need not be incorporated into claim 1.

1.1.2 The omission of the feature "to establish the desired crystal structure" in the amendment, which the Board in point 4 of its communication considered to be inconsistent with the definition "**amorphous** diamond", is in the present case, in line with decision T 172/82 (see OJ EPO 1983, 493), not to be objected under Article 123(2) EPC since its inclusion would result in an inconsistency contrary to Article 84 EPC. Amorphous diamond normally does not have a crystal structure.

1.1.3 There exists also **no** need to incorporate the term "hard carbon" after the expression "amorphous diamond" (see point 1.1 above) since it is clear that the resulting amorphous diamond coating is a particularly hard carbon (see patent, paragraph [0007]). The omission of the term "hard carbon" from the amendment thus complies with Article 123(2) EPC.

1.1.4 The aforementioned passage (see point 1.1 above) is the only one in the description of D5 (the same holds true for the claims dependent upon claim 1 as originally filed) which discloses these - originally preferred - two bias voltage ranges and is taken from the paragraph named "Process Conditions and Adjustments." This passage is preceded by the statement "**Process conditions include a multi-step bias to the substrate; an equal average deposition on both sides of the blade; and attention to the angle of presentation**" (see D5, page 13, lines 20 to 32).

Consequently, according to this more general disclosure the multi-step bias **is to be combined** with an equal average deposition on both sides of the substrate (see also page 14, lines 1 to 3, lines 7 to 9 and lines 29 to 32) and a specific angle of presentation of the substrate to the arc source. This angle is either measured from a line normal to the plane formed by the tips of stacked blades or from the line bisecting the angle enclosed by the tip and the first and second inclined surfaces of the cutting edge of an unstacked blade (see page 15, lines 12 to 23). This disclosure is also in line with the single example of a particular

processing sequence (see page 9, line 9 to page 12, line 8).

1.1.5 The result of this amendment is that claim 1 of the main request - which is now not restricted to depositing a layer of amorphous diamond "at an equal rate or simultaneously on both sides of the substrate" nor to a definition of the angle of presentation - contravenes Article 123(2) EPC, as it has selectively taken up only the bias voltage ranges from the description as originally filed. This amounts to an unallowable "intermediate generalisation" of the two passages disclosed in D5 at page 13, lines 21 to 24 and at page 13, lines 25 to 32 since the two-step bias deposition without the above mentioned two features is **not** directly and unambiguously derivable from D5. A preliminary conclusion to this effect had already been drawn in point 4 of the Board's communication annexed to its summons to oral proceedings.

1.1.6 The arguments of the appellant to the contrary cannot hold for the following reasons.

An argument is that the equal deposition on both sides of the substrate and the angle of presentation of the substrate to the cathodic arc source do not represent essential features of the claimed process. However, this is contradicted by the aforementioned passage of page 13, lines 20 to 24 relating to the process conditions, which include both features. The amendment is therefore not directly and unambiguously derivable from the application as originally filed.

The quoted statement concerning "… an uneven or unbalanced layering" (see D5, page 15, lines 8 to 11) does **not** support the suggestion that the invention could involve the deposition of an amorphous diamond coating on one side of the substrate only. It has to be seen in the context of the disclosure of the whole paragraph comprising it and to which it is restricted. This paragraph, however, deals with preferred forms of depositing the amorphous diamond coating in a thickness of 1000 angstroms **on both sides** of a blade stack, i.e. several substrates, either by a simultaneous deposition **on both sides** or a cyclic alternation **on the first and second side** of the substrate until the desired thickness is built up on both sides (see page 14, line 33 to page 15, line 8). In the Board's view this statement makes only sense in the context of the cyclic alternation embodiment - if there is a simultaneous deposition than there should be equal deposition on both sides of the substrate due to the movement of the substrate or the blade stacks - and could be interpreted as meaning that the cycle lengths for each of the two sides may be different so that the individual intermediate layers produced on the first side of the substrate after a first cycle and on the second side after the second cycle can have different thicknesses (e.g. it may be 100 angstroms on the first side of the substrate after a first coating cycle while that on the second side after the second coating cycle may be 500 angstroms, etc. and so on up to a final total thickness of e.g. 1000 angstroms). This statement, however, does not necessarily imply that the final desired coating thickness on both sides must be different.

1.1.7 Claim 1 of the main request is therefore not allowable.

Claim 1 of the first auxiliary request

1.2 Claim 1 of the first auxiliary request (see point IX above) is based on claims 1 and 6 as originally filed in combination with the features considered inadmissibly left out of the amendment relating to the bias voltage ranges of the two step deposition ("at an equal rate or simultaneously on both sides of the substrate" and "wherein the angle of presentation is greater than 20° but less than 90°, the angle being measured from the line bisecting the angle enclosed by the tip and first and second inclined surfaces of the sharpened edge"), see point 1.1.5 above.
The respondent did not raise any further objections under Articles 84 and 123(2) EPC.

The Board is thus satisfied that claim 1 according to the first auxiliary request now complies with Article 123(2) EPC. Claim 1 is additionally considered to comply with Article 84 EPC.

Due to the restriction to the use of a cathodic arc source, the limitations to the amorphous diamond deposition step (the two bias voltage ranges, the duration of the high bias step, the deposition at an equal rate or simultaneously, the angle of presentation) its subject-matter has been restricted compared to that of claim 1 as granted so that the requirements of Article 123(3) EPC are likewise met.

Claim 1 of the second auxiliary request

1.3 The conclusion of point 1.1.4 above with respect to claim 1 of the main request applies *mutatis mutandis* to claim 1 of the second auxiliary request since it differs from claim 1 of the main request only in that the substrate is further specified as being a steel substrate (see point X above).

Consequently, claim 1 of the second auxiliary request contravenes Article 123(2) EPC, as well. The second auxiliary request is therefore not allowable.

Claim 1 of the third auxiliary request

1.4 The conclusion of point 1.2 with respect to claim 1 of the first auxiliary request applies *mutatis mutandis* to claim 1 of the third auxiliary request since it differs from claim 1 of the first auxiliary request only in that the substrate is further specified as being a steel substrate (see point XI above). Basis for the latter feature is to be found on page 4, lines 35 and 36 of D5.

Consequently, claim 1 of the third auxiliary request complies with Articles 84, 123(2) and (3) EPC.

Claim 1 of the fourth auxiliary request

1.5 Claim 1 of the fourth auxiliary (see point XII above) is based on claims 1 and 12 of the third auxiliary request, with the additional feature of depositing the amorphous diamond coating directly on the substrate, which is derivable from page 2, lines 30 to 35 of D5.

The respondent did not raise any objections under Articles 84 and/or 123(2) EPC.

Consequently, the Board is satisfied that claim 1 of the fourth auxiliary request complies with Articles 84, 123(2) and (3) EPC.

2. *Procedural matters*

2.1 The Board remarks with respect to respondent's request concerning the non-admittance of the fourth auxiliary request that the amended independent claim 1 of the fourth auxiliary request as filed during the oral proceedings of 20 October 2011 - which now clearly excludes any intermediate layer between the steel substrate and the amorphous diamond coating - corresponds to the subject-matter on which the appellant's arguments and submissions concerning inventive step always had been clearly based.

2.2 The Board notes that the respondent is correct in that the appellant, in view of the Board's comments made in its communication annexed to the summons to oral proceedings (see points 5.2 and 5.7) should have been aware of the fact that claim 1 of the main request did not exclude any intermediate layer and therefore could have filed the fourth auxiliary request earlier as a response to the Board's communication.

2.3 However, the Board remarks in this respect that it is within its discretion, in accordance with Articles 13(1) and 13(3) RPBA, to allow such a request in view of the non-complexity of the new subject-matter submitted

since, even at this final state of the proceedings and the need for procedural economy, in the present case the other party can reasonably be expected to deal with this specific amendment without adjournment of the oral proceedings. This is due to the fact that in the present case no basically new arguments are required. Neither can it be held that the respondent did not have sufficient time to react to the new request and to produce counterarguments.

2.4 Therefore the respondent's request not to admit the additional fourth auxiliary request into the appeal procedure is refused.

3. *Inventive step (Article 56 EPC) - remaining requests*

Taking account of the arguments presented by the two parties the Board considers that it has not been shown that the Opposition Division's conclusion was wrong in that the subject-matter claimed in the patent in suit lacks an inventive step. The reasons are, however, different from those given in the impugned decision (see point III above).

3.1 This is due to the fact that, as argued by the appellant, the teachings of D6 and D7 actually are **not** compatible with each other. Firstly, D7 relates to a filtered ion beam deposition using a cathodic arc source for generating the ion beam (see page 4777, paragraph "Experimental Details") whereas the ion beam deposition system according to D6 uses a sputter source for generating carbon ions which, through the use of an auxiliary plasma, are transferred into an ion beam which then is deposited on the substrate using a bias

voltage (see D6, pages 2953 and 2954, paragraph "Ion-Beam Deposition System" and figure 1). Secondly, the DLC films according to D6 are additionally presented as being "at least partially crystalline" (see D6, abstract) and appear to have an amorphous carbon outermost surface layer on an underlying crystalline layer (see D6, page 2955, right hand column, paragraph "Crystallographic Determination").

Consequently, it is not technically reasonable to link the technical information provided in the context of the cathodic arc source D7 with the ion beam deposition system of D6.

First auxiliary request

3.2 D1 represents the uncontested closest prior art for process claim 1 of the first auxiliary request. D1 discloses a process for producing razor blades wherein an interlayer of material selected from the group consisting of Si, SiC, V, Ta, Nb, and Nb-Mo alloy and alloys of such materials is deposited on the wedge-shaped sharpened edge of a steel substrate, said edge having an included angle of less than thirty degrees and a tip radius of less than twelve hundred angstroms. A layer of diamond or diamond-like carbon (DLC) having substantial sp^3 carbon bonding is then deposited on said interlayer (see claims 1, 9, 14, 19 and 22; column 1, lines 47 to 68; column 2, lines 19 to 40). D1 aims to improve the hardness and corrosion resistance of the shaving edge by depositing this DLC coating (see column 1, lines 19 to 25) and to improve razor blades having a molybdenum interlayer from which the DLC

coating can delaminate by an electrochemical reaction (see column 1, lines 40 to 46).

The single example of D1 uses a DC planar magnetron sputtering system for coating blade stacks mounted on a carousel which are RF cleaned with argon for 5 minutes. Then a Nb interlayer is applied from a Nb target with a DC bias of -25 V and subsequently an about 2000 angstroms thick DLC layer is deposited from a graphite target with a 13.56 MHz RF bias of 800 W (-420 V DC self bias voltage). Finally a PTFE coating is applied onto the DLC layer (see column 4, line 9 to column 5, line 9).

D1 mentions plasma decomposition of hydrocarbon gases, sputter deposition using ions from either a plasma or an ion gun to bombard a graphite target, directly using a beam of carbon ions, and an ion beam assisted deposition (IBAD) process using either e-beam or sputtering sources as suitable techniques for depositing the diamond or DLC layer (see column 2, lines 19 to 25).

3.3 The process of claim 1 of the first auxiliary request therefore differs from the one of D1 in that:

i) a cathodic arc source is used for the diamond deposition, and
ii) a layer of amorphous diamond is deposited on said sharpened edge at an equal rate or simultaneously on both sides of the substrate; an initial high bias in the range of 200 to 2,000 Volts is applied to the substrate during deposition for up to two minutes to establish adhesion, and then a second lower bias in the

range of 10 to 200 Volts is applied to the substrate during deposition to optimize the structure of the amorphous diamond coating, and the angle of presentation is greater than 20° but less than 90°, the angle being measured from the line bisecting the angle enclosed by the tip and first and second inclined surfaces of the sharpened edge.

3.3.1 The appellant argued that the objective technical problem underlying the impugned patent is to provide a process for forming an amorphous carbon layer which is easier to perform and which provides an amorphous carbon coating having improved mechanical properties, including an improved hardness and sharpness, and which adheres well to the underlying steel substrate.

However, this definition of technical problem cannot hold. First of all, claim 1 does **not** exclude the deposition of any intermediate layer due to the definition "**comprising** the steps of …". Secondly, **no** evidence has been submitted which would prove any improvement of the hardness or sharpness of the amorphous diamond coating when compared with the DLC coating of D1 as will be explained below.

3.3.2 The definitions of the two scientific documents D4 and D7 do **not** distinguish between DLC-diamond-like carbon and amorphous diamond:

a) according to D4 amorphous carbon films comprise sp^3 bonding leading to the diamond-like structure (DLC) (see page 165, left hand column, first sentence; abstract),

b) according to D7 amorphous carbon films contain significant tetrahedral sp^3 bonding, which is responsible for the high hardness, and are often referred to as "diamondlike carbon" (DLC) (see page 4777, left hand column, first two sentences).

Therefore it is **not** known what the difference between the DLC coating according to D1, which has substantial sp^3 bonding (see column 1, lines 25 and 36 to 40 and figure 5), and the amorphous diamond coating according to the patent in suit should be. There exists also no evidence from the side of the appellant which would allow distinguishing between these two definitions.

3.3.3 The amorphous diamond coating according to the patent in suit "may be characterized as having at least 40% sp^3 bonding" (see patent, paragraph [0007]) but the DLC coating of D1 has - as derivable from the Raman spectrum of figure 5 which shows two overlapping peaks of the same height at about 1331 cm^{-1} and 1550 cm^{-1}, corresponding to sp^3 bonding and sp^2 of the DLC coating, respectively - a content of sp^3 bonding of about 50%, and even if a calibration would be needed to derive the exact value from this spectrum, an error of more than 20% would be necessary to not arrive at the minimum value of 40% sp^3 bonding according to the patent in suit. Hence any improvement of the **hardness** - which is linked to the amount of the sp^3 bonding - when compared to the DLC coating of D1, as alleged in paragraph [0007] of the patent, cannot be seen.

3.3.4 Likewise an alleged improved **sharpness** of the amorphous diamond coating according to the patent in suit cannot be seen since the aspect ratio range of 2:1 to 4:1

according to the patent in suit (see patent, paragraph [0011]) broadly overlaps with the aspect ratio range of 1:1 to 3:1 according to D1 (see column 2, line 62).

3.3.5 There is also no evidence on file showing any improvement of the **adhesion** of the amorphous diamond coating according to the patent in suit in comparison with that of D1.

3.3.6 Furthermore, claim 1 of the first auxiliary request does not contain any corresponding restriction with respect to any parameter of the amorphous diamond coating such as the hardness, the aspect ratio/ sharpness or its adhesion.

3.3.7 As remarked by the Board at the oral proceedings it has also not been shown that the duration of the high bias deposition is actually critical, i.e. that a continuation for more than 2 minutes (e.g. 3 minutes) would clearly affect the adhesion of the amorphous diamond coating.

Gillette's Technical Report No. 4449 only shows the adhesion score of 1st and 2nd bevels with respect to the time per bevel at high bias between 0 and 25 seconds (see page 17, figure 10). Gilette's Technical Report No. 4421 shows the adhesion score of the initial bias between 0 and about 25 seconds (see page 14, figure 9). Both time ranges are far below said maximum value of 120 seconds (i.e. 2 minutes) according to claim 1. The latter Report states, based on the findings of figure 9, that the "… initial bias was set to -600 V dc for 2 minutes" (see page 14, third paragraph). It also states that a high bias (greater

than -200 V) "during the first minute or two of the deposition process improved the adhesion significantly" (see page 8, last paragraph) but this statement, like said figures 10 and 9, does not support this allegation.

3.3.8 Consequently, all these unproven effects need not be considered for the definition of the technical problem underlying the process of claim 1 of the first auxiliary request (see Case Law of the Boards of Appeal of the European Patent Office, 6th edition 2010, chapter I.D.4.2).

3.3.9 The effect of features i) and ii) is thus considered to be simply the deposition of an amorphous diamond coating which adheres to the underlying substrate.

3.4 The objective technical problem is therefore considered to merely represent the provision of an alternative deposition process to the process of D1.

The subject-matter of process claim 1 of the first auxiliary request is, however, obvious for the following reasons:

3.5 The textbook D2 existed at the priority date of the application underlying the patent in suit (i.e. 25.04.1994) for more than 4 years. D2 is generally concerned with cathodic arc deposition (CAPD) of thin films and mentions that with this method DLC films exceeding the microhardness of diamond have been produced (see page 176, fourth paragraph). However, it is relatively silent with respect to the particular field of application of the cathodic arc technology for deposition of DLC. D2 only mentions that the potential

of this method has been demonstrated and that DLC will emerge as a major application for CAPD (see page 194, second and fourth paragraphs).

3.5.1 On the other hand, the Board holds that the scientific documents D4 and D7 in agreement with the established jurisprudence (see Case Law, 6th edition 2010, chapters I.C.1.5 and I.D.7.3), are considered to reflect common general knowledge of the person skilled in the art in this still rapidly developing technical field of amorphous diamond or DLC deposition at the priority date (compare e.g. D4 was published in 1992 and refers to 22 documents, or D7 was published in 1993 and quotes 34 documents).

3.5.2 The textbook D2 further discloses that good cleaning is of vital importance for the adhesion and that the substrates have to be cleaned by high-energy ion bombardment with a high negative bias while the CAPD then takes place at a reduced bias voltage (see pages 171 to 172, paragraph "Coating Cycle"). The outstanding adhesion of the films applied by the CAPD process results from the high deposition energies involved and the cleaning of the substrate at a high bias of 500 to 2000 volts results in a bombardment with either noble gas ions or ions from the arc source itself and further promotes good coating adhesion by additionally heating the substrate (see page 173, paragraph "Adhesion").

The cleaning voltage range of D2 falls entirely within the range for the high bias deposition step of 200-2000 volts according to claim 1 of the first auxiliary request.

3.5.3 It is clear to the person skilled in the art that the CAPD process will be simplified by taking the ions from the arc source itself for the cleaning step since in that case no further gas and/or reactant is needed.

Further, the determination of the necessary duration of this first high bias coating/cleaning treatment lies within the normal competence of the person skilled in the art and can be easily found by routine experiments. In any case, as agreed above (point 3.3.7), the duration of this treatment is not critical.

3.5.4 D7 teaches that a higher content of sp^3 bonding results in higher hardness of the amorphous carbon coating and that the optimum is obtained at a bias of about -100 volts (see figure 5 and page 4777, left hand column, first paragraph). The amorphous DLC coatings of D7 are deposited from a filtered beam of carbon ions produced by CAPD (see page 4777, paragraph "Experimental Details").

3.5.5 Taking account of the fact that D7 represents the up to date knowledge of the CAPD process, the person skilled in the art would select the conditions of bias voltage suggested therein so as to obtain the maximum of sp^3 bonding for a hard amorphous diamond coating.

The Board considers that the person skilled in the art would choose these conditions since the statements in the textbook D2 (see point 3.5.2 above) lead him to it. In any case, D1 already teaches the person skilled in the art that sp^3 bonding is essential to obtain a hard coating and that a substantial amount thereof is

necessary, while D7 teaches him in its figure 5 how to achieve this result.

Consequently, the subject-matter of claim 1 of the first auxiliary request lacks inventive step (Article 56 EPC). The first auxiliary request is therefore not allowable.

3.5.6 The appellant's arguments to the contrary cannot hold for the following reasons.

All arguments based on improved properties of the amorphous coating cannot be accepted since any evidence for proving the same has not been submitted.

D4 does not represent a prejudice since it is a single statement in the prior art and actually discloses that the DLC films exhibit promising mechanical results such as good hardness and an excellent adhesion level on high speed steel (HSS) substrates (see abstract).

The Board also considers that the person skilled in the art would not combine the argon sputter cleaning step of D1 with the CAPD of the amorphous diamond layer according to D7 for the same reasons as why he would not combine the teachings of the apparatuses of D6 and D7 (see point 3.1 above). To the contrary, the person skilled in the art would apply the cleaning procedure for the CAPD process described in the textbook D2 and then select the alternative using the ions of the arc source itself in order to simplify the process (see point 3.5.3 above).

D7 need not describe any cleaning step or bombardment with high energy ions since the necessity of such a process step forms part of the process as evidenced by the text book D2 (see point 3.5.2 above).

Razor blades do not have a complex shape. They have a simple geometric structure with basically flat surfaces which are in any case similar to the flat surface of the Si wafers according to D7.

Third auxiliary request

3.6 Process claim 1 of the third auxiliary request differs from that of the first auxiliary request only in that it is restricted to a steel substrate (see point XI above).

Since it is clear from the subject-matter of dependent claim 12 of the third auxiliary request - which comprises the feature that the "layer of amorphous diamond (60) is deposited **directly** onto said substrate" - that the feature "… depositing on said sharpened edge … or … on both sides of the substrate" of claim 1 of the third auxiliary request is apparently meant to be interpreted in a broader manner, i.e. **not** being restricted to the **direct** deposition on the steel substrate (see also point 3.3.1 above).

Consequently, all the appellant's arguments based on the direct deposition on the steel substrate cannot hold and the arguments of the respondent with respect to lack of inventive step concerning process claim 1 of the first auxiliary request fully apply to claim 1 of the third auxiliary request since the intermediate Nb

layer according to D1 is applied on a steel substrate (see point 3.2 above).

The subject-matter of claim 1 of the third auxiliary request thus lacks inventive step (Article 56 EPC). The third auxiliary request is therefore not allowable.

Fourth auxiliary request

3.7 Process claim 1 of the fourth auxiliary request has been restricted to the direct deposition of the amorphous diamond coating on the sharpened edge of the steel substrate (see point XII above).

D1 is still considered as closest prior art by both parties.

Process claim 1 of the fourth auxiliary request thus differs from the process according to D1 in addition to the features i) and ii) mentioned in point 3.3 above in that the amorphous diamond coating is deposited iii) directly on the steel substrate.

Feature iii) results in a simplified CAPD process by avoiding the intermediate Nb layer according to the teaching of D1. The effect of features i) and ii) is considered to be the deposition of an amorphous diamond coating which adheres well to the underlying substrate (see point 3.3.9 above).

The objective technical problem is therefore considered to be the provision of a simplified alternative deposition process to the process of D1.

3.8 The subject-matter of process claim 1 of the fourth auxiliary request is, however, obvious for the following reasons:

3.8.1 The skilled person when following the arc cleaning and deposition bias voltage conditions as set out in D2 for the CAPD process (see pages 171 and 173) would expect to obtain a well adhering coating. The skilled person would therefore at least try to provide the DLC layer directly on the substrate. This is all the more so in view of the up to date general knowledge of D4 (D4 is published in 1992 citing 22 documents) which reports an excellent adhesion of amorphous diamond coating on steel substrates (see abstract). Thereby the person skilled in the art would arrive at the claimed direct deposition on the steel substrate in an obvious manner.

3.8.2 The appellant's arguments to the contrary cannot hold for the following reasons.

The intermediate layer according to D1, e.g. niobium, on which the DLC layer is deposited by DC sputtering is actually only considered to be essential in view of the applied sputtering process. There exists no evidence that this would hold true with respect to the other processes such as specified in D1 including e.g. plasma decomposition of hydrocarbon gases or direct ion beam deposition, etc. (see column 2, lines 19 to 25) which correspond more or less to the processes specified in claim 6 of the patent as granted.

The fact that D7 only relates to coating of Si-substrates while D2 does not provide any information with respect to the coating of steel substrates with an

amorphous diamond coating (it discloses the TiN coating of steel, see page 173, last paragraph; and generally the coating of HSS cutting and forming tools, see page 184, first paragraph), is not relevant since D4 in general mentions the excellent adhesion of DLC films on HSS (high speed steel) substrates (see abstract) whereas the single experiment of D4 which resulted in a poor adhesion of the thereby obtained coating on a HSS substrate with a low degree of sp^3 bonding containing graphite, was made with uncommon parameters, and was expected to have that poor adhesion due to not using Ar gas (see page 167, table I, left hand column, first paragraph to right hand column, first paragraph).

3.8.3 For the above reasons as well as those mentioned for claim 1 of the first auxiliary request the subject-matter of claim 1 of the fourth auxiliary request lacks an inventive step (Article 56 EPC). The fourth auxiliary request is therefore not allowable.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

G. Nachtigall H. Meinders