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BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

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File Number: T 647/90 - 3.4.2

Application No.: 84 903 219.8

Publication No.: 0 153 384

Title of invention: Process for forming a graded index optical material and structures formed thereby

Classification: G02B 1/10, 5/00, 5/18; C23C 16/48; B01J 19/12

D E C I S I O N
of 17 December 1991

Applicant: Hughes Aircraft Company

Headword:

EPC Article 56

Keyword: "Main and auxiliary requests: no inventive step"

Headnote

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number : T 647/90 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 17 December 1991

Appellant : Hughes Aircraft Company
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Decision under appeal : **Decision of Examining Division of the European Patent Office dated 19 January 1990 and posted on 21 March 1990 refusing European patent application No. 84 903 219.8 pursuant to Article 97(1) EPC.**

Composition of the Board :

Chairman : E. Turrini
Members : W.W:G. Hofmann
C.V. Payraudeau

Summary of Facts and Submissions

I. European patent application No. 84 903 219.8 (international publication number WO 85/01115) was refused by decision of the Examining Division.

II. The reason given for the refusal was that the subject-matter defined in the independent claims according to either of the two requests presented by the applicant did not involve an inventive step. The Examining Division held that the document "Arkiv för Fysik" Vol. 31, no. 14 (1966), pages 191 to 200 (D6) disclosed a single continuous medium the index of refraction of which varied as a function of the thickness according to a periodic pattern, that a person skilled in the art would be encouraged to manufacture such a layer by the method taught in DE-A-3 202 709 (D2), and (with respect to process Claim 1) that the skilled person would turn his attention towards the photochemical vapor deposition (PCVD) method of US-A-4 371 587 (D4) to avoid damage to the substrate.

III. The Appellant lodged an appeal against this decision.

IV. Oral proceedings were held at the end of which the Appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of
Claims 1 to 25 filed on 28 November 1991 (main request), or subsidiarily
Claims 1 to 24 filed on 28 November 1991 (1st auxiliary request), or subsidiarily
Claims 1 to 10 filed on 28 November 1991 (2nd auxiliary request).

V. Independent Claims 1 and 15 according to the main request read as follows:

"1. A process for depositing on the surface of a substrate, excluding an optical fibre, a single continuous layer of chosen optical material in which the index of refraction of said layer varies in a predetermined periodic pattern as a function of the thickness of said layer which pattern is necessary to produce the desired peak reflection wavelength, comprising the steps of:

(a) providing said substrate;

(b) providing first and second selected vapor phase reactants which react upon inducement by radiation of a selected wavelength to form said chosen material which deposits on said substrate;

(c) exposing said substrate to said first and second vapor phase reactants in predetermined proportions in the presence of said radiation to deposit said chosen mnaterial having a first predetermined composition and a first predetermined index of refraction by the photoinduced chemical vapor deposition method (PCVD);

(d) altering said predetermined proportions of said first and second vapor phase reactants as a function of time to correspondingly alter said composition and said index of refraction of said chosen material deposited as a function of time and to thereby produce said varying index of refraction in said chosen material; and

(e) repeating said altering of step "d" for the number of times required to produce said variation of said refractive index in said

predetermined periodic pattern as a function of said thickness of said layer."

"15. An optical element excluding an optical fibre, comprising a selected substrate; and, a single continuous layer of chosen optical material deposited on the surface thereof wherein the composition of said chosen material is varied in a predetermined periodic pattern, which pattern is necessary to produce the desired peak reflection wavelength, so as to result in an index of refraction varying also as a function of the thickness of said layer according to said predetermined periodic pattern."

Claims 2 to 14 and 16 to 24 are respectively dependent on Claims 1 and 15.

Independent Claims 1 and 15 according to the first auxiliary request read as follows:

"1. A process for the manufacture of a high-efficiency optical filter device by depositing on the surface of a substrate a single continuous layer of chosen optical material in which the index of refraction of said layer varies in a predetermined periodic pattern as a function of the thickness of said layer which pattern is necessary to produce the desired peak reflection wavelength comprising the steps of:

(a) providing said substrate;

(b) providing first and second selected vapor phase reactants which react upon inducement by radiation of a selected wavelength to form said chosen material which deposits on said substrate;

(c) exposing said substrate to said first and second vapor phase reactants in predetermined

proportions in the presence of said radiation to deposit said chosen material having a first predetermined composition and a first predetermined index of refraction by the photoinduced chemical vapor deposition method (PCVD);

(d) altering said predetermined proportions of said first and second vapor phase reactants as a function of time to correspondingly alter said composition and said index of refraction of said chosen material deposited as a function of time and to thereby produce said varying index of refraction in said chosen material; and

(e) repeating said altering of step "d" for the number of times required to produce said variation of said refractive index in said predetermined periodic pattern as a function of said thickness of said layer."

"15. A high-efficiency optical filter device, comprising a selected substrate; and, a single continuous layer of chosen optical material deposited on the surface thereof by the photochemical vapor deposition process wherein the composition of said chosen material is varied in a predetermined periodic pattern which pattern is necessary to produce the desired peak reflection (after correction of an obvious typing error) wave length so as to result in an index of refraction varying as a function of the thickness of said layer according to said predetermined periodic pattern."

Claims 2 to 14 and 16 to 24 are respectively dependent on Claims 1 and 15.

Claim 1 according to the second auxiliary request reads as follows:

"1. A high-efficiency diffraction optical element, comprising a selected substrate; and, a single layer of chosen optical material deposited on the surface thereof by the photoinduced chemical vapor deposition process (PCVD) wherein the composition of said chosen material is varied in a predetermined periodic pattern which pattern is necessary to produce the desired peak reflection (after correction of an obvious typing error) wave length so as toi result in an index of refraction varying as a function of the thickness of said layer according to said predetermined periodic pattern, wherein the composition of said layer further varies in a second predetermined pattern across the horizontal said surface of said substrate to produce successive gradations in said index of refraction in said second predetermined pattern as a function of the lateral position on said horizontal surface of said substrate."

Claims 2 to 10 are dependent on Claim 1.

VI. The Appellant argued in substance that the document "The Bell System Technical Journal" Vol.48, No.9 (1969), pages 2909 to 2947 (D8) related to gratings produced by exposure of photosensitive layers to light and subsequent development, without mentioning any disadvantages of this method of production, whereas the invention concerned the production of optically diffractive structures by depositing the layers in a predetermined way as a function of time. Document D8 could therefore only lead a person skilled in the art to look for further methods of exposure and development. Document D6 is only a theoretical study

which mentions neither a method for realizing the described optical structures, nor a specific use. Document D2 discloses a chemical vapor deposition (CVD) method; however, it does not mention the possibility of producing periodic structures and does not relate to filters but only to antireflection coatings. Moreover, the charged particles produced by the plasma discharge according to document D2 may damage th substrate, which effect is avoided by the photochemical vapor deposition (PCVD) method according to the invention. Document D4 describes the PCVD process without, however, disclosing or suggesting that the composition of the layer could be varied as it is deposited. It is only with hindsight that one can consider the combination of documents D6 (or D8), D2 and D4.

Reasons for the Decision

1. The appeal is admissible.

2. Main request

2.1 Novelty

2.1.1 Document D6 describes a plane optical medium in which the index of refraction varies in a periodic pattern as a function of the thickness of the layer, which pattern produces a desired peak reflection wavelength (cf. in particular page 191 and figure 1(c)). As can be seen from figure 1(c), the refractive index has no discontinuities so that the layer comprising the periodic pattern is "continuous".

Although it is true that as far as the effects of the continuously and periodically varying layer are concerned,

document D6 is - as the Appellant claims - only a theoretical study, it is nevertheless clear that the described structures are intended to be applied to a class of really existing optical elements, i.e. filters comprising an interference layer or layers (cf. page 191, paragraph "Introduction", in particular lines 1 to 5; influencing the spectral distribution of light is nothing else but "filtering"). Since such layers have a thickness in the order of magnitude of the wavelength of light, the term "filter" automatically implies the presence of a supporting substrate.

The process for producing the layer is not described in document D6. Thus, the process according to Claim 1 is distinguished from the teachings of document D6 by all the process steps specified in paragraphs (b) to (e) relating to the performance of the PCVD method.

2.1.2 The disclosure of document D8 - as far as it is relevant for the present case - essentially corresponds to that of document D6, a difference being that the method of production of the periodic pattern (recording holographic interference patterns in photosensitive media, a method which is different from the vapor deposition method specified in Claim 1), is explicitly mentioned (cf. pages 2909 and 2910).

2.1.3 Document D2 describes a CVD process for depositing on a substrate a layer of optical material for making optical elements (e.g. antireflection coating of lenses). By altering the proportions of the first and second vapor phase reactants (e.g. reactants containing silicon and nitrogen) as a function of time the composition and the refractive index of the deposited material is varied (cf. page 6, line 11 to page 7, line 31 and page 12, line 20 to page 13, line 10). The process of claim 1 differs from

this disclosure by the fact that the altering of the proportions is performed in a periodic manner, and that the CVD process is not induced by a plasma discharge, but is photoinduced.

2.1.4 A similar disclosure is contained in "Applied Optics" Vol.21, no.6 (1982), pages 1069 to 1072 (D10).

2.1.5 Document D4 describes the photoinduced CVD process for producing e.g. an antireflective coating on a lens (cf. "abstract"; column 2, lines 47 to 53; and column 13, lines 26 to 29). The refractive index of the layer to be made may be adjusted by choosing the proportion of the first and second vapor phase reactants (e.g. column 12, lines 38 to 45 and 57 to 66, and column 14, lines 6 to 11 and 21 to 31). However, the chosen proportion is not altered as a function of time to produce a varying index of refraction in the layer.

2.1.6 The other documents cited during the examining procedure are less relevant.

2.1.7 Therefore, the subject-matter of Claim 1 is novel in the sense of Article 54 EPC.

2.1.8 The features of product Claim 15 correspond to those of Claim 1, except that the product is additionally defined to be an optical element and that a definition of the specific deposition method is lacking.

The subject-matter of Claim 15 is distinguished from the optical elements described in document D6 by the fact that the layer is deposited, which feature, since it relates to the finished product, must be understood in the sense that the material of the layer is of the type which can be applied by a process of deposition. This feature is not expressly mentioned in D6.

2.1.9 Since the other documents are not closer to Claim 15, the subject-matter of this claim is also novel.

2.2 Inventive step

2.2.1 Although not expressly stated in document D6, it is nevertheless self-evident for a skilled person that interference layers for optical filters as they are described in this document, are made by deposition techniques since this is the established technique in this field (cf. page 2, lines 14 to 19 of the present description). For this reason, document D6 is considered to be closer to the claimed subject-matter than document D8, according to which - as the Appellant has pointed out -the interference layers are made by holographically exposing a photosensitive layer to light.

Thus, starting from the teachings of document D6, the objective problem underlying the claimed subject-matter is to be seen in providing a process which is suitable for depositing the known continuous layer having a periodic variation of its refractive index as a function of its thickness (cf. page 5, lines 2 to 7 of the present description).

Finding this problem cannot be considered inventive since it is evidently desirable to be able to actually produce an object which is expected to be advantageous.

2.2.2 The process described in document D2 (see point 2.1.3 above) presents itself to a person skilled in the art for solving the above-mentioned problem since it teaches how a layer of optical quality (e.g. suitable for antireflection coatings) having a continuously varying refractive index can be produced, namely by varying the proportions of two

vapor phase reactants during a CVD process, so that the composition of the deposited layer is varied according to the desired function. The fact that he actually wants a periodic pattern to be deposited, will not -contrary to the opinion of the Appellant - keep the skilled person from applying this known method since he readily recognizes that there are no restrictions as to the particular function according to which the proportions have to be varied.

2.2.3 The Appellant has submitted that the process of D2 is disadvantageous since it is a plasma induced vapor deposition process which might damage the substrate by the effect of the charged particles produced.

This possible disadvantage of the plasma induced process is well known in the art (see document D4, column 1, lines 30 to 60). It is obviously unrelated to the further teaching of document D2 regarding the variation of the proportions of the vapor phase reactants during the CVD process. The skilled person can see that the advantageous principle of varying the reactant proportions can be applied and still the effects of charged particles avoided by choosing another known method for dissociating the reactants necessary for the CVD process. Thus, the skilled person is led to photoinducing this dissociation as described in document D4 for the very purpose of avoiding damage to the substrate (cf. column 2, lines 47 to 61; column 12, lines 32 to 38). This document also envisages optical applications e.g. for antireflection coatings (column 13, lines 27 and 28) and indicates that the refractive index of the deposited layer is a function of the chosen proportion of the reactant gases (column 12, lines 38 to 66). Therefore, it was to be expected that the

photoinduction of the dissociation according to document D4 would be suitable for replacing the plasmainduction according to document D2.

2.2.4 The Board therefore comes to the conclusion that the subject-matter of Claim 1 lacks an inventive step in the sense of Article 56 EPC.

2.2.5 As already indicated above (point 2.2.1), it is self-evident for any skilled reader of document D6 and corresponds to the established technique in this field that interference filters are made by depositing optical material on a substrate. Since the only difference between the subject-matter of product Claim 15 and the filters disclosed in document D6 lies in the feature "deposited" (cf. point 2.1.8 above), the optical element according to Claim 15 cannot be considered to involve an inventive step (Article 56 EPC).

3. First auxiliary request

3.1 In substance, Claim 1 according to the first auxiliary request differs from Claim 1 according to the main request only in that the device to be manufactured is now defined to be a high efficiency optical filter device.
Since, as already mentioned above, document D6 also relates to filters with high efficiency (interference filters), the above considerations regarding inventive step of the subject-matter of Claim 1 (main request) apply just as well to Claim 1 according to the first auxiliary request.

Therefore, the subject-matter of Claim 1 does not involve an inventive step.

3.2 Product Claim 15 differs from the corresponding Claim 15 of the main request by the definition that the optical element is a high efficiency filter device and that the deposition has been carried out by the photochemical vapor deposition process.

As indicated above, the optical elements described in document D6 are also high efficiency filter devices having a periodic variation of the refractive index in the direction of the thickness of the layer.

It is not necessary to examine in detail in how far the manufacturing step of using the PCVD process does or does not form a feature of the product per se since it has been shown above that even the full manufacturing process for an optical filter device including the use of the PCVD process as defined in Claim 1, lacks an inventive step.

The subject-matter of Claim 15 therefore lacks an inventive step.

4. Second auxiliary request

4.1 Claim 1 is directed to a high efficiency diffraction optical element comprising the features of the filter device according to Claim 15 of the first auxiliary request and, additionally, having a composition and consequently a refractive index of the layer which varies as a function of the lateral position on the surface of the substrate, a feature which has been taken from the original Claim 17.

The interference filters described in document D6 are diffraction optical elements in the sense of the present application (cf. page 1, lines 6 to 8).

The fact that the features chosen for such filters according to Claim 15 of the first auxiliary request are not inventive, has been stated in point 3.2 above. The same is therefore true for these features in Claim 1 according to the second auxiliary request.

4.2 Claim 1 mentions additionally a lateral index pattern. However, it leaves completely open what form this pattern should have and what the intended application is. The Appellant has also not given any information regarding the question what purpose should be achieved by these lateral variations.

Such an arbitrary feature cannot be considered as being the result of an inventive activity. Moreover, lateral variations are by no means unusual in the field of optical filters. Apodizers, wedge filters, filter disks comprising different segments on one substrate, or thick holograms having slanted fringes (having periodic lateral variations and automatically acting as filters) as shown in document D8, figure 1, are well known in optics and remind a person skilled in the art of the possibility of providing lateral variations of the filtering properties if this seems desirable for some reasons.

4.3 The subject-matter of Claim 1 therefore lacks an inventive step.

5. Since none of the independent claims according to any one of the three requests defines inventive subject-matter in the sense of Article 56 EPC, none of these requests is allowable (Article 52(1) EPC).

6. The dependent claims must fail together with the independent claims to which they are appended.

The Board has considered whether the dependent claims or the description contained any features which, when inserted into the independent claims, would render their subject-matter inventive. However, no such features were found.

7. Since the claimed invention does not meet the requirements of the EPC, the decision of the Examining Division refusing the application has to be confirmed.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar The Chairman

P. Martorana E. Turrini