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D E C I S I O N
of 25 January 1996

Case Number: T 0082/94 - 3.4.1

Application Number: 86301691.1

Publication Number: 0194835

IPC: H01S 3/085

Language of the proceedings: EN

Title of invention:

A semiconductor laser device with a protective film on the facets

Patentee:

SHARP KABUSHIKI KAISHI

Opponent:

Siemens AG

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (no)"

"Scientific explanation of known exploited technical effect does not support inventive step; see paragraph 1.4"

Decisions cited:

-

Catchword:

-



Case Number: T 0082/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 25 January 1996

Appellant:
(Opponent)

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Representative:

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Respondent:
(Proprietor of the patent)

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Decision under appeal:

Interlocutory decision of the Opposition Division
of the European Patent Office dated 5 November
1993 concerning maintenance of European patent
No. 0 194 835 in amended form.

Composition of the Board:

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

Summary of Facts and Submissions

- I. The respondent is owner of European patent No. 0 194 835.
- II. This patent was opposed by the opponent on the grounds mentioned in Article 100(a) EPC, relying with regard to claim 1 as granted on the prior art which can be derived from documents:

D1: Applied Physics Letters, volume 32, No. 11, 1978, pages 724 to 725; and

D2: EP-A-0 118 746.

During the proceedings before the Opposition Division the proprietor requested to maintain the patent on the basis of an amended claim 1, wherein a protective film for laser facets was narrowed from a "multi-layered" into a "three-layered" film as disclosed in the only embodiment according to Figure 1 of the patent in suit. With regard to this amended claim, the opponent relied additionally on the following textbook:

D3: G. Hass and R. E. Tun: "Physics of Thin Films", volume 2 Academic Press, 1964 New York and London, pages 265 to 271.

The opponent submitted that a skilled person would arrive at the device according to amended claim 1 without requiring an inventive step by an obvious optimisation of the necessary number of layers with regard to production costs based on the general multilayer concept as disclosed in document D1, wherein the specification that "Si" should be "a-Si:H₂" would be obvious in view of document D2 and a limitation of the reflectance to below 30% in the three-layered film a

discretionary adaptation measure which can easily be realised by layer thickness variation on the basis of the general teaching disclosed in document D3.

III. By an interlocutory decision within the meaning of Article 106(3) EPC the Opposition Division decided that the patent could be maintained in amended form, taking the following view. The effect of a-Si:H₂ material to suppress oxidation of the laser facets was not known from document D2. Therefore, it was not obvious for a skilled person to replace in document D2 the single quarter-wave length layer of SiO₂ on the light-emitting facet by a three-layered film comprising a-Si:H₂. Since Figure 2 of document D1 discloses for such a three-layered film a minimum reflectivity of 50%, it was furthermore not obvious to a skilled person to lower the reflectivity to below 30% by variation of the layer thicknesses. The variation of layer thickness for obtaining low reflectivities as disclosed in document D3 concerns antireflection coatings on objects other than lasers and is therefore not relevant. In particular there was no reason for such a variation, because it was not known in the art that the oxidation problem of laser facets could be overcome by a-Si:H₂ material comprised in a three-layered protective film on the light-emitting laser facet.

IV. The opponent lodged an appeal against the interlocutory decision of the Opposition Division.

V. In a communication accompanying a summons to oral proceedings the Board raised objections against amended claim 1 under Articles 84 and 123(2) EPC and informed the parties of its provisional view essentially as follows: Starting from the closest prior art as disclosed in document D2, page 2, lines 8 to 19 and page 9, lines 1 to 8 concerning a laser with a

multi-layered protective film on front and rear facets, which film comprises a-Si:H₂ material as a means for prolonging the service life of the laser, the claimed limitation to three layers appears to be the obvious result of a routine test of the embodiments in Figures 4, 1, 7, 5, of document D2 wherein the layer number varies from 5 to 2. In such a routine test for finding out the optimum relationship between service life prolongation and productive costs, the higher mechanical stability against abrasion of the embodiment with 3 layers according to Figure 7 of document D2 will clearly be observed in practice. Suppression of oxidation deterioration of the laser facets is regarded not as the technical problem underlying the invention but as the scientific explanation of the exploited technical effect of a-Si:H₂. The exploited effect of a-Si:H₂ concerns the desired technical aim of the patent in suit, i.e. to enlarge the life span of the laser. Document D3 would allow a skilled person to recognise that low reflectivities of three-layered laminates are obtainable by a variation of the layer thicknesses. Document D1, page 725, left column, last paragraph would teach that low-facet reflectivity prevents facet damage. This would motivate a skilled person to make use of low reflectivity. The claimed upper limit of R=30% would appear to be arbitrary in view of the missing disclosure of any unexpected effect appearing with the claimed reflectivity region. The calculated value of R=50% in Figure 2 of document D1 would be not interpreted by a skilled person as a prejudice that a reflectivity below R=50% cannot be realised, relying on a skilled person's general knowledge and the teaching in document D3.

VI. Oral proceedings were duly held on 25 January 1996. The opponent requested that the decision under appeal be set aside and that European patent No. 0 194 835 be revoked. The proprietor requested that the appeal be dismissed

and that the patent be maintained on the basis of claim 1 as filed during oral proceedings which was amended to take account of the objections raised under Article 84 and 123(2) EPC (see paragraph V above).

VI. Claim 1 as filed during oral proceedings reads as follows:

"1. A semiconductor laser device with a protective film (B, F) on the facets (2, 5) wherein said protective film is made of a multi-layered dielectric film composed of alternate layers consisting of at least two kinds of dielectric film, one of which is a first dielectric film (31) of low refractive index and the other of which is a second dielectric film (42) of high refractive index, wherein said second dielectric film (42) is made of a-Si:H₂, the protective film which covers one of the facets consists of three-layered dielectric film (F) and the thicknesses of the layers of said three-layered dielectric film (F) are adjusted to form a light-permeable film with a reflectivity of 30% or less."

Claim 2 is dependent on claim 1.

VII. In support of its request, the opponent made essentially the following submissions:

- (a) In view of manufacturing tolerances, the effect of deviations from a quarter-wavelength layer thickness on reflectivity was generally studied in the art. Figure 2 of document D1 represents a two-dimensional diagram wherein the influence of only one variable can be visualised. Therefore, a skilled person does not derive from Figure 2 of document D1 that other parameters cannot be modified. The statement in document D1, page 725, left column, last paragraph, to vary facet

reflectivity from 1 to 99% "by controlling the number of quarter wavelength layers and the thickness of only the final layer" is a recommendation, how to calculate parameters for a desired reflectivity in an easy way. But it casts no doubt on the skilled person's general knowledge, that the thickness of the other layers may be varied too and does not prevent him from calculations wherein all parameters are varied systematically. The calculations in Figures 29 and 30 of document D3 vary only the thickness of the outer or middle layer of the three-layered antireflecting coating, because before 1964 computer programmes allowing an overall parameter variation in an easy way, have not yet been available. A skilled person will not conclude from the selected choice of studied parameters in document D2 or D3, that the effect of layer thicknesses on reflectivity is limited to the specially calculated examples.

- (b) Since the effect of a-Si:H₂ on service life prolongation is known from document D2, a skilled person has no difficulties to include an a-Si:H₂ layer also into a protective film on the light-emitting laser facet. This film is generally known to need a low reflectivity in order to obtain the desired output energy with high efficiency.
- (c) The limitation of granted claim 1 to the only disclosed "best mode" with three layers is no inventive purposive selection but an arbitrary limitation in a typical one-way situation.

VIII. The above submissions were contested by the proprietor who argued essentially as follows:

- (a) The teaching of document D2 is contrary to the present invention in that it discloses in particular on page 5, lines 20 to 25 the use of a protective multilayer for realising only a high reflectivity of 90%. Such highly reflecting multilayer is used as in the invention (see the description column 3 lines 42 to 47) for the back facet. The light-emitting front surface of the laser disclosed in document D2 has - different from the invention - only a single-layered protective film. Document D2 thus teaches against a multilayer for realising a low reflectivity such as necessary for the light emitting front facet of a laser and thereby provides a prejudice that reflectivity of a multilayer cannot be sufficiently reduced for its use on the front facet. Moreover, the problem of the deterioration of the laser facets is not considered in document D2.
- (b) Figure 2 of document D1 supports the fact that in a three-layered protective film reflectivity cannot be lowered below 50%, and teaches that the claimed upper reflectivity limit of 30% can only be realised by a two-layered film. Such two-layered film would be provided with the a-Si:H₂ layer on the outside and be mechanically instable due to the brittleness of a-Si. The disclosure in document D1, page 725, left column, last paragraph that reflectivity may be varied from 1 to 99% by controlling the number of quarter-wavelength layers and the thickness of the final layer, gives a skilled person no hint that and how low reflectivity can be realised by a three-layered film. In particular, document D1 is silent about the fact that such a film can be used for preventing facet damage.

(c) A person skilled in the reflectivity of laser facets does not consider the properties of anti-reflection coatings disclosed in document D2 in view of the opposite propagation direction of light. Since an antireflecting coating lowers reflectivity for light entering from outside of an object, it would not work for light entering from inside a laser. Moreover, document D3 does not deal with life span problems of a laser.

(d) On the basis of the cited prior art it was difficult to predict that the three-layered film works best of all so that its selection from the large variety of disclosed multi-layer solution cannot be regarded as arbitrary.

IX. At the conclusion of the oral proceedings, the decision was announced that the decision of the Opposition Division is set aside and the European patent is revoked.

Reasons for the Decision

1. *Inventive step - Claim 1*

1.1 From the closest prior art disclosed in document D2, it is known in the wording of claim 1:

"A semiconductor laser device with a protective film (see D2; 2, 3, 4, in Figure 7) on the facets wherein said protective film is made of a multi-layered dielectric film composed of alternate layers consisting of at least two kinds of dielectric film, one of which is a first dielectric film (2, 4) of low refractive index (see D2, page 2, lines 10 to 14 and page 11, lines 9 to 12) and the other of which is a second dielectric film (3) of high refractive index, wherein

said second dielectric film is made of a-Si:H₂ (page 2, lines 15 to 17), the protective film which covers one of the facets consists of a three-layered dielectric film (2, 3, 4 in Figure 7)."

1.2 The proprietor cannot be followed in his view according to point IIX-(a) above that document D2 discloses to realise the protective film on the light emitting surface of the laser only by a single layer, because of the text in document D2, page 9, lines 1 to 6 which reads as follows: "In Table 1 described above, the thickness of the passivation layer on the **front** surface is only two kinds, i.e. $\lambda/2$ and $\lambda/4$, but the effect of the present invention can be provided in accordance with each level (of reflectivity) when a different thickness is employed or the passivation layer consists of a **laminated**." Despite the single layer on the front facet in all embodiments which are explained by Figures, a skilled person would seriously contemplate the disclosed alternative with a laminate (i.e. a multi-layer) on front and back facet for the following reasons: A restriction to one dielectric layer on one facet is only claimed in claim 6 of document D2. Moreover, it is obvious to the skilled person that the use of two multi-layers provides the advantage that life span prolonging a-Si:H₂ is present on both facets for the reasons set out below:

1.3 The text in document D2, page 2, lines 4 to 17 reads: "The present invention contemplates to **prolong service life** of the device...The semiconductor laser device of the present invention has at least the following structure. At least one **laminated** of first and second dielectric layers is disposed **on at least one of the two** resonator facets of a semiconductor laser, the refractive index of the first dielectric layer is smaller than that of the second dielectric layer and the

second dielectric layer consists of an **amorphous material containing silicon and hydrogen** (a-Si:H₂) as its **essential** constituent elements." In the Board's view, a skilled person derives therefrom - contrary to the appellant's opinion in paragraph IIX-(b) above - that document D2 considers the deterioration of the laser facets and in particular that optimum life span prolongation will be obtained when the life span prolonging means (i.e. the a-Si:H₂ comprising multi-layer) is present on both facets. The present invention aims at solving the identical technical problem of "attaining the enlargement of the life span of the laser device" see column 2, lines 42 and 43. The patent in suit bases the solution of this problem on the identical technical means, i.e. a multi-layer comprising a-Si:H₂.

1.4 In the Board's view, the suppression of oxidation deterioration of the laser facets as disclosed in the description column 3, lines 40 to 42 has to be interpreted neither as the object nor as the solution of the present invention but as the scientific explanation of the exploited effect which is inherent to the technical means of the solution (a-Si:H₂). The exploited effect of a-Si:H₂ concerns the desired technical aim, i.e. to enlarge the life span of the laser. In the present case, the scientific explanation of the practically exploited effect of the technical means of the solution has no influence on the answer to the question whether this effect was foreseeable, because it was already explicitly disclosed in document D2. In such a case, scientific explanations are no support for an inventive step underlying the claimed technical means.

1.5 The subject-matter of claim 1 is distinguished from the laser disclosed in Figure 7 of document D2 in that

"the thickness of the layers of said three-layered dielectric film are adjusted to form a light-permeable film with a reflectivity of 30% or less."

As follows from document D2, Figure 7 in combination with page 13, the known three-layered structure has a reflectivity of about 70%. The proprietor has submitted no evidence that the selection of a multilayer with three layers and with a reflectivity below 30% contributes to the effect of prolonging the life span of a laser device. Neither the description of the patent in suit nor the submissions of the proprietor persuade the Board to see any further improvement of the life span as an objective problem underlying the present invention when starting from the closest prior art disclosed in document D2. Therefore, starting from this closest prior art, the objective problem underlying the present invention remains to realise in the known three-layered structure a reflectivity of 30% or less. When following the recommendation in document D2, page 9, lines 1 to 6 and replacing layer 1 in Figure 7 of document D2 by a further three-layered structure comprising a-Si:H₂ on the light-emitting facet, low reflectivity of the light emitting facet is in the Board's view, a generally known requirement of an asymmetrically emitting laser (see also paragraph VII-(b) above). Since no evidence was submitted for any special effect within the claimed reflectivity region, its upper limit of 30% has to be regarded as the result of an arbitrary selection which is not inventive. Hence, the formulation of the objective problem does not contribute to an inventive step in the subject-matter of claim 1.

- 1.6 The proprietor is not followed in his view according to paragraph IIX-(d) above. Selecting Figure 7 of document D2 as technical starting point, in the Board's view, is obvious for the following reasons: The Board

regards it to be realistic that a skilled person will start from the technically simplest embodiment in Figure 5 of document D2 with two layers and a-Si:H₂ on the outside. The brittleness of amorphous substances such as a-Si used as second dielectric layer is generally known and leads to mechanical damages of the outer laser surface which can easily be observed in practice. The first dielectric layer is realised in the embodiment of claim 1 and in the laser according to document D2 by Al₂O₃, a ceramic material with a known high resistivity to abrasion. These layer properties are moreover taken into consideration in document D2, disclosing in paragraph 1 of page 14 that the three-layered structure improves the resistance of the two-layered structure against the environment.

- 1.7 Therefore, in the evaluation of inventive step it remains to examine whether it is obvious to a skilled person to lower the reflectivity of the three-layered protective film according to Figure 7 of document D2 from 50% to below 30% by "adjusting the thickness of the layers" as claimed. In the Board's view, Figure 2 of document D1 represents a specific example with quarter-wavelength layers. Such a specific example - contrary to the appellant's view in paragraph IIX-(b) - is not interpreted by a skilled person as a prejudice but as a verification of his school knowledge that the effective global reflectivity of a multilayer is prima facie the result of the interference caused by phase differences between the individual rays back reflected from each interface between two different dielectric films. This follows directly from the position of the minima and maxima of the reflectivity in Figure 2. It is self-evident to a skilled person that such phase differences are caused by the optical path differences between each individually back reflected wave i.e. by the thickness of each layer, and that in a given laminate with fixed

refractive indices for each layer, a variation of the individual layer thickness remains as the one and single technical means for tailoring the desired interference and thereby the desired reflectivity value. Hence, in the Board's view, a skilled person will easily understand that - whenever he decides to use also on the front surface the three-layered protective film (2, 3, 4) in Figure 7 of document D2 according to the recommendation given in document D2, a reflectivity lowering via a modification of the individual layer thicknesses is an indispensable adaptation measure. The Board is satisfied, that a skilled person would at least try out a routine calculation, wherein the individually parameters are systematically varied in order to find out suitable layer thickness combinations for low reflectivity (see also paragraph VII-(a) above).

- 1.8 As follows from the above, a skilled person arrives from the closest prior art disclosed in Figure 7 of document D2 at the subject-matter of claim 1 by following the global technical information derivable from document D2 and by realising indispensable adaptation measures on the basis of his general knowledge. Such activities can be expected from a skilled person within the routine development of the prior art. Since, in the Board's view, a skilled person's general knowledge prevents an interpretation of Figure 2 of document D1 as a general prejudice against the possibility of realizing three-layered protective films for a laser with reflectivities below 50%, it is superfluous to rely on document D3 in order to demonstrate that such prejudice did not exist and to discuss the appellant's corresponding submissions in paragraph IIX-(c) above.

1.9 For the reasons stated above, in the Board's judgement claim 1 lacks an inventive step within the meaning of Article 56 EPC. Claim 2 falls because of its dependency on an unallowable claim 1.

Order

For these reasons it is decided that:

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

The Registrar:

M. Beer

The Chairman:

G. D. Paterson

