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D E C I S I O N
of 19 February 2004

Case Number: T 1068/01 - 3.4.3

Application Number: 94305419.7

Publication Number: 0635893

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Language of the proceedings: EN

Title of invention:
Semiconductor light emitter

Patentee:
SHARP KABUSHIKI KAISHA

Opponent:
Siemens AG

Headword:
LED/SHARP

Relevant legal provisions:
EPC Art. 56, 102(1)

Keyword:
"Inventive step (no)"
"Distinguishing feature immaterial to the performance of the known device"

Decisions cited:
-

Catchword:
-

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Case Number: T 1068/01 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 19 February 2004

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 26 July 2001 revoking European patent No. 0635893 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
M. B. Günzel

Summary of Facts and Submissions

I. European patent No. 0 635 893 was revoked under Article 102(1) EPC in a decision of the opposition division dated 26 July 2003 on the ground that the subject matter of claim 1 according to a main request and first to third auxiliary requests did not involve an inventive step having regard to the prior art document

D5: US-A-4 590 501.

II. Claim 1 according to the main request which formed the basis for the decision under appeal has the following wording:

"1. A semiconductor light-emitting diode having a light emitting region (16, 56, 106, 303); a first transparent layer (15, 55, 85, 105, 304) which is pervious to light radiated from said light emitting region; and a first opaque layer or substrate which is impervious to said radiated light, the light emitting region, the transparent layer and the first opaque layer or substrate being arranged in this order or in the reverse order, the device further comprising:

a first total reflection layer (14, 56, 104, 205) arranged between said first transparent layer and said first opaque layer or substrate so as to contact said first transparent layer, the refractive index of said first total reflection layer being smaller than the refractive index of said first transparent layer,

wherein light which has been radiated from said light-emitting region and which has been reflected by said first total reflection layer thereafter is radiated outward from side surfaces of said first transparent layer or returned to said light emitting region;

wherein the product of the thickness of the first total reflection layer and the refractive index of the first total reflection layer is more than 1.41 times greater than a centre wavelength of light emitted from the light emitting region."

III. Claim 1 according to the first auxiliary request which formed the basis for the decision under appeal has the following wording (emphasis added by the Board):

"1. A semiconductor light-emitting diode having a light emitting region (16, 56, 106, 303); a first transparent layer (15, 55, 85, 105, 304) which is pervious to light radiated from said light emitting region, **the first transparent layer having a wave-guiding effect on light radiated from the light-emitting layer**; and a first opaque layer or substrate which is impervious to said radiated light, the light emitting region, the transparent layer and the first opaque layer or substrate being arranged in this order or in the reverse order, the device further comprising:"

a first total reflection layer (14, 56, 104, 205) arranged between said first transparent layer and said first opaque layer or substrate so as to

contact said first transparent layer, the refractive index of said first total reflection layer being smaller than the refractive index of said first transparent layer,

wherein **non-waveguided** light which has been radiated from said light-emitting region and which has been reflected by said first total reflection layer thereafter is radiated outward from side surfaces of said first transparent layer or returned to said light emitting region;

wherein the product of the thickness of the first total reflection layer and the refractive index of the first total reflection layer is more than 1.41 times greater than a centre wavelength of light emitted from the light emitting region."

IV. The reasons given in the decision under appeal for revoking the patent in suit can be summarized as follows:

(a) Document D5 discloses an LED made of $Al_xGa_{1-x}As$ comprising a light emitting region 4 made of $Al_{0.05}Ga_{0.95}As$, a first transparent layer 2 made of $Al_{0.07}Ga_{0.93}As$ which is pervious to light radiated from the light emitting region 4, a first total reflection layer 1 made of $Al_{0.29}Ga_{0.71}As$ having a thickness of 2.0 µm and contacting the first transparent layer, and a substrate 10 stacked in this order (cf. Figure 1; column 4, lines 53 to 66).

It follows from the formulas on column 3, lines 12 and 31 for the index of refraction and bandgap, respectively, that the first total reflection layer has a lower index of refraction than the first transparent layer, and that the product of the wavelength of the emitted light and the index of refraction of the first total reflection layer is more than 1.41 times the wavelength of the emitted light.

(b) Thus the device of claim 1 according to the main request only differs from that of document D5 in that the substrate is opaque to the emitted light, whereas in document D5, the substrate is not specified.

There is no technical problem which could be solved by providing an opaque substrate in the device of document D5. A skilled person would immediately realise that the problem caused by an opaque substrate would be solved by the structure of document D5, and would therefore routinely employ an opaque substrate without employing inventive skills. Furthermore, the most common substrate in GaAs/AlGaAs technology is GaAs which is opaque for the wavelength in question.

(c) As to the first auxiliary request, it does not meet the requirement of inventive step for the same reasons as for the main request, and furthermore since the additional feature "the first transparent layer having a wave-guiding effect on light radiated from the light-emitting layer" is known from document D5 as well.

V. The appellant (patent proprietor) lodged an appeal on 20 September 2001, paying the appeal fee on 24 September 2001. A statement of the grounds of appeal was filed on 3 December 2001 together with amended claims.

The appellant requested that the decision under appeal be set aside and that the patent in suit be maintained on the basis of either claims 1 to 5 according to the main request, or on the basis of claims 1 to 9 according to the first auxiliary request, both requests being as filed with the statement of the grounds of appeal.

The respondent (opponent) filed observations with a letter dated 12 August 2002 and requested that the appeal be dismissed.

VI. Claim 1 according to the main request differs from that of the main request forming the basis of the decision under appeal (cf. item II above) in that the following feature is added at the end of claim 1:

"wherein the first transparent layer consists of either GaN or AlGaInN and the first total reflection layer consists of AlGaInN."

Claim 1 according to the first auxiliary request has the same wording as that of the first auxiliary request forming the basis of the decision under appeal (cf. item III above).

VII. The appellant (patent proprietor) presented essentially the following arguments in support of his requests:

(a) The patent in suit addresses the problem of improving the radiative efficiency of an LED by preventing the absorption of light in an opaque layer or substrate. None of the available prior art documents relate to this problem. Instead, document D5 relates to the problem of absorption of light within the active layer (cf. column 1, lines 44 to 51).

(b) The problem of preventing absorption of light in the substrate is particularly important for an AlGaInN LED of the kind known from Figure 15 of the patent in suit, since the area of the active layer 303 is reduced due to the need for accommodating the lower electrode 307. Since none of the cited documents relate to the specific problem addressed by the patent in suit, claim 1 according to the main request is inventive.

(c) As to the first auxiliary request, the statement in the decision under appeal that "the guide layer has also some wave guiding effect" has not been justified. In particular, document D5 is entirely silent about there being any wave guiding effect at the boundary face of the first transparent layer 2 facing the light emitting layer 4.

(d) Furthermore, in connection with the first auxiliary request, the decision under appeal overlooks the provision of the "confining layer" 3 in the LED of document D5. The presence of the

confining layer 3 means that the photons are required to quantum mechanically tunnel through the confining layer 3 to enter the first transparent layer 2.

VIII. The respondent (opponent) presented essentially the following arguments:

(a) The device according to claim 1 (main request) only differs from the device of document D5 in that (i) an opaque substrate is used; and (ii) the active layer is made of GaN or AlGaInN and the total reflecting layer is made of AlGaInN.

(b) Regarding feature (i), the respondent agrees with the decision under appeal. It is also pointed out, that document D5 not only relates to the problem of light absorption in the active layer, but it seeks to improve the overall light-emitting efficiency of an edge-emitting LED (cf. column 1, line 52 to column 2, line 15). The problem addressed by the patent in suit is already solved by the device document D5, since light is prevented from entering the cladding layer 1, and therefore, there is no light to be absorbed by the substrate.

(c) The selection of GaN/AlGaInN (feature (ii)) does not contribute to the solution of the problem posed by the patent in suit, and therefore has to be considered a routine selection of a known material for an LED. Reference is made to EP-B-0 483 688 for a disclosure of an LED made of GaN-type materials.

A skilled person would consider other material systems for a given LED, when the measures for improving the efficiency, as in the present case, relate to the structure only and not to the specific material as such. There is no reason why a skilled person would not consider using a total reflecting layer between the substrate and the transparent layer in a GaN- or AlGaInN-LED, since this solution has been shown to be advantageous for GaAs-type materials.

(d) Regarding the arguments put forward in connection with Figure 15 of the patent in suit (cf. item VII(b) above), the structure shown in Figure 15 is not different from that of the device of document D5 in respect of light absorption in the substrate. Furthermore, the claimed device does not have any structural differences from that of document D5.

(e) Regarding the auxiliary request, the respondent agrees fully with the decision under appeal. As to the alleged difference between the claimed device and that of document D5 (see item VIII(d) above), the alleged difference is not incorporated in the wording of claim 1.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. *Inventive step*

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

2.1 *Main request*

2.1.1 It is common ground that document D5 represents the closest prior art. It discloses an edge-emitting LED comprising a light emitting region 4 made of $Al_{0.05}Ga_{0.95}As$, a first transparent layer 2 made of $Al_{0.07}Ga_{0.93}As$, a first total reflection layer 1 made of $Al_{0.29}Ga_{0.71}As$ having a thickness of 2.0 µm and contacting the first transparent layer, and a substrate 10, all layers stacked in this order (cf. Figure 1; column 2, line 32 to column 3, line 14; column 4, lines 53 to 66). The bandgap of the first transparent layer 2 is larger than that of the light emitting region 4 due to the higher aluminium content, and therefore, the first transparent layer is pervious to light radiated from the light emitting region (cf. column 3, lines 15 to 30).

2.1.2 As shown in the decision under appeal, when the values of the aluminium content x is inserted in the formulas in column 3, lines 12 of document D5 for the refractive index, one finds that the refractive index of the first total reflection layer 1 (n = 3.392) is smaller than that of the first transparent layer 2 (n = 3.541).

Furthermore, the light emitted from the light emitting layer having a bandgap of 1.486 eV has a centre wavelength of 0.8345 µm (cf. column 3, line 30). Thus, the product of the thickness (2.0 µm) with the

refractive index (3.392) of the total reflection layer 1 is equal to 6.784 µm which is more than eight times the centre wavelength of the light emitted from the light emitting region 4.

2.1.3 The device of claim 1 according to the main request thus differs from that of document D5 in that (i) the first transparent layer consists of GaN or AlGaInN and the first total reflection layer consists of AlGaInN; whereas in document D5, the corresponding layers are made of AlGaAs; and that (ii) the substrate is opaque, whereas document D5 does not specify the material of the substrate; and

2.1.4 The patent in suit addresses the problem of light being absorbed by the substrate of an edge-emitting LED when a substrate or opaque layer is used which is impervious to the light radiated from the LED (cf. page 3, lines 20 to 24, as well as item VII(a) above). As held in the decision under appeal, however, the device of document D5 comprises a total reflection layer 1 which is sufficiently thick so that tunnelling of light through the total reflection layer is negligible, and consequently, the problem of light absorption by the substrate is already solved by the device of document D5. Therefore, it is immaterial to the performance of the device of document D5 whether the substrate is pervious or not to the radiated light.

Regarding feature (i), the selection of GaN or AlGaInN for the active layer and AlGaInN for the first total reflection layer, these materials have a wider bandgap than AlGaAs used in the device of document D5 for emitting red or infrared light.

Since the two features (i) and (ii) are not functionally interdependent, the objective technical problems which are solved by the claimed invention relate to modifying the device of document D5 so that it emits light with colours other than red, and finding a suitable substrate for the modified device.

2.1.5 It has not been disputed LEDs made of AlGaInN or GaN were *per se* known in the art at the priority date of the patent in suit. Moreover, AlGaAs, AlGaInN, and GaN are all III-V semiconductor materials, which are known to have many physical properties in common. Therefore, a skilled person seeking an alternative to AlGaAs for emitting light with shorter wavelengths than what is possible with the device of document D5 would as a matter of routine consider other III-V semiconductors, such as AlGaInN and GaN, for the light emitting layer.

Having selected a suitable material system for the active layer, the skilled person would as a matter of course use the same material system for the other layers of the LED, in analogy with the materials used in the device disclosed of document D5.

2.1.6 As to the substrate (feature (ii)), it was held in the decision under appeal that the skilled person would routinely employ an opaque substrate in an LED according to document D5 without employing inventive skills. The Board agrees with this assessment, since, as mentioned above, the problem of absorption of the emitted light by the substrate does not arise due to the provision of the first total reflection layer in the device of document D5 which confines the emitted

light to the light emitting region and the first transparent layer, and therefore, the question whether the substrate is opaque or not is immaterial to the performance, such as the light emitting efficiency, of the device of document D5. For these reasons, the skilled person would routinely consider the use of an opaque substrate for growing high-quality AlGaInN layers onto it.

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

2.2 Auxiliary request

2.2.1 With respect to the main request, claim 1 according to the auxiliary request does not specify the materials of the active region and the first total reflection layer. The first transparent layer according to the claim has "a wave-guiding effect on light radiated from the light-emitting layer".

2.2.2 The appellant argued that the decision under appeal was not justified in its finding that first transparent layer 2 of the device of document D5 "has also some wave guiding effect" (cf. item VII(c) above).

The Board cannot follow this argument, since document D5 discloses that the different layers of the LED have compositions such that the index of refraction of the total reflection layer 1 is less than that of the first transparent layer 2 (cf. column 2, line 65 to column 3, line 4). Similarly, the index of refraction of the light emitting layer 4 is larger than that of a layer 5

adjoining the light emitting layer, so that the light generated within the LED is confined within an optical cavity consisting of the first transparent layer 2, the light emitting region 4, and a confining layer 3 between the transparent layer and the light emitting layer. Since the first transparent layer 2 is part of a wave-guide, it therefore must be considered as having a "wave-guiding effect" on the light radiated from the light emitting layer.

2.2.3 The appellant argued furthermore that the decision under appeal overlooked that in the device of document D5, the light radiated from the light emitting region 4 has to tunnel through a confining layer 3 in order to reach the first transparent layer 2 (cf. item VII(d) above).

As the respondent correctly pointed out, the wording of claim 1 does not exclude the presence of a confining layer between the first transparent layer and the light emitting region, and therefore this argument cannot be accepted.

2.2.4 It follows from the analysis of document D5 made above that the device of claim 1 according to the auxiliary request differs from that of document D5 in that the substrate is opaque (impervious) to the light radiated from the light emitting region, whereas document D5 does not disclose any material for the substrate.

2.2.5 Thus, the selection of a substrate for the device of document D5 which is opaque to the radiated light is not considered to involve an inventive step within the meaning of Article 56 EPC for the same reasons as for the main request (cf. items 2.1.4 and 2.1.6 above).

3. Since, for the reasons given above, none of the appellant's requests meets the requirement of inventive step, the patent in suit has to remain revoked pursuant to Article 102(1) EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Meyfarth R. K. Shukla