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D E C I S I O N
of 12 February 1998

Case Number: T 0118/94 - 3.4.1

Application Number: 89202977.8

Publication Number: 0371554

IPC: H01L 33/00

Language of the proceedings: EN

Title of invention:
Electroluminescent diode having a low capacitance

Applicant:
Philips Electronics N.V.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no) - (request to decide on the written documents)"

Decisions cited:
T 0036/82

Catchword:
-

Case Number: T 0118/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 12 February 1998

Appellant: Philips Electronics N.V.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 23 December 1993 refusing European patent application No. 89 202 977.8 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: H. J. Reich
Members: C. Holtz
G. Assi

Summary of Facts and Submissions

I. European patent application No. 89 202 977.8 (publication No. 0 371 554) having a priority date of 29 November 1988, was refused by a decision of the Examining Division dated 23 December 1993.

II. The reason given for the refusal was that the subject-matter of claim 1 filed with letter dated 11 January 1993 did not satisfy the requirements of Articles 52 and 56 EPC having regard to the state of the art disclosed in documents:

D1: Patent Abstracts of Japan, vol. 6, No. 243 (E-145) [1121], 2 December 1982, page 144, & JP-A-57 143 888; and

D2: EP-A-0 161 016.

The Examining Division took the view that the features of the first part of claim 1 were known from document D1. Since the devices of documents D1 and D2 both employed a blocking layer, also the device of document D1 suffered from the occurrence of parasitic capacitances and currents at very high frequencies, resulting in a serious limitation of the modulation bandwidth as mentioned in document D2, page 6, line 35 to page 7, line 4. To overcome this problem, document D2 taught to use a high resistance region having a disturbed crystal structure which extends outside on either side of a strip-shaped active region from the side opposite the substrate. Hence, a skilled person would find a clear motivation to use the solution indicated in document D2 in order to improve the high frequency operation of the device according to document D1. This improvement would result in the characterising features of claim 1, and in particular in a "certain distance" between the contact region and the disturbed crystal structure. The fact that in document D2 the width of the active region was smaller than the contact region, was no hindrance to apply the teaching of document D2 to any other structure suffering from the same drawback. The argument of the applicant that document D2 taught to provide a high-ohmic region bordering the contact region, would render the function of the blocking layer obsolete, which would be inconsistent with the teaching of document D2. The features defined in original dependent claims 2 to 8 were regarded as obvious.

III. The applicant lodged an appeal against this decision, paid the fee and filed the grounds on 26 January 1994, requesting grant on the basis of new claims 1 to 7, wherein claim 1 comprises the features of original claims 1 and 2 refused by the Examining Division.

Claim 1 filed on 26 January 1994 with letter 24 January 1994 reads as follows:

"1. A semiconductor device for producing electromagnetic radiation having a monocrystalline semiconductor body (H) comprising a first region (1) of a first conductivity type and a second region (2) of the second opposite conductivity type forming with the first region (1) a pn junction (3) which can emit electro-magnetic radiation at a sufficiently high current strength in the forward direction, while on the second region (2) and above an active region of the device are disposed a continuous blocking layer (4) of the first conductivity type and highly doped contact layer (8) of the second conductivity type, which contact layer (8) is disposed on the blocking layer (4), adjoins a surface (6) of the body (H) and is connected to a contact region (7) of the second conductivity type, which contact region (7) has a higher doping concentration than the blocking layer (4), also adjoins the surface (6) of the body (H) and extends from the surface (6) of the body (H) through the contact layer (8), through the blocking layer (4) and into the second region (2), thus forming by overdoping an interruption (5) of the blocking layer (4), a first electrode (9) being provided on the first region (1) and a second electrode (10) being provided on the contact region (7) and the contact layer (8), characterised in that a high-ohmic region (11) having a disturbed crystal structure, which is located at a certain distance (d) from the contact region (7) and is obtained by ion bombardment, extends from the said surface (6) at least through the contact layer (8) and the blocking layer (4) and in that the part of the surface not occupied by the high-ohmic region (11) is larger than twice the surface of the contact region (7) and is smaller than 60,000 μm^2, while the distance between the contact region (7) and the high-ohmic region (11) is practically equal throughout the structure."

Claims 2 to 7 as filed with letter dated 24 January 1994 are dependent on claim 1.

IV. In support of his request, the appellant argued essentially as follows:

(a) Thanks to the features that the high-ohmic region is "at a certain distance" of the contact region and has geometrical dimensions as claimed, the resistance reducing function of the contact layer is not lost, and the features surprisingly result in an optimum performance both with respect to the high-frequency behaviour and with respect to a low resistance.

(b) Document D2 does teach a high-ohmic region immediately bordering the contact region. In document D2 the same (strip-shaped) window in the oxide layer is used for a p^{+}-type diffusion into the contact layer, for forming a contact between the conducting electrode layer and the contact layer and for forming the gold mask that is used to implant the high-ohmic regions; see D2, page 9, lines 10 to 19. Thus, application of the teaching of document D2 on the device of document D1 does not result in the device of the present invention.

V. In an annex to a summons to oral proceedings which had been requested auxiliary, the Board informed the appellant of its following provisional views: It appears not to be contested by the appellant that document D1 discloses all the features defined by the wording of the pre-characterising part of claim 1. Document D2 teaches to avoid parasitic lateral leakage currents which are due to parasitic capacitances of the blocking layer by providing a high-ohmic region outside the active region; see document D2, page 4, paragraph 1; page 7, paragraph 2 and page 3, paragraph 4. An equal distance between the contact region and the high-ohmic region throughout the structure follows from its production by ion bombardment. In the device of document D2 there is no contact region as defined in claim 1. In the device of document D2 the channel above the opening of layer 5 above region 4a in Figure 1 is regarded by a skilled person as the analogon to (contact) region 7 of document D1. From the structure of Figure 1 of document D2 a skilled person would derive that a high-ohmic region for reducing parasitic lateral currents has to be provided in such an extension that the effective resistance of the essential current paths on the way to the active region is not increased. The remaining features of the characterising part of claim 1:

"in that the part of the surface not occupied by the high-ohmic region is larger than twice the surface of the contact region and is smaller than 60,000 μm^2"

would be regarded as the result of an obvious optimisation of two conflicting parameters; see also decision T 36/82, OJ EPO 1983, 269. For the above reasons, the subject-matter of claim 1 might possibly be held to be obvious.

VI. In a reply dated 27 August 1997 to the above-mentioned summons, the appellant withdrew his request for oral proceedings and submitted that the applicant wishes the Board to decide the present appeal on the written documents, requesting grant on the basis of the following documents:

Claim 1 as filed with letter dated 27 August 1997; and claims 2 to 7 as filed with letter dated 24 January 1994.

Claim 1 as filed with letter dated 27 August 1997 adds to the wording of the pre-characterising part of claim 1 as filed with letter dated 24 January 1994 after ... "which contact region (7) has a higher doping concentration than the blocking layer (4)" the words:

"and the second region (2)".

VII. In his letter dated 27 August 1997 the appellant submitted essentially the following arguments:

(a) The amendment introduced into claim 1 clarifies the nature of the contact region. Having regard to the analogy of the current channels in documents D1 and D2, the Board ignores the lower figure of D1 which shows that the contact region is broader than the channel in the blocking layer 12, laterally limiting the access to the active region 3.

(b) Defining a contact region - as a region contacting the contact layer and extending locally into the layer structure and having a lower specific resistance than the regions below the contact layer which laterally border said contact region -, the regions between the proton bombarded regions 14 and below contact layer 8 in Figure 1 of document D2 can be considered as a contact region. This implies that document D2 teaches a "zero distance" between the contact region and the proton bombarded region. The lateral distance between the borders of layer 14 and the strip in layer 9 of Figure 1 of document D2 is either not correct or unintentional in view of the gold mask used in the ion bombardment step; see D2, page 9, lines 10 to 20.

Reasons for the Decision

1. The appeal is admissible.

2. The appellant's clarification of the nature of the contact-region according to paragraph VI above, concerns a more precise definition of layer 7 in the

figures of document D1 and in Figure 1 of the present application. This clarification has no technical impact on the invention as claimed in claim 1 filed with letter dated 24 January 1994. Hence, in claim 1 as filed with letter dated 27 August 1997 the essential features of the invention of the present application have been maintained with identical subject-matter.

3. *Claim 1 - inventive step*

3.1 The closest prior art is formed by the device disclosed in document D1, which comprises - as not contested by the appellant - the features defined in the pre-characterising part of claim 1; see document D1, the first region 1, 2; the second region 4; the active region in the centre of layer 3; the blocking layer 5; the contact **layer** 11; the contact **region** 7; and the first and second electrodes 8 and 10.

3.2 Starting from this prior art, the problem underlying claim 1 is to reduce attenuation of optical power at high modulation frequencies above 100 MHz due to the capacitance caused by the contact layer (adjoining the blocking layer) without the resistance reducing function of the contact **layer** being lost; see also the description page 2, lines 43, 44 and 55; page 3, lines 1 and 5 to 8; and Figures 2 and 3. The problem of an undesirable attenuation of the optical power at high frequencies caused by the capacitance formed by the blocking layer together with the adjoining semiconductor material, is known from document D2; page 4, paragraph 1. It is self-evident that a skilled person will intend to find a solution to this problem which does not destroy the known positive properties of the prior art device to be improved, such as the resistance reducing function of the contact layer. Therefore, in the Board's view, no contribution to an inventive step underlying the subject-matter of claim 1, is to be found in the definition of the above problem.

3.3 The above problem is solved by the technical means defined by the wording of the characterising part of claim 1.

3.3.1 Document D2, page 3, paragraph 4 and page 7, paragraph 2 teaches to avoid leakage currents due to the parasitic capacitance of blocking layer 5 by high resistive region 14 having an ion-bombarded disturbed crystal structure "outside" and on either side of the strip-shaped active region 4a. On the basis of such knowledge the Board regards a skilled person to be able to recognise that the undesired attenuation of the optical power at high frequencies in Figure 2 of the present application, i.e. in the device of document D1, is as well caused by parasitic capacitances of the blocking layer. The resulting lateral leakage currents reduce the amount of pumping current which passes through the active region. Thereby the optical output power is reduced. Hence, a skilled person has a technical motive to provide the high resistivity region 14 of document D2 also in the device of document D1. A skilled person arrives thus in an obvious way at the following features claimed in the characterising part of claim 1:

"a high-ohmic region (D2, 14 in Figure 1) having a disturbed crystal structure, which is ... obtained by ion bombardment (page 7, lines 21 to 23), extends from the said surface at least through the contact layer (7) and the blocking layer (5) ... while the distance between the contact region and the high-ohmic region is practically equal throughout the structure (a consequence of the ion bombardment)."

3.3.2 In its arguments according to paragraphs IV and VII above, the appellant employs the term "contact region" for defining two diverging semiconductor structures. Having regard to document D1 (and consistent with the use of this term in the present application) a "contact region" defines a highly doped region 7 which extends from the upper surface into the semiconductor volume above the active region. This region 7 forms by over-doping an "interruption" in the blocking layer. This interruption defines the upper entry area of the pumping current into the semiconductor volume which guides the pumping current to the active region (current channel). With regard to document D2 the appellant uses the term "contact region" for defining those regions of layers 6 and 7 which lie outside the proton-bombarded high-ohmic region 14. Hence, it is a mere logical consequence of such changed definition that a "zero distance" between the correspondingly defined contact area and the proton bombarded region describes the structure of the device disclosed in document D2. However, the Board regards the appellant's interpretation of document D2 in paragraphs IV-(b) and VII-(b) as not appropriate to specify the technical teaching which a skilled person derives from document D2. Instead, in document D2 the upper entry area of the pumping current into the current channel within the semiconductor is formed by the window in SiO_2-layer 9. Hence, with regard to the entry area of the pumping current into the semiconductor, there is clearly an analogy between the "window" in layer 9 of document D2 and the "interruption" in blocking layer 5 of document D1. Contrary to the appellant's implicit opinion in paragraph VI-(a), the dimensions of the entry area of the pumping current are independent from the lateral extension of the deeper lying active region.

3.3.3 The appellant's arguments in paragraphs IV-(b) and VII-(b) concerning the lateral distance between the inner border of high-ohmic region 14 and the limits of the window in layer 9, are not convincing. Document D2, in particular page 9, lines 10 to 20 is silent about the lateral extension of the gold mask used in the proton bombardment. In the Board's view, a skilled person will consider the teaching derivable from Figure 1 of the document D2 - i.e. the fact that region 14 stays outside the opening in SiO_2-layer 9 - as realistic. This fact is consistent with the teaching derivable from the description of document D2, page 7, lines 21 to 23 stating that by high-ohmic region 14 the impedance level is increased in the "non-active parts of the laser". Hence, document D2 teaches to restrict high-ohmic region 14 to non-active parts of the device. Non-active parts are clearly the semiconductor regions which show no pumping current flow and thereby do not contribute to the intensity of the emitted light.

3.3.4 The appellant can be followed in that in the devices of documents D1 and D2 the entry area of the pumping current has a larger width than the strip of the active region. As a consequence, in both these devices the effective series resistance between the upper electrode and the active region is determined by a semiconductor volume in form of a mesa-like funnel. However, the subject-matter of claim 1 is not restricted to a particular strip width of the active region relative to the entry area of the pumping current. Therefore, contrary to the appellant's opinion in paragraph VII-(a), the geometrical shape of the semiconductor volume which guides the pumping current flow to the active region (i.e. the geometrical shape of the current channel) is not relevant with regard to the subject-matter of claim 1. Independent from any particular geometrical form of the current channel, the skilled person will easily recognise that contact region 7 of document D1 (wherein the term "contact region" is consistent with its meaning in the present application) is **in total** part of the current channel and thus an active part of the device. For this reason, in the Board's view, when employing the teaching of document D2 (to provide the high-ohmic region in the non-active part) in the device of document D1, it is obvious to a skilled person to arrange the high-ohmic region outside the current channel, i.e. in such a way that it is "located **at a certain distance** from the contact region" as claimed in claim 1.

3.3.5 In the Board's view, when dimensioning the lateral extension of the high-ohmic region, a skilled person is able to foresee that reducing the part of the surface which is not occupied by the high-ohmic region (i.e. an approach of the limits of the high-ohmic region towards the channel width of the active region) will decrease the negative influence of the parasitic capacitances and as well the known positive resistance reducing effect of the contacting **layer** 11 of document D1. Hence, a skilled person will easily realise in practical use that parasitic capacitance and effective device resistance are conflicting parameters which have to be compromised by an appropriate dimensioning of the high-ohmic region. The effects of such dimensioning as disclosed in the description, in particular page 3, lines 5 to 11 are restricted to such optimisation. The description discloses no additional unexpected effect which is produced by the claimed dimensions of the high-ohmic region. Therefore, the Board sees in the remaining features of the characterising part of claim 1:

"in that the part of the surface not occupied by the high-ohmic region is larger than twice the surface of the contact region and is smaller than 60 000 μm^2"

the mere result of an optimisation of two conflicting parameters, which is regarded to be not inventive; see also decision T 36/82, OJ EPO 1983, 269.

3.4 For the reasons set out in detail in paragraphs 3.1 to 3.3.5 above, in the Board's judgment, claim 1 does not involve an inventive step and is not allowable pursuant to Articles 52(1) and 56 EPC. Claims 2 to 7 fall because of their dependence on claim 1.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer H. J. Reich