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D E C I S I O N
of 1 August 2001

Case Number: T 0049/97 - 3.4.3

Application Number: 90306788.2

Publication Number: 0404565

IPC: H01L 33/00

Language of the proceedings: EN

Title of invention:
Compound semiconductor device and method of surface treatment of such a device

Patentee:
MITSUBISHI KASEI CORPORATION

Opponent:
Siemens AG

Headword:
-

Relevant legal provisions:
EPC Art. 56, 113(2)

Keyword:
"Inventive step (no) no unexpected effect"
"Non-appearance of a party at oral proceedings - Right to be heard (not violated)"

Decisions cited:
T 0930/92, G 0004/92

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0049/97 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 1 August 2001

Appellant: (Opponent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 4 November 1996 rejecting the opposition filed against European patent No. 0 404 565 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: V. L. P. Frank
M. J. Vogel

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal on 20 December 1996 against the decision of the opposition division, dispatched on 4 November 1996, rejecting the opposition against the European patent No. 0 404 565 pursuant to Article 102(2) EPC. The fee for the appeal was paid on 20 December 1996. The statement setting out the grounds of appeal was received on 6 March 1997.

The opposition was filed against the patent as a whole and based on Article 100(a) together with Articles 52(1) and 56 EPC.

The opposition division held that the grounds for the opposition mentioned in Article 100(a) EPC did not prejudice the maintenance of the patent unamended, having regard *inter alia* to the following prior art documents cited in the opposition proceedings:

D3: DD-A-251 905

D4: G. Winstel et al., Optoelektronik I, Springer-Verlag, 1980

D5: Japanese Journal of Applied Physics, vol. 27, no. 12, December 1988, pp. L2404-L2407

II. Oral proceedings, which were requested by the appellant as an auxiliary request, were held before the Board on 1 August 2001. The respondent (patentee), although duly summoned to oral proceedings with the communication of 9 May 2001, did not appear.

III. The appellant requested that the decision under appeal

be set aside and the patent be revoked.

IV. The respondent had requested that the appeal be dismissed.

V. The wording of independent claims 1 and 6 forming the basis of the contested decision reads as follows:

"1. A compound semiconductor device comprising a compound of an element of group III-V of the periodic table, wherein roughness is formed on the surface of said compound semiconductor and a SiN_x film is formed on said rough surface."

"6. A surface treatment method of a compound semiconductor comprising a compound of an element of III-V of the periodic table, wherein roughness is formed on the surface of said semiconductor by a physical or chemical method, and a SiN_x film is then formed on the rough surface by a reduced pressure CVD method, plasma CVD method or sputtering method."

VI. The appellant argued essentially as follows:

- Document D3, which is the closest prior art, discloses a surface roughening method of a group III-V light emitting diode for increasing its luminance. The only difference between the device claimed in claim 1 of the patent in suit and the device disclosed in this document is, therefore, the presence of a SiN_x film on the roughened surface.

- It was known, however, from document D5 that a thin native oxide forms on the surface of III-V

photodiodes when exposed to air, causing long term failure of device performance. To avoid oxidation of the device's surface a SiO_2-, Si_3N_4- or polymide-film was used for surface passivation. This film was also employed as an antireflection coating to maximize the output of light. For a skilled person it was obvious to choose the most suitable material from the three materials mentioned in document D5 as an antireflection coating and a passivation layer in the light emitting diode of document D3.

- The skilled person would also arrive at the claimed device in an obvious manner by using a quarter wavelength layer of SiO, SiO_2 and Si_3N_4 for increasing the transmission of light, as suggested in document D4.

- Moreover, document D5 shows in Figure 1 a cross sectional view of the photodiode used. It is clear to the skilled person that the mesa structure employed was obtained by etching. However, etching a material produces usually a roughened surface. As the patent does not pose any specific requirements on the roughness for the performance of the invention, all the essential elements of the device of claim 1, namely a roughened surface and a SiN_x layer, were at least suggested by this document.

- He further pointed out that with respect to claim 6 of the patent in suit, documents D3 and D5 disclose, respectively, the surface roughening and the SiN_x layer forming methods specified in this claim.

VII. The respondent argued essentially as follows:

- The invention as claimed increases the moisture resistance of a semiconductor device by means of a protective film, which itself is not easily detachable due to the roughened surface of the semiconductor device. The combination of a protective SiN_x film and a roughened surface increases the luminance and durability of the semiconductor device. The resultant effects are surprisingly greater than the sum of the effects of the individual features (see the patent in suit page 5, lines 32 to 35 and Table 1).

- However, the problem of moisture degradation is not addressed by document D3. Furthermore, the oxidation of the material is only mentioned in connection with the chemical etching process. Thus, there is no reason why the person skilled in the art would consider the problems presented by moisture or accelerated ageing when reading this document.

- Document D5 also does not address the problem due to moisture and no distinction is made in this document between the three materials proposed for the passivation layer. This document discloses a high efficiency photodiode, i.e. a light absorbing device, and has, for this reason, no relation with the present invention.

- Moreover, there are no reasons why the skilled person would have combined the teachings of documents D3 and D5, since they are individually concerned with quite different problems.

- Document D4 does also not address the effects of moisture and again no distinction is made between the different materials proposed for the quarter wavelength layer, although such a difference is crucial to the patentee's invention (see the Comparative Example). This document is merely concerned with increasing the transmission coefficient for vertically incident rays on a planar surface.

Reasons for the Decision

1. The appeal is admissible.

2. *Inventive step (Article 56 EPC)*

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

2.1 It is common ground that document D3 represents the closest prior art.

This document discloses a chemical, wet etching method for roughening the surface of III-V light emitting diodes in order to increase their luminance and to improve the contrast between the light emitting and the metallization regions (cf. Abstract and page 1, second full paragraph). The method is employed on easily oxidizable ("oxidationsempfindliche") III-V compounds, such as GaAs and GaAlAs (cf. page 2, second and fourth full paragraphs).

2.2 The compound semiconductor device claimed in claim 1 of the patent in suit differs from this known device in that a SiN_x film is formed on the roughened surface.

2.3 According to the patent in suit, the presence of the SiN_x film improves the moisture resistance of the device, extending its service life by preventing oxidation, and also increases the external quantum efficiency by preventing internal total reflection of the generated light (cf. page 2, lines 24 to 26 and 28 to 33).

The objective technical problem addressed by the patent having regard to document D3 is, therefore, to increase the service life and the light output of a compound semiconductor device.

2.4 It is known from document D5 that GaAs develops a thin native oxide layer when exposed to air and that this effect causes long term failure of the device performance. Although in this document the disclosed semiconductor device is a photodiode, it is clear to the skilled person that the oxidation process is inherent to the material and is not limited to a specific device.

To prevent the oxidation of the material a surface passivation layer made of SiO_2, Si_3N_4 or polymide is employed in this document. This layer is additionally used as an antireflection coating by adjusting its thickness according to the quarter wavelength rule (cf. page L2405, left hand column, first full paragraph).

According to document D5, the dark current is related to the presence of the oxide layer and the smallest reverse-bias dark current is obtained with a passivation layer made of Si_3N_4 (cf. Figure 2). For the skilled person it would therefore be clear that Si_3N_4 is the best choice for surface passivation and for

preventing surface oxidation and, in consequence, he would, apply a Si_3N_4 layer to the device known from document D3 in order to protect it from oxidation and improve its light output.

However, the problem of moisture resistance is, in the Board's view, intimately related to the problem of surface oxidation. In consequence, the skilled person would recognize that the use of a passivation layer as proposed in document D5 would also solve the objective technical problem that the patent in suit addresses.

2.5 Document D4, which is a textbook on optoelectronics, suggests the use of quarter wavelength films of materials having a suitable index of refraction for increasing the light transmission coefficient and, consequently, the external quantum efficiency of a planar light emitting diode. The film's index of refraction (n) should be equal to the geometric mean of the indices of air and the semiconductor material. In the case of GaAs or AlGaAs, having an index of refraction of about 3.3, the geometric mean lies between 1.8 and 1.9. This document further suggests SiO, SiO_2 or Si_3N_4 films as possible film materials.

The skilled person would, for this reason, apply a quarter wavelength film on the light emitting diode known form document D3 in order to increase the light transmission and, accordingly, the light output. In particular, he would select a film material having an index of refraction falling within the range specified in this document.

2.6 The respondent referred to the comparative example given in the patent in suit to show that all the

materials mentioned in documents D4 and D5 are not equivalent to each other and that maximum light transmission is only achieved with a SiN_x film.

In this connection, it was contended by the respondent, that in the comparative example using a SiO_2 protective film (n = 1.5) on an AlGaAs light emitting diode the reflectance reached a minimum value of only 3.6% and, consequently, a high luminance output could not be obtained (cf. page 5, lines 11 to 14 and Figure 11). In contrast, by using a SiN_x protective film (n = 1.9) the minimum reflectance achieved was as low as 0.2% (cf. page 4, lines 44 to 48 and Figure 10). Consequently, according to the respondent, the comparative example illustrates a much higher performance achieved by using SiN_x as material for the antireflection coating.

2.7 The Board, however, does not recognize any unexpected effect in this comparison. In fact, document D4 discloses that for satisfying the quarter wavelength condition the film's refraction index should be between 1.8 and 1.9. This condition is satisfied by the SiN_x film used (n = 1.9) but not by the SiO_2 film (n = 1.5). Consequently, the skilled person would expect a lower reflectance for the former material and would, therefore, use a SiN_x coating instead of a film made of SiO_2.

2.8 The respondent further contended that the moisture resistance achieved by a device in which surface roughness is combined with a SiN_x protective film is surprisingly high. In Table I of the patent in suit values are shown for the residual luminance ratio after having performed a moisture resistance test on the

device. This Table gives the values of a device with only a SiN_x film formed on it, a device having only surface roughness and a device in which both measures are present. For the first two devices the luminance drops to about 82% of its initial value and for the third device to 96.7% after the devices were subjected to moisture resistance tests. After a further test series, the residual luminance further decreases to about 77% when each measure is applied independently and to 93.6% when both measures are combined. This result, according to the respondent, clearly shows a synergetic effect between surface roughness and the protective film which is greater than the sum of the individual effects.

2.9 However, Table 1 of the patent does not provide the luminance reduction after the moisture test in case of a device without a rough surface and without a protective film. Such a reference value is, however, required to determine the effect of each individual measure on the moisture resistance of the device. As the individual contribution of each measure cannot be determined, it cannot be established how the combined effect relates to the effect of each individual measure. In consequence, from the values given in Table 1 of the patent in suit no conclusion can be reached regarding any synergetic effect of both the measures in the claimed device.

2.10 In the Board's view, a skilled person, based on the disclosure of document D5, would have formed a SiN_x film on the device disclosed in document D3 to address the technical problem mentioned above. The subject-matter of claim 1, therefore, does not involve an inventive step.

2.11 The surface treatment method claimed in independent claim 6 differs from the method disclosed in document D3 in that a SiN_x film is formed on the rough surface by a reduced pressure CVD method, a plasma CVD method or a sputtering method.

However, in document D5 the Si_3N_4 film is formed by plasma rf sputtering (cf. D5, page L2405, left hand column, end of the second paragraph).

In consequence, for the above reasons and the reasons advanced in respect of the subject-matter of claim 1 the subject-mater of claim 6 does not involve an inventive step, having regard to the teachings of documents D3 and D5.

3. For the above mentioned reasons, in the Board's judgement, the subject-matters of claims 1 and 6 of the patent in suit do not involve an inventive step in the sense of Article 56 EPC and are, therefore, not patentable.

4. *Non-appearance of a party at oral proceedings*

4.1 As stated under point II above, the respondent did not appear at the oral proceedings without any prior notification that he intended to do so.

4.2 According to decision G 4/92 (OJ 1994, 149) of the Enlarged Board of Appeal, a decision against a party who has been duly summoned but who fails to appear at oral proceedings may not be based on facts or evidence put forward for the first time during those oral proceedings.

As the present decision is based on facts considered already in the written opposition appeal proceedings and no new facts or evidence were presented during the oral proceedings held on the 1 August 2001, the respondent's right to be heard has been respected (Article 113(1) EPC).

4.3 If a party, although having been duly summoned, does not appear at the oral proceedings and did not notify the Board that it intended to do so, an apportionment of costs may be ordered for reasons of equity (cf. T 930/92, OJ 1996, 191). In the present case, as there was no request for the apportionment of costs by the appellant pursuant to Article 104(1) EPC, each party shall meet the costs he has incurred.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla