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**Datasheet for the decision  
of 6 July 2017**

**Case Number:** T 0937/12 - 3.4.03

**Application Number:** 07254673.2

**Publication Number:** 2056368

**IPC:** H01L33/00

**Language of the proceedings:** EN

**Title of invention:**

Light emitting device and method for manufacturing the same

**Applicant:**

LG Electronics Inc.  
LG Innotek Co., Ltd.

**Headword:**

**Relevant legal provisions:**

EPC 1973 Art. 84, 111(1)  
EPC Art. 123(2)  
RPBA Art. 15(1)

**Keyword:**

Amendments - extension beyond the content of the application  
as filed (no)

Claims - clarity (yes)

Remittal to the department of first instance - (yes)

**Decisions cited:**

**Catchword:**



**Beschwerdekammern**  
**Boards of Appeal**  
**Chambres de recours**

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Case Number: T 0937/12 - 3.4.03

**D E C I S I O N**  
**of Technical Board of Appeal 3.4.03**  
**of 6 July 2017**

**Appellant:** LG Electronics Inc.  
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**Appellant:** LG Innotek Co., Ltd.  
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**Decision under appeal:** **Decision of the Examining Division of the European Patent Office posted on 12 December 2011 refusing European patent application No. 07254673.2 pursuant to Article 97(2) EPC.**

**Composition of the Board:**

**Chairman** G. Eliasson  
**Members:** S. Ward  
T. Bokor

## Summary of Facts and Submissions

- I. The appeal is against the decision of the Examining Division refusing European patent application No. 07 254 673 on the ground that the main request and the first and second auxiliary requests were not admissible, as they did not meet the requirements of Article 123(2) EPC. The Examining Division concluded: "it follows that there is no valid request on file, and the application must be refused under Article 97(2) EPC."
- II. At the end of the oral proceedings held before the Board the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of Claims 1-13 of the "New Main Request" filed during the oral proceedings before the Board.
- III. Claim 1 reads as follows:
- "A light emitting device comprising:  
a semiconductor layer (10) having a multi-layered structure including a light emission layer (12); and  
a light extraction structure (50) formed as a photonic crystal on the semiconductor layer (10) with a pattern having unit structures (51), each of the unit structures having a hole shape,  
wherein the side wall of each of the unit structures (51) is sloped at an angle of up to 45° (excluding 0°) from a virtual vertical line being parallel to a main light emitting direction of the light emitting device and extends from an inner surface to an outer surface of the light extraction structure (50), each of the unit structures (51) thus having beveled side walls;  
characterized in that:*

*r<sub>o</sub> is 0.35a and r<sub>i</sub> is from 0 to less than 0.35a, wherein r<sub>o</sub> is the radius of each unit structure (51) on the outer surface, whilst r<sub>i</sub> is the radius of each unit structure on the inner surface, and wherein "a" represents the period of the pattern."*

Claim 10 reads as follows:

*"A method for manufacturing a light emitting device according to claim 1, said method comprising: applying a mask layer on a light extraction layer for forming a light extraction structure (50); forming the light extraction structure (50) as a photonic crystal by using the mask layer, the light extraction structure (50) having a pattern with unit structures (51), each of the unit structures having a hole shape; wherein the side wall of each of the unit structures (51) is sloped at an angle of up to 45° (excluding 0°) from a virtual vertical line being parallel to a main light emitting direction of the light emitting device and extends from an inner surface to an outer surface of the light extraction structure (50), each of the unit structures (51) thus having beveled side walls; characterized in that r<sub>o</sub> is 0.35a and r<sub>i</sub> is from 0 to less than 0.35a, wherein r<sub>o</sub> is the radius of the unit structure (51) on the outer surface, whilst r<sub>i</sub> is the radius of the unit structure on the inner surface, and wherein "a" represents the period of the pattern."*

- IV. With the summons to oral proceedings, the Board sent a communication under Article 15(1) RPBA setting out its provisional view on the main request filed with the statement of grounds of appeal. The Board expressed doubts whether the requirements of Article 123(2) EPC

were met, and whether the definition of the "average filling factor" (a term which appeared in the independent claims) was clear.

- V. The present sole request differs significantly from those on which the contested decision was based, so that the arguments of the Examining Division substantiating its decision to refuse the application are no longer relevant and need not be repeated here.

### **Reasons for the Decision**

1. The appeal is admissible.
2. *Article 123(2) EPC*
  - 2.1 The preamble of claim 1 is principally based on claim 1 as filed. The light extraction structure is now referred to as being "formed as a photonic crystal", which reflects the consistent terminology throughout the description. It is questionable whether "each of the unit structures (51) thus having beveled side walls" adds any further limitation, given that the side walls are defined as "sloped", but in any event the Board sees no reason to object to this feature under Article 123(2) EPC, since the term "beveled walls" explicitly occurs twice in the application (paragraphs [0095] and [0108]).
  - 2.2 The feature "(excluding 0°)" was not originally present in this express form, but is implicit not just from the description, but even on the basis of the other features in claim 1 ("sloped", "beveled", and the

feature referred to under point 2.4, below). Thus no objection under Article 123(2) EPC arises.

2.3 The remainder of the claim is concerned with the range of shapes of the unit structures.

Firstly, each of the unit structures is defined as having a hole shape, which was one of the options of original claim 11 (for basis, see also Figs. 20A and 20C, and paragraph [0102]).

The holes have a radius  $r_o$  on the outer surface of the light extraction structure and a radius  $r_i$  on the inner surface of the light extraction structure. Thus the outer aperture and the inner base of the holes are implicitly circular, and the side wall of each of the unit structures is sloped at an angle of up to  $45^\circ$  from a virtual vertical line being parallel to the main light emitting direction. This is all derivable from the definition of holes given in paragraphs [0102]-[0105] and depicted in Figs. 20A and 20C (it is unnecessary to import the inequality  $r_o > r_i$  from paragraph [0104], as this is implicit in the feature of the claim cited under point 2.4, below).

The holes are therefore understood to be in the form of frustoconical (or conical in the case of  $r_i=0$ ) cavities. The appellant confirmed at oral proceedings that this was also its understanding of the form of the holes.

2.4 Claim 1 defines the following further feature:

*" $r_o$  is  $0.35a$  and  $r_i$  is from 0 to less than  $0.35a$ , wherein ... " $a$ " represents the period of the pattern."*

2.5 As basis the appellant cites Fig. 19A (the terms " $r_{in}$ " and " $r_{out}$ " appearing in the captions of this figure clearly having the same meaning as " $r_i$ " and " $r_o$ " in the claims). Fig. 19A comprises a graph illustrating a relation between a filling factor and extraction efficiency in a photonic crystal having a straight wall (the graph having square data points). It is clear from the figure that "straight" here means non-bevelled (i.e.  $r_i=r_o$ ).

One of the points corresponds to  $r_i=r_o=0.35a$ , and below this radius the graph splits into two branches, one being the continuation of the data for straight walls, and the second (the graph having circular data points) representing a specific example of beveled walls in which  $r_o$  is maintained at  $0.35a$ , and  $r_i$  varies in a range down to  $r_i=0.00a$ . It is this second graph of Fig. 19A which, the appellant argues, provides the basis for the claimed feature.

2.6 Although not expressly stated, this graph clearly relates to unit structures in the form of holes, as claimed, rather than rods, since  $r_i=0$  would make no sense for rods (cf. Fig. 20B).

Moreover, the values  $r_i=0.35a$  and  $r_i=0$  are disclosed as end points of a range. This is clearly shown in the graph itself, and these values would also be recognised by the skilled person as the natural limits of  $r_i$ . For holes with beveled walls the natural lower limit is  $r_i=0$ , and the natural upper limit is  $r_i=0.35a$ , at which radius the wall becomes straight, so that for beveled side walls,  $r_i$  may take values arbitrarily close to (but not equal to)  $0.35a$ . Hence, the disclosed range may be represented mathematically as  $0 \leq r_i < 0.35a$ , or in words as " $r_i$  is from 0 to less than  $0.35a$ ", as claimed.



The appellant confirmed in oral proceedings that this was also its understanding of the disclosed range.

- 2.7 Hence, compared to the very general "unit structures" of original claim 1, the appellant has limited the claimed subject-matter to the particular example of holes having  $r_0=0.35a$  and  $0 \leq r_1 < 0.35a$ , and there can be no doubt that this feature is disclosed *per se* in Fig. 19A.
- 2.8 The Board accepts that limiting the claims to one specific example of the original application is permissible in principle. However, in order to meet the requirements of Article 123(2) EPC, the manner in which the example is claimed must reflect a level of generality which would be unambiguously apparent to a skilled person on the basis of the application as filed, and it is therefore necessary to examine whether amended claim 1 is satisfactory in this respect.
- 2.9 The plotted points in the graphs of Fig. 19A are arrived at by a computer simulation technique described in paragraphs [0081] to [0084] with the results discussed in paragraphs [0085] to [0093].

Running this simulation would necessarily require the selection of various parameters as input. For example, it is expressly mentioned in paragraph [0081] that GaN is selected as the material of the photonic crystal. Other parameters, even if not explicitly mentioned in relation to Fig 19A, would also have to be selected, such as the pattern layout (e.g. square or triangular), and such choices might be expected to have some impact on the results.

2.10 In the opinion of the Board, the question whether claim 1 corresponds to an appropriate level of generality essentially boils down to asking how a skilled person would interpret Fig. 19A in the context of the application as a whole.

In particular, would the skilled person regard the specific choices made in arriving at the graph for beveled side walls (e.g. GaN, pattern layout) as being essentially arbitrary selections made merely to provide a concrete example of the invention? Or would the skilled person derive from the application that the beneficial effects of beveled side walls shown in the figure result from selecting  $r_0=0.35a$  and  $0 \leq r_i < 0.35a$  *in combination with* particular choices of material, pattern layout etc., such that these choices must be regarded as essential features of the invention?

If the former is the case, the Board would see no problem under Article 123(2) EPC arising from the amendment; if the latter, the omission of features at least implicitly disclosed as being essential to the example would result in claimed subject-matter corresponding to an undisclosed level of generalisation.

2.11 Regarding the material of the photonic crystal, it is expressly stated in the description that the use of GaN is for "convenience of explanation" only and that "the photonic crystal proposed by the present invention may be applied regardless of kinds of light emitting devices" (paragraph [0081]).

More generally, the skilled reader would derive from the application that the invention concerns the relationship between the extraction efficiency and the

slope of the side walls of the holes (paragraph [0080]). In paragraph [0095] the "important conclusion" is reached that:

*"among the two photonic crystals having the same filling factor, the photonic crystal having beveled walls has a more excellent light extraction property than the photonic crystal having straight walls".*

Furthermore:

*"an excellent light extraction property is obtained when the wall of the above unit structure is sloped at an angle of  $-45^\circ$  to  $+45^\circ$  from a virtual vertical line being parallel to a main light emitting direction of the light emitting device" (paragraph [0096]).*

According to paragraph [0108], the invention also allows the electrical characteristics to be improved:

*"when the photonic crystal having beveled walls proposed by the present invention is employed, it is possible to minimize the loss of a semiconductor layer without deterioration in a light extraction effect".*

2.12 Thus, although it is evident that some material, some pattern layout etc. will have to be chosen to run the simulation (and to implement the device in reality), there is no disclosure that such parameters are critical for the invention. On the contrary, the teaching disclosed in the application is that superior optical and electrical characteristics may be achieved by providing devices with unit structures having beveled walls rather than straight walls, and claim 1 corresponds to a concrete example of such an arrangement as disclosed in Fig. 19A.

2.13 The Board therefore judges that claim 1 does not represent an inappropriate level of generalisation, and hence the requirements of Article 123(2) EPC are met. Independent claim 10 (based on original claim 20) meets the requirements of Article 123(2) EPC for the reasons as set out above, *mutatis mutandis*. The dependent claims are based on dependent claims as filed, and also meet the requirements of Article 123(2) EPC.

3. *Article 84 EPC*

3.1 In the contested decision it was contended (as *obiter dictum*) that the terms "inner surface" and "outer surface" were not clearly defined, as they did not necessarily refer to actual physical surfaces. In the case of a hole, for example, the outer surface appeared to refer to the virtual surface limited by the perimeter of the top of the hole.

3.2 Claim 1 defines a light extraction structure formed as a photonic crystal with a pattern having unit structures, each having a hole shape. It is not the holes, but the light extraction structure which is defined as having an inner surface and an outer surface, with  $r_o$  being defined as the radius of each unit structure on the outer surface, and  $r_i$  being defined as the radius of each unit structure on the inner surface. This accurately reflects the information shown diagrammatically in Fig. 20A, and is not considered to be unclear.

3.3 Additionally, the Examining Division considered that the definition of the term "average filling factor" was not precise and unambiguous. Since this term no longer appears in the claims, it is not necessary for the

Board to pursue this matter in relation to the requirements of Article 84 EPC 1973.

3.4 No other objections are seen to arise in this regard, and the Board therefore judges that the current claims comply with the requirements of Article 84 EPC 1973.

4. *Further procedure*

4.1 The specific objections leading to refusal of the application have been overcome by amendment. The Board therefore considers it appropriate to exercise its discretionary power under Article 111(1) EPC 1973 to remit the case to the department of first instance for further prosecution. Compliance of the claimed subject-matter with requirements of the EPC other than those dealt with in the present decision can thereby be examined before two instances.

4.2 For the avoidance of any doubt, the Board has decided that claims 1-13 of the "New Main Request" filed during oral proceedings before the Board meet the requirements of Article 123(2) EPC and Article 84 EPC 1973. All other matters remain to be decided by the Examining Division in the remitted procedure.

## Order

### For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the department of first instance for further prosecution.

The Registrar:

The Chairman:



S. Sánchez Chiquero

G. Eliasson

Decision electronically authenticated