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**Datasheet for the decision
of 14 January 2016**

Case Number: T 2325/11 - 3.4.03

Application Number: 06027111.1

Publication Number: 1780748

IPC: H01J9/02, H01J1/304, G02B6/12,
H01L21/306, C23F1/40

Language of the proceedings: EN

Title of invention:
Group III-nitride layers with patterned surfaces

Applicant:
ALCATEL LUCENT

Headword:

Relevant legal provisions:
EPC Art. 76(1)
EPC 1973 Art. 56

Keyword:
Divisional application - added subject-matter (no) -
after amendment
Inventive step (yes) - after amendment

Decisions cited:

Catchword:



**Beschwerdekammern
Boards of Appeal
Chambres de recours**

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Case Number: T 2325/11 - 3.4.03

**D E C I S I O N
of Technical Board of Appeal 3.4.03
of 14 January 2016**

Appellant: ALCATEL LUCENT
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Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 30 June 2011
refusing European patent application No.
06027111.1 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman G. Eliasson
Members: R. Bekkering
C. Heath

Summary of Facts and Submissions

- I. The appeal is against the decision of the examining division refusing the application No. 06 027 111.

The application is a divisional application of earlier application No. 04 250 979 on which patent EP 1 467 404 was granted.

- II. The decision refusing the application was based on the state of the file, as requested by the applicant, with reference to the communication of the examining division dated 2 March 2011, in which the applicant was informed that the amendments according to the main request extended beyond the content of the earlier application, contrary to Article 76(1) EPC, and that the subject-matter of the claims according to the auxiliary request did not involve an inventive step in the sense of Article 56 EPC over document:

D1: Fu D. J. et al., "*GaN Pyramids Prepared by Photo-Assisted Chemical Etching*", Journal of the Korean Physical Society, vol. 42, February 2003, pages S611 to S613.

- III. The appellant requested at the oral proceedings before the board held on 14 January 2016 that the decision under appeal be set aside and a patent be granted on the basis of the following application documents:

Claims: Nos. 1 to 5 of the Main Request as filed during the oral proceedings at 17.00;

Description: Pages 1, 5 and 7 to 12 as originally filed;

Pages 2 to 4 and 6 as filed during the oral proceedings at 17.00;

Drawings: Sheets 1 to 5 as originally filed.

IV. Claim 1 according to the appellant's request reads as follows:

*"An apparatus, comprising:
a substrate (12) with a planar surface; and
a plurality of pyramidal structures (16) located over portions of the surface;
a layer (18) of a first group III-nitride located on another portion of the surface, the pyramidal structures comprising a second group III-nitride and having nitrogen-polarity;
a layer (15) of the second group-III nitride having metal polarity and having a flat surface and being on the layer of the first group III- nitride and being free of pyramidal structures; and
wherein the first and second group III-nitrides have different alloy compositions, wherein a metallic electrode (26) is located directly on the flat surface of the layer of the second group-III nitride having metal polarity."*

V. Reference is made to the following further documents:

D3: Palacios T. et al., "Wet etching of GaN grown by molecular beam epitaxy on Si(111)", Semiconductor Science and Technology, vol. 15, no. 10, October 2000, pages 996 to 1000

D4: Kozawa T. et al., "Field emission study of gated GaN and Al_{0.1}Ga_{0.9}N/GaN pyramidal field emitter

arrays", Applied Physics letters, vol. 75, no. 21, 22 November 1999, pages 3330 to 3332.

VI. The appellant in substance provided the following arguments:

Claim 1 as amended was based on claim 6 and the description as originally filed in the earlier application. Accordingly, the requirement of Article 76(1) EPC was met. Moreover, amended claim 1 did not extend beyond the content of the application as originally filed in accordance with Article 123(2) EPC.

The subject-matter of claim 1, moreover, was novel and involved an inventive step with respect to the cited prior art. In particular, document D3 concerned a photoluminescence device, which had no bearing on the claimed apparatus, and did not require any electrodes.

Reasons for the Decision

1. The appeal is admissible.
2. *Amendments*

Claim 1 as amended is based on claims 7 and 8 as originally filed, as well as the description as originally filed (cf page 4, line 14 to page 6, line 10; figures 1A, 1B and 1C).

Claims 2 to 4 correspond to claims 9 to 11 as originally filed.

Claim 5 is based on the description as originally filed (cf page 5, line 31 to page 6, line 4; figure 1C).

Accordingly, the amendments comply with Article 123(2) EPC.

Moreover, claim 1 as amended is based on claim 6 and on the description and drawings of the earlier application as originally filed. As the description and drawings of the earlier application are essentially identical to those of the present divisional application, reference is made to the same parts thereof.

These parts of the description and drawings of the earlier application also provide a basis for claims 2 to 5.

Accordingly, the amendments also comply with Article 76(1) EPC.

3. *Novelty*

3.1 *Document D1*

Document D1 discloses a method of forming GaN pyramids by photo assisted chemical etching of a GaN epilayer.

There is no provision in D1 of portions of the GaN layer with a flat surface and no pyramids, and no provision of an electrode thereon. There is also no mention of the polarity of the layer.

Accordingly, the subject-matter of claim 1 is new over document D1 (Article 54(1) EPC 1973).

3.2 Document D3

Document D3 discloses a method of forming GaN pyramids by chemical etching of a GaN epilayer. GaN layers are grown on a Si(111) substrate. Two different batches of samples are studied: set A consists of GaN layers with a thin (10-20 nm) AlN buffer, whereas set B refers to layers with thicker (30-50 nm) AlN buffers. Both samples A and B are subjected to a KOH solution. One-half of each sample is covered with a mask of eg metal so as to obtain non-etched and etched surfaces (see section 2 "*Experiment*").

GaN layers grown on thick AlN buffers have Ga polarity, whereas GaN layers grown on thin AlN buffers have N polarity. The samples A with the thin AlN buffer layer are etched by the solution producing pyramidal structures at the surface. The samples B with the thick AlN buffer layer are not etched by the solution. This different behaviour is likely related to the surface layer polarity (see section 4 "*Analysis of the surface polarity*").

The optical quality of etched and unetched samples is studied analysing the low-temperature photoluminescence produced by excitation with a laser (see section 2 "*Experiment*", last paragraph; section 3 "*Results and discussion*").

Not disclosed in D3 is the provision of etched and non-etched surfaces of the GaN layer, having respectively nitride and metal-polarity, in one device, with the provision of a metallic electrode on the non-etched

surface, that is the flat surface having metal-polarity.

Accordingly, the subject-matter of claim 1 is also new over document D3 (Article 54(1) EPC 1973).

3.3 *Document D4*

Document D4 discloses a device with GaN pyramidal field emitters. Adjacent to the GaN pyramids, on portions of the GaN layer having a flat surface, a metallic gate electrode is provided (cf page 3331, left-hand column, second paragraph; figure 2). According to D4, GaN emitters with extraction gate electrodes might be useful in the fabrication of eg a flat panel display (cf page 3330, left-hand column, second paragraph).

In document D4, however, the metallic electrode is provided on a SiO₂ and a polyimide layer on the flat surface of the GaN layer and, thus, not directly on the GaN as per claim 1.

Moreover, there is no mention of the polarity of the layer.

Accordingly, the subject-matter of claim 1 is also new over document D4 (Article 54(1) EPC 1973).

3.4 The subject-matter of claim 1 is also new over the remaining available, more remote prior art.

4. *Inventive step*

4.1 Document D3 is considered to form the closest prior art as it discloses the selectivity with respect to the metal/nitrogen polarity of the GaN layer surface of the

chemical etch process used to form the pyramidal structures, which is the essential part of the method of fabricating the device as disclosed in the application, of which the device as disclosed and claimed is the direct result.

In particular, document D3, when considering sample A, discloses (using the terminology of claim 1), an apparatus, comprising:

a substrate (Si substrate with thin (10-20 nm) AlN buffer layer) with a planar surface; and
a plurality of pyramidal structures (cf figure 4) located over portions of the surface;
the pyramidal structures comprising a (second) group III-nitride (GaN) and having nitrogen-polarity (see section 4 "*Analysis of the surface polarity*").

Conversely, when considering sample B, document D3 discloses (using the terminology of claim 1), an apparatus, comprising:

a substrate (Si substrate) with a planar surface; and
a layer of a (first) group III-nitride (AlN) located on a (another) portion of the surface,;
a layer of the second group-III nitride (GaN) having metal polarity and having a flat surface and being on the layer of the first group III- nitride and being free of pyramidal structures; and
wherein the first and second group III-nitrides have different alloy compositions.

Having regard to sample A, considered the closest prior art, document D3 does not disclose the structure to further have (using the terminology of claim 1)
a layer of a first group III-nitride (in addition to the thin AlN buffer layer) located on another portion of the surface;

a layer of the second group-III nitride (GaN) having metal polarity and having a flat surface and being on the layer of the first group-III nitride and being free of pyramidal structures; and wherein the first and second group III-nitrides have different alloy compositions, wherein a metallic electrode is located directly on the flat surface of the layer of the second group-III nitride having metal polarity.

It is noted that in sample A, on the half covered with the mask of eg metal, the flat surface of the layer of the second group-III nitride (GaN) does not have metal polarity due to the absence of an underlying thicker (eg 30-50 nm) AlN buffer layer. Moreover, the mask of eg metal does not form a metallic electrode of an apparatus.

- 4.2 Starting from document D3, sample A, the objective problem to be solved may be formulated as to use the results to make a usable electronic device.

The appellant's argument in this respect that document D3 concerned a photoluminescence device, which was not relevant to the claimed apparatus and furthermore required no electrodes, is not considered persuasive.

Photoluminescence is used in D3 to analyse the optical quality of the etched and unetched samples. In the board's judgement, it would however be clear to a skilled reader that D3 does not provide a photoluminescence device but pyramidal structures to be used *inter alia* in electronic devices.

Yet, while arguably it may be obvious to a person skilled in the art to use the pyramidal structures of

D3 in eg a field emission display device where such structures are commonly used (see eg document D4) and accordingly provide extraction gate electrodes on the device surface, as is commonly the case, document D3 fails to suggest to provide these electrodes in the manner claimed, that is directly on the flat surface of a GaN layer having metal polarity provided on a (thicker) AlN buffer layer.

- 4.3 The claimed solution is also not rendered obvious by document D1, which does not provide any electrodes as discussed above, or any of the other available prior art documents.
- 4.4 Accordingly, having regard to the available state of the art, the subject-matter of claim 1 is not obvious to a person skilled in the art and, thus, involves an inventive step in the sense of Article 56 EPC 1973.
- 4.5 Claims 2 to 5 are dependent on claim 1, providing further limitations. The subject-matter of these claims, therefore, also involves an inventive step.
5. It is noted that claim 1 is not identical to any of the claims as granted in the earlier application (cf EP 1 467 404) so that no double patenting arises.
6. The patent application documents also meet the remaining requirements of the EPC, so that a patent can be granted on the basis of these documents.

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 with the order to grant a patent with the following application documents:

Claims: Nos. 1 to 5 of the Main Request as filed during the oral proceedings at 17.00;

Description: Pages 1, 5 and 7 to 12 as originally filed;
Pages 2 to 4 and 6 as filed during the oral proceedings at 17.00;

Drawings: Sheets 1 to 5 as originally filed.

The Registrar:

The Chairman:



S. Sánchez Chiquero

G. Eliasson

Decision electronically authenticated