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# Datasheet for the decision of 10 October 2019

**Case Number:** T 1992/14 - 3.4.03

**Application Number:** 11153386.5

**Publication Number:** 2312635

**IPC:** H01L29/778, H01L21/338, H01L29/207, H01L29/20

**Language of the proceedings:** EN

**Title of invention:**
Transistors with fluorine treatment

**Applicant:**
Cree, Inc.

**Headword:**

**Relevant legal provisions:**
EPC 1973 Art. 56, 76(1)
EPC Art. 52(1), 123(2)

**Keyword:**
Amendments - extension beyond the content of the application as filed (no, after amendment)
Divisional application - subject-matter extends beyond content of earlier application (no, after amendment)
Inventive step - (yes, after amendment)

**Decisions cited:**

**Catchword:**

Europäisches Patentamt
European Patent Office
Office européen des brevets

**Beschwerdekammern**

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**Case Number: T 1992/14 - 3.4.03**

# D E C I S I O N
# of Technical Board of Appeal 3.4.03
# of 10 October 2019

| | |
|---|---|
| **Appellant:** (Applicant) | Cree, Inc.<br>4600 Silicon Drive<br>Durham, NC 27703 (US) |
| **Representative:** | Elkington and Fife LLP<br>Prospect House<br>8 Pembroke Road<br>Sevenoaks, Kent TN13 1XR (GB) |
| **Decision under appeal:** | **Decision of the Examining Division of the European Patent Office posted on 10 April 2014 refusing European patent application No. 11153386.5 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. 11 153 386 on the grounds that the subject-matter of the main request did not meet the requirements of Articles 123(2) and 76(1) EPC. The auxiliary request was not admitted into the proceedings in accordance with Rule 137(3) EPC. Although stated not to be part of the decision to refuse the application, comments on novelty and inventive step were also made.

II. The present application is a divisional application, derived from the earlier application EP 06 851 411, which corresponds to the international application with publication number WO 2008/027027 A2 (which will be referred to as the parent application). The description and drawings of the parent application as originally filed and those of the present application as originally filed are identical.

III. In its final written submission dated 2 September 2019, the appellant requested the grant of a patent based on:

Claims: 1-3 of the seventh auxiliary request filed with the letter dated 30 August 2019;

Description: Pages 1-21 filed with the letter dated 2 September 2019; and

Drawings: pages 1/2 - 2/2 as originally filed.

All other requests were withdrawn, subject to the condition "that the claims 1-3 of the seventh auxiliary

request are allowable" (which is the case, as explained in the following).

IV. The following documents are referred to:

D1: CAI Y ET AL, "High-Performance Enhancement-Mode AlGaN/GaN HEMTs Using Fluoride-Based Plasma Treatment", IEEE ELECTRON DEVICE LETTERS, vol. 26, no. 7, pages 435-437;

D2: US 2005/051796.

V. Claim 1 of the sole request reads as follows:

*"A high electron mobility transistor, HEMT, comprising:*
*a plurality of active semiconductor layers (14, 16, 18), comprising:*
*a buffer layer (16) on a substrate;*
*a barrier layer (18) on said buffer layer;*
*and a two dimensional electron gas, 2DEG, (17) at the interface between said buffer layer (16) and said barrier layer (18);*
*a first spacer layer (42) on said barrier layer (18);*
*a first field plate (44) on said first spacer layer (42);*
*a second spacer layer (52) on said first spacer layer (42) and said first field plate (44);*
*a second field plate (54) on said second spacer layer (52) and electrically isolated from said first field plate (44);*
*a gate (24), a source electrode (20) and a drain electrode (22) on said semiconductor layers (14, 16, 18), said first field plate (44) being integral with said gate (24) and extending from said gate (24) toward said drain electrode (22), said second field plate (54) being electrically connected to said source electrode (20), and said first spacer layer (42) being between*

*said gate (24) and said source and drain electrodes (20, 22);*
*and a negative ion region (56) within said barrier layer (18) comprising sections of different thicknesses, with a first (58) of said sections arranged in a region (58) primarily below said gate and which does not extend into said buffer layer (16), a second (60) of said sections arranged primarily below said first field plate (44) and extending into said buffer layer (16), and a third (62) of said sections arranged primarily below a portion of said second field plate (54) extending toward the drain (22) and not extending into said buffer layer (16)."*

## Reasons for the Decision

1. The appeal is admissible.

2. *Articles 76(1) EPC 1973 and 123(2) EPC*

2.1 Under point 1.1 of the "Grounds for the decision", the Examining Division found that independent claims 1 and 6, as then on file, did not meet the requirements of Articles 76(1) and 123(2) EPC. Although these claims were evidently based on the embodiment depicted in Fig. 3, they did not include the first and second field plates (44, 54), nor the first, second and third sections (58, 60, 62) of the negative ion region, and and hence constituted unallowable intermediate generalisations.

2.2 The present sole request has been limited to a single independent claim for a HEMT, and essentially recites

the features of the embodiment depicted in Fig. 3 and described in paragraphs [0046]-[0048] of both the parent application and the present application, as originally filed. In particular, claim 1 comprises first and second field plates, and first, second and third sections of the negative ion region. The form of these elements, and their arrangement within the claimed HEMT, are as set out in paragraphs [0046]-[0048] and shown in Fig. 3. The Examining Division's objections have thereby been overcome.

The Board raises no objection against the omission in claim 1 of the depicted nucleation layer 14, as it is clear from the first sentence of paragraph [0029] that this feature is optional in the HEMT devices according to the invention.

2.3 The subject-matter of claims 2 and 3 can be found throughout both the parent and the present applications, for example, in claims 3, 7, 13, 15 and 24 of the parent application as originally filed, and in claims 3 and 5 of the present application as originally filed.

2.4 The requirements of Article 76(1) EPC 1973 and Article 123(2) EPC are therefore met.

3. *Inventive Step*

3.1 Document D1, which is seen as the closest prior art, discloses a HEMT device in which negatively charged ions are incorporated into the barrier layer. The HEMT of claim 1 differs from that of D1 in at least two respects.

3.2 Firstly, claim 1 defines first and second field plates, and first and second spacer layers, as well as the manner in which these features are arranged in the device.

3.3 Secondly, claim 1 defines a negative ion region having the following particular form:

*"a negative ion region (56) within said barrier layer (18) comprising sections of different thicknesses, with a first (58) of said sections arranged in a region (58) primarily below said gate and which does not extend into said buffer layer (16), a second (60) of said sections arranged primarily below said first field plate (44) and extending into said buffer layer (16), and a third (62) of said sections arranged primarily below a portion of said second field plate (54) extending toward the drain (22) and not extending into said buffer layer (16)."*

3.4 According to paragraph [0048] the technical effect of these differences is as follows:

*"This tailored negative ion region 56 works in conjunction with the field plates 44, 54 to reduce the electric field and enhance device performance."*

3.5 The Board sees no reason to doubt the accuracy of this statement, and hence the technical problem may be seen as reducing the overall operating electric field in a HEMT device (see paragraph [0003], and the explanations given in paragraphs [0023]-[0025]).

3.6 Document D1 discloses improving the performance of HEMT devices using "a fluoride-based plasma treatment and post-gate rapid thermal annealing scheme", whereby the

"plasma treatment can effectively incorporate negatively charged fluorine ions into the AlGaN barrier" (page 435, right-hand column, second paragraph).

This was carried out as follows: "After gate windows ... were opened ... , the sample was treated by $CF_4$ plasma in an RIE system"; the gate electrode was subsequently formed, such that the "plasma treated gate region and the gate electrode were self-aligned" (page 435, right-hand column, final eight lines). Hence, according to the teaching of D1, the negatively charged fluorine ions are introduced only in the region directly under the gate electrode.

3.7 In the contested decision, it was considered implicit that the implanted fluorine ions would, in practice, diffuse into regions adjacent to the region directly under the gate, and it was suggested that the original drawings of the parent application appeared to confirm this (Grounds for the Decision, point 6; Additional observations, point 3.2). However, even if this were accepted, such diffusion would not, in the opinion of the Board, give rise to the particular form of the negative ion region now defined in claim 1.

3.8 Document D2 discloses, in Figs. 7 and 11, HEMT devices having a first spacer layer (96, 154), a second spacer layer (98, 158), a first field plate (102, 156) and a second field plate (104, 159). The incorporation of negative ions into the layers of the device is not disclosed.

The combination of documents D1 and D2 might, at most, lead the skilled person to a HEMT device incorporating the negative ion region of D1 with the double field

plate arrangement of D2. It would not, however, be obvious to incorporate the claimed form of the negative ion region, as this feature is neither disclosed nor suggested in the available prior art.

3.9 The Board therefore concludes that the subject-matter of claim 1 involves an inventive step within the meaning of Article 52(1) EPC and Article 56 EPC 1973. The Board is also satisfied that the description has been suitably adapted to the present claims (Article 84 EPC 1973).

**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 in the following version:

   Claims: 1-3 of the seventh auxiliary request filed with the letter dated 30 August 2019;

   Description: Pages 1-21 filed with the letter dated 2 September 2019; and

   Drawings: pages 1/2 - 2/2 as originally filed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated