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Datasheet for the decision of 5 June 2019

Case Number: T 0538/15 - 3.4.03

Application Number: 11153385.7

Publication Number: 2312634

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 Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

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Case Number: T 0538/15 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 5 June 2019

Appellant: (Applicant)	Cree, Inc. 4600 Silicon Drive Durham, NC 27703 (US)
Representative:	Elkington and Fife LLP Prospect House 8 Pembroke Road Sevenoaks, Kent TN13 1XR (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 10 June 2014 refusing European patent application No. 11153385.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	M. Papastefanou
	T. Bokor

Summary of Facts and Submissions

I. The appeal is against the decision of the examining Division refusing the European patent application No. 11 153 385.7 on the grounds that the Main request before it did not fulfil the requirements of Articles 76(1) and 123(2) EPC.

An Auxiliary request filed in preparation to the first-instance oral proceedings was not admitted by the examining division under Rule 137(3) EPC because, *prima facie*, it contained subject matter extending beyond the originally filed content of the application as well as of the originally filed parent application and lacked novelty.

II. During the appeal proceedings the appellant submitted amended application documents. The appellant (applicant) requests that the decision under appeal be set aside and that a patent be granted on the basis of the following application documents:

- Description, pages:
  1, 3, 9, 12, 13, 15, 16, 18-20 as originally filed;
  2, 4, 7, 10, 11, 21, filed with letter of 25 November 2011;
  5, 6, 8, 14, 17, filed with letter of 22 May 2019;

- Claims 1-11, filed with letter of 22 May 2019;

- Drawings: Sheets 1/2, 2/2 as originally filed.

III. The following documents, cited in the decision under appeal are relevant for this decision:

D1: *"High-Performance Enhancement-Mode AlGaN/GaN HEMTs Using Fluoride-Based Plasma Treatment"*, Cay Y et al., IEEE Electron Device Letters, Vol. 26, NO. 7, July 2005, pages 435-437;

D2: US 2005/051796 A1.

IV. Claim 1 of the sole request has the following wording:

A high electron mobility transistor, HEMT, comprising:
a buffer layer (16) on a substrate;
a barrier layer (18) on said buffer layer;
a two dimensional electron gas (2DEG) (17) at the interface between said buffer layer (16) and said barrier layer (18);
a source electrode (20), a drain electrode (22), and a gate (24) between said source and drain electrodes; and
a negative ion region (56) in said barrier layer (18), characterised in that said negative ion region (56) comprises a plurality of sections of different thicknesses, wherein a first of said plurality of sections (58) is at least partially below said gate (24);
wherein at least part of a second of said plurality of sections (60) is arranged to extend into said buffer layer (16);
and
wherein a third of said plurality of sections (62) is primarily below a field plate (54).

V. Independent claim 3 of the sole request is worded as follows:

A method for fabricating a high electron mobility transistor (HEMT) (10), comprising:

providing a substrate (12);
growing a buffer layer (16) on said substrate (12);
growing a barrier layer (18) on said buffer layer (16); and
forming a negative ion region (56) in said barrier layer (18), characterised in that said negative ion region (56) comprises a plurality of sections of different thicknesses, wherein a first of said plurality of sections (58) is at least partially below said gate (24);
wherein at least part of a second of said plurality of sections (60) is arranged to extend into said buffer layer (16);
and
wherein a third of said plurality of sections (62) is primarily below a field plate (54).

VI. The appellant argued essentially that there was no basis in D1 for the assertion of the examining division that the negative ion region in the HEMT of D1 comprised a plurality of sections of different thicknesses. In addition, even a possible combination of D1 with D2 would fail to disclose all the features of the claimed invention (see page 2 of the statement setting out the grounds of appeal, section titled "Inventive Step").

Reasons for the Decision

1. Amendments (Articles 76(1) and 123(2) EPC)

1.1 Independent claims 1 and 3 are based on the embodiment of Figure 3 and find basis in paragraphs [0046] and [0048] of the originally filed description.

1.2 Dependent claims:

Claim 2 finds basis in original claim 6.
Claims 4-8 correspond to original claims 10-14 respectively.
Claims 9-11 find basis in paragraph [0048] and Figure 3 as originally filed.

1.3 As the originally filed description and claims of the application correspond to the original description and claims of the parent application (No. 06 851411.6 - published as WO 2008/027027 A2), the amendments find also basis in the originally filed parent application.

1.4 The description has been adapted to the claims and D1 is cited therein (page 4).

1.5 The board is satisfied that the application meets the requirements of Articles 76(1), 123(2) EPC and of Rule 42(1) EPC.

2. Inventive Step (Article 56 EPC)

2.1 The invention

The invention relates to high electron mobility transistors (HEMTs) and a method for their fabrication.

HEMTs are mainly used in high-power, high-frequency devices. Materials with a relatively high band gap are used in their fabrication, such as GaN (gallium nitride) based compounds. A common problem in such HEMTs is that they generate high electric field(s), which affect(s) their performance (see paragraphs [0004] to [0008] of the application).

Efforts have been made to counter this operating high electric field(s), such as forming negative ion region in one of the layers of the HEMT. The invention proposes a HEMT with a negative ion region having a plurality of sections of different thicknesses, which are located in specific parts of the HEMT (see Figure 3). This provides a more effective counter measure against the high electric field(s) in the HEMT, improving its performance.

2.2 Closest prior art

2.2.1 It remained uncontested that document D1 represented the closest prior art. D1 describes a HEMT comprising a buffer layer on a substrate, a barrier layer on the buffer layer and a two dimensional electron gas (electron sheet in D1) at the interface between the two layers. The HEMT also comprises source, drain and gate electrodes (see page 435, right column, second paragraph).

2.2.2 In an effort to enhance the performance of the HEMT, D1 proposes that a negative ion region, created by a fluoride-based plasma treatment, is formed in the gate region, under the gate electrode (see also Abstract).

The negative ion region in the HEMT of D1 is formed in the barrier layer through the gate window, i.e. under the gate electrode, before the electrode is formed. D1 further states that the plasma treated gate region (i.e. the negative ion region) and the gate electrode are self-aligned (page 435, last lines of the right column). This indicates that the negative ion region is limited to the area of the barrier layer under the gate electrode and that no scattering of the negative ions beyond the gate window takes place, contrary to the

assertions by the examining division in the decision under appeal (see point 3.2 of the Grounds of Decision and points 3.1 to 3.3 of the Additional observations).

Even if some scattering of the negative ions beyond the gate window during the plasma treatment were to take place, as argued in the decision under appeal, D1 does not provide any information or suggestion about the distribution/concentration of the negative ions beyond the gate region or about the form and dimensions (depth/thickness) of the negative ion region in general. The only relevant information can be found in Figure 3, which shows variations of the ion concentration in various depths within the negative ion region.

2.2.3 Moreover, there is no disclosure or suggestion of any field plate(s) in the HEMT of D1.

2.3 Difference and technical problem

2.3.1 The HEMT according to claim 1 differs thus from the HEMT of D1 in that it comprises a negative ion region comprising a plurality of sections of different thicknesses, wherein a first of said plurality of sections is at least partially below the gate, at least part of a second of said plurality of sections is arranged to extend into said buffer layer and a third of said plurality of sections is primarily below a field plate.

2.3.2 As explained in the application the technical effect of this feature is to reduce the electric field and enhance the performance of the HEMT (see last lines of paragraph [0048]).

2.3.3 The skilled person is thus faced with the technical problem of how to improve further the performance of the HEMT of D1.

2.4 Solution and inventive step

2.4.1 As explained before, D1 does not suggest any particular form of the negative region, other than it is aligned with the gate electrode.

2.4.2 The use of field plates in order to improve the performance of HEMTs, especially with respect to high electric field, were known in the prior art.

Document D2 describes HEMTs of similar structure as in the claimed invention. There is no negative ion region in the HEMT of D2 but field plates are used in order to enhance performance, mainly by increasing the breakdown voltage (paragraph [0028]). As it can be seen in the Figures of D2, the field plates used have similar structure to the ones in the application (e.g. see "28" in Figure 2, "66" in Figure 5 and corresponding paragraphs [0038], [0039] and [0046], [0047]).

2.4.3 The skilled person wishing to improve the performance of the HEMT of D1 would apply the teaching of D2 in D1 and would add field plates to it in an obvious manner. He would still not arrive at the claimed HEMT, however, since there is no indication or suggestion in D1 and D2 of providing a negative ion region comprising a plurality of sections according to claim 1.

2.4.4 Hence, the subject-matter of claim 1 involves an inventive step within the meaning of Article 56 EPC. The same applies also to claim 3, which defines a

corresponding method for fabricating a HEMT.

3. The board concludes, therefore, that the application and the invention to which it relates meet the requirements of the EPC and a European patent is to be granted under Article 97(1) EPC.

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:

- Description, pages:
  1, 3, 9, 12, 13, 15, 16, 18-20 as originally filed;
  2, 4, 7, 10, 11, 21, filed with letter of 25 November 2011;
  5, 6, 8, 14, 17, filed with letter of 22 May 2019;

- Claims 1-11, filed with letter of 22 May 2019;

- Drawings: Sheets 1/2, 2/2 as originally filed.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated