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Datasheet for the decision of 28 March 2019

Case Number: T 2291/15 - 3.4.03

Application Number: 06785888.6

Publication Number: 1897128

IPC: H01L21/314, H01L21/318

Language of the proceedings: EN

Title of invention:
PASSIVATION OF WIDE BAND-GAP BASED SEMICONDUCTOR DEVICES WITH HYDROGEN-FREE SPUTTERED NITRIDES

Applicant:
Cree, Inc.

Headword:

Relevant legal provisions:
EPC 1973 Art. 84
EPC 1973 R. 29

Keyword:
Claims - essential features missing (no)

Decisions cited:

Catchword:

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Case Number: T 2291/15 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 28 March 2019

Appellant: (Applicant)	Cree, Inc. 4600 Silicon Drive Durham, NC 27703 (US)
Representative:	FRKelly 27 Clyde Road Dublin D04 F838 (IE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 16 July 2015 refusing European patent application No. 06785888.6 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	T. M. Häusser
	C. Heath

Summary of Facts and Submissions

I. The appeal concerns the decision of the examining division refusing the European patent application No. 06 785 888 for lack of clarity (Article 84 EPC 1973).

II. In its letter dated 9 January 2019 the appellant (applicant) requested that the decision under appeal be set aside and a patent be granted based on a main request or a first or second auxiliary request, all filed with this letter, and that the case be remitted to the department of first instance for further prosecution.

III. The wording of the independent claims of the requests is as follows (board's labelling "(a)" to "(e)"):

Main request:

"1. A passivated semiconductor structure comprising:

a silicon carbide substrate (11, 23);

a thermal oxidation layer (12, 27) on said silicon carbide substrate for lowering the interface density between said silicon carbide substrate and said thermal oxidation layer; and

a passivated layer comprising:

(a) a first sputtered non-stoichiometric silicon nitride layer (16, 33) on said oxidation layer for reducing parasitic capacitance and minimizing device trapping;

(b) a second sputtered non-stoichiometric silicon nitride layer (17, 34) on said first layer for positioning subsequent passivated layers further from said substrate without encapsulating said structure; and

(c) a sputtered stoichiometric silicon nitride layer (20, 35) on said second sputtered layer for

encapsulating said structure and for enhancing the hydrogen barrier properties of the passivated layers; and

an environmental barrier (14, 36) of a chemical vapour deposited (CVD) stoichiometric nitride."

"11. A method of passivating wide bandgap devices, the method comprising:
(d) sputter-depositing a non-stoichiometric nitride layer selected from silicon nitride and aluminum nitride on a layer of semiconductor material selected from silicon carbide and the Group III nitrides;
(e) sputter depositing a stoichiometric silicon nitride layer on said nonstoichiometric silicon nitride layer and depositing an environmental barrier layer of stoichiometric silicon nitride by chemical vapor deposition on to the sputter-deposited stoichiometric layer."

First auxiliary request:

Claim 1 of the first auxiliary request is identical to claim 1 of the main request.

Claim 11 of the first auxiliary request differs from claim 11 of the main request in that the following feature is inserted at the end of the first sputter deposition step (i. e. after the expression "Group III nitrides"):

", wherein the non-stoichiometric nitride layer is configured to reduce parasitic capacitance and minimise device trapping"

Second auxiliary request:

Claim 1 of the second auxiliary request differs from claim 1 of the main request in that the expression "silicon nitride layer" is replaced - at the three occurrences - by the expression "hydrogen-free silicon nitride layer".

Correspondingly, claim 11 of the second auxiliary request differs from claim 11 of the first auxiliary request in that the expression "nitride layer" is replaced - at the two occurrences - by "hydrogen-free nitride layer" and in that the expression "silicon nitride or aluminum nitride layer" is replaced by "hydrogen-free silicon nitride or hydrogen-free aluminum nitride layer".

IV. The appellant argued essentially as follows:

The independent claims of the main and first auxiliary requests, in particular the absence in these claims of the feature that the nitride layers were hydrogen-free, did not contravene the EPC requirements as to clarity of the claims.

Reasons for the Decision

1. Clarity

1.1 The independent claims of the main and first auxiliary request correspond - apart from minor clarifications and a spelling correction - to the respective independent claims of the main and first auxiliary requests underlying the decision under appeal.

In the contested decision the examining division held that the feature that the sputtered nitride layers were

hydrogen-free was essential for solving the problem of preventing the presence of hydrogen in the oxide layer. Since the independent claims of the main and first auxiliary requests pending at the time did not contain this feature they were unclear (see points 22 and 23 of the Reasons).

1.2 It is established case law of the Boards of Appeal that the requirement under Article 84 EPC 1971 as to clarity of the claims implies that all the essential features of the invention have to be indicated in an independent claim. The essential features are those features which are necessary for solving the technical problem with which the application is concerned (see *Case law of the Boards of Appeal of the EPO*, 8th edition 2016, section II.A.3.2).

1.3 In the present case, the board agrees with the appellant in that the technical problem of the application cannot be considered the prevention of the presence of hydrogen in the oxide layer. Such a formulation contains a pointer to the solution of the invention, which should be avoided as it results in an inadmissible *ex post facto* approach when assessing inventive step.

The description of the invention starts by outlining the relevant state of the art, in particular the use of silicon nitride layers in semiconductor devices in order to improve their electronic properties and to provide an environmental barrier. However, when chemical vapour deposition (CVD) is used to form such nitride layers, they tend to contain hydrogen due to the use of silane (SiH_4) or ammonia (NH_3) as precursors in the CVD schemes. The hydrogen may lead to parasitic capacitances or degraded ohmic contact characteristics and thus limit or degrade device performance of semiconductor

devices made of Group III nitrides or silicon carbide (see paragraphs [0006] to [0012] of the description of the application). These are thus considered the technical problems with which the application is concerned.

1.4 According to the invention the nitride layers are deposited using sputtering rather than chemical vapour deposition. In this manner the nitride layers are substantially hydrogen-free thereby overcoming the above problems (see e. g. paragraphs [0034] and [0039] of the description of the application).

In the decision the examining division was of the opinion that the sputtering technique would not automatically result in a hydrogen-free nitride layer, because other process parameters such as hydrogen contamination in the process chamber could lead to the presence of hydrogen in the nitride layer (see point 22.3 of the Reasons).

The board notes that sputtering is conventionally performed using a noble gas such as argon or krypton as the sputtering gas filling the sputtering chamber in order to avoid reactions with the target source material. Only when such reactions are intended in reactive sputtering schemes the gas may also comprise the desired particles. Accordingly, in the present case of sputter depositing nitride layers the gas comprises argon and nitrogen (see e. g. paragraph [0053] of the description of the application). Hence, the board considers that under realistic conditions there is no hydrogen present when nitride layers are sputter deposited.

Consequently, the features related to the sputter deposited nitride layers and the corresponding deposition

steps as claimed in the independent claims of the main request and first auxiliary request (see features (a)-(c) and (d)-(e), respectively) overcome the technical problems stated above thereby leading to improved device performance.

The independent claims of the main request and of the first auxiliary request are thus considered to contain all the essential features of the invention.

1.5 In the independent claims of the second auxiliary request it is explicitly specified that the sputtered nitride layers are hydrogen-free. Hence, the above issue concerning lack of clarity due to the absence of precisely this feature as an essential feature does not arise for these claims.

1.6 In view of the above the board is of the opinion that the claims of the main request and of the first and second auxiliary requests meet the requirements of the EPC as to clarity of the claims (Article 84 EPC 1973 in combination with Rule 29 EPC 1973).

2. Further procedure

In the decision under appeal only the requirement of the EPC as to clarity of the claims (Article 84 EPC 1973 in combination with Rule 29 EPC 1973) was dealt with. The other requirements of the Convention were not discussed. In order to allow for the examination of these requirements in two instances, remittal of the case to the department of first instance under Article 111(1) EPC 1973 - as requested by the appellant - is deemed appropriate.

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