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Datasheet for the decision of 1 December 2011

Case Number: T 1114/08 - 3.4.03

Application Number: 02802769.6

Publication Number: 1444729

IPC: H01L 21/66, H01L 21/98, H01L 25/07

Language of the proceedings: EN

Title of invention:
Large area silicon carbide devices and manufacturing methods therefor

Patentee:
CREE, INC.

Opponent:
SIEMENS AKTIENGESELLSCHAFT

Headword:
-

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

Keyword:
"Inventive step (no) - patent as granted"
"Inventive step (yes) - auxiliary request"

Decisions cited:
-

Catchword:
-

Case Number: T 1114/08 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 1 December 2011

Appellant: (Opponent)	SIEMENS AKTIENGESELLSCHAFT Postfach 22 16 34 D-80506 München (DE)
Respondent: (Patent Proprietor)	CREE, INC. 4600 Silicon Drive Durham NC 27703 (US)
Representative:	Cross, Rupert Edward Blount Boult Wade Tennant Verulam Gardens 70 Gray's Inn Road London WC1X 8BT (GB)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted 10 April 2008 rejecting the opposition filed against European patent No. 1444729 pursuant to Article 101(2) EPC.**

Composition of the Board:

Chairman:	G. Eliasson
Members:	R. Q. Bekkering
	P. Mühlens

Summary of Facts and Submissions

I. This is an appeal against the rejection of the opposition against EP 1 444 729.

II. Oral proceedings were held before the board.

III. The appellant opponent requested that the decision under appeal be set aside and that the patent be revoked.

IV. The respondent patent proprietor requested as a main request that the appeal be dismissed, or, as a first auxiliary request, that the decision under appeal be set aside and the patent be maintained in amended form in the following version:

- description, pages 2, 2a, 2b and 3 to 7, filed at the oral proceedings,

- claims 1 to 7 of the first auxiliary request, filed at the oral proceedings,

- drawings, figures 1 to 11 as granted.

V. Claim 1 as granted reads:

"*A method of fabricating a silicon carbide device, comprising:*
forming a plurality of a same type of silicon carbide devices on at least a portion of a silicon carbide wafer in a predefined pattern, the silicon carbide devices having corresponding first contacts on a first face of the silicon carbide wafer;

electrically testing the plurality of silicon carbide devices to identify ones of the plurality of silicon carbide devices which pass an electrical test;
and selectively interconnecting the first contact of the identified ones of the plurality of silicon carbide devices by selectively applying a stepper mask so as to provide interconnection between the identified ones of the plurality of silicon carbide devices."

VI. Claims 1 and 6 according to the respondent's first auxiliary read:

"*1. A method of fabricating a silicon carbide device, comprising:*
forming a plurality of a same type of vertical silicon carbide diodes on at least a portion of a silicon carbide wafer in a predefined pattern, the silicon carbide diodes having corresponding first contacts on a first face of the silicon carbide wafer;
electrically testing the plurality of silicon carbide diodes to identify ones of the plurality of silicon carbide diodes which pass an electrical test;
selectively interconnecting the first contact of the identified ones of the plurality of silicon carbide diodes by selectively applying a stepper mask so as to provide interconnection between the identified ones of the plurality of silicon carbide diodes; and
commonly connecting second contacts of the silicon carbide diodes;
wherein selectively interconnecting the first contact comprises:
forming a passivation layer on the silicon carbide diodes which covers the first contacts;

selectively applying the stepper mask to regions of the passivation layer corresponding to the first contacts for the identified ones of the plurality of silicon carbide diodes so as to selectively form openings in the passivation layer corresponding to first contacts for the identified ones of the plurality of silicon carbide diodes; and
electrically connecting the first contact through the selectively formed openings;
wherein the step of electrically testing comprises the step of electrically testing a reverse bias blocking voltage of a silicon carbide diode of the plurality of silicon carbide diodes to determine if the reverse bias blocking voltage of the silicon carbide diode exceeds a predefined voltage value; and
wherein the step of selectively applying a stepper mask comprises the steps of:
applying a stepper mask corresponding to one of the plurality of silicon carbide diodes to an identified one of the plurality of silicon carbide diodes; and
repeating the step of applying the stepper mask for each of the identified silicon carbide diodes."

"6. A method of fabricating a silicon carbide device, comprising:
forming a plurality of a same type of silicon carbide devices on at least a portion of a silicon carbide wafer in a predefined pattern, the silicon carbide devices having corresponding first contacts on a first face of the silicon carbide wafer and corresponding second contacts on the first face of the silicon carbide wafer;

electrically testing the plurality of silicon carbide devices to identify ones of the plurality of silicon carbide devices which pass an electrical test;
selectively interconnecting the first contact of the identified ones of the plurality of silicon carbide devices by selectively applying a stepper mask so as to provide interconnection between the identified ones of the plurality of silicon carbide devices;
selectively interconnecting the second contacts of the identified ones of the silicon carbide devices utilizing the stepper mask;
wherein the steps of selectively interconnecting the first contact and selectively interconnecting the second contacts of the identified ones of the silicon carbide devices comprise:
forming a passivation layer on the silicon carbide devices which covers the first contacts;
selectively forming openings in the passivation layer corresponding to first contacts for the identified ones of the plurality of silicon carbide devices utilizing the stepper mask;
selectively forming openings in the passivation layer corresponding to second contacts for the identified ones of the plurality of silicon carbide devices utilizing the stepper mask;
electrically connecting the first contacts through the selectively formed openings; and
electrically connecting the second contacts through the selectively formed openings; and
wherein the steps of selectively forming openings in the passivation layer corresponding to first contacts for the identified ones of the plurality of silicon carbide devices and selectively forming openings in the passivation layer corresponding to second contacts for

the identified ones of the plurality of silicon carbide devices comprise the steps of:
applying the stepper mask corresponding to one of the plurality of silicon carbide devices to an identified one of the plurality of silicon carbide devices; and repeating the step of applying the stepper mask for each of the identified silicon carbide devices."

VII. Reference is made to the following document:

D2: US 4 816 422 A

VIII. The appellant opponent submitted in substance the following:

Based on the state of the art relating to the use of silicon carbide (SiC) as provided in the patent in suit, the objective problem to be solved was to produce a large semiconductor device from a SiC wafer and reduce the problems caused by material defects of the SiC. The solution to this problem was provided by document D2, disclosing a method for producing large device from a silicon wafer despite the presence of defects. Although D2 disclosed the use of laser ablation to selectively provide contacts to the good device, the use of *per se* well-known stepper photolithography would have been obvious to a person skilled in the art. The subject-matter of claim 1 as granted, thus, lacked an inventive step.

Claim 1 according to the respondent's first auxiliary request further required the stepper mask to correspond to a single one of the plurality of same type devices. The choice of the number of devices to be included in

the stepper mask was, however, a simple design option which the skilled person would select based on the circumstances without an inventive step being involved. The same applied to independent claim 6. The subject-matter of claims 1 and 6 of the respondent's first auxiliary request, thus, also lacked an inventive step.

IX. The respondent patent proprietor argued in substance as follows:

The solution proposed in document D2 involved using laser ablation for opening the contacts to the good devices. There was nothing suggesting the use of a stepper mask as per claim 1 as granted. The subject-matter of claim 1 as granted, thus, involved an inventive step.

Moreover, independent claims 1 and 6 according to the first auxiliary request provided the further limitation that the stepper mask corresponded to one of the plurality of same type devices. The normal use of a stepper mask was for applying the same mask repeatedly to arrays of devices on a wafer. Selective application of the stepper mask to a single device as claimed was a clever implementation of this technology because it allowed creation of connection vias for selected devices only.

The subject-matter of claims 1 and 6 of the first auxiliary request, thus, also involved an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Respondent's main request*

2.1 *Inventive step*

2.1.1 As indicated in the patent in suit, "*silicon carbide (SiC) has been known for many years to have excellent physical and electronic properties which should theoretically allow production of electronic devices that can operate at higher temperatures, higher power and higher frequency than devices produced from silicon (Si) or GaAs*" (cf paragraph [0003]). Moreover it is indicated that "*Many different types of silicon carbide devices which may be suitable for differing high power applications have been described, including diodes, MOSFETs, MESFETs, JFETs and the like. See eg. United States Patent Nos. 5,061,972, 5,264,713, 5,270,554, 5,506,421, 5,539,271, 5,686,737, 5,719,409, 5,831,288, 5,969,378, 6,011,279 and 6,121,633, the disclosures of which are incorporated herein by reference as if set forth fully herein. These devices may take advantage of the characteristics of silicon carbide to provide high power handling capabilities. While such silicon carbide devices may provide improved power handling capabilities over comparably sized silicon devices, it may be difficult to create large scale devices in silicon carbide. For example, in silicon a single device may be made on a wafer such that the device is substantially the same size as the wafer. However, manufacturing defect free silicon carbide wafers may be difficult, if not impossible. Thus, a device which*

consumes an entire wafer may have defects incorporated into the device which may limit its performance" (cf paragraph [0004]).

2.1.2 Starting from this prior art as given in the introductory part of the patent, the objective problem to be solved is to produce larger devices (up to the size of the wafer) despite the defects typically present in the wafer.

D2 provides a method suitable for producing larger devices in the presence of defects.

Accordingly, it would be obvious to a person skilled in the art to apply the method of D2 as a solution to the above problem posed.

In particular, the solution provided in D2 comprises, in the terms of claim 1,

- forming a plurality of a same type of devices on at least a portion of a wafer in a predefined pattern, the devices having corresponding first contacts on a first face of the wafer;
- electrically testing the plurality of devices to identify ones of the plurality of devices which pass an electrical test; and
- selectively interconnecting the first contact of the identified ones of the plurality of devices so as to provide interconnection between the identified ones of the plurality of devices.

The subject-matter of claim 1 as granted differs from the solution provided in D2 in that according to

claim 1 the step of selectively interconnecting the first contact of the identified ones of the plurality of devices is done by selectively applying a stepper mask, whereas in D2 this is done by selectively applying laser ablation.

However, the use of a stepper mask as claimed, instead of laser ablation as is used in D2, constitutes an obvious alternative for a person skilled in the art in view of the widespread use of stepper photolithography in the technical field at issue of semiconductor processing.

2.1.3 It is noted in this respect that, contrary to what is argued by the respondent and held in the decision under appeal, the fact that D2 only considered laser ablation cannot be seen as advising the skilled person against considering suitable alternatives.

The respondent also argued in this respect that the fact that in D2 photolithography was used for patterning the interconnects but not for forming the openings, meant that the skilled person would understand the choice of laser ablation in D2 to have some significance.

It is, however, noted that the skilled person is aware of the respective advantages and disadvantages of laser ablation versus stepper photolithography, both being commonly used for semiconductor processing. For instance, whereas laser ablation directly provides openings in the passivation, stepper photolithography requires several steps including the application of photoresist, exposure, development, passivation etching

and photoresist removal. Conversely, it is known that laser ablation may damage the devices. Which process is adopted depends ultimately on a number of considerations, including process complexity and costs as well as device vulnerability, which are considered to fall within the competence of the person skilled in the art.

The respondent, moreover, argued that none of the prior art discussed selective application of a stepper mask.

It is however noted that it would be clear to the skilled person from D2 that when using stepper photolithography a stepper mask should be applied depending on where interconnects should be made, ie selectively. Claim 1 contains no details as to how the stepper mask is applied selectively, so that no distinction is provided over such well-known, albeit tedious solutions as the use of custom masks.

2.1.4 Accordingly, having regard to the state of the art, the subject-matter of claim 1 as granted would be obvious to a person skilled in the art and therefore lacks an inventive step (Article 56 EPC 1973).

3. *Respondent's first auxiliary request*

3.1 *Amendments*

Claim 1 as amended is based on claims 1, 2 and 4 to 6 as originally filed.

Independent claim 6 is based on claims 1, 10, 12 and 13 as originally filed.

Dependent claims 2 to 5 and 7 are based on originally filed claims 3, 7 to 9 and 15, respectively

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

Furthermore, having regard to claim 1 as granted, the amendments further limit the protection conferred, so that the requirement of Article 123(3) EPC is met as well.

3.2 *Inventive step*

3.2.1 Claim 1 according to the respondent's first auxiliary request contains in particular further limiting features regarding the step of selectively applying a stepper mask. In particular it is specified that

"*the step of selectively applying a stepper mask comprises the steps of:*
applying a stepper mask corresponding to one of the plurality of silicon carbide diodes to an identified one of the plurality of silicon carbide diodes; and
repeating the step of applying the stepper mask for each of the identified silicon carbide diodes."

3.2.2 The appellant argued that the selection of a suitable size of the stepper mask, ie whether the mask corresponded to a given number of devices (eg a 2 x 2 array) or to a single device as claimed, was a common design option which the skilled person would select based on circumstances without an inventive step being involved.

The respondent argued that the inventors of the patent in suit had realised that stepper mask photolithography was particularly advantageous for selective formation of interconnects, because the stepper mask could be applied selectively. The normal use of a stepper mask was for applying the same mask repeatedly to arrays of devices on a wafer. Selective application of the stepper mask was a clever implementation of this technology by the inventors, because it allowed creation of connection vias for selected devices only.

3.2.3 Claim 1 of the respondent's first auxiliary request implies that the stepper mask, which corresponds to one silicon carbide diode, is not applied to those diodes which fail the electrical test. The stepper mask is, thus, not applied systematically to all devices on the wafer, as is the case in conventional stepper photolithography.

The application of the stepper mask according to the respondent's first auxiliary request, thus, is a specific modification which is not considered to be obvious from the skilled person's common general knowledge of conventional stepper photolithography. Neither is there anything in document D2 or in any of the remaining prior art invoked by the appellant in the course of the appeal proceedings suggesting such a modification.

Accordingly, the subject-matter of claim 1 of the respondent's first auxiliary request is considered to involve an inventive step in the sense of Article 56 EPC 1973.

3.2.4 Claim 6 of the respondent's first auxiliary request is directed at a corresponding method of fabricating a silicon carbide device, in which the plurality of the same type silicon carbide devices, rather than being silicon carbide diodes as in claim 1, have first and second contacts on the first face of the silicon carbide wafer. The method involves selectively forming openings in the passivation layer corresponding to the first and second contacts for the identified ones of the plurality of silicon carbide devices utilizing the stepper mask.

The subject-matter of claim 6 involves an inventive step for in substance the same reasons as for claim 1.

3.2.5 Claims 2 to 5 and claim 7 are dependent on claims 1 and 6, respectively, and involve further limitations. The subject-matter of these claims, thus, also involves an inventive step.

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 maintain the patent in amended form in the following version:

   - description, pages 2, 2a, 2b and 3 to 7, filed at the oral proceedings,

   - claims 1 to 7 of the first auxiliary request, filed at the oral proceedings,

   - drawings, figures 1 to 11 as granted.

Registrar: Chair:

S. Sánchez Chiquero G. Eliasson