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Datasheet for the decision of 12 September 2013

Case Number: T 1811/11 - 3.2.08

Application Number: 05810073.6

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IPC: C30B29/36, C30B23/00

Language of the proceedings: EN

Title of invention:
100 MM SILICON CARBIDE WAFER WITH LOW MICROPIPE DENSITY

Applicant:
CREE, INC.

Headword:

Relevant legal provisions:
EPC Art. 87(1)(b), 87(4), 84, 123(2), 54, 56

Keyword:
Main request (priority, no; novelty , no)
Auxiliary requests 1 to 3 (clarity, no)
Auxiliary request 4 (novelty and inventive step, yes)

Decisions cited:

Catchword:

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Case Number: T 1811/11 - 3.2.08

D E C I S I O N
of Technical Board of Appeal 3.2.08
of 12 September 2013

Appellant: (Applicant)	CREE, INC. 4600 Silicon Drive Durham, North Carolina 27703-8475 (US)
Representative:	Isarpatent Patent- und Rechtsanwälte Friedrichstrasse 31 80801 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 5 April 2011 refusing European patent application No. 05810073.6 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: T. Kriner
Members: M. Alvazzi Delfrate
D. T. Keeling

Summary of Facts and Submissions

I. By decision posted on 5 April 2011 the examination division refused the European patent application No. 05 810 073.6.

II. The appellant (applicant) lodged an appeal against this decision on 25 May 2011, paying the appeal fee on the same day. The statement setting out the grounds for appeal was filed on 5 August 2011

III. Oral proceedings before the Board of Appeal were held on 12 September 2013.

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request or one of auxiliary requests 1 to 3, all filed with a letter dated 12 August 2013, or on the basis of auxiliary request 4 filed at the oral proceedings.

IV. The **main request** comprises an independent product claim 1 and an independent method claim 16. Claim 1 reads as follows:

"A high quality SiC single crystal wafer having a diameter of at least 100 mm and a surface micropipe density less than 25 cm^{-2} , including at least one dopant selected from the group consisting of N, P, As, Sb, Bi, B, Al, Ga, In and Tl, and wherein said surface micropipe density represents a count of the total micropipes on said surface divided by the surface area of said wafer."

Claim 1 of **auxiliary request 1** differs from claim 1 of the main request by the addition of the feature according to which the wafer is

"cut from a crystal that has been annealed for at least 30 minutes after termination of sublimation growth".

Claim 1 of **auxiliary request 2** differs from claim 1 of auxiliary request 1 in that the surface micropipe density is

"less than 20 cm^{-2}".

Auxiliary request 3 is limited to product claims and its claim 1 corresponds to claim 1 of auxiliary request 1.

Auxiliary request 4 comprises solely method claims. Independent claim 1 reads as follows:

"A method for producing a high quality crystal of silicon carbide having a diameter of at least 100 mm and a surface micropipe density less than 25 cm^{-2} , the method comprising:
annealing a silicon carbide seed holder at temperatures at or about 2500°C for at least 30 minutes prior to attaching a polished SiC wafer to the silicon carbide seed holder as a seed crystal;
introducing said annealed silicon carbide seed holder into a crucible;
supplying a silicon carbide powder source material into said crucible;
evacuating the crucible to remove ambient air and other impurities;
placing the crucible under inert gas pressure;

heating the crucible to sublimate the silicon carbide powder source material to a SiC growth temperature to create a thermal gradient between the powder source material and the seed crystal and reducing the pressure to encourage vapor phase movement of the powder source material to the seed crystal and condensation of the powder source material on the seed crystal to grow a single crystal of silicon carbide, having a diameter of at least 100 mm;
annealing the single crystal of silicon carbide at or above the growth temperature for at least 30 minutes after termination of growth to produce the high quality crystal of silicon carbide with a surface micropipe density of less than 25 cm^{-2};
slicing the single crystal of silicon carbide into SiC wafers, wherein each SiC wafer has the surface micropipe density of less than 25 cm^{-2} , and wherein said surface micropipe density represents a count of the total micropipes on a surface of the SiC wafer cut divided by the surface area of said SiC wafer; and
polishing the SiC wafers."

V. The following documents play a role in the present decision:

P1: application US 10/957,807 (priority of the application in suit);
D1: US -A- 2004/0187766;
D4: US -A- 2005/0126471; and
D4': WO -A- 2006/011976.

VI. The arguments of the appellant can be summarised as follows:

Main request

Although D4 and P1 had the same inventor, only the the latter document described the subject-matter according to the claims of the main request. In particular, D4 did not disclose a wafer which, according to claim 1 of the main request, comprised at least one dopant selected from the group consisting of N, P, As, Sb, Bi, B, Al, Ga, In and Tl. It was true that paragraphs [0070] to [0072] of D4 mentioned some of those dopants. However their content was so small that the person skilled in the art would have considered that those dopants were not present. Since D4 did not disclose the subject-matter of claim 1, P1 was the first application for that subject-matter. Accordingly, the priority of P1 was validly claimed, D4 itself was not prior art and the subject-matter of claim 1 was novel.

Auxiliary requests 1 to 3

The product according to claim 1 of each of auxiliary requests 1 to 3 was further distinguished over D4 by the feature according to which the wafer was cut from a crystal that had been annealed for at least 30 minutes after termination of sublimation growth. It was true that this feature related to a process step. However, the effect of that step could be detected in the microstructure of the surface of the wafer. Accordingly, the use of a product-by-process feature was allowable.

Auxiliary request 4

Since D4 did not disclose a method according to claim 1 of auxiliary request 4 the priority on that claim was valid. Therefore, its subject-matter was novel. As it was also not rendered obvious by the prior art, it involved an inventive step, too.

Reasons for the Decision

1. The appeal is admissible.

2. Main request

2.1 Priority

D4 is a US application filed before the priority date of the application in suit (filing date of P1). It was published on 16 June 2005 and used for claiming the priority of D4' by the same applicant of the application in suit.

D4 discloses a high quality SiC single crystal wafer having a diameter of at least 100 mm (see paragraphs [0052], [0054] and claims 1 and 2). The wafers have less than 200 micropipes per square centimetre, in more preferred embodiments less than 30 micropipes per square centimetre, and in low and ultra-low density, less than 15 and less than 5 micropipes per square centimetre respectively (see paragraph [0057] and claims 3-6).

Furthermore, D4 discloses in paragraphs [0070] to [0072] that the wafer may comprise dopants, in particular B and N. Whatever the concentration of these

dopants may be, it does not disqualify them as dopants in the sense of present claim 1, since this claim does not stipulate the concentration of the dopants.

Accordingly, D4 discloses a wafer in accordance with claim 1 of the main request.

Hence, claim 1 of the main request is not entitled to the priority of P1, as this document is not the first application for its subject-matter (Article 87(1)(b) and (4) EPC).

2.2 Novelty

As a consequence, D4 itself, which was published in the priority interval of the application in suit, belongs to the prior art. Therefore, the subject-matter of claim 1 of the main request lacks novelty in view of D4.

3. Auxiliary requests 1 to 3

In each of the auxiliary requests 1 to 3 claim 1 comprises a product-by-process feature according to which the wafer is cut from a crystal that has been annealed for at least 30 minutes after termination of sublimation growth.

The appellant submitted that the effect of that process step could be detected in the microstructure of the surface of the wafer. However, it failed to specify in which respect that microstructure could be distinguished from that of a wafer which had not been submitted to that annealing treatment and failed to provide evidence for this statement. Nor does the Board see which product feature, distinguishing the claimed

wafer from that known from D4, may inherently result from that treatment.

Accordingly, it is not clear which product feature, if any, is stipulated by means of the product-by-process feature introduced in claim 1 of each of the auxiliary requests 1 to 3. Therefore, that product-by-process feature is not allowable and those claims lack clarity.

4. Auxiliary request 4

4.1 Article 123(2) EPC

The claims of auxiliary request 4 are based on the application as originally filed. The features of claim 1 are found in particular in originally filed claims 1 and 29, and paragraphs [0045] and [0049] of the description. Those of claim 2 are disclosed in paragraphs [0043] and [0044]. Therefore, the claims of auxiliary request 4 comply with the requirements of Article 123(2) EPC.

4.2 Priority

D4 does not disclose the step of annealing the single crystal of silicon carbide at or above the growth temperature for at least 30 minutes after termination of growth. Hence, it does not describe the subject-matter of claim 1 of auxiliary request 4.

By contrast, that subject-matter can be found in P1 (see in particular claims 1, 15 and paragraphs [0046] and [0050]). Therefore, in the case of auxiliary request 4 the priority of P1 is validly claimed and D4 does not belong to the prior art.

4.3 Novelty

Since none of the prior art documents discloses a method with all the steps according to claim 1, its subject-matter is novel.

4.4 Inventive step

The most relevant prior art is represented by D1, which discloses a seeded sublimation growth process for monocrystalline material (see claim 1 and paragraph [0031]). According to paragraph [0047] that process produces an ingot which may have a large diameter, such as of over 100 mm, and preferably with low defect density, such as of less than 1 cm^{-2}, preferably in the range of about 1 cm^{-2} to 10 cm^{-2} in the case of SiC micropipes. No specific example of the production of SiC monocrystalline material is disclosed.

Starting from this prior art, the object underlying the present invention lies in the provision of an improved growth process for low-defect silicon carbide wafer (see paragraph [0024]).

This object is achieved by the process of claim 1, according to which the seed holder is annealed for at least 30 minutes at or about 2500°C prior to attaching the polished SiC wafer on the seed holder. This step, which is not disclosed in D1, prevents the seed holder from undergoing significant distortion during crystal growth at SiC sublimation temperatures and minimizes or eliminates temperature differences across the seed that would otherwise tend to initiate and propagate defects in a growing crystal (see paragraphs [0045] and [0057]).

The prior art does not render it obvious to achieve the object above in accordance with claim 1. Hence, the subject-matter of claim 1 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 Examining Division with the order to grant a patent on the basis of the following documents:
   - Claims 1 and 2 according to auxiliary request 4 filed at the oral proceedings,
   - A description to be adapted to the claims,
   - Figures 1 to 6 as published (WO -A- 2006/041660).

The Registrar: The Chairman:

V. Commare T. Kriner

Decision electronically authenticated