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D E C I S I O N
of 23 September 2003

Case Number: T 1117/00 - 3.4.3

Application Number: 96300522.8

Publication Number: 0725440

IPC: H01L 23/532

Language of the proceedings: EN

Title of invention:
Silicon carbide metal diffusion barrier layer

Patentee:
DOW CORNING CORPORATION

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1117/00 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 23 September 2003

Appellant: DOW CORNING CORPORATION
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 18 May 2000 refusing European application No. 96300522.8 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: E. Wolff
M. B. Günzel

Summary of Facts and Submissions

I. The examining division refused European patent application No. 96 300 522.8 in a decision dispatched on 14 June 2000 on the ground that the inventions claimed in claim 1 and independent claim 10 as originally filed did not involve an inventive step with regard to the combined teaching of the following documents

D1: US-A-5 103 285

D2: VMIC Conference, June 7-8, 1994, pages 414 to 420

II. The appellant filed the notice of appeal on 24 July 2000 and paid the appeal fee on the same day. The statement setting out the grounds of appeal was filed on 9 October 2000.

The appellant requests that the decision of the examining division be set aside and the patent be granted with the claims as originally filed.

Oral proceedings are conditionally requested.

III. Independent claim 1 of the request reads as follows.

"1. An integrated circuit comprising:

A) a circuit subassembly comprising a semiconductor substrate having solid state device regions and, deposed on the surface of the semiconductor substrate, metal wiring interconnecting the solid state device

regions, the metal wiring having a resistivity of less than 2.5 microhm-centimeters;

B) an amorphous silicon carbide layer covering at least the metal wiring; and

C) a dielectric layer covering at least the silicon carbide layer."

Claims 2 to 9 are claims directly or indirectly dependent on claim 1.

Independent claim 10 of the request reads as follows

"10. A wiring board comprising:

A) a wiring board subassembly containing thereon metal wiring having a resistivity of below 2.5 microhm-centimeters;

B) an amorphous silicon carbide layer covering the metal wiring; and

C) a dielectric layer covering at least the silicon carbide layer."

There are no claims dependent on claim 10.

IV. The reasons given by the examining division for rejecting the application can be summarized as follows.

The claimed invention differed from the disclosure in the nearest prior art document D2 only in that in the case of the invention the dielectric barrier to

diffusion of a metal such as copper, having a resistivity of less than 2.5 microhm-cm, was amorphous SiC. The solution to the objective problem of finding an alternative to the materials disclosed in document D2 for preventing copper diffusion into the dielectric was obvious in the light of document D1 which discloses a doped, conductive SiC layer connecting a metallic layer electrically to a substrate while preventing metallic diffusion from the metallic layer into the substrate.

V. The arguments of the appellant can be summarized as follows.

The problem solved by the invention is not just to find an alternative material to silicon nitrides or oxides for preventing copper diffusion into dielectric material as disclosed in document D2, but to provide an assembly in which low resistivity metal wiring such as copper is isolated from other conductors and active circuits in a manner which prevents biased-temperature-stress (BTS) diffusion of Cu and which maintains the electrical isolation of the wiring. The invention resides in appreciating that amorphous SiC forms a suitable and indeed very good barrier fulfilling these requirements. Document D1 is concerned with using crystalline SiC to provide a conductive barrier against aluminium diffusion. It contains no disclosure at all of non-conducting amorphous SiC which is quite different in structure and properties and therefore the claimed invention cannot be obvious over the combined teaching of documents D2 and D1.

Reasons for the Decision

1. The appeal is admissible

2. *Inventive step*

Claim 1

2.1 The invention is concerned with the problem of diffusion of Cu and other high-conductivity, low resistance metals such as Ag and Au (application as filed, page 2, lines 11 to 14) into dielectric materials. The Board concurs with the finding of the examining division (page 3 of the decision, paragraph 2) that document D2 is the closest prior art document. Document D2 addresses the problem of diffusion of Cu into silicon nitride and oxide dielectric films (page 414, "Introduction", lines 13 to 16), and concludes that silicon nitride and oxynitride show the best barrier properties (page 416, second paragraph lines 18 to 21).

2.2 The objective problem was in the Board's view correctly identified to be that of finding an alternative to the materials disclosed in document D2 for preventing copper diffusion into the dielectric (paragraph 4 on page 3 of the decision).

2.3 The examining division considered that document D1 made the solution adopted by the invention obvious (page 3, last two paragraphs), because it discloses a doped, conductive SiC layer which electrically connects a metallic layer to a substrate, but prevents metallic diffusion from the metallic layer into the substrate.

2.4 The Board cannot accept this argument and, instead, agrees with the appellant's submission that document D1, although referring in passing to metals in general, specifically addresses the prevention of aluminium diffusion into silicon which is a well-known problem in the art. For the reasons which follow, it cannot be derived from document D1 that a SiC barrier would prevent diffusion of metals such as Cu and Ag, which have a resistivity of less than 2.5 μΩ-cm, as opposed to Al which has a resistivity of 2.822 μΩ-cm.

2.4.1 As submitted by the appellant, there are important differences in the diffusion mechanisms involved in documents D1 and D2 (statement of grounds, page 5, point 13, to page 7, point 17). As discussed in document D2, one of the main mechanisms for the diffusion of copper into dielectric materials is biased temperature stress (BTS) diffusion, that is, diffusion under the influence of an applied electric field (e.g., document D2, page 415, "Results and Discussion", 2nd paragraph, lines 4 to 14, and page 417, second paragraph together with the graph in Figure 8 on page 419). In contrast, document D1 relates to preventing thermal diffusion of Al from a wiring layer into, for example, underlying pn junction regions during heat treatment processing steps (Document D1, column 1, lines 32 to 42). The Al layer is formed on crystalline SiC which is doped to make it electrically conductive, thereby precluding the establishment of electric fields that could cause BTS diffusion. In view of the quite different diffusion mechanisms, the skilled person had no reason to consider on the basis of the disclosure in document D1 of doped conductive

crystalline SiC providing a barrier to thermal diffusion of Al into semiconductor material, that amorphous SiC as claimed in claim 1 would provide a suitable barrier for BTS induced diffusion of, for example, Cu into a dielectric material.

2.5 As the appellant has argued convincingly, there are also important differences between SiC as used in the claimed invention and as disclosed in document D1. Thus, in contrast to the amorphous SiC required by the claim, the SiC material disclosed in document D1 is described as having a lattice constant similar to that of crystalline Si (document D1, column 2, lines 35 to 44) and is therefore without doubt crystalline SiC (statement of the grounds of appeal, page 9, point 22). Crystalline SiC has a uniform composition of equal moles of Si and C atoms, arranged in a lattice structure (page 8, point 20, subparagraph 1). In contrast, amorphous SiC is a ceramic-type material which contains molecules which range in composition about 5 silicon atoms to 1 carbon atom to 5 carbon atoms to 1 silicon atom (page 9, point 20, subparagraph 2). As the crystalline or amorphous nature of a material is generally known to influence considerably its diffusion properties, the teaching of document D2 cannot be regarded as suggesting that amorphous SiC would also prevent diffusion of Al.

2.6 For the foregoing reasons, the Board concludes that the disclosure in document D1 would not lead the skilled person to consider replacing the silicon nitride or oxynitride barrier layers disclosed in document D2 by amorphous SiC.

Claim 10

2.7 The foregoing arguments apply in equal measure to claim 10 which differs from claim 1 in that it relates to a wiring board rather than an integrated circuit but otherwise claims the same solution to the same problem as claim 1.

3. In the judgement of the Board, for the reasons given, claims 1 and 10 of the application in suit are not obvious with regard to documents D1 and D2 and hence involve an inventive step as required by Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent on the basis of the following documents:

Claims: claims 1 to 10 as originally filed

Description: pages 1 to 7 as originally filed

Drawings: sheet 1/1 as originally filed

The Registrar

R. Martorana

The Chairman

R. K. Shukla

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