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**D E C I S I O N**  
of 11 September 2001

**Case Number:** T 0612/95 - 3.4.3

**Application Number:** 90112253.1

**Publication Number:** 0405501

**IPC:** H01L 23/485

**Language of the proceedings:** EN

**Title of invention:**  
Semiconductor device

**Applicant:**  
KABUSHIKI KAISHA TOSHIBA

**Opponent:**  
-

**Headword:**  
Interposed silicon carbide layer/KABUSHIKI KAISHA TOSHIBA

**Relevant legal provisions:**  
EPC Art. 123(2), 54(3), 51(2), 56

**Keyword:**  
"Amendments - admissible"  
"Novelty - yes"  
"Inventive step - yes"

**Decisions cited:**  
-

**Catchword:**  
-



Case Number: T 0612/95 - 3.4.3

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.3  
of 11 September 2001

**Appellant:**

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**Representative:**

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**Decision under appeal:**

Decision of the Examining Division of the  
European Patent Office posted 9 March 1995  
refusing European patent application  
No. 90 112 253.1 pursuant to Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** R. K. Shukla  
**Members:** E. Wolff  
M. J. Vogel

## Summary of Facts and Submissions

- I. This is an appeal against the decision of the examining division, posted 9 March 1995, to refuse European patent application No. 90 112 253.1 on the ground that the claims forming the basis of the decision lacked an inventive step in view of the following prior art documents:

D1: GB-A-2 092 376

D2: EP-A-0 271 110

D5: Patent Abstracts of Japan, Vol. 1, No. 139  
(E-064), 15 November 1977; & JP-A-52 077 588

The following documents were also mentioned in the decision under appeal:

D3: US-A-4 507 673

D4: EP-A-0 328 262

- II. The notice of appeal was filed on 9 May 1995, and the appeal fee was paid on the same day. The statement of grounds was filed on 6 July 1995.

Together with the notice of appeal, the applicant filed a new set of claims as main request, and a further set of claims as an auxiliary request. Oral proceedings were requested in the event that the main request was considered to be unallowable.

- III. In response to communications from the Board informing the appellant that the claims according to the main request were allowable but that the description required amendments for consistency with the claims,

the appellant filed new pages of the description and requested the grant of a patent on the basis of the following documents.

**Description:** pages 1 and 3 as originally filed,  
pages 2 and 5 as filed 27 March 2001,  
page 4 as filed 12 June 2001;

**Claims:** claims 1 to 3 according to the main  
request as filed on 6 July 1995

**Drawings:** Figures 1 to 4 as originally filed

Claim 1 of the main request reads as follows:

"1. A semiconductor device comprising:  
a semiconductor substrate (31),  
a first insulation film (33) made of silicon oxide  
formed on said semiconductor substrate,  
a metal film (35) made of aluminum having a  
bonding pad portion formed above said first  
insulation film,  
a second insulation film (36) formed between said  
first insulation film and bonding pad portion and  
being in contact with said first insulation film  
and said bonding pad portion, and  
a bonding wire (39) connected to said bonding pad  
portion  
characterized in that  
said second insulation film is formed directly  
under said bonding pad portion, and is stiffer  
than said first insulation film for preventing  
stress from locally concentrating under said  
bonding pad portion,

said second insulation film is made of silicon carbide, and  
said bonding wire (39) is made of one of copper and an alloy containing copper."

IV. The arguments put forward by the appellant can be summarized as follows:

The aim of the invention is to prevent stress from locally concentrating directly under a bonding pad. This eliminates damage caused when using bonding wires of copper or a copper alloy, which are generally stiffer and hence cause greater mechanical stress when being applied to the bonding pad compared to gold wire or the like as disclosed in D1, for example. The solution adopted by the invention as now claimed is to form underneath the bonding pad an insulating layer of mechanically stiff silicon carbide (SiC) on top of an insulating layer of silicon oxide (SiO). Routine consideration of the mechanical, electrical and chemical properties of the device structures and materials disclosed in document D1 and the other cited documents would neither lead the skilled person to address the problem with which the claimed invention is concerned nor suggest to the skilled person the device structure as claimed in order to overcome that problem.

## Reasons for the Decision

1. The appeal is admissible.
2. *Amendments (Article 123(2))*

Claim 1 of the main request is based on claim 6 of the application as originally filed, with additional limitations taken from the originally filed description and claims, which are:

- (i) that the metal film having a bonding pad is formed of aluminium (page 4, lines 6 and 7),
- (ii) that the second insulating film must be stiffer than the first insulating film, and is formed directly under the bonding pad so that stress can be prevented from locally concentrating under the bonding pad (page 4, lines 25 to 29),
- (iii) that the material of the second insulating film is silicon carbide which is explicitly referred to in a list of materials in the description (page 5, line 30), and
- (iv) that a bond wire of copper or an alloy of copper is used (claim 9, dependent on claim 6, in the application as filed).

Claim 2 of the main request corresponds to claim 8 of the application as filed, and all the elements specified in claim 3 are disclosed in the claimed relationship in the first paragraph on page 4 of the description.

For consistency with the claims, the description has been amended to refer throughout just to silicon carbide as the material for the second insulation layer.

The Board is therefore satisfied that the description and claims of the main request as amended do not contain subject matter extending beyond the content of the application as filed and, hence, comply with the requirements of Article 123(2).

### 3. Novelty

#### 3.1 Document D4 relates to a programmable bonding pad.

Beneath a metal bonding pad 30 is a p-doped region 34. A sandwich layer made up of a silicon dioxide 36 layer and a silicon nitride layer 37 separates the metal pad 30 from the p-doped region 34 (column 3, lines 48 to 56). The sandwich of two layers is used to protect the components below the bonding pad (column 4, lines 24 to 27), with the silicon nitride layer being used because "silicon nitride is more mechanically resistant to pressure than silicon dioxide" (column 4, lines 31 and 31).

Document D4 was cited by the examining division as novelty destroying under Article 54(3) EPC against the claims then on file. However, as now claimed the invention is clearly novel in that instead of an upper layer of silicon nitride it employs an upper layer of silicon carbide.

None of the remaining documents are relevant to the issue of novelty as will become apparent from the ensuing discussion on inventive step.

The invention as claimed in claim 1 is therefore new in accordance with Article 54 EPC.

4. *Inventive step*

4.1 The decision of the examining division is based on document D1 as constituting the closest prior art, and the Board has no reason to depart from this assessment.

4.2 Document D1 discloses a semiconductor device in which a insulating layer 9 such as silicon nitride is interposed between a layer of phosphorus silicate glass 3 and an aluminium bonding pad electrode 4' (page 3, lines 126 to page 4, line 2). As the basic ingredient of phosphorus doped silicon glass (PSG) is silicon oxide, the PSG layer 3 and the underlying silicon dioxide layer 2 together constitute an insulating layer which is formed on the substrate 1 (page 3, lines 37 to 43) and which in the plain meaning of the words is "made of silicon oxide". In the terms of claim 1 of the main request, therefore, document D1 discloses a device in which a second insulating layer (9) is interposed between a silicon oxide insulating layer (2,3) formed on the substrate (1) and a bonding pad (4'). The bonding pad 4' is attached to an external lead through a thin metallic wire (page 3, lines 9 to 11). The semiconductor device disclosed in document D1 thus exhibits all the structural features recited in the preamble of claim 1 of the main request.

4.3 The device claimed in claim 1 differs from the device disclosed in document D1 in that in the claimed device the second insulating film is required to be stiffer than the first insulation film and to be made of silicon carbide rather than silicon nitride, and in that the bonding wire is made of copper or an alloy containing copper. Moreover, the explicitly stated function of the second insulating layer of the claimed invention is to prevent stress from locally concentrating under said bonding pad portion, while the insulation layer 9 of document D1 is required to be



"hardly moisture permeable" (page 3, lines 126 and 127) thereby "isolating the high concentration PSG from invading moisture" (page 2, line 130 to page 3, line 1).

4.4 Comparing the invention as claimed in claim 1 with the prior art known from document D1, the objective problem to be solved is to prevent stress from locally concentrating directly under a bonding pad and so avoid damage caused by bonding a wire made of copper or an alloy containing copper.

4.5 The material used for the bond wires in the device disclosed in document D1 is "gold and the like" (page 3, lines 11 and 12). Gold is an expensive but also rather soft material. Replacing gold wires with wires made from a cheaper material will be routinely contemplated by the skilled person. Although wires of copper or an alloy containing copper will always rank high on a list of replacement materials to be considered because of their high conductivity, the skilled person will also bear in mind that the use of such materials will lead to a higher stress being imposed on the bonding pad during bonding because these materials are generally significantly harder than gold. Greater stress brings with it an increased risk of damaging the device during the bonding process, and this will motivate the skilled person to look for solutions which lessen the risk of causing damage to the device.

4.6 The purpose of the silicon nitride layer 9 known from document D1 is to protect the PSG layer from moisture ingress and so prevent high concentrations of phosphorus in the PSG insulating layer from reacting with moisture to form corrosive phosphoric acid (e.g. page 1, line 122 to page 2, line 4). In view of the complete absence in document D1 of any pointer to the

problem addressed by the claimed invention, the Board concludes that the skilled person looking for a solution to the problem addressed by the invention would not consider the layer structure known from document D1 to be of any assistance. Moreover, the materials specified in claim 1 of the application in suit for the second insulating layer and the bonding wires are different from those referred to in document D1.

4.7 Document D2 aims to reduce the stress on the semiconductor material of a device which uses copper or copper alloy bonding wires. The solution adopted is to use a triple layer metal structure (18, 19, 29) as electrode pad, in which the first layer (18) provides a suitable metal-to-semiconductor interface, the second layer (19) is "hard enough to resist the pressing force" applied during the bonding process, and the third layer (20) is a metal layer of a composition suitable for bonding to a copper bonding wire (subparagraphs 2, 3 and 4 of claim 1). There is no suggestion that stress could be contained by anything other than a three-layer metal structure employed to form the bonding pad itself. Document D2 therefore does not suggest providing a silicon carbide film between the first insulation layer of silicon oxide and the bonding pad portion.

4.8 Document D3 discloses a semiconductor memory device in which the gate voltage is reduced by employing a composite gate insulation film of silicon dioxide (4) on top of which is formed a silicon carbide film(5). In document D3, however, the hole 29 for the bond wire 10 is not located above the gate insulation film (column 4, lines 40 to 45, referring to Figure 4M and hence implicitly also to Figures 2, 4N, 5 and 6). It follows that the bonding pad is located away from the gate insulation film and therefore bonding does not

apply stress to the film. Accordingly, nothing in the structure of the device disclosed in document D2 suggests providing a silicon carbide film between the first insulation layer of silicon oxide and the bonding pad portion.

- 4.8 Document D5, just like document D1, is concerned with improving the moisture resistance of a semiconductor device (as well as its thermal resistance) by using a silicon carbide film doped with phosphorus and aluminium and a composite film of phosphorus silicate glass and silicon nitride. There is no indication that the document concerns itself with locally improving the mechanical properties of the device either generally or specifically directly underneath a bonding pad. Document D5 therefore cannot suggest forming directly underneath a bonding pad a silicon carbide layer which prevents stresses from concentrating under the bonding pad when bonding wires of copper or a copper containing alloy.
5. For the foregoing reasons, in the Board's judgement the invention as claimed in claim 1 of the request involves an inventive step within the meaning of Article 56 EPC as required by Article 52(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 the first instance with the order to grant the patent on the basis of the documents listed in paragraph III of this decision.

The Registrar:

The Chairman:



D. Spigarelli



R. K. Shukla