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File Number: T 663/91 - 3.4.1  
Application No.: 83 307 762.1  
Publication No.: 0 115 158  
Title of invention: Substrate for semiconductor module

Classification: H05K 3/02

D E C I S I O N  
of 17 December 1992

Applicant: Kabushiki Kaisha Toshiba

Opponent: Asea Brown Boveri AG

Headword:

EPC Article 56

Keyword: "Inventive step - denied"



Case Number : T 663/91 - 3.4.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.1  
of 17 December 1992

**Appellant :**  
(Proprietor of the patent)

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**Respondent :**  
(Opponent)

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**Decision under appeal :**

Decision of the Opposition Division of the  
European Patent Office dated 2 July 1991 revoking  
European patent No. 0 115 158 pursuant to  
Article 102(1) EPC.

**Composition of the Board :**

**Chairman :** G.D. Paterson  
**Members :** R.K. Shukla  
H.J. Reich

## Summary of Facts and Submissions

I. The present appeal lies from a decision of the Opposition Division revoking European patent No. 0 115 158 pursuant to Article 102(1) EPC. The Opposition Division considered that the subject-matter of Claim 1 of the patent under dispute lacked an inventive step in view of the prior art as disclosed in the following documents :

D4: BBC- Nachrichten, vol.64, no.7, 1982, pages 196-200  
D7: IEEE Transactions on Electron Devices, vol.ED 23, no.8 (1976), pages 961 to 967; "New hybrid power technique utilizing a direct copper to ceramic bond" by Y.S. Sun et al.

A further document, D2, US-A-3 994 430, was also relied upon by the Respondent during the proceedings before the Opposition Division.

II. In his Statement of Grounds of Appeal, the Appellant (Patentee) requested that the impugned decision be set aside and the patent be maintained on the basis of a set of two new claims, the only independent claim of the set having the following wording:

"A method of manufacturing a substrate for receiving a semiconductor module in which either a sheet of tough pitch electrolytic copper or a sheet of copper having an oxide surface coating thereon is disposed on a surface of a non-oxide ceramic plate; the plate and the sheet are heated to a temperature in the range 1065 - 1083°C at which temperature a thin eutectic layer of melt is formed; and the plate and sheet are allowed to cool to cause the melt to bond the sheet to the substrate; characterised in that, prior to heating of the ceramic plate in contact with the copper sheet, the ceramic plate is subjected to a

process to form an oxide surface coating thereon, and, after the copper sheet is bonded to the substrate, the copper sheet is shaped by etching."

III. The Appellant presented essentially the following arguments in support of his request:

Document 7 discloses that the sheet of copper may have a controlled amount of oxygen uniformly distributed through it or the copper sheet may be oxidised to form a  $Cu_2O$  layer on its surface, but does not disclose the following features of the claimed invention:

- (a) prior to heating the ceramic plate in contact with the copper sheet, the ceramic plate is subjected to a process to form an oxide coating thereon; and
- (b) the copper sheet is shaped by etching.

The teaching of document D7 applies to both the oxide and non-oxide ceramics. Moreover, it is reported in this document on page 962, left-hand column, lines 6 to 19 that for directly bonding copper to ceramic, a liquid skin capable of wetting both the copper and the ceramic must form around the copper, and that in utilizing the oxygen copper eutectic melt this requirement is met. Thus, there is no hint in the document that a satisfactory bond cannot be formed between copper and non-oxide ceramic if the process as described in the document is followed, and that the process of the document needs to be modified in the case of a non-oxide ceramic. The document therefore does not encourage a skilled person to find a solution to the problem encountered by the Patentee in bonding copper to non-oxide ceramics.

The purpose of providing an oxide coating on the non-oxide ceramic is not to supply oxygen to the copper-copper oxide eutectic melt, but to enable the eutectic melt to wet the non-oxide ceramic. Although Figure 3 of document D7 shows that the interfacial surface energy between a molten copper containing oxygen and alumina ceramic decreases rapidly as oxygen content in the copper increases, it cannot be derived from this Figure that for good wettability, and therefore good bonding, an oxide coating is required on the ceramic.

- IV. The Respondent presented essentially the following arguments in support of his request to dismiss the appeal:

Non-oxide ceramics are generally known to be unstable in air, and as a result, a thin oxide layer is always formed on its surface during the storage of these ceramics. In certain applications, the presence of such a native oxide layer can be disturbing, so that special elaborate measures are required to remove the layer. In document D7 no such measures are employed. Moreover, in document D7 the bonding process is carried out in the presence of oxygen at a high temperature, so that this necessarily leads to further oxidation of the ceramic. In document D7, therefore, additional oxidation of a non-oxide ceramic prior to the bonding process is not mentioned, and is also not required.

A person skilled in the art would, as a matter of routine, take into account the effect of formation of an oxide layer on a non-oxide ceramic on the wettability of the eutectic melt, and if experiments to ascertain such an effect should show that a somewhat thicker oxide layer is desirable, then the skilled person knows from the prior art, such as document D3 (US-A-3 108 887), how to form

such an oxide layer. Thus the claimed measure to improve the bonding of copper to a non-oxide ceramic forms part of the normal activities of the skilled person.

Document D4 mentions that a copper foil directly bonded to a ceramic plate can be shaped by etching either before or after the bonding process, so that the second of these two alternatives as claimed in the patent under dispute, would be regarded as obvious by the skilled person.

- V. At the conclusion of the oral proceedings on 17 December 1992, the decision was announced that the appeal is dismissed.

#### Reasons for the Decision

##### 1. Inventive step

- 1.1 In the Board's view, the prior art coming closest to the claimed invention is disclosed in document D7 relating to a technique of bonding copper directly to ceramic employing the copper-copper oxide eutectic melt. The basic concept of the direct copper bond, as disclosed in the document (see page 962, left-hand column, lines 6 to 19), is to form at the surface of copper a liquid skin of the copper-copper oxide eutectic melt which wets both the copper and the ceramic and, therefore, bonds to the ceramic. As is disclosed on page 962, right-hand column, lines 13 to 17, copper is oxidised to form a  $\text{Cu}_2\text{O}$  layer on its surface so that the eutectic melt can be formed during the subsequent bonding process which involves heating the ceramic in direct contact with the oxidised copper to a temperature between  $1065^\circ\text{C}$  and  $1083^\circ\text{C}$  (see Figure 4(b)). According to the "Abstract" and the "Summary" in document D7, ceramics which can be bonded to copper using the

direct bonding technique include, respectively, boron nitride and silicon carbide, both of which are non-oxide ceramics.

1.2 The method of manufacturing a substrate according to Claim 1 of the patent under dispute is thus distinguished over the above prior art in that

- (a) prior to heating the ceramic plate in contact with the copper sheet, the ceramic plate is subjected to a process to form an oxide surface coating thereon, and
- (b) after the copper sheet is bonded to the substrate, the copper sheet is shaped by etching.

1.3 As correctly pointed out by the Respondent, the measure (b) is already known from document D4, wherein a direct bonded copper to ceramic substrate, which is used for mounting integrated power semiconductor modules thereon, can be shaped by etching after the bonding process (see page 199, left-hand column, lines 2 to 4). This measure, in the Board's view, therefore, does not go beyond the routine activities of the skilled person, and would have been regarded as obvious by him.

1.4 In connection with the measure (a), it was submitted by the Appellant that the Proprietor of the patent found that following the direct bonding technique described in document D7 a satisfactory bond could not be obtained in case of non-oxide ceramics and that the measure (a) above provided a solution to this problem.

The above submissions of the Appellant are supported, in qualitative terms, by the disclosure in the patent specification as published (see column 2, lines 48 to 50)

according to which, for non-oxide ceramics oxidation treatment of the ceramic is considered as a necessary surface treatment for forming a bond (emphasis added).

In view of the above, the objective problem to which the present invention seeks to provide a solution can be seen as developing the direct bonding technique known from document D7 with a view to providing a satisfactory bond with a non-oxide ceramic.

1.5 It was contended by the Appellant that according to document D7 the Cu-Cu<sub>2</sub>O eutectic wets both the copper and the non-oxide ceramic, so that the prerequisite for forming a satisfactory bond is reported to have been met. The problem underlying the patent under dispute is therefore not derivable from this document. The Board agrees with the Appellant in this respect. However, in the Board's view, bond strength is one of the most essential properties of any metal-ceramic bond, so that its measurement in the case of direct bonded copper to a non-oxide ceramic forms part of the normal control activities of a skilled person. The skilled person would, therefore, come across the above problem during the course of his normal activities. No contribution to inventive step can therefore be seen in the identification of the above problem.

1.6 In document D2 a method of directly bonding a metal, such as copper, to a ceramic using a copper-copper oxide eutectic is disclosed (see column 1, lines 6 to 9; column 5, lines 19 to 28). From the disclosure in column 5, lines 29 to 50, it is evident that in order to achieve a satisfactory bond, formation of a eutectic melt between the metal and the substrate is required, and apparently, a covalent bonding or a potential compound is necessary between the substrate and the eutectic melt.

Using the example of Cu-stainless steel bonding, it is explained that a bond is not formed because apparently steel, rather than forming a bond with the copper oxide, scavenges oxygen from the eutectic because iron oxide is more stable than copper oxide at the elevated temperatures involved. Document D2 also suggests that appropriate substrate and eutectic combinations can be ascertained by simple trial and error processes.

Referring to document D7 (see page 963, left-hand column, lines 4 to 14 and Figure 3), it follows that in direct bonding of copper to alumina, the interfacial energy between copper and the ceramic should be sufficiently low, so that the eutectic melt spreads on the ceramic and wets it. It is also suggested that the decrease in interfacial energy between copper and alumina, which is an oxide ceramic, results on account of the formation of a chemical bonding between the  $\text{Cu}_2\text{O}$  and the alumina.

Thus the skilled person learns from documents D2 and D7 that for achieving a direct copper-ceramic bond, (i) a chemical bond between the  $\text{Cu}_2\text{O}$  and the ceramic may be required. From document D7 he derives that (ii) in case of alumina, which presents an oxide surface to the  $\text{Cu}_2\text{O}$  eutectic melt, such a chemical bond is apparently formed, this being evidenced by the decrease in interfacial energy. Additionally, he learns from document D2 that (iii) during the bonding process the substrate itself should not scavenge oxygen from the eutectic melt, so that the formation of the eutectic melt, which is essential for bonding, is not prevented.

In view of the above teachings of documents D2 and D7, in the Board's view, a skilled person confronted with the problem of a relatively weak bond between copper and a non-oxide ceramic would deduce that the weak bond was possibly because either (a) a chemical bond between  $\text{Cu}_2\text{O}$

and the non-oxide ceramic was not formed or (b) the non-oxide ceramic scavenged oxygen from the  $\text{Cu}_2\text{O}$  thereby preventing the formation of the eutectic melt. With respect to (b), the Board agrees with the submissions made by the Respondent that non-oxide ceramics such as silicon carbide and aluminium nitride are generally known to form a thin oxide layer on its surface when exposed to oxygen containing atmosphere at elevated temperatures, so that the possibility of such a scavenging of oxygen by a non-oxide ceramic during the bonding process would not be ruled out by the skilled person. In the Board's view, the skilled person was in a position to realise that irrespective of which one of the above causes was responsible for the poor quality of the bond, both the formation of a chemical bond and the prevention of scavenging of oxygen would be achieved by providing oxygen at the surface of the non-oxide ceramic. It was therefore obvious for the skilled person to consider providing an oxide layer on the surface of the non-oxide ceramic as in the claimed invention.

- 1.7 For the foregoing reasons, in the Board's judgment, the subject-matter of Claim 1 lacks an inventive step within the meaning of Article 56 EPC and, therefore, does not comply with the requirements of Article 52(1) EPC.

**Order**

**For these reasons, it is decided that:**

The appeal is dismissed.

The Registrar:

The Chairman:

M. Beer

G.D. Paterson