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D E C I S I O N
of 12 September 2001

Case Number: T 0071/96 - 3.4.3

Application Number: 88110305.5

Publication Number: 0297511

IPC: H01L23/50

Language of the proceedings: EN

Title of invention:
Connection structure between components for semiconductor apparatus

Applicant:
SUMITOMO ELECTRIC INDUSTRIES, LIMITED

Opponent:
-

Headword:
Stress relieving member/SUMITOMO

Relevant legal provisions:
EPC Art. 54, 56, 84

Keyword:
"Priority claimed valid (yes) - after amendment"
"Inventive step (yes) - after amendment"

Decisions cited:
-

Catchword:
-

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Case Number: T 0071/96 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 12 September 2001

Appellant: SUMITOMO ELECTRIC INDUSTRIES, LIMITED
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 12 September 1995 refusing European patent application No. 88 110 305 .5 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
M. J. Vogel

Summary of Facts and Submissions

I. European patent application No. 88 110 305 5 was refused in a decision of the examining division dated 12 September 1995 on the ground that claim 1 was not clear (Article 84 EPC).

II. The reasoning given by the examining division in its decision can be summarized as follows:

(a) Claim 1 included the possibility that the materials of the stress relieving member and the lead frame could be identical, in particular since a Ni-alloy is specified for the stress relieving member and Fe-Ni-alloys are commonly used for lead frames. Thus, it was unclear what was meant by the stress relieving member, and how it was distinguished from the connection member. Moreover, the term "having a high plastic deformability" in claim 1 was not only vague, but also failed to distinguish clearly the connection member from the stress relieving member.

(b) The examining division also observed in the contested decision that independent claims 1 and 8 were not entitled to any of the four priority dates claimed in the application in suit. Consequently, the documents

D1: EP-A-0 252 519; and

D2: EP-A-0 252 518

both belonged to the state of the art within the meaning of Article 54(1) and (2) EPC.

(c) The examining division held that the subject matter of claims 1 and 2 was not new with respect to document D1, and that the subject matter of claims 8 to 11 did not involve an inventive step having regard to documents D1, D2, and the documents

D3: EP-A-0 153 618;

D4: Patent Abstracts of Japan, volume 10, No. 192, 5 July 1986 & JP-A-61-39 560; and

D5: Patent Abstracts of Japan, volume 10, No. 347, 21 November 1986 & JP-A-61-150 351.

III. The appellant (applicant) lodged an appeal on 13 November 1995, paying the fee the same day. A statement of the grounds of appeal was filed on 12 January 1996. Oral proceedings were requested in case the Board intended to dismiss the appeal.

IV. In response to communications of the Board, the appellant filed new application documents with the letters dated 3 May 2001 and 30 July 2001. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following documents:

Claims: 1 to 13 filed on 1 August 2001 with the letter dated 30 July 2001;

Description: pages 1 to 9 and 11 to 45 filed on 15 February 1996 with the letter dated 14 February 1996,

page 10 filed on 11 May 2001 with the letter dated 3 May 2001;

Drawings: Sheets 1/6 to 6/6 filed on 15 February 1996 with the letter dated 14 February 1996,

V. Independent claims 1, 5, and 11 of the appellant's request read as follows:

"1. A connection structure between components of a semiconductor package comprising:

- a base member (1) formed of aluminum nitride having a major surface on which a semiconductor device is to be mounted,

- a metallized layer (2) disposed on a bonding surface of the base member (1),

- a lead frame (3) to be joined to the base member (1) via the metallized layer (2), the lead frame including, as a main material, any of iron-nickel alloys and iron-nickel-cobalt alloys,

- a stress relieving member (13) interposed between the metallized layer (2) of the base member (1) and the lead frame (3), the stress relieving member being formed of copper based or nickel based materials which materials cause the stress relieving member to become softened near a temperature of soldering and to become readily plastically deformable so that a thermal stress

caused by a difference between a thermal expansion coefficient of the base member (1) and that of the connecting member (3) at the time of soldering is relieved and

- a soldering material (9) for joining the base member (1) with the stress relieving member (13) and the stress relieving member (13) with the lead frame (3)."

"5. A connection structure between components of a semiconductor package comprising:

- a base member (1) formed of aluminum nitride having a major surface on which a semiconductor device is to be mounted,

- a metallized layer (2) disposed on a bonding surface of the base member (1),

- a lead frame (3) to be joined to the base member (1) via the metallized layer (2),

- the lead frame including a lead frame layer (23) of any of iron-nickel-alloys and iron-nickel-cobalt-alloys and at least one additional layer as a stress relieving layer out of a material selected from the group comprising copper, copper alloy, iron and aluminum which stress relieving layer (13) is plastically deformed when soldered so that thermal stress caused by a difference between a thermal expansion coefficient of the base member (1) and that of the lead frame member (3) at the time of soldering is relieved, and

- a soldering material (9) for joining the base member (1) to the stress relieving layer (13) of the lead frame (3)."

"11. A cap for airtightly enclosing a semiconductor device mounting on an insulating base plate comprising:

- a covering member (11), formed of aluminum nitride provided over the semiconductor device (4) to protect the same,

- a metallized layer (2), disposed on a bonding surface of the covering member (11),

- a frame member (30) to be joined to the covering member (11) to surround the semiconductor device located under the covering member, the frame member (30) being formed by a three-layer composite metal including, as a main material iron-nickel alloys and iron-nickel-cobalt alloys, and, as stress relieving layers, outer layers formed of any material selected among the group of copper, copper alloys, nickel, nickel alloys, iron and aluminum, and

- a soldering material (9) for joining the covering member (11) to the stress relieving layer (130) of the frame member (30), whereby

- the stress relieving layer (130) is to relieve by plastic deformation of itself, a thermal stress caused by a difference between a thermal expansion coefficient of the covering member and that of the frame member at the time of

soldering."

Claims 2 to 4, 6 to 10 and 12 to 13 are dependent on claims 1, 5, and 11, respectively.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. *Amendments and clarity*

Claim 1 contains the features of originally filed claims 1 to 3 and 6. Independent claim 5 corresponds to originally filed claims 10 to 12, and independent claim 11 contains the features of claims 17 to 19 and page 37, lines 2 to 8 of the application as filed. Claims 2 and 3 correspond to claims 4 and 7 as filed, respectively, and claim 4 is based on claims 8 and 9, page 29, lines 6 to 8 and page 30, lines 19 to 25. Claims 9 and 12 are based on page 27, lines 12 to 19, page 34, lines 11 to 20. Claims 6 and 7 are based on the embodiments Figures 5C and 6C, respectively. Claim 8 is based on claim 14 as filed. Claims 10 and 13, finally, are based on page 35, lines 3 to 10 and page 37, lines 18 to 21, respectively, of the application as originally filed.

Therefore, in the Board's judgment, the requirements of Article 123(2) EPC are met. The Board furthermore considers the claims to be clear, as required by Article 84 EPC. In particular, the stress relieving member is now specified in all the independent claims

to be "softened near a temperature of soldering", instead of the term "having a high plastic deformability" which was objected to in the decision under appeal. Furthermore, the stress relieving member in claim 1 is now clearly distinguished from the lead frame member (cf. item II(a) above).

3. *Priority*

All features of claim 1 as amended are disclosed in the priority document JP 165 190/87 filed on 3 July 1987. Likewise, the features of independent claim 5 are disclosed in the priority documents JP 175 070/87 of 14 July 1987 and JP 275 277/87 of 30 October 1987, and the features of independent claim 11 are disclosed in JP 315 330/87 of 15 December 1987. Thus, in the Board's judgement, the priority is validly claimed.

4. *Prior art and novelty*

4.1 The application in suit relates to a connection structure between components of a semiconductor package having a member made of AlN soldered to a metal frame member made of Fe-Ni or Fe-Ni-Co alloys. In order to take advantage of the mechanical strength of the above metal alloys and the excellent thermal properties of AlN, a solder with a high melting point, such as Ag, is commonly used. Due to a difference in thermal expansion coefficient of lead frames or metal frames on one hand and that of AlN on the other hand, cracks in the solder may arise due to thermal stress during the cooling process after soldering (cf. the application as published, page 5, lines 11 to 20).

The applicant in suit solves the above problem by

having a "stress relieving member" interposed between the AlN member and the lead or metal frame. This stress relieving member is made of a metal which is softened and thereby readily plastically deformable at about the temperature of soldering. The independent claims 1, 5 and 11 define three different embodiments each containing the stress relieving member. Claims 1 and 5 define a connection structure having an AlN substrate and a lead frame comprising Fe-Ni or Fe-Ni-Co alloys soldered to the substrate. Independent claim 11 defines a cap for sealing a semiconductor member, which comprises *inter alia* a covering member made of AlN which is soldered to a frame member comprising Fe-Ni or Fe-Ni-Co alloys.

4.2 Document D1 discloses a device comprising lead frames 5, 6 soldered to metallized layers 3 of an AlN substrate using a silver solder 4 (cf. abstract; page 4, lines 36 to 49). In order to avoid cracks in the solder due to thermal expansion, the thermal expansion coefficient of the lead frames is about the same as that of AlN.

In the device of document D1, a stress relieving member is not interposed between the AlN substrate and the lead frame, as claimed in claim 1, and the lead frame does not have a two-layer structure, as claimed in independent claim 5.

4.3 Document D2 discloses a device comprising an AlN substrate 2 soldered with silver solder 7, 8 to an Al_3O_4 substrate 1 (cf. Figure 3; page 3, lines 38 to 54). In order to accommodate the different thermal expansion coefficients of AlN and Al_3O_4, an intermediate layer 9 is inserted between the two substrates such that the

intermediate layer can undergo plastic deformation.

Document D2 discloses neither a lead frame soldered to an AlN substrate, as claimed in independent claims 1 and 5, nor a cap for airtightly enclosing a semiconducting device, as claimed in independent claim 11.

4.4 Document D3 discloses Cu lead frame 12 attached to an AlN substrate 11 using an alloy solder 13, such as Ag-Cu-Ti (cf. abstract). Thus, document D3 does not disclose a lead frame having a layer made of an Fe-Ni or Fe-Ni-Co alloy, as specified in both the independent claims 1 and 5.

4.5 Document D4 discloses a lead frame 16 soldered on a metallized surface 12 of a ceramic substrate 11 using a silver solder 14 (cf. abstract). The lead frame 16 consists of a three-layer structure comprising an inner layer 16 made of an Fe-Ni-Co alloy, surrounded by outer layers 15 made of nickel. The outer layer 15 has the purpose of avoiding diffusion of silver into the Fe-Ni-Co layer which may deteriorate the strength of the lead frame.

The subject matter of independent claim 5 differs from the device of document D4 firstly in that the substrate is made of AlN, whereas document D4 does not appear to specify the material of the ceramic substrate 11; and secondly that the outer layers of the lead frame member are made of copper, copper alloy, iron or aluminum and relieve thermal stress by plastic deformation of itself, whereas for the device of document D4, the outer layers 15 are made of nickel and act as a diffusion barrier for silver.

4.6 Document D5 discloses a semiconductor device 2 on an AlN substrate 1 which is covered with an AlN cap 5 (cf. abstract). The cap and the substrate are molded together with glass 6. Thus, in contrast to the device of independent claim 11, document D5 does not disclose any metal frame member which is soldered to the cap.

4.7 Therefore, the subject matter of all the independent claims 1, 5, and 11 is new having regard to the documents D1 to D5 (Article 54 EPC).

5. *Inventive step*

5.1 Documents D1 and D2 are European patent applications both having a priority date of 11 July 1986. They were published on 13 January 1988 which is after the last priority date of 15 December 1987. Consequently, documents D1 and D2 belong to the prior article as defined under Article 54(3) and (4) EPC and therefore cannot be taken into consideration for the assessment of inventive step.

5.2 The subject matter of claim 1 involves an inventive step, since none of the prior art documents D3 to D5 disclose a stress relieving member interposed between two members joined with a soldering material.

5.3 Likewise for the subject matter of independent claim 11, none of the available prior art document D3 to D5 is considered relevant, since they do not relate to a device for airtightly enclosing a semiconductor device using a metal frame member soldered to a ceramic.

5.4 As to independent claim 5, document D4 is considered to

be the closest prior art. As discussed under item 4.5 above, it discloses a lead frame having an inner layer made of an Fe-Ni-Co alloy covered on both sides by a Ni plating layer 13, ie a three-layer composite metal structure similar to that specified in claim 5.

5.4.1 The technical problem addressed by the present invention relates to reduce the residual strain due to thermal stress caused by the cooling process after soldering a lead frame comprising a Fe-Ni or Fe-Ni-Co alloy to a metallized layer on an aluminum nitride substrate (cf. item 4.1 above, and the application as published, page 5, lines 11 to 20), whereas document D4 addresses the problem of preventing diffusion of silver solder into the Fe-Ni-Co lead frames. Therefore, the skilled person faced with the task of reducing residual thermal stress would, in the Board's view, not consider document D4, since it does not address the problem of reducing thermal stress. Therefore, he would have no reasons to contemplate the replacement of nickel by copper, copper alloy, iron or aluminum, in particular since the available prior art documents do not provide any indication that the above-mentioned metals could be useful for relieving thermally induced stress.

5.4.2 Therefore, in the Board's judgement, the subject matter of independent claim 5 involves an inventive step.

5.5 Since claims 2 to 4, 6 to 10, and 12 to 13 are dependent on claims 1, 5, and 11, respectively, the subject matter of these claims involves an inventive step as well.

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 a patent on the basis of the documents as specified under item IV above.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla