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D E C I S I O N
of 25 October 1995

Case Number: T 0564/93 - 3.4.1

Application Number: 88307023.7

Publication Number: 0301892

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Language of the proceedings: EN

Title of invention:
Semiconductor device on a substrate

Applicant:
KABUSHIKI KAISHA TOSHIBA

Opponent:
-

Headword:
Ceramic substrate/TOSHIBA

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0564/93 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 25 October 1995

Appellant: KABUSHIKI KAISHA TOSHIBA
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Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 9 February 1993 refusing European patent application No. 88 307 023.7 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. D. Paterson
Members: R. K. Shukla
Y. J. F. van Henden

Summary of Facts and Submissions

I. European patent application No. 88 307 023.7 was refused by a decision of the Examining Division on the ground that the subject matter of independent claim 1 did not involve an inventive step as required by Articles 52 and 56 EPC in view of the prior art disclosed in the following documents:

D1: EP-A-0 185 244 and
D2: US-A-4 540 673

II. Independent claim 1 forming the basis for the above decision reads as follows.

"An electronic apparatus for an ignitor, comprising: a ceramic substrate (11) of sintered aluminium nitride having a thermal conductivity of not less than 50 W/mK; said ceramic substrate (11) having first and second surfaces formed on opposite sides of the ceramic substrate (11);
a metallized layer (12) formed on the first surface of said ceramic substrate (11);
a semiconductor device (15) mounted on said metallized layer (12); and
an aluminium vessel (16) for holding and sealing said ceramic substrate (11) with said semiconductor device (15) thereon, said aluminium vessel (16) being bonded on the second surface of said ceramic substrate (11) by means of a thermal stress and strain-resistant adhesive agent (17), an internal portion of said aluminium vessel (16) being resin-sealed."

Dependent claim 6 as originally filed is relevant to the present decision and reads as follows.

"The electronic apparatus of claim 1, wherein said metallized layer comprises at least one element selected from the group consisting of molybdenum, tungsten and tantalum and at least one element selected from the III group and the IVa group in the periodic table."

III. In the above decision, the Examining division held essentially as follows.

The subject matter of claim 1 differs from the state of the art known from document D1 only in that :

(i) the ceramic substrate of high thermal conductivity is sintered aluminium nitride having a thermal conductivity of not less than 50 W/mK; and in that

(ii) the aluminium heat sink is an aluminium vessel which also serves for sealing said ceramic substrate, an internal portion of said vessel being resin-sealed.

The skilled person knows from, for example, document D2 that sintered aluminium nitride is a suitable substrate for semiconductor devices and that it has a thermal conductivity of 0.2 cal/cm s °C or higher, which corresponds to 84 W/mK or higher, i.e. a thermal conductivity of not less than 50 W/mK.

Furthermore, the use of a vessel as a heat sink is well known in the art as also indicated on page 2, lines 5 to 13 of the description of the present application. Moreover, it is a well known measure in the art to use various types of resins for filling the interior of a ceramic or metal package for protecting a semiconductor

device from environmental influences, such as humidity, such a protection being particularly important in automobile applications (cf. document D1, page 4, lines 1, 5 to 8 and 18 to 19).

For these reasons, the features (i) and (ii) would be obvious to the skilled person in the device of document D1. Also their combination does not involve an inventive step since the combination does not show any surprising effect or unexpected working interrelationship. The subject matter of claim 1 does not therefore involve an inventive step.

The dependent claims do not contain subject-matter which could be regarded as involving an inventive step for the reasons given in the official communication dated 5 June 1992.

IV. In the above mentioned official communication the Examining Division held that the subject matter of the originally filed claim 6 was obvious to the skilled person, since, as exemplified by

document D3-EP-A-0 217 584,

it is known in the art to use for aluminium nitride substrate a metallising layer comprising at least one element selected from the group consisting of molybdenum, tungsten and tantalum and at least one element selected from group III and group IVa in the periodic table.

V. The Applicant lodged an appeal against the decision of the Examining Division and requested that a patent be granted on the basis of an amended set of claims filed with the grounds of appeal.

There is no request for an oral hearing.

The only independent claim 1 of this set is a combination of claim 1 forming the basis of the decision under appeal and the originally filed claim 6.

Claim 1 under consideration differs from claim 1 forming the basis of the impugned decision in that:

after the phrase "a metallised layer (12) formed on the first surface of said ceramic substrate", the following phrase is inserted,

"in said metallized layer comprising at least one element selected from the group consisting of molybdenum, tungsten and tantalum and at least one element selected from group III and group IVa of the periodic table;"

VI. In support of its appeal, the Appellant has submitted essentially the following arguments.

Despite the fact that aluminium nitride is mentioned frequently as a ceramic substrate for semiconductor devices, in practice it is used only in research devices and occasionally in certain sophisticated microcircuits of high integration density. It is not used routinely in commercial devices because of its high cost, its poor water repellency and because it is difficult to bond to. The skilled person would never have therefore considered the use of aluminium nitride in a heavy duty application such as an ignitor mounting.

The inventors surprisingly discovered that the use of an aluminium nitride substrate can solve the problem of poor thermal conductivity/heat dissipation inherent in conventional ceramic substrates despite the fact that a

difference in thermal expansion between aluminium nitride and aluminium may produce strain on the solder and that the metallised layer may not have sufficient bonding strength with the aluminium nitride substrate.

In the present invention a thermal stress/strain resistant adhesive compensates for the difference in thermal expansion between the aluminium nitride substrate and aluminium vessel and allows strain-resistant bonding. The composition of metallised layer according to the invention improves the bonding strength between the aluminium nitride substrate, the metallised layer and the semiconductor device.

Although document D1 discloses the use of an adhesive layer between the substrate and the heat sink, this adhesive layer is not necessary there since a conventional ceramic substrate, such as alumina (as disclosed in prior art referred to at page 2, lines 3 to 18 of the application in suit), had already been used for mounting an ignitor on an aluminium heat sink without use of such a resin.

Reasons for the Decision

1. *Inventive step*

In the present appeal the only issue to be decided is that of inventive step.

1.1 The Board agrees with the Examining Division that document D1 constitutes the closest prior art (see in particular figure 1 and the corresponding part of the description) and that it discloses an electronic apparatus for an ignitor, comprising:

a ceramic substrate 4 of high thermal conductivity; said ceramic substrate 4 having first and second surfaces formed on opposite sides of the ceramic substrate 4; a metallized layer 3 formed on the first surface of said ceramic substrate 4;
a semiconductor device 1 mounted on said metallized layer 3; and
an aluminium heat sink 6 (see page 2, lines 8 to 13) for holding said ceramic substrate 4 with said semiconductor device 1 thereon, said aluminium heat sink 6 being bonded on the second surface of said ceramic substrate 4 by means of a thermal stress and strain-resistant adhesive agent 7.

1.2 Document D1 however does not disclose any specific materials for the ceramic substrate and the metallization layer and it does not disclose that the heat sink is in the form of a vessel with an internal resin-sealed portion.

The subject matter of claim 1 is therefore distinguished over the state of the art known from document D1 in that:

(i) the ceramic substrate is sintered aluminium nitride having a thermal conductivity of not less than 50 W/mK;

(ii) said metallized layer comprises at least one element selected from the group consisting of molybdenum, tungsten and tantalum and at least one element selected from group III and group IVa of the periodic table; and

(iii) the aluminium heat sink is a vessel which also serves for sealing the ceramic substrate, an internal portion of said vessel being resin-sealed.

1.3 The Board agrees with the finding of the Examining Division in its decision (see page 3, paragraphs 2 and 3) that it is known from document D2 to produce sintered aluminium nitride having high thermal conductivity, high electrical resistivity and low coefficient of thermal expansion and to use it as a substrate material for semiconductor devices (see column 2, lines 37 to 41). Moreover, document D2 also specifies that the sintered aluminium nitride has a thermal conductivity of 0.2 cal/cm s °C or higher (see column 2, lines 48 to 49), which corresponds to 84 W/mK or higher, i.e. a thermal conductivity of not less than 50 W/mK as claimed in the present invention. Since the electronic apparatus for an ignitor according to document D1 requires the ceramic substrate to be a good thermal conductor, the Board, in agreement with the finding in the impugned decision, considers that it would be obvious to the skilled person that aluminium nitride ceramic having high thermal conductivity (as specified in document D2) would be an appropriate substrate for heavy duty application as in the apparatus according to document D1.

1.4 As correctly pointed out by the Examining Division in its communication mentioned in item IV above and as acknowledged by the Appellant on page 2, paragraph (b) of the grounds of appeal, document D3 discloses a composition of a metallisation layer which is suitable for use with aluminium nitride substrate. In particular, document D3 teaches that a suitable metallisation layer for a sintered aluminium nitride substrate comprises molybdenum and titanium (see page 7, lines 5 to 26); i.e. the layer comprises at least one element selected

from the group consisting of molybdenum, tungsten and tantalum and at least one element selected from group III and group IVa in the periodic table. In the Board's view, therefore, it would be obvious to the skilled person to use such a metallisation layer known from document D3 on a sintered aluminium nitride substrate for a device as disclosed in document D1. Moreover, it follows from the above disclosure in document D3 that the Appellant's contention that aluminium nitride substrate is difficult to bond to a metallisation is not well founded in so far as the metallisation concerned has a composition as disclosed in document D3.

1.5 Furthermore, the Board follows the view of the Examining Division in its decision that the use of a vessel as a heat sink and the use of a resin for sealing semiconductor devices mounted on a substrate for protection from the environment are measures generally well known in the art. These measures would therefore be regarded as obvious by the skilled person.

1.6 The Appellant has disputed that the skilled person would consider using aluminium nitride ceramic substrate on an aluminium heat sink despite the difference in thermal expansion between these materials. In this connection, in document D1 the heat sink is made, inter alia, of aluminium and is bonded to a ceramic substrate of unspecified material using a highly flexible adhesive agent (see page 3, line 21). Contrary to the submission of the Appellant, in the Board's judgement, a skilled person would realise that the highly flexible adhesive agent would accommodate any difference in thermal expansion between the ceramic substrate and the aluminium heat sink. Consequently, the Board finds that

the skilled person would not be deterred from using aluminium nitride substrate on an aluminium heat sink, but would accommodate the difference in thermal expansion using an appropriately flexible adhesive agent.

With regard to the Appellant's submission that aluminium nitride ceramic is a poor water repellant material and is expensive, so that the skilled person would not consider using it in a heavy duty application, the Board notes that the application in suit does not address these problems. Moreover, the primary consideration for the selection of aluminium nitride in a heavy duty application in the present invention is its high thermal conductivity, so that the skilled person concerned mainly with good heat dissipation would regard aluminium nitride as a suitable substrate despite its drawbacks.

In view of the above, the Appellant's submissions in support of an inventive step are not convincing.

1.7 For these reasons, in the Board's judgment, incorporation of features (i), (ii), and (iii) in the electronic apparatus of document D1 would be regarded as obvious by the skilled person. The subject-matter of claim 1 therefore does not involve an inventive step within the meaning of Article 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. D. Paterson