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D E C I S I O N
of 7 December 1999

Case Number: T 0947/96 - 3.4.3

Application Number: 90119255.9

Publication Number: 0422558

IPC: H01L23/498

Language of the proceedings: EN

Title of invention:
Ceramic substrate used for fabricating electric or electronic circuit

Applicant:
Mitsubishi Materials Corporation

Opponent:
-

Headword:
Ceramic substrate/MITSUBISHI

Relevant legal provisions:
EPC Art. 56, 123(2)

Keyword:
"Inventive step - (yes) after amendments"
"Inventive step - supplementary experiments"
"Amendments - selection of a narrow range of a parameter (allowed)"

Decisions cited:
T 0571/89, T 0053/82, T 0002/81

Catchword:

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0947/96 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 7 December 1999

Appellant: Mitsubishi Materials Corporation
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Representative: Pätzold, Herbert, Dr.-Ing.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 28 May 1996 refusing European patent application No. 90 119 255.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
A. C. G. Lindqvist

Summary of Facts and Submissions

I. European patent application No. 90 119 255.9 was refused by the decision of the examining division dated 28 May 1996 on the ground that it did not meet the requirements of Article 123(2) EPC.

Claim 1 forming the basis for the decision under appeal defined a ceramic substrate comprising conductive islands of aluminum having a specific level of purity (greater than 99.98%) for the aluminum material forming the conductive islands whereas according to original claim 1 the conductive islands are formed either of aluminum or an aluminum alloy. According to the decision, there was no indication in the application as filed of the claimed purity limit of 99.98% and of any significance which might be attributed to the claimed purity range, since it was evident from Tables 1 to 5 of the application in suit that not only pure aluminum but any aluminum alloy solved the problems of decreasing the weight of the substrate and improving its resistance against crack formation when subjected to repeated thermal cycling.

Furthermore, it was held in the decision under appeal that claim 1 amended so as to be limited to the use of aluminum for the conductive islands would not have been open to an objection under Article 123(2) EPC. Such a claim, however, would have lacked novelty in view of the prior art document

D4: EP-A-0 097 944.

II. The appellant (applicant) lodged an appeal on 27 July

1996 paying the appeal fee the same day, and filed a statement of the grounds of appeal on 30 September 1996 along with claims 1 to 11. With the letter dated 11 November 1996, the appellant filed results of experiments carried out on samples of ceramic substrates according to the invention, in the following referred to as "supplementary experiments".

III. In its communication annexed to the summons to the oral proceedings requested by the appellant as an auxiliary request, the Board informed the appellant of its provisional views that whereas the claims forming the appellant's main and auxiliary requests complied with the requirements of Article 123(2) EPC, they did no appear to meet the requirements of novelty and inventive step, respectively. In response, the appellant filed with the letter dated 8 November 1999 three sets of claims forming a main request, and first and second auxiliary requests, respectively.

IV. At the end of the oral proceedings held on 7 December 1999, the appellant filed amended description pages and requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: No. 1 to 6 of set I (main request) filed with letter dated 8 November 1999;

Description: Pages 1 to 30 as filed in the oral proceedings;

Drawings: Sheets 1/5 to 5/5 as originally filed.

V. Claim 1 under consideration reads as follows:

"1. A ceramic substrate used for an electric or electronic circuit comprising

(a) a ceramic plate (11) formed of a substance mainly composed of aluminum nitride,

(b) conductive island means (12/13) bonded to one surface of said ceramic plate and providing a conductive path for at least one circuit component (16/17) connected thereto,

characterized in that

(c) a metallic heat sink (14;24) is connected to the other surface of said ceramic plate, and said conductive island means (12/13) and said metallic heat sink (14; 24) consist of aluminum having purity equal to or greater than 99.98 percent."

VI. The appellant presented essentially the following arguments in support of his request:

(a) Although document D4 discloses the combination of having conductive islands made of aluminum on a substrate made of AlN, the degree of purity of aluminum as specified in claim 1 is not disclosed in this document. Moreover, aluminum is mentioned in document D4 as merely one of many possible metals.

(b) There is no suggestion in document D4 or any other of the cited prior art documents that conductive

islands made of aluminum with high purity on AlN substrates would be particularly resistant against the repetition of thermal stress, as in the case of the ceramic substrate according to the claimed invention.

(c) The results of the supplementary experiments where the samples referred to in the application as filed were subjected to a higher number of thermal cycles than reported in the application as filed show the advantages of the claimed purity range of aluminum. In particular, the supplementary experiments showed that only the samples falling within the scope of claim 1, i.e. where both the conductive islands and the heat sink had an aluminum purity of 99.98% or above, withstood 700 heat cycles or more without cracks.

Reasons for the Decision

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

2. *Amendments*

2.1 Claim 1 contains the features of claims 1 and 2 as originally filed with the added restriction that the purity of the aluminum in the conductive islands and the heat sink is equal to or greater than 99.98 percent. Original claims 1 and 2 merely specify that the conductive islands and the heat sink, respectively, are made of aluminum or an aluminum alloy.

Referring to Tables 1 and 4 of the application as filed, specimens 9, 25, 36, and 38 have an purity of 99.98% of the aluminum in the conductive island and the heat sink; specimens 10, 27, 32, and 37 have a purity of 99.995%; and specimens 1, 6, 7, 24, 26, 29, 33, and 39 comprise "pure aluminum".

Thus, the end-points (99.98% and 100%), as well an intermediate point (99.995%) are disclosed in the application as filed. Moreover, figure 5 of the application as filed shows continuous graphs between the aluminum content of a substrate and the number of heat cycles applied to the substrate. It is evident from these graphs that the crack resistance of the substrate improves as the aluminum content is increased continuously from about 97.0% to just below 100%.

2.2 In the decision under appeal, the examining division argued that in the application as filed, no significance of the claimed range of purity was derivable, since it was evident from Tables 1 to 5 of the application in suit that there were several aluminum alloys which fell outside the claimed range but nonetheless solved the problems of decreasing the weight of the substrate and of improving its crack resistance in repeated thermal cycling, at least with respect to samples having conductive islands and heat sink made of copper.

In the Board's view, however, in the consideration of the requirement of Article 123(2) EPC, it is irrelevant whether or not there is any significance in selecting a narrow range or improvement over the selected range in relation to the disclosed broad range; what is relevant

is whether or not the narrow range is clearly derivable from the application as filed.

Moreover, it is apparent from Tables 1, 2, 4, and 5 that the specimens 1, 6, 7, 9, 10, 24 to 27, 29, 32, 33, 36 to 39 having the narrow range of aluminum according to the invention provide an improved crack resistance in repeated thermal cycling and reduced weight ratio in relation to specimens having conductive islands and heat sink both made of copper, and thus solve the problems addressed in the application as filed.

Thus the limitation of claim 1 merely represents a reduction to a range already envisaged within the application as filed (cf. also T 571/89, unpublished, reasons 2.1; T 53/82, unpublished, reasons 2; T 2/81, OJ EPO 1982, 394, reasons 3).

In the Board's view, therefore the requirements of Article 123(2) EPC are met by the application as amended.

3. *Novelty*

3.1 Document D4, which the Board considers as the closest prior art, discloses a "metal member" bonded to a substrate of a non-oxide ceramic such as AlN (cf. page 3, lines 10 to 16 and 23 to 25). According to the document, the "metal member" may consist of "a simple body of copper, iron, chromium, nickel, molybdenum, silver, cobalt, or aluminum; or, alloys or mixtures thereof" (cf. page 5, lines 22 to 25). From page 9, lines 23 to 26, it is evident that the "metal member"

corresponds to the conductive islands of the application in suit. Thus, document D4 discloses the alternative of having conductive islands made of aluminum bonded to a surface of an AlN substrate.

3.2 The device of claim 1 differs from that of document D4 in that (i) a heat sink is provided on the opposite surface of the conductive islands; and (ii) both heat sink and the conductive islands are made of aluminum having a purity equal to or greater than 99.98 percent. Document D4, on the other hand, neither mentions a heat sink nor specify any degree of purity for the metal used for the conductive islands.

Thus, the subject matter of claim 1 is new with respect to document D4 within the meaning of Article 54(1) and (2) EPC.

4. *Inventive step*

4.1 In the application as filed, the technical problems to be solved are two-fold: firstly to reduce the weight of the substrate; and secondly to enhance the crack resistance of the substrate against repeated thermal stress (cf. application as filed, page 2, last line to page 3, second paragraph).

4.2 In the application in suit, the above two problems are solved by providing the AlN substrate with the two features (i) and (ii) referred to in item 3.2 above. From the supplementary experiments provided by the appellant, it is evident that the technical effect of obtaining a high resistance against cracks due to repeated thermal stress is only obtained when **both** the

conductive islands and the heat sink are made of aluminum having a purity of 99.98% or higher: Tables 2 and 5 of the supplementary experiments show the results of treating same specimens as described in the application as filed to between 400 and 700 heat cycles. The results showed that only specimens 1, 6, 7, 9, 10, 24 to 27, 29, 32, 33, 36 to 39, i.e., those falling within the scope of claim 1, withstood 700 heat cycles without cracks. Furthermore, specimens having only one of the conductive islands or the heat sink was made of aluminum having a purity of 99.98% or higher showed cracks after 400 heat cycles, although the same samples were shown in Tables 2 and 5 of the application as filed to withstand 200 heat cycles without cracks.

4.3 Document D4 on the other hand is concerned with the problem of adhesion of metal members bonded to the surface of a ceramic substrate and does not address any of the above problems. Heat sinks are also not mentioned in document D4. Nevertheless, as the problem of weight reduction is routinely encountered in the technical field of substrates for electronic circuits, the skilled person would consider this problem although this is not explicitly emphasized in the prior art document.

4.4 The skilled person faced with the task of decreasing the weight of a device according to document D4 and at the same time ensuring an adequate heat dissipation would in the Board's view consider the substrate made of AlN together with the "metal members" made of aluminum, since it is commonly known that AlN has superior heat dissipation properties and aluminum has low density.

It could be argued that while considering further improvement in heat dissipation, the skilled person would consider using a heat sink on a surface of the substrate opposite to that provided with the conductive islands, since the use of heat sinks is generally known in the art. Nevertheless, in the consideration of weight reduction of the substrate and the heat sink, the Board in agreement with the submission of the appellant, is of the view that the level of purity of aluminum would play an insignificant role, so that there was no reason for the skilled person to select the claimed range of purity of aluminum for **both** the conductive islands and the heat sink.

4.5 As discussed in section 4.2 above, the supplementary experiments clearly demonstrate that a combination of the heat sink and the conductive islands both made of aluminum having a purity equal to or greater than 99.98% remarkably improves the crack resistance of the substrate in relation to a combination falling outside the claimed range of purity. The Board finds no indications in the available prior art which would prompt the skilled person to investigate whether the crack resistance of the substrate against repeated thermal stress is influenced by the degree of purity of aluminum in both the conductive islands and the heat sink.

4.6 For the foregoing reasons, in the board's judgment, the subject matter of claim 1 is not obvious having regard to the cited prior art, and accordingly involves an inventive step as required by Article 52(1) EPC.

Claims 2 to 6 are dependent on claim 1, and therefore

involve an inventive step.

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 following:

Claims: 1 to 6 of set I filed with letter dated 8 November 1999;

Description: pages 1 to 30 as filed in the oral proceedings;

Figures: sheets 1/5 to 5/5 as originally filed.

The Registrar: The Chairman:

D. Spigarelli R. K. Shukla