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D E C I S I O N
of 1 December 2003

Case Number: T 1103/01 - 3.4.3

Application Number: 94309423.5

Publication Number: 0676806

IPC: H01L 23/492

Language of the proceedings: EN

Title of invention:
Ball grid array intergrated circuit package with high thermal conductivity

Applicant:
STMicroelectronics, Inc.

Opponent:
-

Headword:
Ball grid array/STMICROELECTRONICS

Relevant legal provisions:
EPC Art. 56
EPC R. 68(2)

Keyword:
"Inventive step (yes) - after amendment"
"Claim forming basis for the decision under appeal missing from the examination file (see Reasons, item 2)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1103/01 - 3.4.3

D E C I S I O N
of the Technical Board of Appeal 3.4.3
of 1 December 2003

Appellant: STMicroelectronics, Inc.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 7 May 2001 refusing European application No. 94309423.5 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: R. K. Shukla
Members: G. L. Eliasson
M. B. Günzel

Summary of Facts and Submissions

I. European patent application No. 94 309 423.5 was refused in a decision of the examining division dated 7 May 2001. The ground for the refusal was that the subject matter of claim 1 filed at the oral proceedings before the examining division did not involve an inventive step having regard to the prior art documents:

D1: US 5 285 352 A;

D2: US 5 157 480 A; and

D3: FR 2 609 841 A.

II. Claim 1 forming the basis of the decision under appeal was missing from the examination file. During the appeal proceedings, the appellant in response to a request from the department of the first instance, supplied a copy of the claim received by him along with the minutes of the oral proceedings held before the examining division.

III. The appellant (applicant) lodged an appeal on 5 July 2001, paying the appeal fee the same day. A statement of the grounds of appeal was filed on 5 September 2001 together with new claims 1 to 15.

IV. In a response to a communication of the Board, the appellant filed amended claims and description pages with the letter dated 7 July 2003.

V. The appellant requests that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: 1 to 15 filed with the letter dated 7 July 2003;

Description: pages 1 to 3 and 5 to 13 as filed, pages 4, 4a, 4b, 4c filed with the letter dated 7 July 2003;

Drawings: Sheets 1/2 to 2/2 filed with the letter dated 16 February 1995.

Oral proceedings are requested in the event that the Board is not minded to grant the above request.

VI. The independent claims 1 and 9, with the correction of an obvious error in claim 1, read as follows (in claim 1, penultimate line, the Board has replaced "effective thermal conductive" with "effective thermal **conduction**"):

"1. A packaged integrated circuit (10, 30) mounted on an upper surface of a circuit board (28, 46), said packaged integrated circuit comprising:

a substrate (16, 36) having an opening disposed therethrough and having a plurality of electrical conductors;

a slug (14, 34) connected to the substrate and comprised of a thermally conductive material;

an integrated circuit chip (12, 32), mounted on an upper surface of the slug which is exposed in said opening in the substrate, and electrically connected to the conductors of the substrate; and

a plurality of solder balls (24, 42), attached to a lower surface of the substrate in electrical connection with the conductors of the substrate and secured to the circuit board by a reflow procedure; characterised in that

an undersurface of the slug contacts the upper surface of the circuit board, and a portion of the upper surface of the slug contacts the lower surface of the substrate, a portion of the slug between the substrate and the circuit board thereby defining a stand-off distance between the upper surface of the circuit board and the lower surface of the substrate, which stand-off distance set by the slug determined a collapse distance for the solder balls during reflow, thereby providing effective thermal conduction through the slug between the chip and the circuit board."

"9. A method of mounting a packaged integrated circuit (10, 30) on an upper surface of a circuit board (28, 46), comprising the steps of:

attaching a thermally conductive slug (14, 34) onto a substrate (16, 36), said substrate having an opening disposed therethrough and having a plurality of electrical conductors;

mounting an integrated circuit chip (12, 32) on an upper surface of the slug which is exposed in said opening in the substrate and electrically connecting the integrated circuit chip to the plurality of conductors;

encapsulating the integrated circuit chip;

attaching a plurality of solder balls (24, 42) to a lower surface of the substrate in electrical connection with the conductors of the substrate;

whereby the packaged integrated circuit (10, 30) comprises the thermally conductive slug, the substrate, the integrated circuit chip and the solder balls;

placing the packaged integrated circuit on an upper surface of the circuit board; and characterised in that said method further comprises the steps of

attaching the conductive slug to the lower surface of the substrate wherein an undersurface of the slug lies below the plane of the lower surface of the substrate; and

conducting a reflow procedure such that the undersurface of the thermally conductive slug (14, 34) contacts upper surface of the circuit board and a portion of the upper surface of the slug contacts the lower surface of the substrate, a portion of the slug between the substrate and the circuit board thereby defining a stand-off

distance between the upper surface of the circuit board and the lower surface of the substrate, which stand-off distance set by the slug determines a collapse distance for the solder balls during reflow, thereby providing effective thermal conduction through the slug between the chip and the circuit board."

VII. In the decision under appeal, the examining division reasoned essentially as follows:

(a) Document D3 is considered the closest prior art from which the device of claim 1 only differs in that a plurality of solder balls are attached to a lower surface of the substrate in electrical connection with the conductors of the substrate and secured to the circuit board by a reflow procedure, so that the stand-off distance set by the slug determines the collapse distance of the solder balls, whereas in document D3, the conductors of the substrate are directly bonded to the circuit board.

(b) For the skilled person, the replacement of surface-mounted leads by solder balls would be a routine matter, as known from document D2 (cf. column 3, lines 27 to 43).

(c) Having decided to employ solder balls and a reflow method for connecting the package of document D3 to the circuit board, the skilled person is then faced with the choice of how to couple the heat slug and the circuit board, given the fact that the heat slug of document D3 is also a ground

electrode and therefore must be connected thermally and electrically.

(d) Document D2 indicates that thermal dissipation can be optimized by employing the collapse of solder balls, whereby during reflow of the solder balls, the package is pulled into close thermal contact with the circuit board. As shown in Figure 6 of document D2, a heat sink is provided externally to the package and the distance by which the heat sink protrudes above the level of the circuit board determines the collapse distance of the solder balls (cf. D2, column 6, lines 31 to 27). Faced with this information, it is considered that the skilled person would provide a slug on the package of document D3 to define a collapse distance for the solder balls during reflow.

VIII. The appellant presented essentially the following arguments in support of his requests:

(a) Document D3 should not be considered closest prior art, as this document is primarily concerned with the problems of inductance of power supply lines in packages for high-speed circuits. Instead, document D1 represents the closest prior art.

(b) Document D1 teaches the skilled person that the substrate and the slug should be substantially planar (cf. column 3, lines 46 to 50; column 5, lines 9 to 15, column 8, lines 38 to 51), so that the chip can be attached onto the top surface and terminals onto the bottom surface of the substrate.

(c) Reviewing the prior art, the skilled person would consider document D3 but he would not learn anything relevant to the present invention regarding the mounting of an integrated circuit package.

(d) The skilled person may well consider document D2 as it discloses the mounting of the package which is not incompatible with that of document D1. However, as document D2 teaches to use a further slug extending through a hole in the circuit board, a combination of documents D1 and D2 would not result in the claimed invention.

Reasons for the Decision

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

2. *Formal matter - Rule 68(2) EPC*

Although claim 1 forming the basis of the decision was missing from the examination file, the applicant had received a copy of the claim (see item II above). The impugned decision was therefore reasoned as required by Rule 68(2) EPC.

3. *Amendments and Clarity*

Independent claims 1 and 9 have been amended for clarity and the Board is satisfied that they also comply with the requirements of Article 123(2) EPC.

4. *Inventive step*

4.1 The application in suit relates to a packaging device of an integrated circuit chip having solder balls located on each connector location, a type of package commonly known as a Ball Grid Array (BGA).

The problem addressed by the application in suit is to provide a package which has an improved thermal conduction to the system circuit board upon which it is mounted in order to allow it to be used in small computing systems, such as laptop computers (cf. application as published, column 2, lines 17 to 45).

This problem is solved by mounting the integrated circuit chip on an upper surface of a thermally conducting slug which extends through an opening of a substrate of the packaged integrated circuit. The bottom surface of the slug protrudes beyond the lower surface of the substrate, so that when the package is mounted on a circuit board by heating and reflowing the solder balls of the package, capillary forces pull the slug towards the circuit board resulting in a tight contact between the thermally conducting slug and the circuit board.

4.2 Document D1 discloses a BGA having a metal slug 28 extending through the substrate 14 of the package onto which an integrated circuit chip 12 is mounted (cf. abstract). The slug (thermal conductor) 28 is attached to a circuit board through solder balls 26. In order to permit reliable contacts, the upper and lower surfaces of the slug 28 have to be coplanar with the respective

upper and lower surfaces of the substrate (cf. column 5, lines 5 to 15).

4.2.1 The device of claim 1 thus differs from that of document D1 in that the lower surface of the slug extends below the lower surface of the substrate, a portion of the upper surface of the slug contacts the lower surface of the substrate, and that the lower surface of the slug is in direct contact with the surface of the circuit board, whereas in the device of document D1 the lower surface of the slug is flush with the lower surface of the substrate and the lower surface of the slug is attached to the circuit board via solder balls.

4.3 Document D2 discloses a packaged integrated circuit having an integrated circuit chip 62 attached to a die receiving area 64 of a lead-frame (cf. Figure 6). The integrated circuit chip and the lead frame are sealed in a package body 65, such that the leads and the die receiving area 64 are exposed at the bottom surface of the package body. The leads of the packaged integrated circuit are connected to a circuit board through solder balls 83. The die receiving area 64 is in contact with a cold plate 84 which protrudes through an opening in a in a circuit board 82. The die receiving area 64 and the cold plate 84 are pushed together by capillary forces which arise during reflow of the solder balls 83 (cf. column 6, lines 33 to 40).

4.3.1 The device of claim 1 differs from that of document D2 in that the lower surface of the slug extends below the lower surface of a substrate and a portion of the upper surface of the slug contacts the lower surface of the

substrate, whereas in the device of document D2, a substrate is not present; instead, the integrated circuit chip is mounted on a die receiving area of a lead-frame and the assembly of integrated circuit chip and lead frame is sealed in a package body, such that the surface of the die receiving area is flush with the lower surface of the package body (cf. D2, Figure 6). The cold plate 84 extending through the circuit board of the device of document D2 corresponds to the slug of the claimed device.

4.4 Document D3 was considered the closest prior art in the decision under appeal. It discloses a packaged integrated circuit for very high-speed integrated circuits (cf. abstract). In order to improve the performance of high-speed switching circuits, the packaged integrated circuit is equipped with capacitors 18 for reducing fluctuations in power supply voltage during rapid switching (cf. page 5, lines 14 to 16). The integrated circuit chip is placed on a ground plate 14 placed on a thermally conducting slug 30 (cf. Figure 7). The slug 30 acts as a ground electrode and also transfers heat away from the chip (cf. page 6, lines 34 to 35). The bottom surface of the slug extends beyond the surfaces of the substrate with the same amount as the signal electrodes (cf. page 3, lines 34 to 36 and page 4, lines 34 to 37).

4.4.1 The device of claim 1 differs from the device of document D3 in that a plurality of solder balls are attached to a lower surface of the substrate in electrical connection with the conductors of the substrate and secured to the circuit board by a reflow procedure, so that the stand-off distance set by the

slug determines the collapse distance of the solder balls, whereas in document D3, the outer leads of the substrate are directly bonded to the circuit board.

4.5 In the decision under appeal it was held that document D3 represented the closest prior art (cf. item VII(a) above). As the appellant convincingly argued, however, document D3 relates to the specific problems associated with a package for high-speed circuits, and in particular the detrimental effects by inductance of the power supply line (cf. item VIII(a) above; D3, page 1, lines 12 to 25). This problem is overcome *inter alia* by matching the thickness of the ground plate with the thickness of the outer leads (cf. D3, page 4, line 34 to page 5, line 2). Therefore, a skilled person faced with the task of providing a BGA packaged integrated circuit with high thermal conduction would not consider document D3 to be the closest prior art.

Even if it were accepted to consider document D3 as closest prior art, it would not be considered routine to replace the surface-mounted leads in the device of document D3 with solder balls, since as stated above, document D3 is concerned with the problem of minimizing parasitic inductances in a packaged integrated circuit, and the use of surface-mounted leads is an essential part of the teaching for achieving this aim (cf. item VII(b) above).

4.6 In the light of the above, the Board follows the appellant's submissions that document D1 should be considered the closest prior art, since it relates to a packaged integrated circuit having a ball grid array and a thermally and electrically conducting slug.

4.7 The device known from document D1 has the disadvantage that the thermal conduction from the integrated circuit chip 12 to the circuit board is limited due to the use of solder balls 26 for connecting the slug 28 to the circuit board. Thus, the technical problem addressed by the present invention relates to increasing the thermal conductance, i.e. the same problem as disclosed in the application as filed (cf. item 4.1 above).

4.8 A skilled person seeking to solve the above problem would in the Board's judgement not consider document D3 but rather the solution offered in Figure 6 of document D2, since this solution can directly be applied to the integrated circuit package of document D1. The only modification of the device of document D1 which would be required is to omit the solder balls on the surface of the slug. The device resulting from a combination of the teaching of document D2 to the device of document D1, however, would not have all the features of the claimed device.

4.9 As to document D3, the skilled person would recognise that the particular shape of the slug 30 in the device of Figure 7 has the purpose of ensuring that the stand off distance between the lower surface of the substrate and the lower surface of the slug is equal to the thickness of the outer leads 15 in order to minimize impedance mismatch (cf. D3, page 6, lines 22 to 26). Therefore, the purpose for choosing the shape of the slug 30 in Figure 7 of document D3 is unrelated to that of improving the thermal conductance. Hence the skilled person seeking to improve thermal conductance of the device of document D1 would not consider document D3.

4.10 Therefore, in the Board's judgement, the subject matter of claim 1 involves an inventive step within the meaning of Article 56 EPC.

4.11 Since the method of independent claim 9 results in a device having all the features of claim 1, the subject matter of claim 9 involves an inventive step for the same reasons as set out above.

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 V above with the correction of the following obvious errors:

    - In Claim 1, penultimate line, replace "conductive" with "conduction";

    - On page 4b, first paragraph, penultimate line, replace "conductive" with "conduction".

The Registrar: The Chairman:

P. Martorana R. K. Shukla