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WO 2012/001644 A1

(54) Title: METHOD FOR ENCAPSULATING INTEGRATED CIRCUIT COMPONENT SOLDER JOINTS WITH EPOXY FLUX AND APPARATUS PROVIDED WITH ENCAPSULATED SOLDER JOINT

(57) Abstract: In accordance with an example embodiment of the present invention, a method, comprises receiving an integrated circuit component comprising at least one solder ball substantially surrounded by a first epoxy flux, applying a second epoxy flux to at least one integrated circuit component contact point of a printed circuit board, and performing a reflow process such that the integrated circuit component adheres to the printed circuit board and the first and second epoxy flux forms an encapsulating layer around at least one solder joint.

Method for encapsulating integrated circuit component solder joints with epoxy flux and apparatus provided with encapsulated solder joint.

TECHNICAL FIELD

The present application relates generally to a method and apparatus for improving the reliability of solder joints.

BACKGROUND

In the field of surface-mount circuit board manufacturing, components are placed on pads or lands on the outer surfaces of the printed circuit board and then electrically and mechanically coupled to the circuit board with molten metal solder. There are a variety of soldering techniques used to attach components to printed circuit boards. High-volume production of circuit boards is usually accomplished using machine placement and bulk wave soldering or reflow ovens.

SUMMARY

Various aspects of examples of the invention are set out in the claims.

According to a first aspect of the present invention, a method comprises receiving an integrated circuit component comprising at least one solder ball substantially surrounded by a first epoxy flux, applying a second epoxy flux to at least one integrated circuit component contact point of a printed circuit board and performing a reflow process such that said integrated circuit component adheres to the printed circuit board and the first and second epoxy flux forms an encapsulating layer around at least one solder joint.

According to a second aspect of the present invention, a method comprises applying epoxy flux to an interposer of an integrated circuit component and placing at least one solder ball on the interposer.

According to a third aspect of the present invention, an apparatus comprises at least one solder joint coupled with a printed circuit board, the solder joint being substantially encapsulated by epoxy flux.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

Figure 1 is a block diagram of an apparatus comprising an integrated circuit component, printed circuit board and a solder joint coupling the integrated circuit component and printed circuit board according to an example embodiment of the invention;

Figure 2 is a block diagram of the apparatus of Figure 1 further comprising the solder

joint being encapsulated by epoxy flux according to an example embodiment of the invention;

Figure 3 is a block diagram of an integrated circuit component comprising a plurality of solder balls substantially surrounded by epoxy flux according to an example embodiment of the invention;

Figure 4 is a block diagram of the integrated circuit component of Figure 3 and a printed circuit board having at least one integrated circuit contact point with epoxy flux disposed thereon according to an example embodiment of the invention;

Figure 5 is a block diagram of an apparatus, the apparatus comprising an integrated circuit component comprising at least one solder joint coupled with a printed circuit board, the at least one solder joint being substantially encapsulated by epoxy flux according to an example embodiment of the invention; and

Figure 6 is a flow diagram illustrating a method for coupling at least one integrated circuit component with a printed circuit board according to an example embodiment of the invention.

DETAILED DESCRIPTON OF THE DRAWINGS

An example embodiment of the present invention and its potential advantages are understood by referring to Figures 1 through 6 of the drawings.

Figure 1 is a block diagram of an apparatus 100 comprising an integrated circuit component 105, printed circuit board 130 and a solder joint 110 coupling the integrated circuit component 105 and printed circuit board 130 according to an example embodiment of the invention. In an embodiment, the integrated circuit component 105 is a wire bonded chip scale package, however, any type of chip scale package may used including but not limited to flip-chip, non-flip-chip, ball grid array packages and/or the like. In an embodiment, a wire bonded chip scale package is a single-die, direct surface mountable integrated circuit package generally comprising a die such as die 125 mounted on an interposer such as interposer 115 using nonconductive epoxy. In an embodiment, die 125 is wire bonded to the interposer using gold or aluminum wires such as wires 120. At least one solder ball is affixed to the bottom side of the interposer 115 providing the integrated circuit component with an electrical and mechanical connection to a printed circuit board such as printed circuit board 130. In an embodiment, during a process known in art as a reflow process, the integrated circuit component is physically and electrically coupled with at least one integrated circuit contact point on a printed circuit board such as integrated circuit contact point 135. In an embodiment, a reflow process is a soldering process in which solder paste is used to temporarily attach one or more electrical components to their contact points on a printed circuit board, after which the assembly is subjected to controlled heat, which melts the solder permanently connecting the solder joints. In an embodiment, an integrated circuit contact point is a solder pad.

Figure 2 is a block diagram of the apparatus 100 of Figure 1 further comprising the solder

joint 110 being encapsulated by epoxy flux 220 according to an example embodiment of the invention. In an embodiment, epoxy flux such as Epoxy Flux available from Indium Corporation of America of 1676 Lincoln Avenue, Utica, New York 13502, is a product combining the properties of solder flux and epoxy for ribbon connector surface mount technology applications as well as ball grid array and chip scale packages.

According to Figure 2, in an embodiment, epoxy flux substantially surrounds and/or encapsulates solder joint 110 providing for a more mechanically reliable solder joint. Further, epoxy flux 220 adheres to integrated circuit component 105, solder joint 110 and printed circuit board 130 further protecting the solder joint 110 from mechanical vibration and stress. In an embodiment, epoxy flux is non-conductive. In another embodiment, epoxy flux is conductive.

Figure 3 is a block diagram of an integrated circuit component 300 comprising a plurality of solder balls such as solder balls 305 substantially surrounded by epoxy flux 310 according to an example embodiment of the invention. In an embodiment, integrated circuit component 300 is at least one of a chip scale package, surface mount component, wafer level chip scale package, application specific integrated passive, application specific instruction processor, package-on-package component and/or the like. However, integrated circuit component 300 may be any type of surface mounted integrated circuit component. In an embodiment, a solder ball is a volume of solder substantially in a shape of a small sphere, which provides an electrical and mechanical connection between an integrated circuit component and a printed circuit board. In an embodiment, a solder ball is a solder sphere.

In an embodiment, during manufacturing of an integrated circuit component, epoxy flux is applied to the integrated circuit component interposer such as interposer 320 prior to placement of each solder ball. The epoxy flux can be placed on the integrated circuit component by any process known to those skilled in the art such as but not limited to jetting, pin transfer, stencil printing and/or the like. In an embodiment, after epoxy flux is applied to the integrated circuit component interposer, solder balls may be placed on the interposer in a process known to those skilled in the art as ball bumping. In an embodiment, once solder balls are placed on the integrated circuit component interposer, a reflow process takes place in which the epoxy flux forms an encapsulating layer substantially surrounding each solder ball as shown in Figure 3. In an embodiment, after the reflow process, the height of the epoxy flux 325 is approximately 50% of the solder ball height 330 as depicted in Figure 3.

Figure 4 is a block diagram of the integrated circuit component 300 of Figure 3 and a printed circuit board 435 having at least one integrated circuit contact point such as integrated circuit contact point 430 with epoxy flux 425 disposed thereon according to an example embodiment of the invention. In an embodiment, an integrated circuit contact point on a printed circuit board is also known as a solder pad. In an embodiment, prior to placement of integrated circuit component 300 on printed circuit board 435, epoxy flux is applied to at least one integrated

circuit contact point such as 430 on printed circuit board 435. In an embodiment, the volume of epoxy flux, which is applied to an integrated circuit contact point, is related to the size of integrated circuit contact point.

Figure 5 is a block diagram of an apparatus, the apparatus comprising an integrated circuit component 510 comprising at least one solder joint coupled with a printed circuit board, the at least one solder joint being substantially encapsulated by epoxy flux according to an example embodiment of the invention. In an embodiment, integrated circuit component 510 is at least one of a chip scale package, surface mount component, wafer level chip scale package, application specific integrated passive, application specific instruction processor and/or the like. In an embodiment, after a reflow process, epoxy flux such as epoxy flux 520 forms a protective layer around and substantially encapsulates solder joint 530 providing for improved mechanical reliability. Further, epoxy flux 520 adheres to integrated circuit contact points such as integrated circuit contact point 535 on printed circuit board, solder joint 530 and integrated circuit component 510 further protecting the solder joint 530 from mechanical vibration and stress. In an embodiment, epoxy flux is non-conductive. In another embodiment, epoxy flux is conductive. In an embodiment, integrated circuit component 510 is integrated circuit component 300 of Figure 3.

Figure 6 is a flow diagram 600 illustrating a method for coupling at least one integrated circuit component with a printed circuit board according to an example embodiment of the invention. The method begins at 605. At 607, a determination is made to proceed to 612 if an integrated circuit component comprising at least one solder ball surrounded by epoxy flux will be received. Otherwise, 610 is executed.

At 610, epoxy flux is applied to an interposer of an integrated circuit component such as interposer 320 of Figure 3. The epoxy flux may be placed on the integrated circuit component by any process known to those skilled in the art such as but not limited to jetting, pin transfer, stencil printing and/or the like. Further, at 610, at least one solder ball is placed on the interposer. In an embodiment, solder balls are placed on the interposer in a process known to those skilled in the art as ball bumping. In an embodiment, once solder balls are placed on the integrated circuit component interposer, a reflow process takes place in which the epoxy flux forms an encapsulating layer substantially surrounding each solder ball as shown in Figure 3. In an embodiment, after the reflow process, the height of the epoxy flux such as epoxy flux 325 of Figure 3 is approximately 50% of the solder ball height 330. In an embodiment, epoxy flux is applied prior to ball placement. In an embodiment, an integrated circuit component is at least one of a chip scale package, surface mount component, wafer level chip scale package, application specific integrated passive, application specific instruction processor and/or the like. In an embodiment, epoxy flux is non-conductive. In another embodiment, epoxy flux is conductive.

Alternatively, at 612, an integrated circuit component such as integrated circuit component 300 of Figure 3 comprising at least one solder ball substantially surrounded by epoxy

flux is received. In an embodiment, the integrated circuit component is at least one of a chip scale package, surface mount component, wafer level chip scale package, application specific integrated passive, application specific instruction processor and/or the like. In an embodiment, integrated circuit component is integrated circuit component 300 of Figure 3. In an embodiment, the integrated circuit component is received by a circuit board manufacturer from an integrated circuit component manufacturer. For example, the circuit board manufacturer may be a company that produces circuit boards for mobile computers, communication devices and/or the like. In an embodiment, epoxy flux is non-conductive. In another embodiment, epoxy flux is conductive.

At 615, epoxy flux is applied to at least one integrated circuit component contact point of a printed circuit board such as integrated circuit component contact points 430 of Figure 4. Any manufacturing process known in the art, which is capable of applying epoxy flux to a printed circuit board, may be used including but not limited to jetting. In an embodiment, epoxy flux is applied to the at least one integrated circuit component contact point prior to integrated circuit component placement on the printed circuit board. In an embodiment, the integrated circuit component is integrated circuit component 300 of Figure 3. In an embodiment, an integrated circuit component contact point of a printed circuit board is a solder pad. In an embodiment, epoxy flux is non-conductive. In another embodiment, epoxy flux is conductive.

In an embodiment, a volume of epoxy flux, which is applied to the at least one integrated circuit component contact point is related to the at least one solder ball size of the integrated circuit component. For example, a larger solder ball size on an integrated circuit component may require a larger volume of epoxy flux on the corresponding integrated circuit component solder pads.

At 620, the integrated circuit component is placed in position on the corresponding solder pads of the printed circuit board such as in assembly 500 of Figure 5. Placement of surface mounted integrated circuit components is well known in the art circuit board manufacturers. In an embodiment, an integrated circuit component is placed in position on corresponding solder pads of a printed circuit board using a high-speed, high precision, robotic circuit component placement machine.

At 625, a reflow process is performed such that the integrated circuit component adheres to the corresponding solder pads of the printed circuit board. Further, during the reflow process, the epoxy flux previously applied to the base of the integrated circuit solder balls and to the solder pads on the printed circuit board forms an encapsulating layer surrounding at least one solder joint. The encapsulating layer of epoxy flux surrounding each solder joint of the integrated circuit provides protective layer, which reduces mechanical stress and increases the mechanical reliability of each solder joint.

Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments disclosed herein

is to provide a solder joint, which has improved mechanical reliability and a better tolerance of mechanical stress.

If desired, the different functions and/or methods discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS

1. A method, comprising:

receiving an integrated circuit component comprising at least one solder ball substantially surrounded by a first epoxy flux;

applying a second epoxy flux to at least one integrated circuit component contact point of a printed circuit board; and

performing a reflow process such that said integrated circuit component adheres to said printed circuit board and said first and second epoxy flux forms an encapsulating layer around at least one solder joint.

2. A method according to claim 1, wherein said second epoxy flux is applied to said at least one integrated circuit component contact point by jetting.

3. A method according to claim 1, wherein said integrated circuit component is at least one of a surface mount component, chip scale package, wafer level chip scale package, application specific integrated passive, application specific instruction processor and package-on-package component.

4. A method according to claim 1, further comprising placing said integrated circuit component on said printed circuit board.

5. A method according to claim 4, wherein said applying said second epoxy flux occurs prior to said placing said integrated circuit component on said printed circuit board.

6. A method according to claim 1, wherein said applying said second epoxy flux is performed prior to said reflow process.

7. A method according to claim 1, wherein said epoxy flux is non-conductive.

8. A method, comprising:

applying epoxy flux to an interposer of an integrated circuit component; and

placing at least one solder ball on said interposer.

9. A method according to claim 8, wherein said applying epoxy flux to said interposer is performed by jetting.

10. A method according to claim 8, further comprising applying epoxy flux to at least one integrated circuit component contact point of a printed circuit board.

11. A method according to claim 10, further comprising placing said integrated circuit component on a printed circuit board.

12. A method according to claim 11, further comprising performing a reflow process such that said integrated circuit component adheres to said printed circuit board and said epoxy flux forms an encapsulating layer around at least one solder joint.

13. A method according to claim 12, wherein said reflow process is performed subsequent to said placing said integrated circuit component on said printed circuit board.

14. A method according to claim 12, wherein said reflow process is performed subsequent to applying epoxy flux to at least one integrated circuit component contact point of a printed circuit board.

15. A method according to claim 8, wherein a volume of said epoxy is related to a size of said at least one solder ball.

16. A method according to claim 8, wherein said integrated circuit component is at least one of a surface mount component, chip scale package, wafer level chip scale package, application specific integrated passive, application specific instruction processor and package-on-package component.

17. A method according to claim 8, wherein said epoxy flux is non-conductive.

18. An apparatus, comprising:

an integrated circuit component comprising at least one solder joint coupled with a printed circuit board, said solder joint being substantially encapsulated by epoxy flux.

19. An apparatus according to claim 18, wherein said at least one integrated circuit component is at least one of a surface mount component, chip scale package, wafer level chip scale package, application specific integrated passive, application specific instruction processor and package-on-package component.

20. An apparatus according to claim 18, wherein said epoxy flux is non-conductive.

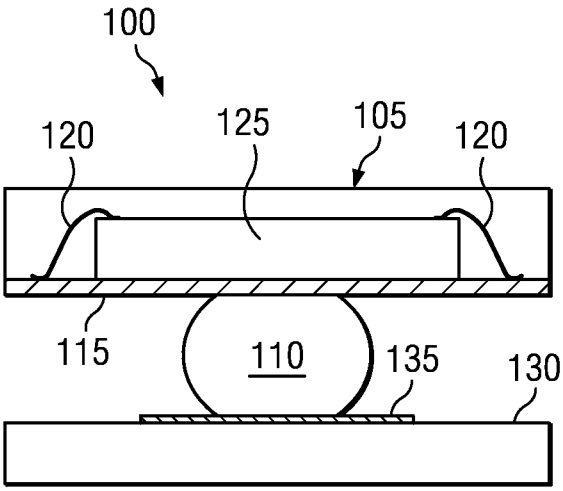

FIG. 1

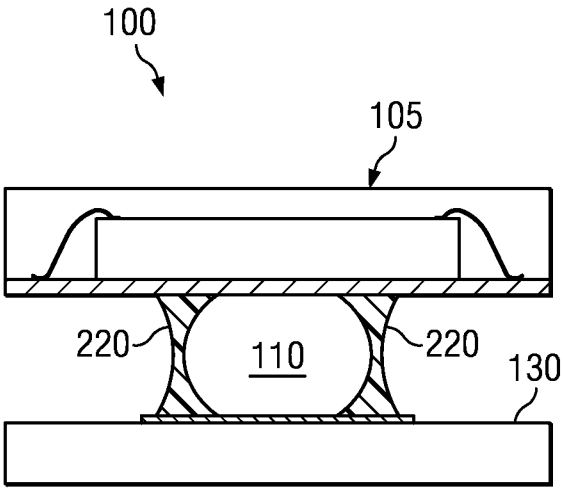

FIG. 2

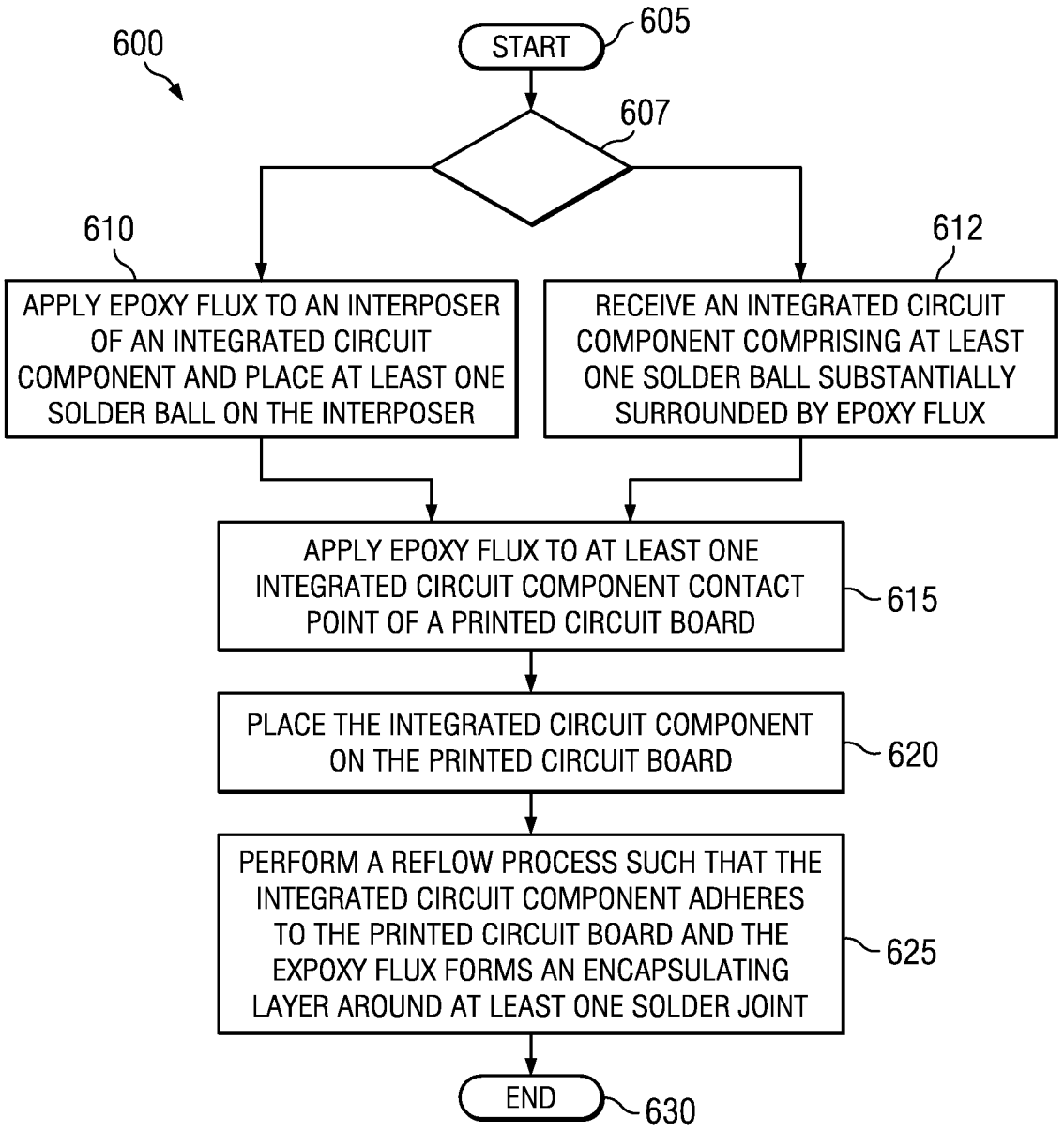

FIG. 6

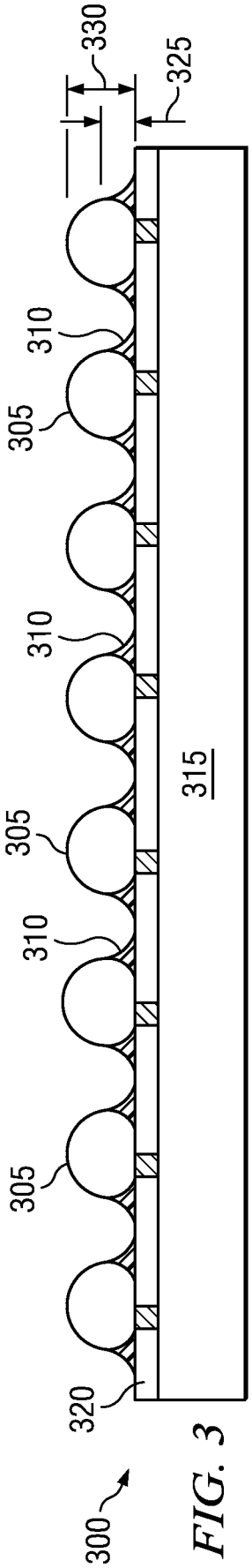

FIG. 3

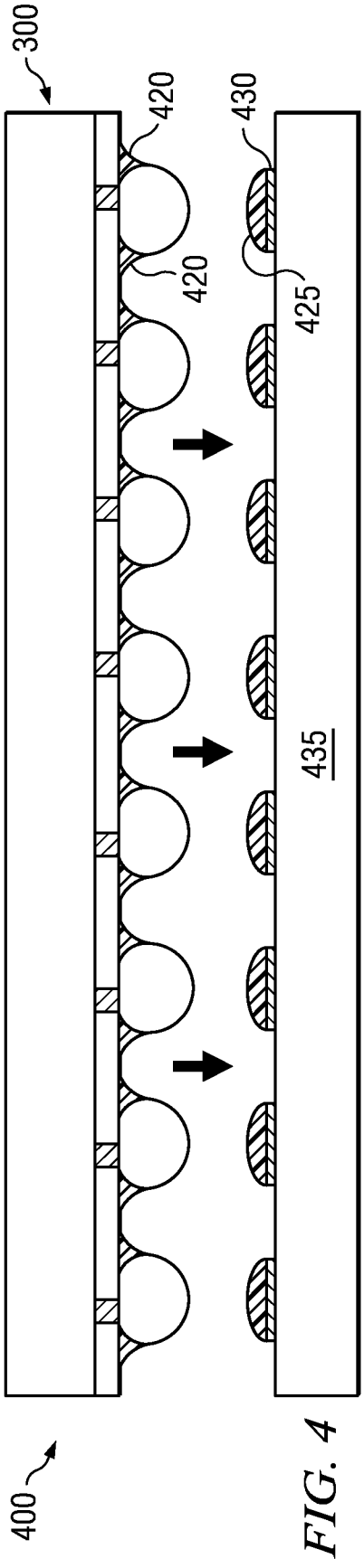

FIG. 4

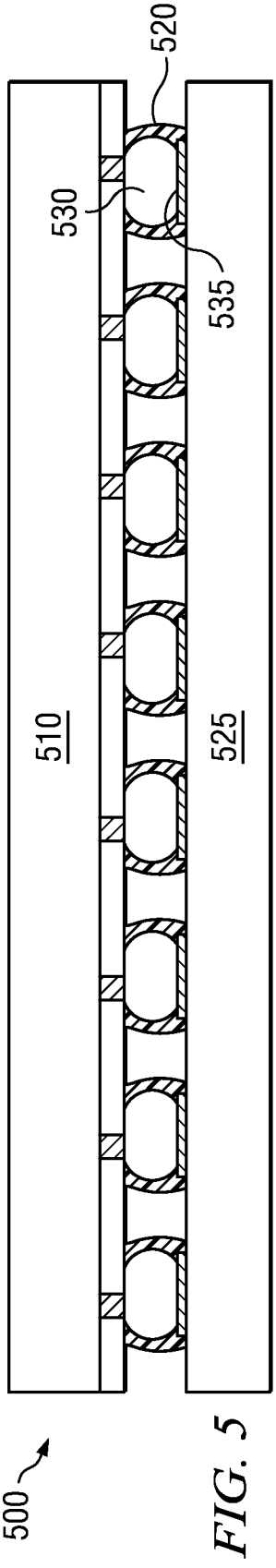

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB20 11/052870

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B23K, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 201 001 0 1845 A 1 (KISHI ARATA ET AL), 29 April 201 0 (201 0-04-29); paragraphs [001 0], [01 29]-[01 39], [01 60]; figures 2-3	1-20
	--	
X	EP 1762329 A 1 (TDK CORP), 14 March 2007 (2007-03-1 4); paragraphs [0034]-[0035]; figure 1	18-20
A		1-17
	--	
X	US 5128746 A (PENNISI ROBERT W ET AL), 7 July 1992 (1992-07-07); column 3, line 39 - line 51; figures 1-2	18-20
A		1-17
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international fding date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03-1 1-201 1	04-1 1-201 1

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-1 02 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Bertil Dahl Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB20 11/052870

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7608479 B2 (NAKAYAMA HIROHISA ET AL), 27 October 2009 (2009-1 0-27)	1-20
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A	US 57041 16 A (GAMOTA DANIEL ROMAN ET AL), 6 January 1998 (1998-01 -06)	1-20
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A	US 7122905 B2 (GRIGG FORD B), 17 October 2006 (2006-10-1 7)	1-20
	--	
A	US 200901 16203 A1 (MATSUNO KOSO ET AL), 7 May 2009 (2009-05-07)	1-20
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Continuation of: second sheet

International Patent Classification (IPC)

H05K 3/34 (2006.01)
B23K 7/20 (2006.01)

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Use the application number as username. The password is **GTTKNTDMSN.**

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB201 1/052870

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. Ill Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The following separate inventions were identified:

1: Claims 1-7, 12-14 and 18-20 directed to a method for encapsulating integrated circuit component solder joints with epoxy flux and an apparatus provided with encapsulated solder joints.

2: Claims 8-1 1 and 15-1 7 directed to a method for applying epoxy flux to an integrated circuit

.../...

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Continuation of: Box No. Ill

component and placing at least one solder ball thereon.

The present application has been considered to contain 2 inventions which are not linked such that they form a single general inventive concept, as required by Rule 13 PCT for the following reasons:

Invention 1 relates to the problem of improving reliability of solder joints. This problem appears to be solved by the encapsulation with epoxy flux.

Invention 2 relates to the problem of applying flux and solder to an integrated circuit component. This problem is solved by applying epoxy flux and at least one solder ball on the component.

As both the problems and solutions are technically different, no single general concept can be formulated based on the technical features of the inventions. Consequently, the requirements of Rule 13.1 PCT are not met.

It was investigated under Rule 13.2 if any further feature, either in the claims or derivable from the description, could be considered as a same or corresponding feature, and could be considered a special technical feature establishing a technical link between the two inventions.

No such features were identified.

Consequently, the two inventions are not so linked as to form a single general inventive concept as required by Rule 13.1 PCT.

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				JP	20091 35470	A	18/06/2009
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