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(54) **INTEGRATED CIRCUIT PACKAGE HAVING A SUBSTRATE VENT HOLE**

EINE INTEGRIERTE SCHALTUNGSPACKUNG MIT EINER LÜFTUNGSÖFFNUNG

BOITIER DE MICROCIRCUIT MUNI D'UN TROU D'AERATION DU SUBSTRAT

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US-A- 5 311 059

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Description

BACKGROUND

1. Field of the Invention

[0001] This invention relates in general to an integrated circuit package, and more particularly, to an integrated circuit package having a substrate vent hole.

2. Description of Related Art

[0002] Integrated circuits are typically assembled into a package that is soldered to a printed circuit board. Figure 1 illustrates a type of integrated circuit package that is commonly referred to as flip chip of C4 package. The integrated circuit 1 contains a number of solder bumps 2 that are soldered to a top surface of a substrate 3.

[0003] The package may include an underfill material 4 that is located between the integrated circuit 1 and the substrate 3. The underfill material 4 is typically an epoxy which strengthens the solder joint reliability and the thermomechanical moisture stability of the IC package.

[0004] The package may have hundreds of solder bumps 2 arranged in a two dimensional array across the bottom of the integrated circuit 1. The epoxy 4 is typically applied to the solder bump interface by dispensing a single line of uncured epoxy material along one side of the integrated circuit. The epoxy then flows between the solder bumps. The epoxy must be dispensed in a manner that covers all of the solder bumps 2.

[0005] It is desirable to dispense the epoxy 4 at only one side of the integrated circuit to insure that air voids are not formed in the underfill. Air voids weaken the structural integrity of the integrated circuit/substrate interface. Such air voids are typically formed from trapped air or from gasses released during the underfill cure process. Moisture released during the underfill process may also be absorbed by the substrate, resulting in delamination and other reliability-related failures during the surface mount process. Moreover, the bumps may extrude into the voids during thermal loading, particularly for packages with a relatively high bump density.

[0006] Accordingly, there is a need in the technology for an apparatus and method for providing an integrated circuit package that avoids the aforementioned problems.

SUMMARY

[0007] The present invention involves a method of providing an integrated circuit package having a substrate with a vent opening. The integrated circuit package includes a substrate having an opening and an integrated circuit mounted to the substrate. An underfill material is dispensed between the substrate and the integrated circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The features and advantages of the present invention will become apparent from the following detailed description of the present invention in which:

Figure 1 is a side view of an integrated circuit package of the prior art.

Figure 2A is a top view of an embodiment of an integrated circuit package of the present invention.

Figure 2B is a bottom view of the integrated circuit package as shown in Figure 2A.

Figure 3 is an enlarged cross-section of one embodiment of the integrated circuit package of Figures 2A and 2B.

Figures 4A-D are schematics showing a process for assembling the integrated circuit package of Figures 2A and 2B.

DESCRIPTION

[0009] In the following description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the present invention. In other instances, well-known electrical structures and circuits are shown in block diagram form in order not to obscure the present invention unnecessarily.

[0010] Figures 2A and 2B are respectively, a top and bottom view of an integrated circuit package of the present invention. Figure 3 is an enlarged cross-section of one embodiment of the integrated circuit package of Figures 2A and 2B. With reference to Figures 2A-2B and 3, the package 10 may include a substrate 12 which has a first surface 14 and a second opposite surface 16. An integrated circuit 18 may be attached to the first surface 14 of the substrate 12 by a plurality of solder bumps 20. The solder bumps 20 may be arranged in a two-dimensional array across the integrated circuit 18 and to the substrate 12 with a process commonly referred to as controlled collapse chip connection (C4).

[0011] The solder bumps 20 may carry electrical current between the integrated circuit 18 and the substrate 12. In one embodiment the substrate 12 may include an organic dielectric material. The package 10 may include a plurality of solder balls 22 that are attached to the second surface 16 of the substrate 12. The solder balls 22 can be reflowed to attach the package 10 to a printed circuit board (not shown).

[0012] The substrate 12 may contain routing traces, power/ground planes, vias, etc., which electrically connect the solder bumps 20 on the first surface 14 to the

solder balls 22 on the second surface 16. The substrate 12 also includes a substrate vent opening 15 that is provided through the substrate at a predetermined location. In one embodiment, the substrate vent opening 15 is located at a low stress area of the substrate. In another embodiment, the substrate vent opening 15 is located at the center of the substrate 12. In a further embodiment, the substrate vent opening 15 is sized to provide efficient out-gassing of moisture, while preserving the stability and integrity of the substrate 12. In one embodiment, the substrate opening is selected from a range from 20-62 mm in diameter, although in alternate embodiments, the size of the substrate vent opening 15 may be determined according to need and other design specifications.

[0013] The package 10 may include an underfill material 24 that is located between the integrated circuit 18 and the substrate 12. The underfill material 24 may form a circumferential fillet that surrounds and seals the edges of the IC 18. The uniform sealing function of the underfill material 24 may inhibit moisture migration, and cracking of the IC 18. The seal process may also reduce delamination. The underfill material 24 also reduces stresses on the solder bumps 20. In one embodiment, the underfill material 24 is an epoxy. The integrated circuit 18 may be encapsulated by an encapsulant (not shown). The encapsulant may be an injection molded material. Additionally, the package 10 may incorporate a thermal element (not shown) such as a heat slug or a heat sink to remove heat generated by the integrated circuit 18.

[0014] Figures 4A-D illustrates a process for assembling the package 10. In one embodiment, the process is a single pass four-sided dispensing process. In particular, the use of a vent hole 15 in implementing the IC package 10 facilitates the use of a single pass four-sided dispensing process.

[0015] A substrate vent opening 15 is first drilled or lazed into the substrate 12 at a predetermined location during the substrate manufacturing process. The substrate 12 may then be baked in an oven 28 to remove moisture from the substrate material, as shown in Figure 4A. The substrate 12 is preferably baked at a temperature greater than the process temperatures of the underfill process steps to insure that moisture is not released from the substrate 12 in the subsequent steps. By way of example, the substrate 12 may be baked at 163 degrees Centigrade (C).

[0016] The integrated circuit 18 may then be mounted onto the substrate 12, as shown in Figure 4B. The integrated circuit 18 is typically mounted by reflowing the solder bumps 20.

[0017] The underfill material 24 may be dispensed onto the substrate 12 along all four sides 26a-d of the IC 18 at a dispensing station 30, as shown in Figures 4C and 4D. Figure 4C illustrates the flow of a typical underfill material 24 when the underfill material 24 is dispensed along all four sides 26a-d of the IC 18. Figure 4D illustrates a top view of the underfilled IC package 10 having a substrate vent hole 15.

[0018] The underfill material 24 may be dispersed in a manner which creates a fillet that encloses and seals the IC 18. One advantage of using the four-sided dispense pattern is that it is able to form a uniform fillet at all four sides of the IC 18. A non-uniform fillet can result in cracking of the IC 18. In addition, the use of a four sided dispense process typically results in a fillet that provides a tight seal, so that delamination between the IC 18 and the underfill material 24 and/or between the underfill material 24 and the substrate 12 does not occur. This in turn results in strong adhesion between the IC 18 and the underfill material 24 and/or between the underfill material 24 and the substrate 12. The process control for forming this uniform fillet is simple and the process yield is high. By way of example, the underfill material 24 may be dispensed at a temperature of approximately 80°-120°C.

[0019] The use of a single pass dispense pattern reduces the underfill material interaction effects of multiple passes. During multiple passes, the underfill material is subjected to heating and gelling before subsequent passes. The use of a single pass dispense process results in a more robust process, reduced processing time and eliminates the need for tight material gelling control.

[0020] The underfill material 24 may be cured into a hardened state. The underfill material 24 may be cured at a temperature of approximately 150° C. After the underfill material 24 is cured, solder balls 22 can then be attached to the substrate 12, typically with a reflow process, to complete the package 10.

[0021] The implementation of the present invention reduces void formation by allowing out-gassing of trapped air from the center of the substrate 12 when the underfill material 24 is dispensed at four sides of the IC 18. In addition, the vent hole 15 allows the underfill material 24 to flow under capillary effect before and during the curing process. As a result, the time control of the underfill material 24 is not as critical as compared to existing processes in which multiple passes are required. This provides the opportunity for eliminating infra red (IR) and/or convective heating, which are typically required in processes utilizing multiple passes, so as to enhance the underfill material 24 flow for subsequent dispense passes.

[0022] The use of a substrate vent hole 15 also shortens the flow travel distance to half, since a four sided dispense process may be used, as described above. This in turn reduces the time needed for providing a full underfill and thus provides the opportunity for eliminating a flow enhancement heating process, such as the IR and BTU heating processes, after underfill dispensing. The use of a vent hole 15 reduces the characterization work needed for underfill process development, which in turn reduces the intense handling and timing interaction associated with the equipment and process. As a result, operational costs are reduced, while manufacturing yields are increased.

[0023] While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various

modifications of the illustrative embodiments, as well as other embodiments of the invention, which are apparent to persons skilled in the art to which the invention pertains are deemed to lie within the scope of the invention.

Claims

1. An integrated circuit package for location on a printed circuit board, the package comprising:

a substrate (12) having an opening (15) of a diameter of 20-62 micrometres;
an integrated circuit (18) attached to said substrate over the opening spaced by a space from said substrate; and
underfill material (24) located in the space by dispensing the underfill material on at least one side of the integrated circuit to fill the space while venting otherwise trapped gas through the opening.

2. The package of Claim 1, wherein said opening is located at a predetermined position on said substrate.

3. The package of Claim 2, wherein said predetermined position is a center of said substrate.

4. The package of Claim 2, wherein said predetermined position is a low-stress area of said substrate.

5. The package of Claim 1, wherein said underfill material is an epoxy.

6. The package of Claim 1, further comprising a solder bump (20) for attaching said integrated circuit to said substrate.

7. A package as claimed in any of the preceding claims, comprising a solder ball (22) on the substrate for attaching the package to a printed circuit.

8. A process of assembling an integrated circuit package for location on a printed circuit board, comprising the steps of:

a. providing a substrate (12) having an opening (15) of a diameter of 20-62 micrometres;
b. providing an integrated circuit (18) and attaching said integrated circuit to said substrate over the opening spaced by a space from said substrate; and
c. dispensing an underfill material (24) on at least one side of the integrated circuit to fill the space while venting otherwise trapped gas through the opening.

9. The process of Claim 8, wherein the act of providing a substrate comprises drilling said opening (15) through said substrate (12).

10. The process of Claim 8, wherein the act of providing a substrate comprises lazing said opening (15) through said substrate (12).

11. The process of Claim 8, wherein the act of providing said substrate having an opening comprises providing a substrate having a substantially circular opening.

12. The process of claim 8, wherein the act of providing a substrate comprises providing said opening at a predetermined location of said substrate.

13. The process of claim 12, wherein the act of providing a substrate comprises providing said opening at a low-stress location of said substrate.

14. The process of Claim 8, wherein the act of providing a substrate comprises providing said opening (15) at a center of said substrate (12).

15. The process of Claim 8, further comprising attaching a solder bump (20) to said substrate (12) for attaching the integrated circuit to the substrate.

16. A process as claimed in any of claims 8 to 15, wherein the step of dispensing an underfill material comprises a further step of out-gassing moisture through the opening.

17. A process as claimed in any of claims 8 to 16, comprising a further step of attaching a solder ball (22) to the substrate for attaching the package to a printed circuit.

18. A process for underfilling an integrated circuit (18), comprising:

a. providing a substrate (12) having a vent opening (15), said vent opening (15) having a diameter ranging from 20 micrometers (mm) to 62 mm
b. mounting said integrated circuit (18) to said substrate (12), said integrated circuit (18) having four sides; and
c. venting otherwise trapped gas through said vent opening (15) while dispensing an underfill material (24) said underfill material (24) being attached to said integrated circuit (18) and said substrate (12), said underfill material (24) completely filling a space between said integrated circuit (18) and said substrate (12), and said dispensing comprising a single pass dispensing pattern.

19. The process of Claim 18, further comprising curing said underfill material (24).

20. The process of Claim 19, wherein the act of dispensing further comprises dispensing said underfill material (24) along four sides of the integrated circuit.

Patentansprüche

1. Integriertes Schaltungsgehäuse zur Anordnung auf einer gedruckten Leiterplatte, wobei das Gehäuse folgendes umfasst:

ein Substrat (12) mit einer Öffnung (15) mit einem Durchmesser zwischen 20 und 62 Mikrometern;
eine integrierte Schaltung (18), die an dem genannten Substrat über der Öffnung durch einen Zwischenraum räumlich getrennt von dem genannten Substrat angebracht ist; und
ein Unterfüllungsmaterial (24), das in dem Zwischenraum angeordnet ist, wobei das Unterfüllungsmaterial auf mindestens eine Seite der integrierten Schaltung abgegeben wird, um den Zwischenraum zu füllen, wobei ansonsten eingeschlossenes Gas durch die Öffnung entlüftet wird.

2. Gehäuse nach Anspruch 1, wobei die genannte Öffnung an einer vorbestimmten Position an dem genannten Substrat angeordnet ist.

3. Gehäuse nach Anspruch 2, wobei es sich bei der genannten vorbestimmten Position um eine Mitte des genannten Substrats handelt.

4. Gehäuse nach Anspruch 2, wobei es sich bei der genannten vorbestimmten Position um eine Niederbelastungsfläche des genannten Substrats handelt.

5. Gehäuse nach Anspruch 1, wobei es sich bei dem genannten Unterfüllungsmaterial um ein Epoxidharz handelt.

6. Gehäuse nach Anspruch 1, wobei dieses ferner eine Lötperle (20) zur Anbringung der genannten integrierten Schaltung an dem genannten Substrat umfasst.

7. Gehäuse nach einem der vorstehenden Ansprüche, wobei dieses ferner eine Lötkugel an dem Substrat zur Anbringung des Gehäuses an einer gedruckten Schaltung umfasst.

8. Verfahren zum Zusammenbau eines integrierten Schaltungsgehäuses zur Anordnung auf einer gedruckten Leiterplatte, wobei das Verfahren die folgenden Schritte umfasst:

a) das Bereitstellen eines Substrats (12) mit einer Öffnung mit einem Durchmesser zwischen 20 und 60 Mikrometern;
b) das Bereitstellen einer integrierten Schaltung (18) und das Anbringen der genannten integrierten Schaltung an dem genannten Substrat über der Öffnung, räumlich durch einen Zwischenraum von dem genannten Substrat getrennt; und
c) das Abgeben eines Unterfüllungsmaterials (24) auf mindestens eine Seite der integrierten Schaltung, um den Zwischenraum zu füllen, wobei ansonsten eingeschlossenes Gas durch die Öffnung entlüftet wird.

9. Verfahren nach Anspruch 8, wobei der Vorgang des Bereitstellens eines Substrats das Bohren der genannten Öffnung (15) durch das genannte Substrat (12) umfasst.

10. Verfahren nach Anspruch 8, wobei der Vorgang des Bereitstellens eines Substrats das Lasern der genannten Öffnung (15) durch das genannte Substrat (12) umfasst.

11. Verfahren nach Anspruch 8, wobei der Vorgang des Bereitstellens des genannten Substrats mit einer Öffnung das Bereitstellen eines Substrats mit einer im Wesentlichen runden Öffnung umfasst.

12. Verfahren nach Anspruch 8, wobei der Vorgang des Bereitstellens eines Substrats das Bereitstellen der genannten Öffnung an einer vorbestimmten Position auf dem genannten Substrat umfasst.

13. Verfahren nach Anspruch 12, wobei der Vorgang des Bereitstellens eines Substrats das Bereitstellen der genannten Öffnung an einer Niederbelastungsposition des genannten Substrats umfasst.

14. Verfahren nach Anspruch 8, wobei der Vorgang des Bereitstellens eines Substrats das Bereitstellen der genannten Öffnung (15) in einer Mitte des genannten Substrats (12) umfasst.

15. Verfahren nach Anspruch 8, wobei das Verfahren ferner das Anbringen einer Lötperle (20) an dem genannten Substrat (12) zum Anbringen der integrierten Schaltung an dem Substrat umfasst.

16. Verfahren nach einem der Ansprüche 8 bis 15, wobei der Schritt des Abgebens eines Unterfüllungsmaterials einen weiteren Schritt des Entgasens von Feuchtigkeit durch die Öffnung umfasst.

17. Verfahren nach einem der Ansprüche 8 bis 16, wobei

es den weiteren Schritt des Anbringens einer Lötkugel (22) an dem Substrat zum Anbringen des Gehäuses an einer gedruckten Schaltung umfasst.

18. Verfahren zum Unterfüllen einer integrierten Schaltung (18), wobei das Verfahren folgendes umfasst:

a) das Bereitstellen eines Substrats (12) mit einer Entlüftungsöffnung (15), wobei die genannte Entlüftungsöffnung (15) einen Durchmesser im Bereich zwischen 20 Mikrometern (mm) und 62 mm aufweist;
b) das Anbringen der genannten integrierten Schaltung (18) an dem genannten Substrat (12), wobei die genannte integrierte Schaltung (18) vier Seiten aufweist; und
c) das Entlüften von ansonsten eingeschlossenem Gas durch die genannte Entlüftungsöffnung (15), während ein Unterfüllungsmaterial (24) abgegeben wird, wobei das genannte Unterfüllungsmaterial (24) an der genannten integrierten Schaltung (18) und dem genannten Substrat (12) angebracht wird, wobei das genannte Unterfüllungsmaterial (24) einen Zwischenraum zwischen der genannten integrierten Schaltung (18) und dem genannten Substrat (12) vollständig füllt, und wobei das genannte Abgeben ein Abgabemuster in einem Durchlauf umfasst.

19. Verfahren nach Anspruch 18, wobei das Verfahren ferner das Härten des genannten Unterfüllungsmaterials (24) umfasst.

20. Verfahren nach Anspruch 19, wobei der Vorgang der Abgabe ferner das Abgeben des genannten Unterfüllungsmaterials (24) entlang vier Seiten der integrierten Schaltung umfasst.

Revendications

1. Boîtier de microcircuit à placer sur une carte de circuit imprimé, le boîtier comprenant :

un substrat (12) ayant une ouverture (15) d'un diamètre de 20 à 62 micromètres ;
un microcircuit (18) fixé audit substrat sur l'ouverture espacée par un espace dudit substrat ; et
un matériau de remplissage (24) situé dans l'espace en distribuant le matériau de remplissage sur au moins un côté du microcircuit pour remplir l'espace tout en aérant le gaz piégé via l'ouverture.

2. Boîtier selon la revendication 1, dans lequel ladite ouverture est située à une position prédéterminée sur ledit substrat.

3. Boîtier selon la revendication 2, dans lequel ladite position prédéterminée est un centre dudit substrat.

4. Boîtier selon la revendication 2, dans lequel ladite position prédéterminée est une zone à contrainte faible du substrat.

5. Boîtier selon la revendication 1, dans lequel ledit matériau de remplissage est un matériau époxy.

6. Boîtier selon la revendication 1, comprenant en outre un bossage de soudure (20) pour fixer ledit microcircuit sur ledit substrat.

7. Boîtier selon l'une quelconque des revendications précédentes, comprenant une boule de soudure (22) sur le substrat pour fixer le boîtier sur un circuit imprimé.

8. Procédé d'assemblage d'un boîtier de microcircuit à placer sur une carte de circuit imprimé, comprenant les étapes consistant à :

a. fournir un substrat (12) ayant une ouverture (15) d'un diamètre de 20 à 62 micromètres ;
b. fournir un microcircuit (18) et fixer ledit microcircuit audit substrat sur l'ouverture espacée par un espace dudit substrat ; et
c. distribuer un matériau de remplissage (24) sur au moins un côté du microcircuit pour remplir l'espace tout en aérant le gaz piégé via l'ouverture.

9. Procédé selon la revendication 8, dans lequel la fourniture d'un substrat comprend l'étape consistant à percer ladite ouverture (15) à travers ledit substrat (12).

10. Procédé selon la revendication 8, dans lequel la fourniture d'un substrat comprend l'étape consistant à détendre ladite ouverture (15) à travers ledit substrat (12).

11. Procédé selon la revendication 8, dans lequel la fourniture dudit substrat ayant une ouverture comprend l'étape consistant à fournir un substrat ayant une ouverture sensiblement circulaire.

12. Procédé selon la revendication 8, dans lequel la fourniture d'un substrat comprend l'étape consistant à fournir ladite ouverture à un emplacement prédéterminé dudit substrat.

13. Procédé selon la revendication 12, dans lequel la fourniture d'un substrat comprend l'étape consistant à fournir ladite ouverture à un emplacement à faible

contrainte dudit substrat.

14. Procédé selon la revendication 8, dans lequel la fourniture d'un substrat comprend l'étape consistant à fournir ladite ouverture (15) à un centre dudit substrat (12).

15. Procédé selon la revendication 8, comprenant en outre l'étape consistant à fixer un bossage de soudure (20) sur ledit substrat (12) pour fixer le microcircuit au substrat.

16. Procédé selon l'une quelconque des revendications 8 à 15, dans lequel la distribution du matériau de remplissage comprend une autre étape consistant à évacuer l'humidité via l'ouverture.

17. Procédé selon l'une quelconque des revendications 8 à 16, comprenant une autre étape consistant à fixer une balle de soudure (22) au substrat pour fixer le boîtier à un microcircuit.

18. Procédé de remplissage d'un microcircuit (18), comprenant les étapes consistant à :

a. fournir un substrat (12) ayant une ouverture d'aération (15), ladite ouverture d'aération (15) ayant un diamètre allant de 20 micromètres (mm) à 62 mm ;
b. monter ledit microcircuit (18) sur ledit substrat (12), ledit microcircuit (18) ayant quatre côtés ; et
c. aérer le gaz autrement piégé via ladite ouverture d'aération (15) tout en distribuant un matériau de remplissage (24), ledit matériau de remplissage (24) étant fixé audit microcircuit (18) et audit substrat (12), ledit matériau de remplissage (24) remplissant complètement un espace entre ledit microcircuit (18) et ledit substrat (12), et ladite distribution comprenant un modèle de distribution à passage unique.

19. Procédé selon la revendication 18, comprenant en outre l'étape consistant à sécher ledit matériau de remplissage (24).

20. Procédé selon la revendication 19, dans lequel la distribution comprend en outre l'étape consistant à distribuer ledit matériau de remplissage (24) le long de quatre côtés du microcircuit.

FIG. 1
(PRIOR ART)

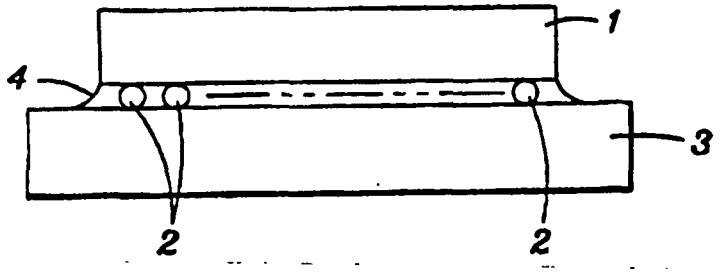


FIG. 2A

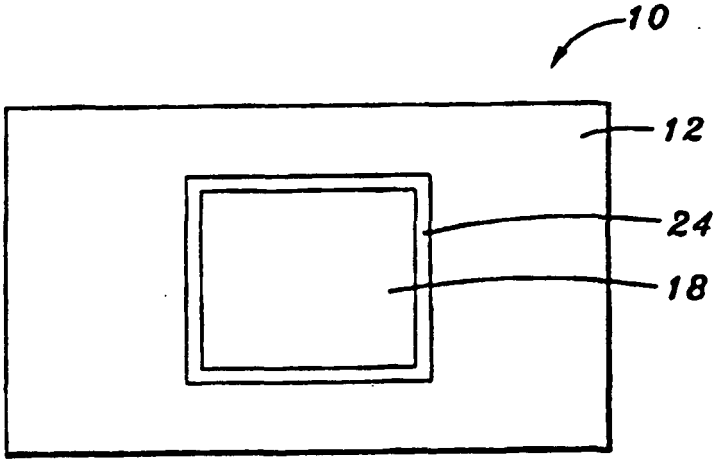


FIG. 2B

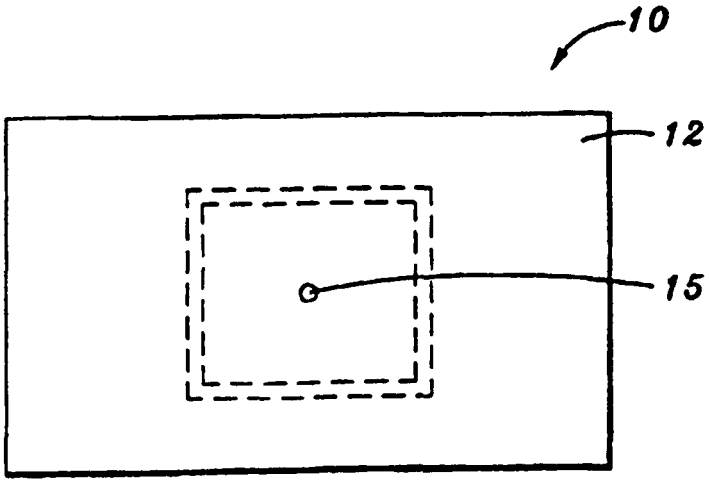


FIG. 3

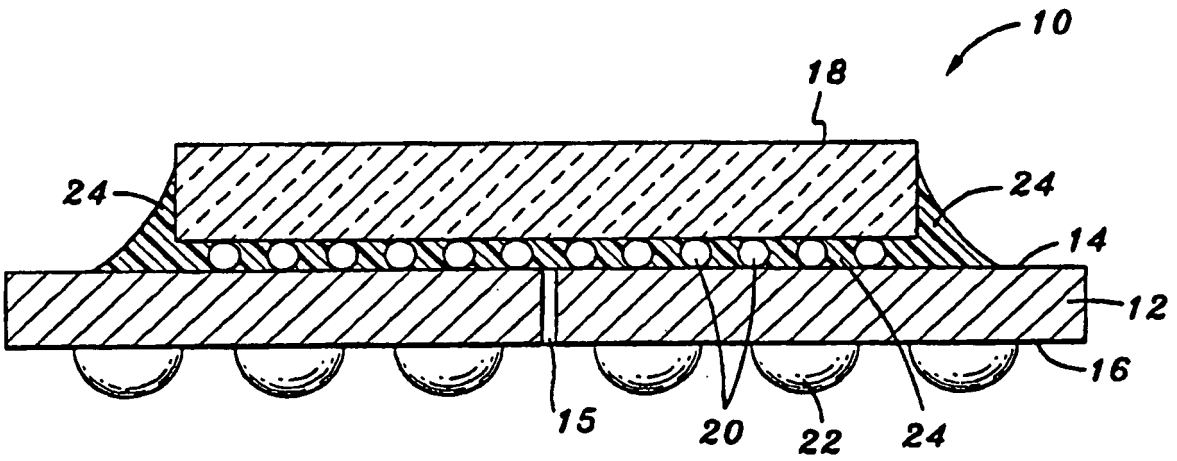


FIG. 4A

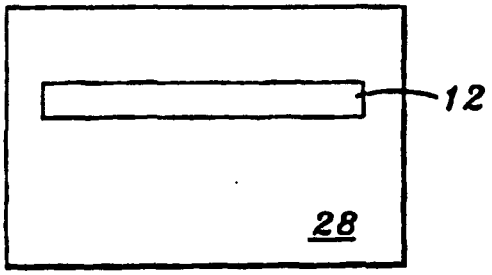


FIG. 4B

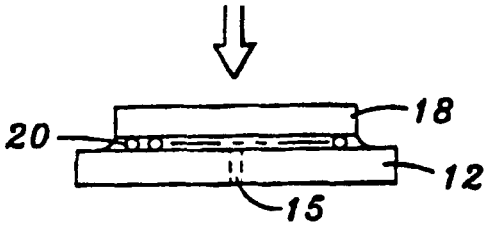
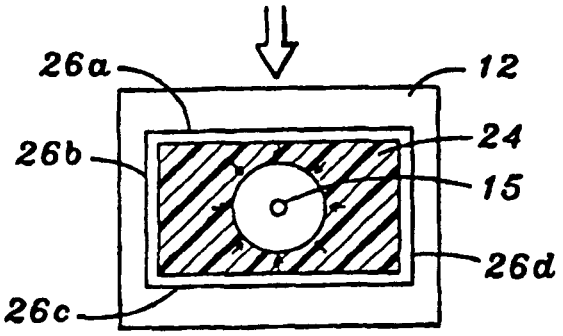
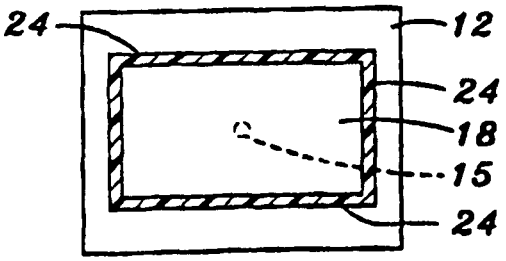


FIG. 4C



STATION 30

FIG. 4D



STATION 30