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"Cast Solder Leads For Leadless Semiconductor Circuits"

5 The present invention relates to the fabrication
of electronic circuit packages and in particular to a
method for forming solder leads and a method for attaching
such leads to leadless electronic components and circuits.

Over the past few years, packaging of
semiconductor integrated circuits utilizing chip carriers
10 bonded to film circuits and/or to printed wiring boards
(PWB) has become a major area of research and development
(see, for example, the article by P. R. Jones entitled
"Leadless Carriers, Components Increase Board Density
by 6:1" in Electronics, August 25, 1981, pages 137 to 140).
15 When attaching leadless components and leadless chip
carriers (LCC) to film circuits or printed wiring boards by
means of soldering techniques, care should be taken to
provide a spacing between the component/LCC and the film
circuit or the PWB. Such spacing is required to enable the
20 cleaning of the area underneath the component/LCC and to
protect the circuitry under the LCC and on the PWB.
Moreover, the LCC and the PWB often exhibit different
thermal characteristics leading to in-plane stresses
therebetween as the result of thermal mismatch. Also, any
25 flexures of the film circuit or the PWB result in
out-of-plane stresses on the leads connecting the LCC to
the film circuit or the board. Prior art techniques have
28 used small solder spheres or solder paste to attach LCC's

to substrates. Although such known techniques have been used for surface mounting of electronic circuits on substrates, there exists a need for a compliant solder joint to compensate for large stresses resulting from thermal mismatches between the chip carrier and the board, as well as from board warpage and flexure.

According to the present invention there is provided a method for forming an electrically conductive lead, comprising positioning an electrically conductive preform in alignment with a mold cavity of a molding plate; heating the molding plate to or above the preform reflow temperature; applying a force on the preform thereby forcing molten preform material into said mold cavity; and cooling the molding plate and removing the applied force.

In an embodiment of the present invention there is provided a method for forming an electrically conductive lead which method comprises positioning a predetermined amount of thermally moldable electrically conductive material, referred to as a preform, in alignment with a mold cavity of a molding plate, heating the molding plate to or above a preform reflow temperature, the latter being the temperature at which the said conductive material will flow, applying a force on the preform thereby forcing molten preform material into the mold cavity, and cooling the molding plate and removing the applied force.



Embodiments of the invention have the advantage of being able to provide reliable and consistent spacings between leadless electronic circuits or components (e.g. chip carriers) and substrates.

Another advantage is to selectively control the distance
5 between adjacent leads of a chip carrier while maintaining sufficient clearance between the chip carrier and the substrate.

Further advantages are the capability of providing arrays of compliant electrically conductive leads for leadless electronic circuits and components; and the ability to control the geometry of
10 solder joints thereby substantially improving the reliability of the joints.

For a better understanding of the invention, reference is made to the accompanying drawing, in which:

FIGS. 1A, 1B and 1C schematically illustrate a method for
15 forming a lead in accordance with one embodiment of the present invention;

FIGS. 2A and 2B are perspective views of a known leadless chip carrier;

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FIG. 3 is an exploded perspective view of an arrangement for casting an array of leads for a leadless electronic circuit in accordance with an embodiment;

FIGS. 4A, 4B and 4C are cross-sectional views taken along the line 4-4 of FIG. 3 which schematically illustrate a method for casting an array of solder leads in accordance with a specific embodiment of the present invention; and

FIGS. 5A, 5B and 5C schematically illustrate a method for attaching a plurality of cast leads to a leadless chip carrier in accordance with a further embodiment of the present invention.

The scale of all of the drawings to be described hereafter has been substantially enlarged in order to assist in the understanding of the various aspects of the present invention.

Shown in FIGS. 1A to 1C are various steps of a method for forming an electrically conductive lead in accordance with one embodiment of the invention. In FIG. 1A, a molding plate 10 has a mold cavity 11 therein with an upper opening region 12 adapted to receive a preform 13. The latter may comprise any electrically conductive material capable of being formed, shaped, or cast in a mold. Although the following description relates to a preform 13 made of a solder, alternative materials may be employed.

Preferably, mold cavity 11 has a generally tapered shape, and solder preform 13 has a spherical form in order to facilitate its positioning in alignment with the upper opening region 12 of cavity 11. The next steps of the proposed method comprise the heating of the molding plate 10 to a temperature at least equal to the reflow temperature of solder preform 13, and the application of a force on the preform to force molten solder into the cavity 11. Illustratively shown in FIG. 1B is a flat bottomed mass 14 contacting the preform and forcing the molten solder 15 into the cavity 11. However,

other means of forcing molten solder in the cavity may alternatively be used. For example, by applying vacuum to the bottom side of molding plate 10, molten solder 15 can be forced to fill the mold cavity 11.

5 Next, the method comprises the steps of cooling the molding plate 10 with the just-cast solder lead 15 therein, and removing the force applied by mass 14. Shown in FIG. 1C is the solder lead 15 cast in the molding plate and ready to be transferred to leadless electronic circuits or components. In the illustrative embodiment of FIGS. 10 1A to 1C, molding plate 10 may be made of aluminum, titanium or any other material capable of withstanding the casting process. A titanium plate is preferred due to its high durability and due to its thermal expansion 15 characteristics matching those of ceramic electronic circuits. Several solder alloys were found to satisfactorily accomplish the foregoing lead casting technique. Cast leads were formed comprising 100% Sn; 96% Sn and 4% Ag; 88% Pb, 10% Sn and 2% Ag; and 75% Pb 20 and 25% In. Preform material, such as 100% Sn, or 96% Sn and 4% Ag, are preferred because of consistency of fabrication, improved surface appearance and cast lead uniformity, enhanced joint strength in shear, and high temperature melting point. Heating of the molding plate 10 25 and the solder preform 13 to a temperature of about 300°C which is above the melting temperature of the solder material yields a fast and reliable casting operation. The thickness of molding plate 10 is selected depending upon the desired length of the cast solder lead. Solder 30 leads of between 15 and 50 mils in length were successfully formed using the foregoing technique.

FIGS. 2A and 2B respectively show the top and bottom perspective views of a leadless chip carrier 20 (hereinafter sometimes referred to as the "LCC 20"). The 35 carrier comprises a body having a recessed portion in the middle thereof. On the bottom part of the recessed portion, a metal layer 21 is deposited to act as contact 38 pad for the underside of an integrated circuit chip 22.

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Contact pads 23 are deposited on a raised step along the peripheral area of the recessed portion. A plurality of connecting wires 24 couple predetermined contact regions of chip 22 with their corresponding contact pads 23. Each
5 metal portion constituting the contact pad extends down a groove 25 along the edges of the carrier or through internal vias (not shown) to its underside to form a contact area 26 on the bottom surface of such carrier as shown in FIG. 2B. A metal layer 27 covers the upper
10 surface of the carrier and serves as a bonding area for a carrier cap (not shown). Typically, leadless chip carrier 20 has overall dimensions ranging from 300 mils by 300 mils to one inch square with thicknesses of about 75 mils. Although shown as having 24 input/output contact
15 areas, such an LCC may comprise any number of contact areas.

An embodiment of the present invention is directed to an improved technique for surface mounting a leadless electronic circuit or component (for example, of
20 a type shown in FIGS. 2A and 2B) on a supporting substrate or printed wiring board. For illustration purposes only, the following description will refer to a leadless chip carrier as the leadless electronic circuit to be surface mounted on a PWB. However, the herein disclosed surface
25 mounting techniques may be applied to other types of circuits and components (e.g., small leadless substrates, individual leadless passive components, etc.).

FIG. 3 of the drawings shows an exploded perspective view of an arrangement for casting an array of electrically conducting solder leads to be used as
30 connection leads for the LCC 20 of FIGS. 2A and 2B. Molding plate 30 comprises a plurality of mold cavities 31 spaced at a predetermined distance from each other. Such a predetermined distance between adjacent cavities 31
35 corresponds to the distance between the metallization contact areas 26 of LCC 20 in FIG. 2B. Each mold cavity 31, which preferably has a tapered shape as explained in connection with cavity 11 in FIGS. 1A-1C, is adapted to
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receive solder preforms 33. A flat bottomed non-wetting mass 34, capable of moving in directions substantially perpendicular to the top surface of molding plate 30 (as shown by the arrow 35), is dimensioned to contact the solder preforms 33 and to force the molten solder material into the mold cavities 31. Melting of the solder preforms 33 is achieved, for example, by heating the molding plate 30 by means of a heating source 36 in contact with the bottom surface 37 of the plate. In order to achieve a fast and reliable cast lead fabrication process, heat source 36 is adapted to heat the molding plate 30 and the solder preforms 33 to a reflow temperature higher than the melting point of the solder. Preferably, the flat bottomed non-wetting mass 34 is heated to a temperature below the reflow temperature to prevent thermal energy loss from the casting site.

FIGS. 4A to 4C illustratively show the various steps of the method for casting the array of electrically conductive solder leads according to an embodiment of the invention. Shown in FIG. 4A is the molding plate 30 having six mold cavities 31 spaced at a predetermined distance from each other. Each mold cavity 31, which has preferably a tapered shape, has its upper opening region 32 adapted to receive the solder preform 33. The latter has preferably a spherical form in order to facilitate its positioning in the upper opening regions 32 of the cavities 31.

The next step of the proposed casting method comprises the heating of the plate 30 to or above the preform reflow temperature by means of heat source 36, and then apply a force by means of the flat bottomed mass 34, to all the solder preforms. The foregoing steps result in forcing molten solder 38 into the mold cavities 31 as illustratively shown in FIG. 4B. Next, the method comprises the steps of cooling the molding plate 30 with the just-cast solder leads 38 therein, and removing the force applied by mass 34. Shown in FIG. 4C is an array of solder leads 38 cast in the molding plate 30 and ready to be used as connection leads for leadless chip carriers,

circuits, components, or other purposes.

Although the foregoing method was described in connection with a molding plate 30 having twenty-four mold cavities 31 arranged in a 6x6 square, the present method is applicable to a smaller, as well as larger, number of required connection leads. Mold cavities 31, may be machined in an aluminum plate, a titanium plate or any other plate capable of withstanding a casting process. For example, if applicable to the surface mounting of an LCC having 68 input/output leads, mold cavities 31 would be arranged in a square configuration (matching the metallization contact areas of the chip carrier) having 17 cavities on each side thereof. When used to surface mount an LCC having 84 input/output leads, mold cavities 21 would be arranged in a square having 21 cavities on each side thereof.

A method for attaching a plurality of electrically conductive cast solder leads to a leadless chip carrier (LCC)

is schematically illustrated in FIGS. 5A, 5B and 5C. Referring to FIG. 5A, an array of solder leads 38 within a molding plate 30 (e.g., of a type shown in FIG. 4C) is to be attached to an LCC 20 (e.g., of a type shown in FIGS. 2A and 2B). Solder leads 38 should attach to the respective metallization contact areas 26 of the LCC 20. Therefore, LCC 20 and molding plate 30 are positioned such that each solder lead is aligned with its corresponding metallization contact area. Prior to such alignment, a commercially available soldering flux is applied to the metallization contact areas 26 in order to insure good wetting thereof. Next, as shown in FIG. 5B, the contact areas 26 are contacted with the upper portion 39 of their corresponding leads 38, and the LCC and the molding plate are heated to or above the reflow temperature to achieve a "transfer" of the leads from the plate to the chip carrier.

For example, when using cast solder leads 38 made of 96% Sn and 4% Ag, the reflow temperature would preferably be of the order of 300°C, i.e., well above the melting temperature of 221°C of such alloy.

5 The LCC 20 and the molding plate 30 are next cooled to enable the molten solder lead material to solidify. The LCC with the solder leads attached thereto is then separated from the molding plate, as shown in FIG. 5C, resulting in a cast-leaded chip carrier 21. The
10 separation of the LCC from the molding plate is preferably achieved by first freezing the contacted structure including the LCC and the molding plate, and then removing the leads from the plate while the latter is still hot. The foregoing technique allows an easy release of the leads
15 from the molding plate and prevents any excess stress on the solder leads due to dimensional changes associated with cooling.

 Surface mounting of the cast-leaded chip carrier 21 to a printed wiring board (not shown) would
20 comprise depositing solder (e.g., 60% Sn and 40% Pb) on predetermined contact zones of the PWB, aligning and contacting the cast-leads of the carrier with such zones, and reflowing the 60/40 solder. Reflow temperature, reflow time, relative volumes of solder, and cast-lead alloy are
25 parameters which control the dissolution of the 60/40 solder into the higher melting point solder lead. Controlled dissolution results in a diffuse interface providing a smooth metallurgical transition from one type solder to the other. At the same time, an adequate
30 clearance between the chip carrier and the PWB is maintained.

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CLAIMS

1. A method for forming an electrically conductive lead, comprising positioning an electrically conductive preform in alignment with a mold cavity of a molding plate; heating the molding plate to or above the preform reflow temperature; applying a force on the preform thereby forcing molten preform material into said mold cavity; and cooling the molding plate and removing the applied force.

2. A method according to claim 1, wherein the electrically conductive preform is of solder.

3. A method according to claim 1 or 2, when used for forming an array of electrically conductive solder leads, wherein a plurality of electrically conductive preforms are in alignment with respective ones of a plurality of mold cavities of the molding plate; and the preforms are forced into the cavities of the molding plate.

4. A method for attaching an electrically conductive lead formed by the method according to claim 1 or 2, to a leadless component, wherein flux is applied to an electrical termination of the component; the electrical termination is contacted with the formed conductive lead; the component and the formed lead are heated to or above the preform reflow temperature and then cooled until the material of the formed lead solidifies; and the formed lead is removed from the mold.

5. A method for attaching a plurality of electrically conductive leads formed by the method according to claim 3, to electrical terminations of a leadless chip carrier, wherein flux is applied to the electrical terminations of the carrier; said electrical terminations are contacted with corresponding solder cast leads of a molded cast lead array; the carrier and the molded cast lead array are heated to or above the preform reflow temperature, and then cooled until the solder material solidifies; and the solder leads are removed from the mold.

6. A method according to any one preceding claim, wherein the electrically conductive preform comprises a relatively high melting

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point material.

7. A method according to claim 6, wherein the relatively high melting point material is selected from 100% Sn; 96% Sn and 4% Ag; 88% Pb, 10% Sn and 2% Ag; and 75% Pb and 25% In.

5 8. A method of forming an electrically conductive lead, substantially as hereinbefore described with reference to FIGS. 1A, 1B, 1C or FIG. 3, or FIGS. 4A, 4B, 4C of the accompanying drawings.

9. A method of attaching leads to a leadless component, substantially as hereinbefore described with reference to FIGS. 5A, 10 5B, 5C of the accompanying drawings.

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