Method and device for encapsulating electronic component using a flexible pressure element

The invention relates to a method for partially encapsulating with encapsulant an assembly of a carrier with an electronic component connected thereto as according to the preamble of claim 1. The invention also relates to a device for applying this method as according to the preamble of claim 6.

The encapsulating of electronic components mounted on a carrier by means of encapsulant is a generally applied technique. The carrier with electronic components which are not yet encapsulated is here usually clamped between two mould parts in a manner such that mould cavities are formed around the electronic components for encapsulating (in particular, but not exclusively, semiconductor components). Heated (liquid) encapsulant is then transported in the usual manner through runners to the mould cavities by means of a plunger system such that the mould cavities are filled with the encapsulant. After at least partial curing of the encapsulant, the mould parts are moved apart such that the carrier provided with the electronic components now covered with encapsulant can be released from the mould parts. Such a process is also referred to as transfer moulding.

There is also a need for only partial encapsulation by means of transfer moulding of electronic components placed on a carrier, i.e. embedding thereof in encapsulant such that a part of the electronic component still remains free. It is hereby possible for instance to only partly encapsulate electronic components wherein the part of the electronic component left free forms a sensor (for instance a sensor sensitive to light, pressure, temperature and/or chemical substances), forms a heat exchanger or can be used for the input or output of optical data. A method and device for encapsulating a chip with encapsulant, one portion of the surface of which chip must remain free of encapsulant, is disclosed in WO 03/028086. The portion of the surface of this chip that must remain free is covered with a material that is clamped between said part of the chip and a part of a mould after the mould has been closed. The material partially covering the surface of the chip is preferably produced from a relatively soft heat-resistant material. The pressure for realizing a suitable pressure from the chip on the material partially covering the surface is obtained by the encapsulant working on the side of the

chip opposite the side contacted by the material partially covering the surface. The problem of the method as disclosed is that it only provides a solution for chips that are covered with encapsulant on the side opposite the surface of the chip that must remain free. This type of product is however not always demanded by the market.

Another known method and device for encapsulating a chip with encapsulant is disclosed in WO 03/050856. The method disclosed therein provides encapsulating an assembly of a carrier and a chip while preventing void formation between chip and carrier, i.e. at solder bumps height. To this end WO 03/050856 proposes to adapt the dimensions of the mould cavity. The mould may also be provided with elastic bumpers to avoid damaging the surface of the chip and the substrate with the upper mould part. The possibility of partly encapsulating an electronic component is not disclosed, nor is it possible with the method of WO 03/050856 t o inject encapsulating resin at high speed and pressure without incurring the risk of damage to the solder bumps.

Another method for encapsulating a chip of the type using a lead frame is disclosed in EP-A-1220309. The disclosed method provides a chip package having window access to the surface of the chip by only partly encapsulating the chip. The window is achieved by providing a cavity in the upper mould, which is sealed off by a flexible membrane, partly covering the surface of the chip. During injection of the encapsulating resin the membrane is prevented from collapsing by pressurizing the cavity behind it. This system is difficult to operate and requires separate means for pressurization.

The object of the present invention is to provide in simple manner a method and device for leaving partly free of encapsulant an assembly of a carrier with an electronic component connected thereto, wherein the side remote from the electronic component remains free of encapsulant, and whereby the risk of damaging the electrical connections between chip and carrier is minimized.

The invention provides for this purpose a method as according to claim 1. Using such a method electronic components placed on a carrier can be encapsulated while leaving free a portion of the surface, while the side of the carrier remote from the electronic components nevertheless remains free of encapsulant. This is possible because the connection of the electronic component to the pressure-distributing body is realized

partly by the encapsulant admitted between the component and the carrier. The pressure exerted on the encapsulant can still be employed for an adaptive connecting force of the electronic component on the pressure-distributing body without the usually undesired presence in the end product of a package of encapsulant on the side of the carrier remote from the electronic component. A space between the electronic component and the carrier is for instance present in so-called "flip chips". In such flip chips an electronic component (chip) is placed via solder bumps on a carrier (board, lead frame). The solder bumps herein provide electrical connections between the carrier and the electronic component, and are therefore critical. When too great a load is exerted on the side of flip chips remote from the carrier, the solder bumps will deform, and this is undesirable/unacceptable. The method according to the invention now provides the possibility of limiting the pressure on the flip chips, prior to feed of the encapsulant, to a level at which the solder bumps do not deform (or hardly so), while during feed of the encapsulant, owing to the pressure which the encapsulant also exerts on the pressure-distributing body, the pressure exerted by the encapsulant flowing between the electronic component and the carrier is nevertheless prevented from dislodging (pressing) the electronic component from the carrier.

A pressure-distributing body is understood to mean a body manufactured from a deformable medium, for instance also referred to as a gel and commercially available under, among others, the brand name "Gel-Pak®". Such a material, manufactured for instance as a layer of gel (or gel film) has the very important advantage that the load exerted locally on the electronic component and/or on the carrier can hereby remain limited. This load can more particularly remain limited before starting of the feed of the encapsulant to the mould cavity. Simultaneously with the displacement of the mould parts, the flexible pressure-distributing body can be urged against the side of the electronic component remote from the carrier. A significant advantage of the use of one or more pressure-distributing bodies (at least one pressure-distributing body) is that variations in dimensions of the electronic components for encapsulating and/or the carrier on which they are mounted can (and will) be compensated by the pressure-distributing body. A good connection (with a uniform distribution of the closing force exerted on the assembly of the electronic components and the carrier) can thus be obtained to the assembly of the electronic components and the carrier for encapsulating,

wherein relatively large variations in dimensions of the components (both carrier and electronic components) will not result in disturbance.

In a preferred variant of the method according to the invention, the flexible pressure-distributing body is urged via a flexible material layer against the assembly of the carrier with the electronic component mounted thereon. A foil manufactured from for instance plastic can herein form a protective intermediate layer. The occurrence of undesired contact can thus be avoided between the assembly of the carrier with the electronic component mounted thereon and the pressure-distributing body, for instance so as to prevent adverse effects on the electronic component and/or the carrier and/or to prolong the lifespan of the pressure-distributing body.

The flexible pressure-distributing body can if desired be placed releasably in the counter-mould part. This is possible by placing an individual pressure-distributing body in the mould, but it is also possible to arrange the pressure-distributing body which is placed on a foil layer, or wherein the "foil" is provided wholly or on parts with a "gel layer" or "gel bodies". In order to thus place pressure-distributing bodies in the mould use can for instance be made of a known automatic feeder for foil material.

In another application variant of the method according to the invention, the flexible pressure-distributing body is urged at least partially against the carrier of the assembly, for instance against the side of the carrier remote from the electronic component. Such an application of the method provides a solution for the manufacture of the above mentioned "leadless packages", without making use therein of cover f oil. Instead of the cover foil applied heretofore, parts of the carrier as desired can now be left clear using one or more flexible pressure-distributing bodies.

The invention also provides a device as according to claim 6 for partially encapsulating with encapsulant an electronic component mounted on a carrier. Such a device differs only very slightly from the existing encapsulating devices, so that conversion/modification of an already existing device into a device according to the invention can be realized in very simple manner. With the device according to the invention the advantages can be realized as already described above with reference to the method according to the invention. In a preferred embodiment of the device, holder

means for receiving a flexible pressure-distributing body are at least partially formed in a space recessed into a wall of the mould cavity. The position of the pressure-distributing body can thus be secured in simple manner. The device can also be provided with supply means and discharge means for the pressure-distributing body and/or for foil material which are positioned to the side of the mould parts. As also already described above, a pressure-distributing body can be placed between and removed from the mould parts by means of such a supply and discharge respectively.

The invention will be further elucidated with reference to the non-limitative exemplary embodiments shown in the following figures. Herein:

figure 1A shows a cross-section through a carrier with flip-chip placed in a mould, wherein the flip-chip is engaged by a pressure-distributing body, prior to the feed of encapsulant,

figure 1B shows a cross-section corresponding with the section shown in figure 1A, during the feed of encapsulant,

figure 1C shows a cross-section through a carrier with flip-chip placed in a mould, wherein the flip-chip is engaged by an alternative embodiment variant of a pressure-distributing body, prior to the feed of encapsulant,

figure 2 shows a top view of a carrier with four chips encapsulated such that a portion of the chips is left free of the encapsulant,

figure 3A is a perspective view of a pressure-distributing body for use with the method according to the invention,

figure 3B is a perspective view of an alternative embodiment variant of a pressure-distributing body provided with a plastic foil layer,

figure 3C shows a cross-section through a second alternative embodiment variant of a pressure-distributing body encased by a plastic foil layer, and

figure 3D is a perspective view of a foil layer provided with a plurality of pressure-distributing bodies.

Figure 1A shows a (flip-)chip 1 which is connected via solder bumps 2 to a carrier 3. Carrier 3 is placed in a mould part 4 such that a flat side of carrier 3 is fully supported by mould part 4. Placed connecting onto mould part 4 is a counter-mould part 5 which leaves clear a mould cavity 6 which encloses chip 1. Gel body 7 (pressure-distributing body) is placed between counter-mould part 5 and chip 1 such that gel body 7 exerts a

pressure on chip 1, which pressure is however limited such that solder bumps 2 do not deform substantially under the influence of the pressure exerted by gel body 7. A recess 8 is provided in counter-mould part 5 for positioning of the gel body.

In figure 1B the mould cavity 6 enclosed by mould part 4 and counter-mould part 5 is filled with liquid encapsulant 9. The relatively high pressure on encapsulant 9 is also present in the space 10 between chip 1 and the carrier 3 in which solder bumps 2 are also situated. The same pressure is however also exerted on gel body 7 by encapsulant 9, so that there still results a pressure difference over chip 1 (over the side of chip 1 directed toward counter-mould part 5 to the side of chip 1 adjoining space 10) which is theoretically as great as the same pressure difference in the situation shown in figure 1A. Although this pressure difference will not remain exactly as great, the advantageous effect that results is that, with a limited pressure on chip 1 in the situation shown in figure 1A, the chip 1 is still also pressed against carrier 2 with a sufficiently large resultant force in the situation as shown in figure 1B. The encapsulant 9 present in mould cavity 6 encloses chip 1 such that the side of chip 1 remaining free of encapsulant 9 is located at more or less the same level as the side of the cured encapsulant 9 remote from carrier 3. After application of the encapsulant, for instance a cooling element (not shown) can thus be fixed in simple manner to chip 1.

Figure 1C shows a (flip-)chip 1 which is connected via solder bumps 2 to carrier 3 as shown in the foregoing figures. Carrier 3 is placed in mould part 4. Placed connecting onto mould part 4 is a counter-mould part 25 which leaves clear a mould cavity 26 which encloses chip 1. Otherwise than in the mould cavity 6 and gel body 7 shown in figures 1A and 1B, the mould cavity 26 and gel body 27 shown in this figure 1C are formed such that gel body 27 does not engage on only one side of chip 1. Gel body 27 Engages on chip 1 such that the encapsulant to be applied later not only leaves one side of chip 1 clear, but that chip 1 will also protrude out of the encapsulant.

Figure 2 shows a top view of a carrier 12 which is partially covered with encapsulant 11 and on which there are mounted four chips 13 which are left partially free. Chips 13 can for instance be sawn off in a subsequent operation.

Figure 3A shows a gel body 15 for applying the method according to the invention.

Figure 3B shows a gel body 16, one side of which is provided with a foil layer 17 for protecting the gel material 18 from (a part of) the surrounding area. The cross-section of figure 3C shows a gel body 19, the gel material 20 of which is enclosed on all sides by a protective foil layer 21. Instead of gel material 20, it is also possible in this embodiment variant of gel body 19 to apply a material fulfilling less stringent requirements in respect of holding the material together. Gel material 20 could thus be replaced by an (optionally viscous) liquid. Figure 3D shows a foil layer 22 which can for instance be easily placed in and removed from a mould with existing means, not shown in this figure. A plurality of gel bodies 23 is placed on foil layer 22.

Claims

1. Method for partially encapsulating with encapsulant (9) an assembly of a carrier (3) with an electronic component (1) connected thereto, comprising the processing steps of:

A) enclosing at least apart of the carrier (3) and the electronic component (1) mounted thereon between a mould part and a counter-mould part such that at least one mould cavity (6) is formed which encloses the electronic component (1),

B) introducing a liquid encapsulant (9) into the mould cavity (6), and

C) removing the carrier (3) with encapsulated electronic component (1) from the mould parts after at least partial curing of the encapsulant (9),

wherein a flexible pressure-distributing body (7) is urged against the side of the electronic component (1) remote from the carrier (3) prior to feed of the liquid encapsulant (9) to the mould cavity (6) as according to processing step B), characterized in that

the side of the carrier (3) remote from the electronic component (1) is placed against a mould part (4),

a second counter-mould part (5) is urged against the side of the carrier (3) bearing the electronic component (1), and

at least during processing step B) a space (10) located between the carrier (3) and the electronic component (1) is filled with encapsulant (9), wherein the side of the carrier (3) remote from the electronic component (1) remains free of encapsulant.

2. Method as claimed in claim 1, characterized in that the flexible pressure-distributing body (7) is clamped between the side of the electronic component (1) remote from the carrier (3) and the counter-mould part(5).

3. Method as claimed in the foregoing claims, characterized in that the flexible pressure-distributing body (7) is urged via a flexible material layer (17) against the assembly of the carrier (3) with electronic component (1) mounted thereon.

4. Method as claimed in any of the foregoing claims, characterized in that the flexible pressure-distributbing body (7) is placed releasably in the counter-mould part (5).

5. Method as claimed in any of the foregoing claims, characterized in that the flexible pressure-distributing body (7) is urged at least partially against the side of the carrier (3) remote from the electronic component (1).

6. Device for partially encapsulating with encapsulant (9) an electronic component (1) mounted on a carrier (3), comprising:

- a number of mould parts (4, 5) displaceable relative to each other and adapted to at least partially receive the carrier (3) between the mould parts (4, 5), wherein a first mould part (5) is provided with at least one mould cavity (6) connecting onto the carrier (3),
- feed means for encapsulant (9) connecting to the mould cavity (6), and
- holder means located in the mould cavity (6) for receiving a flexible pressure-distributing body (7),

characterized in that the device is provided with a second mould part (4) adapted to support the side of the carrier (3) remote from the electronic component (1), and that the device is also provided with supply means for foil material (22) positioned to the side of the mould parts (4, 5).

7. Device as claimed in any of the claims 6, characterized in that the device is also provided with discharge means for foil material (22) positioned to the side of the mould parts (4, 5).

8. Device as claimed in any of the claims 6 or 7, characterized in that the device is also provided with supply means for the pressure-distributing body (7).