Title: PACKAGING METHOD OF CHIP OR PACKAGE EQUIPPED WITH BUMPS

Abstract: To provide a packaging method that connects a semiconductor chip and a substrate through an under-fill material and after an operation confirmation test is conducted, the under-fill material is heat cured. A packaging method of a semiconductor chip or package equipped with bumps, comprises the steps of arranging a heat-fluidizing and thermosetting under-fill material film between a semiconductor chip or package equipped with bumps and a substrate; applying heat and pressure at a temperature and a pressure sufficiently high to cause fluidization of the under-fill material film and to achieve provisional electrical connection; conducting an operation confirmation test; and if the operation confirmation test proves successful, further heating and curing the under-fill material film to obtain the final electronic device, or if the operation confirmation test proves unsuccessful, removing a defective chip or package at a temperature and a pressure sufficient to cause fluidization of the under-fill material film, and repeating the steps described above by using a new chip or package equipped with bumps.
PACKAGING METHOD OF CHIP OR PACKAGE EQUIPPED WITH BUMPS

TECHNICAL FIELD

The present invention relates to a packaging method of a chip or package equipped with bumps.

BACKGROUND

Semiconductor packages such as a semiconductor chip equipped with bumps, a ball grid array (BGA) and a chip scale package (CSP) have been used in the past as means that is effective for reducing the size of semiconductor devices. A plurality of chips or packages equipped with such bumps (hereinafter called "chips equipped with bumps" inclusive of bare chips having bumps and packages having chips fabricated therein) is packaged onto a main substrate and forms an electronic device. When the chips equipped with bumps are connected and packaged onto the substrate, an under-fill material is generally arranged as a sealing resin between the chips equipped with bumps and the substrate. When any one of the plurality of semiconductor chips is defective or when defective connection exists between the main substrate and the chips, however, the electronic device cannot be used. Therefore, repairability has been desired so that when any defect occurs after the operation confirmation of all the semiconductor chips or packages and the electronic device as a whole, the chip or chips can be removed and replaced by new ones. It is ordinarily after the under-fill material (generally a thermosetting resin) has been cured that the operation confirmation is carried out. For this reason, it has been extremely difficult to secure the repairability.

Several methods have been proposed to solve these problems. For example, Japanese Unexamined Patent Publication (Kokai) No. 10-209217 proposes a method comprising provisionally connecting the semiconductor chip and the substrate by using a conductive paste before the under-fill is introduced, conducting the test and if no problem occurs, injecting the under-fill. The sizes of the semiconductor chips and packages have become smaller with the higher density of the electronic devices and the number of input/output terminals has become greater with the increase of their functions. As a result, the distance between the bumps must be reduced and the size of the bumps has become
smaller correspondingly. In consequence, the spacing between the chip and the substrate has become smaller and a process step of injecting a liquid type resin has become difficult.

L. Wang and C. P. Wong, *J. Appl. Polym. Sci.*, 81, pp. 1868-1880, 2001 discloses a repair method comprising blending a component thermally decomposed at a high temperature to generate large quantities of gases into an epoxy resin as the under-fill material and removing the chip from the substrate. Japanese Unexamined Patent Publication (Kokai) No. 11-40624 discloses a repair method comprising removing the chip from the substrate by dissolving the under-fill by using fuming nitric acid. Furthermore, Japanese Unexamined Patent Publication Nos. 2000-22048 and 2003-504893 disclose a repair method wherein a urethane type thermosetting resin is used as the under-fill material, and it is heated to a high temperature to cause the decomposition reaction of urethane to remove the chip from the substrate.

The repair methods described above involve the decomposition reaction or dissolution of the under-fill material, are not desirable for the health of operators, degrade the under-fill material and may result in new defects.

**SUMMARY OF THE INVENTION**

It is therefore an object of the present invention to provide a packaging method of a semiconductor chip or package equipped with bumps to a substrate that causes flip-chip connection between the semiconductor chip or package equipped with bumps and the substrate conducts an operation confirmation test while an under-fill material is arranged between the semiconductor chip or package equipped with bumps and the substrate, and thereafter cures thermally the under-fill material.

In one embodiment (1), the present invention provides a packaging method of a semiconductor chip or package equipped with bumps, comprising the steps of:

(a) preparing a semiconductor chip or package equipped with bumps and a substrate for executing packaging by electrically connecting the bumps of the semiconductor chip or package equipped with bumps to connection terminals on the substrate;

(b) arranging a heat-fluidizing and thermosetting under-fill material film between the semiconductor chip or package equipped with bumps and the substrate, and aligning the bumps and the connection terminals of the substrate;
(c) applying heat and pressure at a temperature and a pressure sufficiently high to cause fluidization of the under-fill material film, and provisionally connecting the bumps electrically to the connection terminals;

(d) conducting an operation confirmation test of the semiconductor chip or package or the resulting electronic device as a whole; and

(e) if the operation confirmation test proves successful, further heating and curing the under-fill material film to obtain the final electronic device, or if the operation confirmation test proves unsuccessful, removing a defective chip or package at a temperature and a pressure sufficient to cause fluidization of the under-fill material film, and repeating the steps (c) to (e) by using a new chip or package equipped with bumps.

In a packaging method according to another embodiment (2) of the present invention, the under-fill material film exhibits heat fluidity at a certain stress or above but does not exhibit heat fluidity at a stress lower than the certain stress.

In a packaging method according to still another embodiment (3) of the present invention, the under-fill material film is partially cured before the provisional electrical connection in said step (c).

In a packaging method according to still another embodiment (4) of the present invention, further heating for heat curing in the step (e) is carried out at a temperature lower and for a longer time than heating in the provisional electrical connection step (c).

In a packaging method according to still another embodiment (5) of the present invention, when the operation confirmation test does not prove successful in the step (d), a shearing force is applied in a direction parallel to a flat surface of the substrate under the heating state to release connection between the semiconductor chip or package equipped with bumps and the connection terminals of the substrate.

In a packaging method according to still another embodiment (6) of the present invention, provisional electrical connection is carried out by heating at a temperature of 120 to 220°C for 0.5 to 10 seconds in the step (c), and curing is carried out by heating at a temperature of 30 to 100°C for 1 to 5 hours to obtain an electronic device.

In a packaging method according to still another embodiment (7) of the present invention, post cure heating is further carried out at a temperature of 100 to 180°C after heating for heat curing in the step (e).
In a packaging method according to still another embodiment (8) of the present invention, the under-fill material film contains both a thermoplastic component and a thermosetting component.

In a packaging method according to still another embodiment (9) of the present invention, the under-fill material film contains a polycaprolactone modified resin.

In a packaging method according to still another embodiment (10) of the present invention, the under-fill material film contains organic particles.

Unlike the conventional repair method, the packaging method according to the present invention releases the connection by re-heating. Therefore, connection can be made again without involving the decomposition reaction of the under-fill material and its melting, without adversely affecting the health of operators and without degradation of the under-fill material.

Even when the under-fill material film is partially cured beforehand in provisional connection, a sufficient fluidity is retained so that connection can be released by further carrying out heating when the repair is necessary. When the under-fill material film is partially cured, on the other hand, connection can be kept when the under-fill material is further heat-cured to establish final connection after the operation confirmation test proves successful.

When heating for heat curing for establishing the final connection is carried out at a temperature lower than the heating temperature at the time of provisional connection, accidental release of the connection during the final connection can be prevented.

When heating is further carried out at a higher temperature after the final connection is established, the under-fill material is cured completely and connection having higher reliability can be acquired.

The ability to carry out the different steps above is because the under-fill material film has properties of both heat fluidity and heat curing property because it contains both thermoplastic component and thermosetting component. Applying high temperatures for a short time causes the thermoplastic component of the under-fill material to fluidized. This allows for provisional connections. Applying lower temperatures for a long time causes the thermosetting component to cure. This allows for establishing a final connection.

After the final connection is made, post cure at a temperature higher than the curing
temperature causes the thermosetting component to fully cure, which allows for a highly reliable connection.

The bonding strength in provisional connection can be improved when the underfill material film contains a caprolactone modified resin.

When the under-fill material film contains organic particles, plastic fluidity (that is, the property that lowers the viscosity when shearing stress becomes high) increases. Consequently, connection can be maintained when the resin is heat cured but when the repair is made, connection can be easily released by applying the shearing stress.

When a plurality of semiconductor chips or packages is packaged to the substrate by using a prior art method, the overall electronic device cannot be used if any one of the semiconductor chips or packages is defective. According to the method of the present invention, however, the operation of the individual chips or packages is confirmed under the state of provisional electric connection. When any defect is found, only the defective chip or package may be replaced and connection may well be carried out again. Heat setting is collectively made after the operation confirmation is made. Therefore, connection having high reliability can be efficiently acquired.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a process step view of a packaging method according to the invention.

Fig. 2 is a schematic view showing a conductor pattern of a substrate used for Examples.

Fig. 3 is a schematic view showing the arrangement of bumps used for Examples.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is described based on the following practical mode, but the present invention is not limited to this specific practical mode.

First, the present invention will be explained with reference to the drawings. Fig. 1 shows a process diagram of a method of packaging a semiconductor chip or semiconductor package equipped with bumps to a substrate. The term "semiconductor chip or semiconductor package" means that it may be a bare chip equipped with bumps or bump array package. The term "bump array package" means a semiconductor package having a plurality of bumps as input/output terminals of a semiconductor chip in a planar
shape. More concretely, such a semiconductor package is an area bump array package such as a ball grid array (BGA), a chip scale package (CSP) and a wafer level CSP. On the other hand, the substrate is not specifically limited but is a printed wiring board ordinarily having a copper wiring formed on a resin substrate such as glass epoxy. A resin board such as a bismaleimide-triazine resin (BT-resin), a polyimide-based resin or an aramide-based resin can be used as the substrate. It is also possible to use a process (COG; Chip On Glass) for packaging a chip on a glass substrate by vacuum depositing ITO (Indium Tin Oxide) or a metal on glass. The substrate may be a rigid substrate or a flexible substrate. The bump is generally formed of gold, nickel, silver, copper, conductive paste, etc, but it may also be formed of solder. When the bump is formed of the solder, provisional electric connection should be carried out at a temperature lower than the melting point of the solder.

First, a semiconductor chip or package 1 equipped with bumps and a substrate 10 for which packaging is made by electrically connecting the bumps 2 of the semiconductor chip or package 1 equipped with the bumps to connection terminals 11 are prepared. A heat setting under-fill material film 3 capable of undergoing heat fluidization is arranged between the bumps 2 of the semiconductor chip or package 1 equipped with the bumps 2 and the connection terminals 11 of the substrate 10, and the bumps 2 and the connection terminals 11 of the substrate 10 are positioned to one another (Fig. 1(a)). In this instance, the under-fill material film 3 may be heat bonded in advance to the side of the bumps 2 of the chip or package or to the side of the connection terminals 11 of the substrate 10 to permit an easy work. This process step can be carried out by covering the under-fill material film with a release film such as polytetrafluoroethylene (PTFE) film or a polyester film subjected to silicone treatment and applying a temperature and a pressure onto the film. When heat bonding is conducted in advance, it may be carried out under the same heating and pressurization condition as the condition used for the provisional electric connection, described below.

Next, while the chip or package 1, the under-fill material film 3 and the substrate 10 are kept stacked, they are heated and bonded at a temperature and a pressure sufficient for the fluidization of the under-fill material film 3 to provisionally electrically connect the bumps 2 to the connection terminals 11 (Fig. 1(b)).
Such a heating and pressing step can be carried out by using a thermal bonder such as a pulse heat bonder. A bonder head having a size greater than a chip size should be used and a stress should be applied to the chip in a vertical direction. According to the invention, heat bonding is carried out preferably at a temperature of 120 to 220°C for a time of 0.5 to 10 seconds at a pressure of 1 to 10 MPa though they can vary depending on the properties of the under-fill material film. Owing to this heat bonding step, the under-fill material is fluidized and the bumps penetrate through the under-fill material. However, the under-fill material is fluidized under a stress higher than a yielding point at which a plastic flow occurs. The under-fill material is not fluidized under a stress no higher than a yielding point at which a plastic flow starts. Therefore, excessive fluidity of the under-fill material film is suppressed during the subsequent heating step for curing and connection can be continuously kept.

In the stage where this provisional electric connection is made, an operation confirmation test of the semiconductor chip or package 1 and an overall electronic device 20 obtained after the connection is carried out (Fig. 1(c)). This operation confirmation test is conducted by bringing a probe 4 of a testing instrument into contact with the circuit of the electronic device and causing a current to flow.

When the electronic device test proves successful, heating is further conducted and the under-fill material film 3 is heat cured (curing step) to obtain the final electronic device 20 (Fig. 1(d)). In this stage, the under-fill material film is cured and electric connection is stabilized. This heat curing step is preferably carried out at a temperature lower than the temperature that is used for the provisional electric connection. It is because it is possible at such a temperature to prevent the under-fill material film 3 from fluidizing again and releasing the connection by thermal expansion. When the provisional electric connection is made at a temperature of 120 to 220°C, for example, curing is made at a temperature of 30 to 100°C, for example. When curing is made at 30 to 100°C, a time of about 1 to about 5 hours is necessary for sufficient curing. To conduct further complete curing, post cure is made at a higher temperature of 100 to 180°C for about 0.5 to about 3 hours to obtain connection having higher reliability.

On the other hand, when the operation confirmation test proves unsuccessful, the defective chip or package 1 is removed at a temperature and a stress at which the under-fill material film 3 sufficiently fluidizes (Fig. 1(e)). This removal operation is preferably
carried out at a temperature substantially equal to the temperature used for the provisional electric connection such as 120 to 220°C. In this instance, the chip or package 1 can be easily removed while a shearing force in a direction parallel to the substrate 10 is being applied. The chip or package 1 can be ordinarily removed by applying the shearing force of 0.01 to 1 MPa at a temperature of 120 to 220°C for 0.5 to 10 seconds. The packaging method according to the invention can be executed by repeating the process steps described above by using new chips or packages having bumps after the chip or package 1 is removed.

The method according to the invention uses the under-fill material film containing a heat fluidizing and heat curing resin that exhibits heat fluidity when it is heated to a certain temperature and external force exceeding a certain stress is applied, and is cured when it is further heated. Such a heat fluidizing and heat curing resin is the one that contains both thermoplastic component and thermosetting component. The thermoplastic component and the thermosetting component may exist inside the same polymer compound or a mixture of a thermoplastic resin and a thermosetting resin. Examples where the thermoplastic component and the thermosetting component exist inside the same polymer compound include epoxy resins modified by the thermoplastic component such as a polycapro lactone modified epoxy resin and a rubber modified epoxy resin. Another example may be a copolymer resin having a thermosetting group such as an epoxy resin with the basic structure of the thermoplastic resin. Examples of such a copolymer resin is a copolymer between ethylene and glycicyl (meth)acrylate. The resin containing both thermoplastic component and thermosetting component may be a single resin or may further contain other thermoplastic component and/or other thermosetting component. When the molecular weight of polycapro lactone is great in the polycapro lactone modified epoxy resin, for example, the resin need not contain other thermoplastic resin but may be used alone, since sufficient heat fluidity can be secured. When the molecular weight of polycapro lactone is low, on the other hand, it is sometimes advantageous to have other thermoplastic resin contained, and those skilled in the art should appropriately decide the resin composition.

A concrete composition suitable for the present invention will be explained in the following paragraphs but the invention is in no way limited thereto. The composition that can be used particularly suitably for the under-fill material film includes the
polycaprolactone modified resin. When the composition contains the polycaprolactone modified resin, the resin imparts suitable flexibility to the under-fill material and can improve the viscoelastic characteristics. As a result, the under-fill material has cohesive force before it is completely cured, and exhibits bonding strength upon heating.

The compositions suitable for the under-fill material film contain a polycaprolactone modified phenoxy resin, an epoxy resin, an epoxy resin curing agent and organic particles, or contain a phenoxy resin, a polycaprolactone modified epoxy resin, an epoxy resin curing agent and organic particles, or contain a polycaprolactone modified phenoxy resin, a polycaprolactone modified epoxy resin, an epoxy resin curing agent and organic particles.

Such a polycaprolactone modified epoxy resin is commercially available under the trade name "Plack-Cell™ G series" from Daicell Kagaku Kogyo K.K. The polycaprolactone modified phenoxy resin is commercially available under the trade name "InCemReZ Phenoxy (e.g. PKCP-80)" from InChem Co.

The under-fill material composition may contain an epoxy resin that is not modified by polycaprolactone (hereinafter merely called "non-modified epoxy resin") besides the polycaprolactone modified phenoxy resin or the polycaprolactone modified epoxy resin. The non-modified epoxy resin is not particularly limited as long as it remains within the scope of the present invention and examples of such a resin include a bisphenol-A type epoxy resin, a bisphenol-F type epoxy resin, a bisphenol-A type diglycidyl ether type epoxy resin, a phenol novolak type epoxy resin, a cresol novolak type epoxy resin, a fluorene epoxy resin, a glycidylamine resin, an alicyclic epoxy resin, a brominated epoxy resin, a fluorinated epoxy resin, and so forth. Such epoxy resins are easily compatible with the phenoxy resin in the same way as the modified epoxy resin and hardly bleeds from the under-fill material. The improvement of the heat resistance is remarkable particularly when the under-fill material contains preferably 50 to 200 parts by weight, and more preferably 60 to 140 parts by weight, of the non-modified epoxy resin on the basis of 100 parts by weight of the modified epoxy resin. One aspect of the present invention can use the bisphenol-A diglycidyl ether type epoxy resin (hereinafter called "diglycidyl type epoxy resin", too) as the preferred non-modified epoxy resin. This diglycidyl ether type epoxy resin is liquid and can improve the high temperature characteristics of the under-fill material, for example. The chemical resistance at high temperatures due to curing and the
glass transition temperature can be improved when this diglycidyl ether type epoxy resin is used. The application range of the curing agent can be expanded and the curing condition is relatively gentle, too. Such a diglycidyl ether type epoxy resin is commercially available under the trade name "D.E.R. TM32" from Dow Chemical Japan Ltd., for example. Another preferred epoxy resin is also commercially available under the trade name "YD128" from Toto Kasei Co., Ltd.

The under-fill material preferably contains a melamine/isocyanuric acid adduct (hereinafter called "melamine/isocyanuric acid complex", too) in combination with the polycaprolactone modified phenoxy resin or polycaprolactone modified epoxy resin described above. The useful melamine/isocyanuric acid complex is commercially available under the trade name "MC-600" from Nissan Kagaku Kogyo, for example, and is effective for increasing toughness of the under-fill material and suppressing its hygroscopicity and fluidity. When the viscosity of the under-fill material is too low, the under-fill material swells out from the chip area. When the viscosity of the under-fill material is too high, on the other hand, provisional electric connection is impeded. Therefore, the viscosity of the under-fill material should be strictly controlled and this material operates as the viscosity adjusting agent. To prevent brittleness after curing without spoiling the effects described above, the under-fill material may contain generally 1 to 200 parts by weight, preferably 2 to 100 parts by weight and more preferably 3 to 50 parts by weight, of the melamine/isocyanuric acid complex on the basis of 100 parts by weight of the sum of the polycaprolactone modified phenoxy resin and polycaprolactone modified epoxy resin.

The thermosetting adhesive composition contains the curing agent and this curing agent is useful for the curing reaction of the modified epoxy resin and the non-modified epoxy resin. The amount of use of the curing agent and its kind are not limited, in particular, as long as the desired effects can be obtained. From the aspect of the improvement of the heat resistance, however, generally 1 to 50 parts by weight, preferably 2 to 40 parts by weight and more preferably 5 to 30 parts by weight, of the curing agent are contained on the basis of 100 parts by weight of the modified epoxy resin and the non-modified epoxy resin. Examples of the curing agent include an amine curing agent, an acid anhydride, dicyandiamide, a cation polymerization catalyst, an imidazole compound, a hydrazine compound and phenols though they are in no way restrictive. Dicyandiamide, in particular, can be cited as a promising curing agent because it has thermal stability at
room temperature. From the relationship with the diglycidyl ether type epoxy resin, it is preferred to use alicyclic polyamine, polyamide, amide amine or their modified products.

The under-fill material film described above preferably contains organic particles, and the following effects can be obtained by adding 35 to 100% of organic particles on the basis of the total mass of the under-fill material film. When the organic particles are added, the resin exhibits plastic fluidity. In the case of the resin having such properties, the resin undergoes fluidization when the bumps are bonded at a relatively high pressure and allows penetration of the bumps. On the other hand, the organic particles suppress excessive fluidity of the under-fill material film and prevent the drop of the contact pressure between the bump and the conductor of the substrate during heat curing.

The organic particles added are particles of an acryl resin, a styrene-butadiene resin, a styrene-butadiene-acryl resin, a melamine resin, a melamine-isocyanurate adduct, polyimide, a silicone resin, polyether imide, polyether sulfone, polyester, polycarbonate, polyether ether ketone, polybenzimidazole, polyarylate, liquid crystal polymer, an olefin resin and an ethylene-acrylic copolymer. The particle size is not greater than 10 μm, preferably not greater than 5 μm.

The under-fill material film may contain inorganic fillers such as silica, aluminum oxide and glass bead. Because the inorganic filler can keep the thermal expansion coefficient of the film after curing to a low level, it can avoid the occurrence of the thermal stress in the substrate and the chip or the package at the time of the temperature change during the use of the electronic device.

After the components of the under-fill material film are dissolved in a suitable solvent such as tetrahydrofuran, the solution is applied to a substrate subjected to peel treatment, and is then dried to form a film on the substrate. The film can then be removed from the substrate. It is also possible to heat and fuse the components of the under-fill material film, to apply the molten matter to the substrate, to dry it to form the film on the substrate and then to remove the resulting film.
EXAMPLES

Examples 1 and 2

1. Preparation of under-fill material film

   A solution of each composition tabulated in Table 1 was stirred at room temperature, was knife-coated onto a silicone treated polyethylene terephthalate (PET) film, was dried inside an oven at 100°C for 30 minutes and was further heat-treated at 70°C for 6 hours to obtain an under-fill material film having a thickness of 25 μm.

   **Table 1**
   **Under-fill material (parts by weight)**

<table>
<thead>
<tr>
<th></th>
<th>PKCP-80</th>
<th>YD128</th>
<th>BAFL</th>
<th>EXL2314</th>
<th>THF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>60</td>
<td>34</td>
<td>16.4</td>
<td>100</td>
<td>600</td>
</tr>
<tr>
<td>Example 2</td>
<td>60</td>
<td>34</td>
<td>16.4</td>
<td>50</td>
<td>600</td>
</tr>
</tbody>
</table>


YD128: epoxy resin, Toto Kasei Co., Ltd., epoxy equivalent 184 to 194

BAFL: bis-aniline fluorine, Shin-Nittetsu Kagaku Co., Ltd.

EXL2314: acryl particle, KUREHA EXL, Kureha Kagaku Kogyou Co., Ltd.

THF: tetrahydrofuran

2. Measurement of bonding strength of under-fill material

   The under-fill material film was put on a 2 mm thick glass epoxy (FR4) and a 35 m thick rolled copper foil having a width of 10 mm was press bonded at 150°C and 200 kgf (4.0 MPa) for 20 seconds to establish a provisional connection. Bonding strength was measured by measuring load when an end part of the copper foil was peeled at an angle of 90° relative to the glass epoxy at a tensile rate of 60 mm/min for each of the samples after establishing a provisional connection, and further curing at 80°C for 2 hours after the provisional connection. The result is shown in Table 2.
Table 2
Bonding strength

<table>
<thead>
<tr>
<th></th>
<th>initial bonding strength after provisional connection (N/cm)</th>
<th>bonding strength after curing (N/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>7.1</td>
<td>9.2</td>
</tr>
<tr>
<td>Example 2</td>
<td>6.5</td>
<td>9.7</td>
</tr>
</tbody>
</table>

3. Connection test between chip and substrate

3.1. Resistance measurement method

A chip having 24 gold stud bumps shown in Fig. 3 was heat bonded to a substrate having a conductor pattern shown in Fig. 2. The substrate was a 0.5 mm-thick glass epoxy substrate (FR4) and the conductor pattern on the substrate was formed by applying nickel/gold plating onto a 12 μm-thick copper foil. When the chip was electrically connected onto this substrate, a circuit having 23 connections (stud bumps and conductors) was formed between ab and ij. The resistance between them was measure by four-terminal measurement. The measurement was carried out for a sample after a provisional connection, a sample the connection of which was released after a provisional connection and was again connected by a provisional connection and a sample cured after re-connection.

3.2. Provisional connection

The under-fill material film prepared as described above was arranged between the chip and the substrate and was heat bonded at a load of 200 N (5.6 MPa) for 3 seconds by using a pulse heat bonder (product of Avionix Co., TCW-215/NA66). The resin temperature was measured by burying a thermo-couple into the film and the maximum value of the resin temperature at the time of heat bonding was 155°C.

3.3. Repair

The chip provisionally connected as described in 3.2 was removed by applying an iron at 250°C to allow a shearing load of about 1 kg to operate. In this instance, the temperature of the resin rose to 130°C when measured by using a thermocouple. The chip having the under-fill material film (25 μm) described in 1 above was heat bonded to the chip removal position and was connected under the same condition as that of provisional connection described above.
3.4. Curing

Curing was further carried out for the sample repaired as described in 3.3 above at 80°C for 2 hours.

The result of the resistance measurement carried out for the sample after a provisional connection, the sample whose connection was removed after a provisional connection and was again provisionally connected and the sample cured after reconnection by the provisional connection is shown in Table 3.

Four samples were measured for each kind of these samples.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Resistance value measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>provisional connection state resistance value</td>
</tr>
<tr>
<td>No. 1</td>
<td>0.78</td>
</tr>
<tr>
<td>No. 2</td>
<td>0.75</td>
</tr>
<tr>
<td>No. 3</td>
<td>0.85</td>
</tr>
<tr>
<td>No. 4</td>
<td>0.78</td>
</tr>
</tbody>
</table>

unit: Ω

Example 3

1. Preparation of under-fill material film

A solution of each composition tabulated in Table 4 was stirred at room temperature, was knife-coated onto a silicone treated polyethylene terephthalate (PET) film, was dried inside an oven at 100°C for 20 minutes and was further heat-treated at 70°C for 6 hours to obtain an under-fill material film having a thickness of 30 μm.

To confirm that the resulting film exhibited plastic fluidization, a layer of under-fill material was provisionally connected (200°C, 5 MPa, 1 sec) between two copper sheets. Observation was made for 3 hours while a shearing stress of $2.5 \times 10^4$ Pa was allowed to act between the copper sheets, but fluidization could not at all be observed. However, remarkable fluidization could be observed when a shearing stress of $7.8 \times 10^5$ Pa was allowed to act at the same temperature.
Table 4
Under-fill material

<table>
<thead>
<tr>
<th>component</th>
<th>parts by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>YP50S</td>
<td>30</td>
</tr>
<tr>
<td>YD128</td>
<td>34</td>
</tr>
<tr>
<td>G402</td>
<td>30</td>
</tr>
<tr>
<td>BAFL</td>
<td>16.4</td>
</tr>
<tr>
<td>MC600</td>
<td>20</td>
</tr>
<tr>
<td>EXL2314</td>
<td>80</td>
</tr>
<tr>
<td>THF</td>
<td>600</td>
</tr>
</tbody>
</table>

YP50S: phenoxy resin, Toto Kasei Co., Ltd., number average molecular weight 11,800
YD128: epoxy resin, Toto Kasei Co., Ltd., epoxy equivalent 184 to 194
G402: polycaprolactone modified epoxy resin, Daicell Kagaku Kogyo Co., Ltd.,
      epoxy equivalent 1350
BAFL: bis-aniline fluorine, Shin-Nippon Seitetsu Kagaku Co., Ltd.
MC-600: melaminecyanuric acid complex, Nissan Kagaku Kogyo Co., Ltd.
EXL2314: acryl particles, EXL2314, Kureha Paraloid EXL, Kureha Kagaku Kogyo Kabushiki Kaisha
THF: tetrahydrofuran

2. Connection test between chip and substrate
   2.1. Resistance measuring method
       The measurement was carried out by the same method as that of Examples 1 and 2.
   2.2. Provisional connection
       The under-fill material film prepared as described above in section 1 was arranged
       between the chip and the substrate and was heat bonded at a load of 100 N (2.8 MPa) by
       using a pulse heat bonder (product of Avionix Co., TCW-215/NA66). The resin
       temperature was measured by burying a thermo-couple into the film and the maximum
       value of the resin temperature at the time of heat bonding was 200°C ± 10°C. The
       application of the constant load of 100 N was continued until the temperature was below
140°C ± 10°C and the time required for heat bonding was 4.5 seconds ± 0.5 seconds inclusive of the time for the temperature rise and lowering.

3.3. Repair

The chip provisionally connected as described in 2.2 was removed by applying an iron at 250°C to allow a shearing load of about 1 kg to operate. In this instance, the temperature of the resin rose to 130°C when measured by using a thermocouple. The chip having the under-fill material film (30 μm) described in 1 above was heat bonded to the chip removal position and was again connected under the same condition as that of provisional connection described above.

3.4. Curing

Curing was further carried out for the sample repaired as described in 2.3 above at 150°C for 2 hours.

The result of the resistance measurement carried out for the sample after provisional connection, the sample whose connection was removed after provisional connection and was again provisionally connected and the sample cured after provisional reconnection is shown in Table 5.

Five samples were measured for each kind of these samples.

Table 5

<table>
<thead>
<tr>
<th></th>
<th>provisionally connected state resistance value</th>
<th>resistance value after provisionally reconnected</th>
<th>resistance value after curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>0.76</td>
<td>0.80</td>
<td>0.81</td>
</tr>
<tr>
<td>No. 2</td>
<td>0.76</td>
<td>0.79</td>
<td>0.80</td>
</tr>
<tr>
<td>No. 3</td>
<td>0.82</td>
<td>0.76</td>
<td>0.76</td>
</tr>
<tr>
<td>No. 4</td>
<td>0.77</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>No. 5</td>
<td>0.76</td>
<td>0.78</td>
<td>0.78</td>
</tr>
</tbody>
</table>

unit: Ω
Claims

1. A packaging method of a semiconductor chip or package equipped with bumps, comprising the steps of:

   (a) preparing a semiconductor chip or package equipped with bumps and a substrate for executing packaging by electrically connecting said bumps of said semiconductor chip or package equipped with bumps to connection terminals on said substrate;

   (b) arranging a heat-fluidizing and thermosetting under-fill material film between said semiconductor chip or package equipped with bumps and said substrate, and aligning said bumps and said connection terminals of said substrate;

   (c) applying heat and pressure at a temperature and a pressure sufficiently high to cause fluidization of said under-fill material film, and provisionally connecting said bumps electrically to said connection terminals;

   (d) conducting an operation confirmation test of said semiconductor chip or package or the resulting electronic device as a whole; and

   (e) if said operation confirmation test proves successful, further heating and curing said under-fill material film to obtain the final electronic device, or if said operation confirmation test proves unsuccessful, removing a defective chip or package at a temperature and a pressure sufficient to cause fluidization of said under-fill material film, and repeating said steps (c) to (e) by using a new chip or package equipped with bumps.

2. The method as claimed in claim 1, wherein said under-fill material film exhibits heat fluidity at a certain stress or above but does not exhibit heat fluidity at a stress lower than said certain stress.

3. The method as claimed in claim 1 or 2, wherein said under-fill material film is partially cured before the provisional electrical connection in said step (c).

4. The method as claimed in any of claims 1 through 3, wherein further heating for heat curing in said step (e) is carried out at a temperature lower and for a longer time than heating in said provisional electrical connection step (c).
5. The method as claimed in any of claims 1 to 4, wherein, when said operation confirmation test does not prove successful in said step (d), a shearing force is applied in a direction parallel to a flat surface of said substrate under the heating state to release connection between said semiconductor chip or package equipped with bumps and the connection terminals of said substrate.

6. The method as claimed in any one of claims 1 to 5, wherein provisional electrical connection is carried out by heating at a temperature of 120 to 220°C for 0.5 to 10 seconds in said step (e), and curing is carried out by heating at a temperature of 30 to 100°C for 1 to 5 hours to obtain an electronic device.

7. The method as claimed in any one of claims 1 to 6, wherein post cure heating is further carried out at a temperature of 100 to 180°C after heating for heat curing in said step (e).

8. The method as claimed in any one of claims 1 to 7, wherein said under-fill material film contains both a thermoplastic component and a thermosetting component.

9. The method as claimed in claim 8, wherein said under-fill material film contains a polycaprolactone modified resin.

10. The method as claimed in claim 8 or 9, wherein said under-fill material film contains organic particles.