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PLASTIC CAVITY PACKAGE LID SEAL PROCESS

TECHNICAL FIELD OF THE INVENTION

This invention pertains in general to cavity packaging of semiconductor devices and more particularly to a process for obtaining a seal between the lid and body of a cavity package.

BACKGROUND OF THE INVENTION

Conventional integrated circuit plastic packaging methods involve encapsulating the integrated circuit using transfer molding techniques. In such a method, the molding compound is in contact with the surface of the integrated circuit. Since the various materials used in the chip and the package have different mechanical and physical properties, changes in the environment in which the packaged chip is used limit the package performance.

Chip reliability problems are often the result of the differences in properties of the packaging material. Many common reliability problems such as metal shear, passivation, silicon, and package cracking during printed wiring board attach are at least partially attributable to the difference in properties. As an example, the thermal performance of the package is limited by the thermal conductivity of the molding compound used to encapsulate the chip.

The cavity package concept allows manufacture of a package with various thermal connection options not available with conventional plastic packages. Cavity packages also provide a package with a cavity for mounting the integrated circuit chip with no contact between molding compound and the chip. With the thermal connection options available with the cavity package,

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more costly ceramic packaging can be avoided.

Prior art plastic cavity packages and processes have not provided a durable and reliable lid seal, which affects the reliability of the packaged integrated circuit chip.

One such prior art method is the comb mold approach with package seals at the leadframe interface. The disadvantage of this method is difficulty in manufacturing, poor moisture performance, difficult mold alignment and high tooling cost.

Another problem with prior art plastic cavity packaging efforts involves adhesion and surface preparation of the various parts which are to be bonded together. Adhesion between the adhesive and polymer and metal adherands are inadequate. Additionally, prior surface preparation methods were not compatible with process flow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a cavity package mounted to a printed wiring board.

FIG. 2 is a graph showing the cleaning effect of different plasma gases on adhesion.

FIG. 3 is a graph showing the effect of cleaning time on adhesion.

Fig. 4 is a cross-sectional view of the cavity package of Fig. 1 during a portion of the packaging process.

FIG. 5 is a block diagram of the process flow of the instant invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

This application is related to U.S. Patent No. 4,874,722, which is incorporated by reference herein.

A plastic cavity package 10 of the present invention is illustrated in Fig. 1. The cavity package 10 is shown attached to printed wiring board 12. An integrated circuit chip 14 is attached to the die pad 11 of a lead frame 13 with an adhesive

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11a. The chip 14 is positioned in cavity 15 within package 10. Wire bonds 17 attach the bond pads (not shown) of chip 14 to the lead frame 13. Portions of the lead frame 13 extend through cavity package 10 for electrically connecting the package 10 to the printed wiring board 12. A thermal adhesive 19 attaches the die pad 11 to lid 22. A silicone overcoat 14a may also be formed over chip 14 for further protection.

The cavity package 10 has a ring portion 18, preferably a polymer compound, which forms cavity 15 and is adapted to enclose integrated circuit chip 14. While in the preferred embodiment as shown in Fig. 1 the ring 18 is rectangular, it could be any suitable shape. The ring 18 is formed around lead frame 13 by a process as described in co-pending U.S. patent application serial No. 511,877, filed 04/20/90, reference No. TI-13619.1, also owned by the assignee hereof, and incorporated by reference herein.

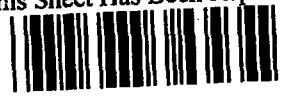
As seen in Fig. 1, ring 18 has lid-engaging shoulders 20, which extend into cavity 15. In the preferred embodiment, shoulders 20 extend around the entire inner side of ring 18. The shoulder 20 has lid-engaging surfaces 21 which also preferably extend aound the periphery of cavity 15. The surfaces 21 are adapted to sealingly engage upper lid 22 and lower lid 23.

Upper lids 22 and lower lids 23 are adapted to fit within the opening defined by ring 18 and engage surfaces 21 of shoulder 20 and contact surface 24 which extends around the periphery of lids 22. Contact surfaces 24 are adapted for sealing engagement with shoulders 20 when lids 22 are placed on the package 10.

The lids may be made of different material, depending upon the application of the package. They can be metal, such as aluminum,stainless steel, copper, or metal alloys. Plastic, either thermoset or thermoplastic may also be used. If necessary, high thermoconductivity materials, such as tungsten or tungsten alloys, silver, gold plating or cadmium plating could be used.

If the package of the instant invention is to be used to package EPROMS, it is necessary that the lid transmit UV light. Materials such as quartz, borosilicate glass, or sapphire may be

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used. Another possibility would be gold plated Kovar with bullseye quartz glass centers for passage of UV light.

It is also within the scope of the present invention that the package 10 may also have only one lid 22 or 23. As an example, if the package 10 is used to package an EPROM, it would be possible to use ring 18 and lid 23, with only an overcoat of some type in place of lid 22. Any other type of semiconductor chip could also be packaged in the same way.

The shape of the lid 22 may also differ from that shown if the package is required to have high power capability. Since heat dissipation is necessary in such application, the lid may have fins, or other protrusions extending from it.

In order to form a seal between surfaces 24 and lid-engaging surfaces 20, an adhesive 26 is placed between surfaces 24 and lid-engaging surfaces 20. In order to have a seal which will withstand stress and moisture, it is necessary to prepare surfaces 24 and 20 prior to assembly of the cavity package 10.

Surface preparation of the Ring 18 and Lid 22 is essential to achieve effective bonding of the ring 18 and lid 22 together in order to assure reliability of the finished product. Proper preparation of the adherands (ring 18 and lid 22) ensures that the adhesive will properly wet the surfaces to be bonded. If the adhesive does not wet the surfaces properly, the bond will be weaker and unreliable. The strongest bond results when the weakest point in the joint is in the adhesive layer itself, not in the interface between the adhesive and the adherand.

Preparation of the surface of lid 22 may require one or all of the folloowing steps: cleaning, roughening, stabilization, and activation.

If the package is to include a plastic lid, the preferred method of the present invention involves preparing the surfaces 20 and 24 with a plasma. The plasma is preferably isotropic in nature so that complex surface geometries can be prepared. Since materials used in the assembly process other than the lids 22 and the ring 18 may be exposed to the plasma, the plasma used should not be harmful to the non-adherand materials used in the assembly

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process.

The polymer surfaces are prepared (which can include cleaning and modification) using a plasma surface treatment process. The adherands (ring 18 and lids 22) are placed in the plasma environment. The plasma is preferably generated using radio frequencies of 40 KHz or 13.56 MHz. Source gases are preferably argon or nitrogen. The ring 18 and lids 22 are supported in a plasma chamber either directly on the electrodes or on shelves between electrodes.

An example of a surface preparation process used with a plastic ring 18 and lid 22 assembly is as follows: applying RF frequency energy at 13.56 MHz and 150 Watts, with a gas flow reate of 90 CC/Min at a pressure in the plasma chamber of 240 microns. The process runs for 10 minutes at a temperature between 85-100C. The gas is preferably argon.

The process described above is not harmful to non-adherand materials used in the assembly process, such as silicon nitride and silicone overcoats, gold bond wires, leadframe plating, chip metallization and bumps. The process is also easily inserted in-line with the remainder of the overall cavity packaging process flow, thus minimizing cost and process flow disruption.

The process of preparing the adherands of the instant invention effectively prepares the surfaces without the necessity of chemical or mechanical preparation. This process also changes the fracture modes in the package from adhesion failure to cohesive fracture mode, which is desirable as it gives maximum strength to the package.

Figures 2 & 3 compare the adhesion with various types of plasma gases and varying preparation times. As shown in Fig. 2, the adhesion strength of bonds made after preparation with either an argon plasma or nitrogen plasma are substantially greater than bonds made when no plasma preparation has taken place.

Fig. 3 demonstrates the increase in adhesion strength as a function of plasma preparation time in a plasma generated with a frequency of 13.56 MHz.

If the lid 22 is made of metal, surface preparation using

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chemical methods may be used. Copper metals can be prepared using, either a black oxide coating, such as Ebonol "C", or an Ammonium Persulfate preparation process can be utilized. If the lid is Kovar, a nitric acid or chromium trioxide-hydrochloric acid mixture could be used to prepare the surface.

A glass lid 22 used on EPROM packages could be prepared using one of several methods. One method would be a solvent clean or vapor degrease using a light sandblast with a fine grit, followed by blowing the surface clean with filtered air. A second method would be a degrease as a first step, wash in a mixture of Chromium Trioxide (1 PBW) and distilled water (4 PBW) for 15-20 Min. at room temperature, followed by a wash with disltilled water and drying at 180-200 F for 20-30 minutes. A third method would be an ultrasonic detergent bath followed by a rinse in distilled water and drying at room temperature.

For a ceramic lid, a recommended preparation process would be a vapor degrease, sanding with 200 sandpaper, and a vacuum or air spray clean. The glaze finish should be completely removed from the surface in contact with adhesive for maximum strength.

If the lid 22 is aluminum, the preferred method of preparation is Preparation of Aluminum Surfaces for Structural Adhesive Bonding (Phosphoric Acid Anodizing), designated as ASTM Designation D3933-80 (Annual Book of ASTM Standards, Part 22. This method is outlined below:

1. a degrease step, using 1,1,1 Trichloroethane for 10-15 min. @ 90+/-5C.

2. Alkaline clean, using Oakite No. 164, for 10-15 min @ 60-72C.

3. Rinse, using distilled water for > 5 min. @ >43 C.

4. Deoxidize (Forest Products Laboratories method), using Sodium Dichromate/Sulfuric for 10-15 min. @ 65-72C.

5. Double Rinse using distilled water for >5 min @ 25C.

6. Phosphoric Anodize, with Phosphoric Acid (75%)/Water, for 20-25 min. @ 15 +/- 1V.

7. Rinse with distilled water for 10-15 min @ 25C.

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8. Dry with heated air for 45 min. @ 70C (max).

9. Inspect, using a Mercury Vapor Lamp with optical polarizing filter.

10. Adhesive Primer Application

a. Spray primer, such as American Cyanamide BR-127 to 0.001"-0.003" thickness.

b. Air dry > 30 min @ 25 C.

c. Oven dry for 30 min @ 112-121C.

Other methods of preparing the surface of various metals can be found in Preparation of Metal Surfaces For Adhesive Bonding (ASTM Designation D2651-79 Reapproved 1984), which is incorporated by reference herein.

There is also disclosed a novel method for sealing a cavity package after cleaning and assembly steps have been completed, as illustrated in Fig. 4. In figure 4, a package 10 has been placed in a press 50. The press 50 applies pressure on both the top and bottom of the package 10, as shown by arrows 51. The press 50 may be either a single opening or multi opening press.

At both the top and bottom of package 10, a rigid metal sheet 52, of material such as stainless steel, is positioned between package 10 and press 50. A release film 54, preferably Pacothane(tm), is positioned between rigid sheets 52 and press pads 56. The press pads are preferably silicone rubber, such as COHRlastic (R) 3320.

The sealing process takes place with the pressure uniformly distributed over all the packages 10 within press 50. Special platen designs and a preprogrammed thermal profile applied throughout the sealing process result in reliable seals.

After the packages 10 and related sealing equipment described above are placed in press 50, a predetermined pressure at a predetermined temperature is applied to the packages 10 for a specific period of time. The pressure and temperature may follow a predetermined variable profile, or one or both may be constant.

An example would be: 50 +/- 5PSI per package with the process temperature holding at 175 C for 60 minutes, with a cycle

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time of 75 minutes. Proper control of temperature during the sealing process is important, since the adhesive flow properties can depend on the heating rate, which will influence the bond line thickness.

During the sealing process, the seal between the press pads 56 and the package 10 is also very important, since internal pressure can develop within package 10. The pressure applied to the package 10 by press 50 should balance the internal pressure inside the package 10 to maximize bondline density and to prevent adhesive runoff from occurring. If runoff does occur, the bondline will not pack, and voids in the bondline may result, which causes a substandard bond. The use of silicone press pads 56 aids in preventing leakage. Also, since the pressure inside package 10 effectively packs the bondline, the silicone also acts as a stop for the flow of adhesive out onto the surface of the package 10, which would be a visual package defect.

After the temperature and pressure have been applied for the proper amount of time, a cooling cycle is begun, during which the pressure is maintained during controlled cooling. Some adhesives require that pressure be maintained until the adhesive sets or gels. In the preferred embodiment, the temperature at which the pressure is removed is approximately 200F.

An assembly flow for assembling an integrated circuit and a cavity package components could include the following steps:

1. Surface preparation of the lids, as described above for each type of material used.
2. Adhesive application to lid.
    a. adhesive preform applied to entire lid.
    b. adhesive preform applied in "window frame" fashion.
3. Plasma treatment of molded rings
4. assemble lids into molded rings.
5. Assemble heatspreaders into molded rings.
    a. silver filled material same as or similar to die attach adhesive.
    b. lid seal adhesinve covering the entire heat spreader and the thermal attach is automatic.

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6. lid seal step.

While the present invention has been described for use in a packaging process for a cavity package lid seal enhancement, the processes described herein could advantageously be used for cleaning any microelectronics package surface, such as degreasing prior to symbolization. It could also be used with metal cavity packages, plastic packages, high power products, hybrid stacked memory, or multi-chip products.

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I CLAIM:

1. A process for preparing adherands comprising the steps of:

Exposing the adherands to a plasma.

2. The process of claim 1, wherein the step of exposing the adherands further includes the steps of:

placing the adherands in a plasma reactor such that the adherands are positioned between the electrodes; and

generating a plasma in the plasma reactor.

3. The process of claim 1, further including the step of:

generating the plasma from one of the group of nitrogen and argon.

4. A process for increasing the bond between a plastic cavity package lid and plastic cavity package body, comprising the steps of:

placing the lid and the body in a plasma reactor; and

generating a plasma in the plasma reactor.

5. The process of claim 4, wherein the step of generating a plasma further comprises the steps of:

introducing a reactant gas into the reactor; and

exciting the reactant gas.

6. The process of claim 5, wherein the step of exciting the reactant gas includes the step of applying rf power to the plasma chamber.

7. The process of claim 5, further including the step of:

reducing the pressure in the plasma chamber to below 760 Torr.

8. A method for sealing a cavity package, comprising the steps of:

applying pressure to the cavity package for a predetermined time; and

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heating the cavity package to a predetermined temperature during the step of applying pressure.

9. The method of claim 8, wherein the step of applying pressure includes the step of placing the package in a press.

10. The method of claim 9, further comprising the step of:

placing a pad between the press and the package prior to applying pressure to the package.

11. The method of claim 8, further comprising the step of:

cooling the package below a predetermined temperature while maintaining the package at a pressure.

12. A method of assembling a cavity package, the package having a body and at least one lid, comprising the steps of:

preparing the lid and body;

applying adhesive to the lid or the body;

placing the lid on the body; and

sealing the lid to the body.

13. The process of claim 12, wherein the step of preparing includes the step of:

placing the lid and body in a plasma chamber; and

generating a plasma in the plasma chamber.

14. The process of claim 12, wherein the step of sealing further comprises the steps of:

heating the package to a predetermined temperature; and

applying uniform pressure to the package for a predetermined time.

15. The process of claim 14, further comprising the step of:

cooling the package to a predetermined temperature while maintaining uniform pressure.

16. A method of packaging a semiconductor chip, comprising the steps of:

Attaching the chip to a lead frame;

interconnecting the chip to the lead frame;

forming a ring around the chip;

placing a lid on the ring such that the ring and lid totally surround the chip; and

sealing the lid to the ring.

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17. The method of claim 16, further comprising the step of preparing the ring and lid.

18. The method of claim 17, wherein the step of preparing comprises the steps of:

placing the ring and lid in a plasma chamber; and

generating a plasma in the plasma chamber.

19. The method of claim 16, further comprising the step of placing an adhesive on the lid or ring.

20. A method of packaging a semiconductor chip, wherein the package has a lid transparent to UV light and a ring surrounding the chip, comprising the steps of:

preparing the ring in a plasma reactor;

preparing the lid;

applying an adhesive to the ring or lid;

sealing the lid to the ring, such that the chip is surrounded by the sealed package.

21. The method of claim 20, Wherein the step of preparing the lid further comprises degreasing the lid.

22. The method of claim 20, wherein the step of preparing the lid further comprises placing the lid in an ultrasonic bath.

23. A method of packaging an integrated circuit, the package having a ring formed around the integrated circuit and at least one lid, comprising the steps of:

preparing the surface of the lid;

applying an adhesive to the lid;

preparing the rings;

placing the lid into the ring;

placing heatspreaderes into the ring; and

sealing the lid to the ring.

24. The method of claim 23, wherein the step of preparing the surface of the lid further comprises cleaning the surface of the lid.

25. The method of claim 23, wherein the step of preparing the lid further comprises the steps of:

cleaning the surface of the lid;

degreasing the surface of the lid;

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deoxidizing the surface of the lid;

anodizing the surface of the lid;and

applying an adhesive primer to the surface of the lid.

26. The method of claim 23, wherein the step of preparing the lid further comprises the steps of:

degreasing the surface of the lid;

immersing the lid in a sulphuric acid bath;

rinsing the lid in distilled water; and

drying the lid.

26. The method of claim 23, wherein the step of preparing the surface of the lid comprises the step of cleaning the surface with an acid mixture.

27. A method of sealing a lid to the body of a semiconductor chip package, comprising the steps of:

applying adhesive to the lid;

placing the lid on the body;

placing the lid and body in a press;

applying a predetermined pressure to the lid and body for a predetermined time.

28. The method of claim 27, further comprising the step of;

maintaining the temperature of the lid and body according to a predetermined profile during the step of applying pressure.

29. The method of claim 27, wherein the step of applying a predetermined pressure comprises maintaining the pressure such that it follows a predetermined profile.

30. The method of claim 27, further comprising the step of maintaining a predetermined pressure while cooling the lid and body to a predetermined temperature.

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