ENCAPSULATION FOR SEMICONDUCTOR INTEGRATED CIRCUIT CHIP

This invention relates to encapsulations for semiconductor integrated circuit chips.

Semiconductor chips are encapsulated both for protection and for convenience in interconnecting the chip circuits with terminals on mounting media such as printed circuit boards. Encapsulation also facilitates testing and the automatic assembly of chips into apparatus. There is a considerable variety of integrated circuit chip packages, but of chief interest are the nonhermetic, post-moulded plastic types known as the dual-in-line package and the chip carrier type. Standards exist or are under development for packages of these types which prescribe general dimensions, types of external contacts, and contact spacing.

However, the encapsulation of semiconductor devices constitutes a considerable proportion of the total cost of a completed device. Accordingly, there is a continuing effort to develop packages and encapsulation techniques which reduce cost, provide high reliability, and which are compact in size. Automatic fabrication, test, and assembly techniques contribute to lower cost and higher reliability. It is desirable also, that a particular package design accommodate, with little or no change in that design, a variety of different semiconductor chips. As a consequence, the total number of package sizes required for all chip sizes is minimized.

United States Patent no. 4,132,856 discloses an encapsulation for a semiconductor integrated circuit chip in which unitary lead members are connected to electrodes on the front side of the chip and terminate in contacts external to the moulded plastics encapsulating body. A separate metal member is required to provide thermal contact to the backside of the chip and to provide mechanical support prior to the formation of the moulded plastics body. The lead members can be formed from a single piece of metal foil, such as a beam tape, but the necessity for the separate metal member complicates the encapsulation process.

In the present invention thermal and, if desired, electrical contact to the backside of the chip and mechanical support during processing are provided by unitary lead members integral with large-area tab members in contact with the backside of the chip.

This form of encapsulation lends itself particularly well to reel-to-reel beam tape processing since all the lead members and the tab members can be formed from a single sheet of metal foil.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:-

FIG. 1 is a perspective view, partially cut away and sectioned of an encapsulation according to the invention;

FIG. 2 is a plan view of a single lead frame shaped in a portion of a beam tape during the manufacture of the encapsulation of FIG. 1;

FIG. 3 is a perspective detail view of the inner end of one of the front-side beam members of the encapsulation of FIG. 1;

FIG. 4 shows a variant form of the detail of FIG. 3 and

FIG. 5 is a perspective view, partially cut away and sectioned, showing several encapsulations in accordance with this invention in a stick type of magazine.

FIG. 1 shows, in perspective, a chip carrier comprising a post-moulded plastic body member 10 which holds the various elements of the encapsulation in cooperative relation and provides a package outline suitable for stick-type handling equipment. The carrier is partially cut away in sections to illustrate the arrangement of the various elements within the moulded plastic body member 10.

The semiconductor chip 11 is disposed within the body member 10. In the drawing, the front or active face of the chip is uppermost and has thereon a plurality of electrodes 15 consisting of metal areas for making connection to the semiconductor integrated circuit.

Interconnection between the electrodes 15 on the semiconductor chip 11 and the external contacts 13 is by way of the lead members 12. On the front face of the chip, internal to the package, the lead members 12 terminate in finger portions 14, the tips of which include an area adapted for bonding to a chip electrode 15 where "bonding" intended to encompass all known means of making conductive attachment including, but not restricted to, thermal compression bonding, thermosonic and ultrasonic bonding, eutectic and conductive adhesive bonding, soldering, brazing, and various forms of welding. External to the body 10, the lead members 12 terminate in external contacts 13, adapted for making contact to terminal areas on interconnecting circuit apparatus, including thick and thin film ceramic elements and rigid and flexible printed circuit boards. Such contacts may rely on spring pressure, bonding, welding, or soldering. Although shown in this embodiment as L-shaped feet for surface mounting, the leads 12 and contacts 13 could as well be adapted for another type of connection, for example, by insertion into holes in a mounting member. Alternatively, the leads 12 and external contacts 13 may be bent in the opposite direction with respect to the orientation of the semiconductor chip. This results

in a mirror image connection of the electrodes 15 on the semiconductor chip 11 to the terminal areas on the interconnecting circuit apparatus with no changes to the semiconductor chip. Importantly, each lead member 12 is one single continuous element from the frontside finger portion 14 to the external contact 13. There are no intermediate connections which would tend to add to the cost and reduce reliability.

The under or backside of the semiconductor chip 11 is contacted by four relatively large paddle-like tab members 16 which likewise are shaped in the beam tape. Each tab member 16, in turn, is connected to and integral with a pair of lead members 17 terminating in external contacts 18. The lead members 17 are placed at the ends of the rows of lead members 12. The tab members 16 provide large-area mechanical support for the semiconductor chip 11, as well as thermal contact and electrical contact thereto, if the latter is desired. Typically, the tab members 16 are bonded conductively to the backface of the chip 11 and provide for heat dissipation by both convection and conduction and by the spreading of heat within the silicon semiconductor chip.

Alternatively, other arrangements of backside contacts formed integrally from the lead frame may be arranged. The number, shape, and disposition of the tab members 16 may differ from that shown. For example, another arrangement may have two tab members disposed centrally on opposite sides of the chip rather than at the corners. Likewise, a considerable variety of arrangements of lead members for the tab members may be used.

Further features of the chip carrier structure of FIG. 1 will become apparent from the manner in which the encapsulation is made. In particular, the unitary structure of each contact lead 12 for the front side contacts and of each contact lead 17 for the backside contacts stems from the way in which the lead frame is produced and assembled. FIG. 2 shows a portion 20 of one beam tape of the type adapted for transporting,

reel-to-reel with precise positioning at work stations. For this purpose, the tape is furnished with sprocket holes 22. The triangular hole 31 is an identification and orientation mark. The tape 21 typically is a gold-plated copper foil having a thickness typically of about 0.1 mm (.004 inch).

Alternatively, the copper foil may be of other thicknesses and may be plated with other metals such as tin, or may be unplated. Likewise, other conductive metals, such as aluminum and suitable ferrous alloys, may be used instead of copper foil.

FIG. 2 shows the portion 20 of the tape, shaped to provide the lead frame and assembled, by bonding, to a semiconductor chip 23. Several processing steps intervene between the provision of the beam tape and the assembly shown in FIG. 2. First of all, an etch-resistant mask is formed on the tape to define a specific configuration of the lead frame. This mask defines the various frontside contact lead members 24 and the contact lead members 26 to the backside contact tabs 27. The backside contact tabs 27 also are shaped in the tape in the vacancies 30 at the corners of the lead frame pattern. Thus, the lead frame is patterned in the tape in a single plane and comprises the array of lead members 24 which terminate in frontside contacts, lead members 25 which are unused, and lead members 26 which terminate in the backside tabs 27.

As can be seen from FIG. 2 the area of contact between each of the backside tabs 27 and the backside of the chip 23 is about twenty percent of the backside area, or eighty percent for all four tabs 27.

Turning to FIG. 3, the end portion 41 of a frontside contact lead 24 of FIG. 2 is shown turned over in order to show the bonding pad 43 at the tip of the lead and the adjoining portion 42 of reduced cross-section. This configuration of bonding area and reduced cross-section portion likewise is formed by means of a specialized masking and etching operation. The adjoining

portion 42 of reduced cross-section provides strain relief for thermally induced stresses to avoid attachment failures at the contact on the semiconductor chip.

An alternative arrangement for the end portion 51 of the frontside contact lead is shown in FIG. 4. In this configuration, it is advantageous to provide a raised electrode on the semiconductor chip to which the area 53 of the lead is bonded. Strain relief is provided by a portion 52 adjoining the bonding area 53 in both of which the cross-section is reduced.

After the lead frame is formed in the beam tape, it may be coated in whole or in part with one or more thin layers of metal. Next, the lead frame is positioned in contact with a semiconductor chip 23 with the tips of the frontside contact lead members 24 over electrode members 28 on the semiconductor chip. A tool then is applied to attach the bonding pads 43 to the chip electrodes 28. The lead frame shown in FIG. 2 comprises a standard array of fourteen lead members on each of four sides, thus totaling 56. This is one specific configuration in a family of lead frames of similar size and shape. As shown, the end lead members 26, totaling eight in number, are used for making external contacts for the backside contact tabs 27. The remaining frontside contact leads are available for connecting electrodes on the semiconductor chip to external circuits. However, not all leads, such as the lead 25, are necessarily used in a particular semiconductor chip design. All of the lead portions comprising the external contacts are fabricated and retained within the moulded body to enhance mechanical strength and package uniformity. Unused members such as the lead 25 may be removed later depending on specific design needs. The tab 32 on the one lead 24 provides identification.

It will be appreciated that herein lies the design flexibility of this lead frame arrangement. Simple changes in the etch mask design can produce a variety of lead member configurations enabling accommodation to a wide variety of electrode patterns on the frontside of the semiconductor chip 23. The frontside contact lead members 24 may have a variety of configurations at the frontside lead ends and various lead ends may be omitted to adapt to various arrangements of electrodes 28 on the front surface of the chip. If desired, the backside contact tabs 27 also may be altered in shape, location, or partially omitted, as previously described. Alternatively, some of the backside contact tabs 27 may be omitted, and their respective leads 26 may be used for connecting to semiconductor chip electrodes 28.

After the frontside contact leads 24 have been bonded to the electrodes 28 on the semiconductor chip 23, the tape is reeled up, advantageously with an interleaving member which ensures that the semiconductor chips are suspended by the attached leads and therefore are available for cleaning or other processing. Thus, for example, the entire reel may be batch processed by immersion in a cleaning bath or treatment in a bake oven.

Subsequently, the tape is fed into another work station, and the backside tab members 27 are folded through 180 degrees to place them in the orientation indicated in FIG. 2 by the partially dotted outlines. This step is carried out by tool means to bend the tab members in the area 29 thereby to provide a clearance equal generally to the thickness of the semiconductor chip 23. Thus the backside contact tabs 27 make substantially planar contact with the back surface of the semiconductor chip.

The backside contact tabs 27 may be conductively attached by any of the various means previously ascribed to the term "bonding" to produce electrical or thermal contact between the tabs and chip. If a conductive epoxy is used, it is usually cured in an oven. As previously indicated,

thermal or electrical interconnection, or both, to the backside contact tabs 27 is made ultimately through the lead members 26.

Next, the tape portion 20 which remains a part of a reel, with the semiconductor chip contacted both front and back as described above, is fed into a mould wherein the plastic moulded body 10 is produced as shown in FIG. 1. In some instances, it may be advantageous, before the moulding step, to apply a protective coating to the active surface of the semiconductor chip. This may be conformal coating material such as an appropriate silicone rubber which vulcanizes at room temperature.

In a specific example the body 10 is injection moulded using a thermoplastic material such as Ryton BR06-A. Ryton is a trademark of Phillips Petroleum Corp. Thermoplastic material generally does not require a post-moulding cure period, and the moulding process may be accomplished in a time of the order of seconds, typically from about six to twenty seconds.

The injection moulded body 10 may be formed at a plurality of tape sites simultaneously, and the moulding apparatus may accommodate more than one tape. Next, in further reel-to-reel processing, the moulded packages are deflashed to remove excess moulding material and cleaned. Finally, in further reel-to-reel processing, each moulded package is excised from the tape, and the external leads are formed and trimmed. The individual packages then are fed automatically in uniform orientation into a stick-type magazine. One feature of the excising, trimming, and bending operations is that they are performed subsequently to the package moulding step. Thus, there is inherent mechanical support for the lead frame assembly during those operations. The use of special jigs or other supports to prevent deflection or distortion of the lead frame assembly during the metal-working steps is avoided.

Referring to FIG. 5, a portion 61 of a stick magazine is shown containing several packages 62, 63, 64. The plastics body of each of the packages 62, 63, 64 bears

on the internal rails 66-67, 72-73, 74-75. These rails ensure suspension of the packages in the stick in such a way that the external leads 71 do not contact any internal surfaces of the stick. The rail suspension arrangement also provides clearance all around the package so that debris within the stick will not hinder movement of the packages. The corners 69 of the moulded packages extend beyond the external leads 71 and ensure that the leads of one package do not contact those of an adjacent package or the side rails 72-73.

The packages are most advantageously handled when loaded into sticks from which they may be fed and reinserted during various testing, aging, and other operations.

CLAIMS

1. An encapsulation for a semiconductor integrated circuit chip, the chip having a front and a back side, the front side having electrodes thereon, the encapsulation comprising a moulded body member enclosing the chip, first unitory lead members connected to respective ones of the said electrodes and having integral contact portions external to the body member and second unitary lead members integral with large-area tab members in contact with the back side of the chip.

2. An encapsulation as claimed in claim 1 wherein the second unitary lead members include at least one integral contact portion external to the body member for each of the tab members.

3. An encapsulation as claimed in claim 1 or claim 2 wherein the body member is generally rectangular in plan outline and the corner portions of the body member project from the body member to protect the external contact portions of the lead members.

4. An encapsulation as claimed in claim 3 wherein the pair of external contact portions adjacent to each corner are integrally connected to a respective one of the tab members.

5. An encapsulation as claimed in any of the preceding claims wherein the first and second lead members and the tab members are all formed from a single sheet of metal foil.

6. An encapsulation for a semiconductor integrated circuit chip substantially as herein described with reference to the accompanying drawings.