

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Versatile Semiconductor Package.

We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organised according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to semiconductors. More particularly it relates to semiconductors encapsulated in a nonconductive medium and having a tab and leads which can be bent to desired shapes for mounting purposes.

Semiconductor devices have typically been mounted on solid metal headers, such as copper or steel, and have been adapted for mounting to a chassis by such means as a stud package or the conventional header which has two mounting holes such as is exemplified by the well-known TO-3 header. Such devices have been characterized by an inherent lack of flexibility and by inefficient use of the available volume of space into which components may be placed. The stud package, in particular, but also the two mounting hole header, described above, are also sensitive to torque pressures applied in mounting the device to the chassis and thus are torque-limited.

According to the present invention, an intermediate semiconductor device structure comprises a substantially flat metallic unitary member having a semiconductor mounting area, a heat conductive mounting tab portion at one end of the said member integral with the semi-conductor mounting area, an outwardly extending portion integral with the semiconductor mounting area and having a terminal cross portion having at least one finger portion extending inwardly

towards the semiconductor mounting area, the finger portion having one free end and one end integral with the terminal cross portion; a semiconductor device having at least one active region therein mounted on the semiconductor mounting area; lead means connected between the active region and the free end of the inwardly extending finger portion; and an insulating medium encapsulating the semiconductor device and the free end of the finger portion, its terminal cross-portion being exposed, whereby the terminal cross portion may be severed from the member thereby to electrically isolate the inwardly extending finger portion from the outwardly extending portion.

In a particular embodiment the terminal cross portion has a further finger portion extending inwardly towards the semiconductor mounting area, and severance of the terminal cross portion electrically isolates the two finger portions from each other.

The invention also provides a semiconductor device structure comprising: a substantially flat metallic member, one end of the member being a mounting tab, a substantially centralized portion of the member being a semiconductor mounting area and a second end of the member extending outwardly from the semiconductor mounting area; a semiconductor device having at least one active region therein mounted on the semiconductor mounting area; an insulating medium encapsulating the semiconductor device; a metallic finger extending from the encapsulation; and electrical lead means connected from the said active region to the metallic finger.

Preferably, the mounting tab protrudes from the encapsulation and is relatively wider than the finger portions.

By way of example, the invention will be

[Price 4s. 6d.]

described in greater detail with reference to the accompanying drawings, in which:

Figure 1 is a pictorial view of a transistor fabricated according to the invention;

5 Figures 2a-2d illustrate four examples of utilization of a semiconductor fabricated according to the invention;

Figure 3 illustrates a plan view of a typical mounting tab and mounting surface used in the fabrication of a semiconductor package according to the invention;

Figure 4 illustrates a pictorial view of a transistor mounted on the surface of Figure 3; and

15 Figures 5a and 5b illustrate an alternative method of mounting a semiconductor wafer to the surface of Figure 3.

The embodiment of the invention to be described, in brief, comprises a versatile semiconductor package whereby a transistor, for example, is mounted on a unitary metallic structure, one end of which serves as a flexible collector tab useful both as a mounting means and as a heat sink for the collector, and the other end is comprised of an E-shaped group of fingers. The base and emitter leads are respectively secured to the fingers, as by ball-bonding, welding or the like, and the transistor is then encapsulated in some insulating medium such as epoxy or plastic. After the plastic body is firmed, the E-shaped fingers are severed from each other to provide the leads for the semiconductor device. The leads and the collector tab would normally have holes punched therein to facilitate the mounting and provide for external wiring connections. As will be explained in greater detail below, both the tab and the leads may be formed in several configurations to provide an almost unlimited mechanical flexibility.

For a more detailed description, with specific reference to Figure 1, there is illustrated a transistor structure fabricated according to the invention, having an epoxy encapsulation 6, a collector lead 2, a base lead 3, an emitter lead 4, and a collector tab 1, having therein a mounting hole 5. It should be appreciated that the tab 1 could be severed from the body 6 if power dissipation is maintained at a low level, in which case the device may be mounted by the lead 2, 3 or 4. If desired, the tab 1 can be used as the collector lead and the lead 2 either severed to conserve space or left with no external wiring connection. In any event, the tab 1 and the leads 2, 3 and 4 can be formed into a number of different configurations to facilitate the external mounting and wiring, as more readily understood by referring to Figures 2a-2d.

In Figure 2a, the body 6 is maintained relatively flush, with the tab secured to the chassis 7, as illustrated. The leads can be formed in a variety of ways, with the solid

and dotted lines showing two examples. Another way of mounting the device is illustrated in Figure 2b, wherein the body 6 is mounted substantially perpendicular to the chassis 7, and once again the leads may be formed as desired. Figure 2c illustrates how the body 6 may be "fed through" the chassis 7, while Figure 2d illustrates how the package would appear when neither the tab nor the leads are bent away from the normal. It should be appreciated that these are merely illustrative of examples for mounting a semiconductor device fabricated according to the invention, and are in no sense to be construed as a limitation upon the invention.

Figure 3 illustrates the unitary mounting and lead structure, which consists of the mounting tab 1 and the collector, base and emitter leads 2, 3 and 4, respectively. This unitary structure may be either metallic or metallic coated, such as with copper, gold, silver, aluminum or some other good electrical and thermal conductor. The dotted line 15 represents the location of the severance which will be subsequent to the mounting of the transistor (not illustrated) and the insulating encapsulation (also not illustrated).

In Figure 4 there is illustrated a transistor 9 mounted on the collector tab 1 as by soldering. The well-known techniques of using a molybdenum substrate and so-called "hard" (high temperature) solders can also be used, as the soldering operation forms no part of the invention. The emitter lead 14 is secured both to the emitter and to the emitter lead 4, while the base lead 13 is secured both to the base region and to the base lead 3. The collector of the transistor is normally mounted directly to the tab. The transistor can have diffused emitter and base regions and, if desired, the transistor could have a planarized collector surface with another external lead secured to the collector lead 2.

After the transistor has been mounted as above described, and the lead wires secured as above, the encapsulation is formed over the transistor, illustrated by the dotted line as an epoxy body 6. Subsequently, the leads are severed at the dotted line 15 as illustrated in Figure 3. Of course, the severance could be done prior to encapsulation but would not be practical.

Figure 5 illustrates an alternative method of mounting the transistor on the tab 1 in lieu of the soldering operation. This type of mounting would probably be used most frequently whenever the process includes a heavy etching step or some other such stringent processing. Heavy etching normally carries with it an expensive plating process of the mounting surface so as to not harm the surface. In lieu of plating the whole tab, a copper slug 10, which has been adequately plated such as with nickel and gold, and which has the appearance of a rivet, and which

is effectively used as rivet, is used as the mounting surface for the semiconductor wafer 9. After the transistor is mounted on the slug and the device is electrically tested, the slug is inserted in a hole (not illustrated) in the collector tab 1 and swaged to the tab as illustrated in Figure 5b. The lip 11 of the slug helps in the swaging process.

While the device shown has been with reference to a transistor, it should be appreciated that any semiconductor device, such as a diode, capacitor, resistor, field effect device, integrated circuit, thin film circuit, hybrid circuit and the like could be so fabricated, the transistor fabrication being merely illustrative of a semiconductor device which can be packaged according to the invention. For example, if it should be desired to package an integrated circuit, the unitary structure of Figure 3 need only be expanded to have the requisite number of fingers.

Likewise, while the intermediate structure has been illustrated with reference to a single unitary member configuration, it should be appreciated that the member is merely illustrative of one embodiment and the invention is to be limited only by the appended claims.

WHAT WE CLAIM IS:—

1. An intermediate semiconductor device structure comprising:

- (a) a substantially flat metallic unitary member having a semiconductor mounting area, a heat conductive mounting tab portion at one end of the said member integral with the semiconductor mounting area, an outwardly extending portion integral with the semiconductor mounting area and having a terminal cross portion having at least one finger portion extending inwardly towards the semiconductor mounting area, the finger portion having one free end and one end integral with the terminal cross portion;
- (b) a semiconductor device having at least one active region therein mounted on the semiconductor mounting area;
- (c) lead means connected between the active region and the free end of the inwardly extending finger portion; and
- (d) an insulating medium encapsulating the semiconductor device and the free end of the finger portion, its terminal cross-portion being exposed, whereby the terminal cross portion may be severed from the member thereby to electrically isolate the inwardly extending finger portion from the outwardly extending portion.

2. A structure according to claim 1, in which the terminal cross-portion has at least one further finger portion extending inwardly towards the semiconductor mounting area,

and in which severance of the terminal cross-portion electrically isolates the finger portions from each other.

3. An intermediate semiconductor device structure according to claim 2, wherein: the terminal cross-portion has one further inwardly extending finger portion, the semiconductor device comprises a transistor having collector base and emitter regions respectively diffused therein, and the lead means comprise metallic wires respectively connecting the base and emitter regions with the two inwardly extending finger portions.

4. An intermediate semiconductor device structure according to claim 2 or claim 3, wherein the heat conductive mounting tab portion protrudes from the encapsulation, thereby to provide means for mounting the ultimate device structure.

5. An intermediate semiconductor device structure according to claim 4, wherein the mounting tab portion is relatively wider than the finger portions and provides a sturdy mounting means and an improved thermal conduction means.

6. An intermediate semiconductor device structure according to any one of the preceding claims, wherein the semiconductor device is soldered to the mounting area.

7. An intermediate semiconductor device structure according to any one of claims 1—5, wherein the semiconductor device is mounted on a metal slug swaged to the mounting area.

8. An intermediate semiconductor device structure according to claim 7, wherein the metal slug is a nickel and gold plated copper slug.

9. An intermediate semiconductor device structure according to claim 2, substantially as described herein with reference to the accompanying drawings.

10. A semiconductor device structure comprising:

- (a) a substantially flat metallic member, one end of the member being a mounting tab, a substantially centralized portion of the member being a semiconductor mounting area and a second end of the member extending outwardly from the semiconductor mounting area;
- (b) a semiconductor device having at least one active region therein mounted on the semiconductor mounting area;
- (c) an insulating medium encapsulating the semiconductor device;
- (d) a metallic finger extending from the encapsulation; and
- (e) electrical lead means connected from the said active region to the metallic finger.

11. A semiconductor device structure according to claim 10, wherein: the semiconductor device comprises a transistor having collector base and emitter regions

is effectively used as rivet, is used as the mounting surface for the semiconductor wafer 9. After the transistor is mounted on the slug and the device is electrically tested, the slug is inserted in a hole (not illustrated) in the collector tab 1 and swaged to the tab as illustrated in Figure 5b. The lip 11 of the slug helps in the swaging process.

While the device shown has been with reference to a transistor, it should be appreciated that any semiconductor device, such as a diode, capacitor, resistor, field effect device, integrated circuit, thin film circuit, hybrid circuit and the like could be so fabricated, the transistor fabrication being merely illustrative of a semiconductor device which can be packaged according to the invention. For example, if it should be desired to package an integrated circuit, the unitary structure of Figure 3 need only be expanded to have the requisite number of fingers.

Likewise, while the intermediate structure has been illustrated with reference to a single unitary member configuration, it should be appreciated that the member is merely illustrative of one embodiment and the invention is to be limited only by the appended claims.

WHAT WE CLAIM IS:—

1. An intermediate semiconductor device structure comprising:

- (a) a substantially flat metallic unitary member having a semiconductor mounting area, a heat conductive mounting tab portion at one end of the said member integral with the semiconductor mounting area, an outwardly extending portion integral with the semiconductor mounting area and having a terminal cross portion having at least one finger portion extending inwardly towards the semiconductor mounting area, the finger portion having one free end and one end integral with the terminal cross portion;
- (b) a semiconductor device having at least one active region therein mounted on the semiconductor mounting area;
- (c) lead means connected between the active region and the free end of the inwardly extending finger portion; and
- (d) an insulating medium encapsulating the semiconductor device and the free end of the finger portion, its terminal cross-portion being exposed, whereby the terminal cross portion may be severed from the member thereby to electrically isolate the inwardly extending finger portion from the outwardly extending portion.

2. A structure according to claim 1, in which the terminal cross-portion has at least one further finger portion extending inwardly towards the semiconductor mounting area,

and in which severance of the terminal cross-portion electrically isolates the finger portions from each other.

3. An intermediate semiconductor device structure according to claim 2, wherein: the terminal cross-portion has one further inwardly extending finger portion, the semiconductor device comprises a transistor having collector base and emitter regions respectively diffused therein, and the lead means comprise metallic wires respectively connecting the base and emitter regions with the two inwardly extending finger portions.

4. An intermediate semiconductor device structure according to claim 2 or claim 3, wherein the heat conductive mounting tab portion protrudes from the encapsulation, thereby to provide means for mounting the ultimate device structure.

5. An intermediate semiconductor device structure according to claim 4, wherein the mounting tab portion is relatively wider than the finger portions and provides a sturdy mounting means and an improved thermal conduction means.

6. An intermediate semiconductor device structure according to any one of the preceding claims, wherein the semiconductor device is soldered to the mounting area.

7. An intermediate semiconductor device structure according to any one of claims 1—5, wherein the semiconductor device is mounted on a metal slug swaged to the mounting area.

8. An intermediate semiconductor device structure according to claim 7, wherein the metal slug is a nickel and gold plated copper slug.

9. An intermediate semiconductor device structure according to claim 2, substantially as described herein with reference to the accompanying drawings.

10. A semiconductor device structure comprising:

- (a) a substantially flat metallic member, one end of the member being a mounting tab, a substantially centralized portion of the member being a semiconductor mounting area and a second end of the member extending outwardly from the semiconductor mounting area;
- (b) a semiconductor device having at least one active region therein mounted on the semiconductor mounting area;
- (c) an insulating medium encapsulating the semiconductor device;
- (d) a metallic finger extending from the encapsulation; and
- (e) electrical lead means connected from the said active region to the metallic finger.

11. A semiconductor device structure according to claim 10, wherein: the semiconductor device comprises a transistor having collector base and emitter regions



respectively diffused therein, a further metallic
finger extending from the encapsulation, and
electrical lead wires are respectively con-
5 nected between the base and emitter regions
and the two fingers, whereby the two fingers
and the said second end of the member
extending outwardly from the semiconductor
mounting area comprise respectively the base,
emitter and collector leads to the semi-
10 conductor device structure.

12. A semiconductor device structure
according to claim 9, substantially as de-
scribed herein with reference to the accom-
panying drawings and as illustrated by Figs.
1, 4 and 5 of the accompanying drawings. 15

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