

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,173,443

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Date of Application (No. 24471/67) and filing Complete Specification: 25 May, 1967.

Application made in United States of America (No. 554564) on 1 June, 1966.

Complete Specification Published: 10 December, 1969.

Index at Acceptance:—H1 K (217, 312, 356, 35X, 36Y, 40X, 406, 411, 41Y, 412, 422, 427, 455, 464, 470, 518, 520, 53Y, 53X, 54Y).

International Classification:—H 01 1 7/00.

COMPLETE SPECIFICATION

Semiconductor Device and Method of Fabrication thereof

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, 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 the manufacture of semi-conductor devices.

A substrate is provided herein onto which a semi-conductor device is to be assembled. A semi-conductor pellet is mounted in pre-selected position on the substrate. A terminal means having an extending or cantilevered contact is engaged with the substrate with the free end of the contact engaged with a pre-selected spot on the pellet. The relative positioning of the contact, pellet, and substrate is fixed, as for example, by encapsulating a portion of the substrate, the pellet, and a portion of the contact in a solidifying encapsulating material. The terminal means is then disengaged from the substrate, and the contact is separated from the terminal means, as by cutting, leaving the contact extending outwardly from the encapsulating material to serve as a terminal for the device.

In a preferred embodiment, a workpiece carrier comprising a plurality of connected substrates is utilized, whereby the carrier may be sequentially indexed past successive operating stations wherein the above-described operations can be automatically performed.

In the drawings:

FIGURE 1 is a plan view of a workpiece carrier;

FIGURE 2 is a plan view of a terminal

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means;

FIGURE 3 is a side elevation of the terminal means shown in FIGURE 2;

FIGURE 4 is a front elevation of the terminal means shown in FIGURE 2;

FIGURE 5 is a plan view showing a first step in the assembly of a semi-conductor device;

FIGURE 6 is a plan view showing a later step in the assembly process;

FIGURE 7 is a bottom view of the parts shown in FIGURE 6;

FIGURE 8 is a sectional view taken along line 8-8 of FIGURE 6;

FIGURE 9 is a plan view showing a still later step in the assembly process;

FIGURE 10 is a view in perspective showing a completed device;

FIGURE 11 is a view in perspective showing a modification of a workpiece carrier and a terminal means carrier;

FIGURE 12 is a sectional view showing the first step in the assembly of a device from the parts shown in FIGURE 11; and

FIGURE 13 is a view in perspective showing a completed device made from the parts shown in FIGURE 11.

With reference to FIGURE 1, an elongated, strip-like carrier 10 is shown comprising a plurality (only two of which are shown) of identical connected substrates 12. A dashed line 14 indicates the boundary between adjacent substrates. Each substrate 12 comprises a workpiece onto which a semiconductor device is to be assembled. The carrier 10 may be fabricated by known processes, such as stamping and coining.

Each substrate 12 comprises a square area 16 defined by a dovetailed groove 18 (see FIGURE 8), four clip locking slots 20, two terminal insulating slots 22, and two mounting slots 24. By "dovetailed" is meant a groove wherein one or both walls,

Each substrate 12 comprises a square area 16 defined by a dovetailed groove 18 (see FIGURE 8), four clip locking slots 20, two terminal insulating slots 22, and two mounting slots 24. By "dovetailed" is meant a groove wherein one or both walls,

or portions thereof, converge upwardly from the bottom of the groove. The purpose of these substrate portions appears hereinafter. In this embodiment, the device is a power output semiconductor, and the substrate 12 serves as a heat sink. To this end, the substrate 12 is made from a high thermal conductivity material, such as nickel plated copper, having a thickness of 125 mils.

With reference to FIGURES 2, 3 and 4, a terminal means or clip 28 is shown which is to be assembled one each onto each substrate 12. The clip 28 has a generally U-shaped or channel-iron shape including a pair of spaced cross straps 30 joined by dependent sides 32 each having a cutout 34. Two contact members 36 extend towards one another from the cross straps 30. Each contact member 36 includes a rectangular opening 38, and terminates in a downwardly extending tip 40. The purpose of these clip portions appears hereinafter.

The clip 28 may be formed from sheet metal by known stamping and forming processes. The clip is made from an electrically conductive, readily bonded material, such as nickel strip of 10 mils thickness.

In the assembly of a semiconductor device on each substrate 12 of the carrier 10, identical operations are performed either successively or simultaneously on each substrate. Apparatus for performing these operations, including apparatus for indexing the carrier to an accurately positioning the substrates at each operating station, are described either only generally or not at all since the provision of suitable apparatus for performing these functions is well within the ability of persons skilled in the arts.

In a first assembling operation, a semiconductor pellet 44, as shown in FIGURE 5, is placed and held on the area 16 of the substrate 12. Placing and holding means comprising a pair of oppositely acting combing members 46, of known type, can be used, for example, to hold the pellet 44 in precise relationship with the substrate 12. Although not shown, means can be utilized for automatically feeding the pellets 44 from a magazine onto the substrate 12.

The semiconductor pellet 44 used depends upon the type of semiconductor device being assembled, and may be of a known type used in transistors, integrated circuits, or the like. In this embodiment, the device is an NPN transistor using a pellet 44 of silicon. Details of the pellet 44 are not shown, since such pellets are well known. The pellet 44 is provided with bonding pads, of known type, to which contacts or terminals of the semiconductor device are to be attached. In this embodiment, the

bonding pads comprise a thin layer of a solder material such as lead. The bottom surface of the pellet, which, in this embodiment, is electrically connected to an electrode of the pellet, is likewise coated with lead.

While the pellet 44 and the substrate 12 are held in fixed relation with respect to one another, a clip 28 is mounted onto the substrate. To accomplish this, the clip 28 is disposed across the substrate 12, as shown in FIGURES 6 and 7, with the inner ends 35 of the walls 32 extending into the clip locking slots 20. Means, not shown, are utilized to accurately position the clip 28 with respect to the substrate 12 and the pellet 44 thereon, and to force the clip downwardly against the substrate 12, whereby the contact tips 40 are engaged with their respective pellet bonding pads (FIGURE 8). The relative dimensions of the assembly parts are so selected that as the clip 28 is forced downwardly against the substrate 12, the contact tips 40 are firmly pressed against the pellet bonding pads and the contact members 36 are upwardly flexed. The flexed contact members 36 thus serve as tensioned springs holding the pellet 44 firmly clamped against the substrate 12. While the assembly is so held in pressed relationship, the clip 28 is locked to the substrate 12. This is accomplished by inwardly swaging the outer slot walls 20' (FIGURE 9) of the clip locking slots 20 to firmly lock or clamp the clip sides 32 between the walls of the slots 20. Suitable swaging devices are well known. A relatively rigid workpiece assembly is thus produced.

The assembly is then heated to melt the solder on both sides of the pellet 44 to fusion bond or solder the pellet 44 to the substrate 12, and to solder the contact tips 40 to the pellet bonding pads.

An encapsulating material 56 is then molded onto the assembly, as shown in FIGURE 9. Means for applying the encapsulating material are known, hence are not shown. The rectangular openings 38 (FIGURE 6) in the contact members 36 facilitate passage of the encapsulating material into the region adjacent the pellet 44. As shown, the encapsulating material 56 completely encapsulates the pellet 44 and substantially all of each contact member 36. The encapsulating material 56 also lines the walls of the terminal insulating slots 22 (FIGURE 10). Upon hardening, the encapsulating material 56 forms a solid enclosure rigidly fixing the relative positioning of the substrate 12, the pellet 44, and contact members 36.

The encapsulating material 56 also enters into the dovetail groove 18 (FIGURE 8) thereby firmly anchoring the encapsulating material, when hardened, within the groove,

hence to the substrate 12. This provides the finished device with great mechanical strength.

To complete the device, the workpiece assembly is separated from the carrier 10 by cutting through the carrier along the dashed lines 14 shown in FIGURE 1. The unencapsulated portions of the clip 28 are also removed, as by cutting through the slot walls 20' to release the clip. In this embodiment, two elongated device contacts or terminals 36' are provided by cutting the clip straps 30 along the dashed lines 58 shown in FIGURE 9.

The completed device is shown in FIGURE 10 with the two terminals 36' extending horizontally away from the device. Although not shown, the terminals 36' can be bent to extend in any direction, including a downward direction through the terminal slots 22. Shorting of the terminals 36' against the substrate 12 is prevented by the presence of the encapsulating material lining the slot 22 walls.

In this embodiment, a third terminal of the device is the substrate 12 to which the pellet is directly bonded. In another embodiment, not shown, the semiconductor pellet is insulated from the substrate 12 by means of an intermediate ceramic plate bonded to the substrate and to the pellet by known means. In such case, a clip having three contact members is used. Preferably, a high thermal conductivity ceramic such as beryllia is used.

Likewise, for semiconductor devices such as integrated circuits having larger numbers of terminals, clips having the required number of terminals can be used.

In use, the completed device is mounted on a chassis by means of screws, or the like, extending through the mounting slots 24. The substrate 12 directly engages the chassis, not shown, whereby excellent heat sinking of the device can be obtained.

In another embodiment, a strip 60 (FIGURE 11) of a plurality of connected substrates 62, and a strip 64 of a plurality of connected terminal means or clips 66 are provided, only two substrates and two clips being shown. Each substrate 62 includes a clip locking slot 68. Each clip 66 is provided with a pair of extending contacts 70 having dependent, converging tips 72 on the ends thereof, and a locking contact 74. The locking contact 74 is L-shaped with the angle α between the two legs 76 and 78 thereof being greater than 90° . In this embodiment, the angle α is 95° .

In the assembly of semiconductor devices from the substrates 62 and clips 66, each clip 66 of the clip strip 64 is simultaneously engaged and locked to a respective substrate 62 of the substrate strip 60. For convenience, the assembly of a single device

is illustrated.

As shown in FIGURE 12, a clip 66 is mounted on a substrate 62 having a pellet 80 thereon by inserting the clip locking contact 74 into the slot 68. The dependent tips 72 of the contacts engage pre-selected portions of the pellet 80, with the flat portion 82 of the clip 66 spaced above the substrate 62. Because of the angle α between the legs 76 and 78 of the contact 74, only the leading tip 78' of the leg 78 engages the substrate 62. At this time, the pellet 80 is being held by combing means, not shown, in pre-selected position on the substrate.

The clip 66 is then locked to the substrate 62 by swaging over the slot 68 walls 68' against the contact 74. The swaging pressure forces the leg 78 of the contact 74 into full surface contact with the slot wall 69, whereby the clip 66 is tilted or pivoted in a clockwise direction, as viewed in FIGURE 12. The tilting of the clip 66 serves to press the dependent tips downwardly against the pellet 80 firmly clamping the pellet in place between the tips 72 and the substrate 62.

The assembly is then heated to melt soldering material previously provided on the pellet 80 and the clip 66 to fusion bond or solder the pellet to the substrate, and to solder the contacts 70 and 74 to the pellet 80 and the substrate 62, respectively. The pellet 80 and the contacts 70 and 74 are then encapsulated in a suitable encapsulating material 84 (FIGURE 13). The clip 66 is then cut along the dashed lines 86 (FIGURE 11) to provide three terminals 70' and 74' for the device. The terminals 70' are electrically connected to a pellet 80, and the terminal 74' is electrically connected to the substrate 62.

Devices made as described herein are inexpensive and simple to make, and are extremely rugged and reliable. Also, as will be apparent to those skilled in the art, the herein described processes are readily adaptable to mechanization, whereby large numbers of devices can be quickly and inexpensively fabricated by automated processes.

WHAT WE CLAIM IS:—

1. A method of fabricating semiconductor devices including positioning a semiconductor pellet on a substrate in preselected relation therewith; engaging a contact member of a terminal means with said pellet, and securing said terminal means to said substrate for maintaining said contact member firmly pressed against said pellet; bonding said contact member to said pellet; and disengaging portions of said terminal means from said substrate leaving said contact member engaged with and extending outwardly from said pellet as a lead therefor.

2. A method as claimed in Claim 1

hence to the substrate 12. This provides the finished device with great mechanical strength.

To complete the device, the workpiece assembly is separated from the carrier 10 by cutting through the carrier along the dashed lines 14 shown in FIGURE 1. The unencapsulated portions of the clip 28 are also removed, as by cutting through the slot walls 20' to release the clip. In this embodiment, two elongated device contacts or terminals 36' are provided by cutting the clip straps 30 along the dashed lines 58 shown in FIGURE 9.

The completed device is shown in FIGURE 10 with the two terminals 36' extending horizontally away from the device. Although not shown, the terminals 36' can be bent to extend in any direction, including a downward direction through the terminal slots 22. Shorting of the terminals 36' against the substrate 12 is prevented by the presence of the encapsulating material lining the slot 22 walls.

In this embodiment, a third terminal of the device is the substrate 12 to which the pellet is directly bonded. In another embodiment, not shown, the semiconductor pellet is insulated from the substrate 12 by means of an intermediate ceramic plate bonded to the substrate and to the pellet by known means. In such case, a clip having three contact members is used. Preferably, a high thermal conductivity ceramic such as beryllia is used.

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In another embodiment, a strip 60 (FIGURE 11) of a plurality of connected substrates 62, and a strip 64 of a plurality of connected terminal means or clips 66 are provided, only two substrates and two clips being shown. Each substrate 62 includes a clip locking slot 68. Each clip 66 is provided with a pair of extending contacts 70 having dependent, converging tips 72 on the ends thereof, and a locking contact 74. The locking contact 74 is L-shaped with the angle α between the two legs 76 and 78 thereof being greater than 90° . In this embodiment, the angle α is 95° .

In the assembly of semiconductor devices from the substrates 62 and clips 66, each clip 66 of the clip strip 64 is simultaneously engaged and locked to a respective substrate 62 of the substrate strip 60. For convenience, the assembly of a single device

is illustrated.

As shown in FIGURE 12, a clip 66 is mounted on a substrate 62 having a pellet 80 thereon by inserting the clip locking contact 74 into the slot 68. The dependent tips 72 of the contacts engage pre-selected portions of the pellet 80, with the flat portion 82 of the clip 66 spaced above the substrate 62. Because of the angle α between the legs 76 and 78 of the contact 74, only the leading tip 78' of the leg 78 engages the substrate 62. At this time, the pellet 80 is being held by combing means, not shown, in pre-selected position on the substrate.

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The assembly is then heated to melt soldering material previously provided on the pellet 80 and the clip 66 to fusion bond or solder the pellet to the substrate, and to solder the contacts 70 and 74 to the pellet 80 and the substrate 62, respectively. The pellet 80 and the contacts 70 and 74 are then encapsulated in a suitable encapsulating material 84 (FIGURE 13). The clip 66 is then cut along the dashed lines 86 (FIGURE 11) to provide three terminals 70' and 74' for the device. The terminals 70' are electrically connected to a pellet 80, and the terminal 74' is electrically connected to the substrate 62.

Devices made as described herein are inexpensive and simple to make, and are extremely rugged and reliable. Also, as will be apparent to those skilled in the art, the herein described processes are readily adaptable to mechanization, whereby large numbers of devices can be quickly and inexpensively fabricated by automated processes.

WHAT WE CLAIM IS:—

1. A method of fabricating semiconductor devices including positioning a semiconductor pellet on a substrate in preselected relation therewith; engaging a contact member of a terminal means with said pellet, and securing said terminal means to said substrate for maintaining said contact member firmly pressed against said pellet; bonding said contact member to said pellet; and disengaging portions of said terminal means from said substrate leaving said contact member engaged with and extending outwardly from said pellet as a lead therefor.

2. A method as claimed in Claim 1



including the step of securing said terminal means to said substrate with said contact member firmly pressed against said pellet for clamping said pellet against said substrate.

3. A method as claimed in Claim 1 or 2 including the step of disposing a portion of said terminal means in a slot in said substrate and swaging the walls of said slot onto said portion for locking said terminal means to said substrate.

4. A method as claimed in any preceding claims including temporarily securing portions of said terminal means to said substrate, permanently securing said contact member to said pellet, and severing said temporarily secured portions of said terminal means from said contact member leaving said contact member extending outwardly from said pellet.

5. A method as claimed in Claim 4 including the step of fusion bonding said contact member to said pellet and fusion bonding said pellet to said substrate.

6. A method as claimed in any preceding claim including a step of encapsulating said pellet, a surface portion of said substrate, and portions of said contact member in a solidifying encapsulating material.

7. A method as claimed in Claim 1 including positioning a semiconductor pellet on a substrate in pre-selected relation therewith, locking a clip onto said substrate with an extending contact member of said clip firmly pressed against a pre-selected portion of said pellet thereby clamping said pellet against said substrate, encapsulating said pellet, portions of said substrate, and portions of said contact member in a solidifying encapsulating material, and removing portions of said clip leaving a terminal member extending outwardly from said encapsulating material.

8. A method as claimed in Claim 7 including the step of severing a portion of said clip locked to said substrate and severing portions of said clip adjacent to

said contact member leaving an elongated terminal member extending outwardly from said encapsulating material.

9. A method as claimed in Claim 7 or 8, including the steps of fusion bonding said contact member to said pellet and fusion bonding said pellet to said substrate.

10. A method of fabricating a semiconductor device substantially as hereinbefore described with reference to the accompanying drawings.

11. A semiconductor device fabricated by the method as claimed in any of claims 1 to 9 including, a substrate, a semiconductor pellet mounted on one surface of said substrate, encapsulating material forming a solid enclosure encapsulating said pellet and a portion of said one surface, and a terminal member electrically engaging said pellet and extending through and outwardly of said enclosure.

12. A semiconductor device as claimed in Claim 11 wherein said substrate is of a high thermal conductivity material, and the surface of said substrate opposite said one surface is unencapsulated.

13. A semiconductor device as claimed in Claim 11 or 12 including means for anchoring said encapsulating material to said one surface said anchoring means comprising a dovetailed groove.

14. A semiconductor device as claimed in any preceding claim wherein said substrate has a slot therethrough, the walls of said slot being covered by said encapsulating material, and said terminal extends through said slot.

15. A semiconductor device substantially as hereinbefore described with reference to the accompanying drawings.

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