

One of the most widely used plastic encapsulations for small-power semiconductor devices, such as transistors, thyristors, or similar three-lead semiconductor devices, is the standardized T0-92 package, which has the shape of a cylinder with a segment cut off parallel to the center line. The semiconductor chip and its leads are hermetically embedded in plastic and, thus, protected against mechanical and chemical influences, such as the penetration of moisture.

In the fabrication of such semiconductor devices with a plastic encapsulation, the manufacture of the die starts with a semiconductor wafer on which several hundred to several thousand identical dice are fabricated, and the manufacture of the leads of the semiconductor device starts with a lead frame in which several thousand leads are firmly interconnected by cross-links which are removed in one of the last process steps before the final test in order to eliminate the short circuit caused by the cross-links.

In the set of leads belonging to a single semiconductor device - in the case of the T0-92 package, this is a lead triplet - the inner end of one of the leads has such a large area that the die can be conductively attached thereto, e.g., by means of a conductive adhesive.

During manufacture, the unequipped lead frame unwinds from a reel and first reaches a die-mounting station, in which the individual dice are removed from the semiconductor wafer and mounted on the lead area intended therefor. In a bonding station, the inner ends of the other leads of the semiconductor device are then connected with contact areas of the die by fine wires. Next, the die and the fine wires are provided with a synthetic-resin cover, after which the lead frame is reeled again, because packaging is performed in a fabrication step spatially separated from the steps described so far. As a result, the time required by a lead frame to pass through all stages of the manufacturing process is very long.

The mounting of the die on the lead frame, the bonding of the latter to the contact areas of the die, and the covering of the die are spatially separated from the packaging step for several reasons. On the one hand, the devices needed for these operations greatly differ in size, so that they cannot be directly spatially associated with one another. On the other hand, the encapsulating devices are molds, for example, which operate with high pressure and, thus, require heavier foundations than the die-mounting, bonding and covering devices. Finally, the latter devices and the presses have different cycle times, which are difficult to adapt to one another.

The manufacturing method described also results in so-called webs between the individual leads, which are unavoidable because one of the above-mentioned cross-links is necessary to seal the injection or compression mold. These webs must be removed in a separate, sandblasting-like process step, so that the lead frames, which are wound on a reel after the plastic encapsulation, must be transported to the place where this step is performed.

Finally, the manufacturing process described requires the use of plastics whose composition is adapted to the specific requirements of both the molding process and the above-mentioned properties, i.e., the selection of the plastics is subject to a number of constraints. For example, they must be sufficiently flowable at as low a pressure as possible so as to fill the mold without forming shrink holes, and nevertheless perform their protective function on the finished semiconductor device.

Although the process described is a well-proved mass-production process and, being the least expensive process so far, has gained such wide acceptance that it can be described as today's standard process, efforts are being made, particularly with a view to further reducing the manufacturing costs of the semiconductor devices, to modify it and provide semiconductor devices which can be manufactured at even lower cost.

From Patent Abstracts of Japan, Volume 7, No. 233 (E-204) [1378], 15 October 1983, and JP-A-58121652, a semiconductor device is known where the leaded semiconductor component is fixed on the bottom of a can-shaped housing which is filled with a cast resin. The sidewalls of the housing have a groove extending parallel to the bottom. The cast resin penetrates into the groove, with the strength of the cast resin in the can being improved.

Accordingly, the object of the invention as claimed is to provide a semiconductor device which has a plastic encapsulation that is constructed differently from the hitherto widely used plastic encapsulations to achieve the cost reduction. Also, the design of the leads is to differ

from the conventional design to the extent required by the novel plastic encapsulation. It is also within the scope of the object of the invention to provide an apparatus with which the plastic encapsulation can be placed on the lead frame provided with the chips etc. Finally, an assembly facility is to be provided which the unequipped lead frame enters and from which the lead frame equipped with the plastic-encapsulated semiconductor devices can be taken.

One of the fundamental ideas of the invention is to manufacture the plastic package, hitherto formed at the lead frame only during the molding of the die, as a can-shaped housing in a separate step, which offers the advantage of, e.g., greater freedom in the choice of the starting plastic and the temperatures and pressures to be used in the molding process, to fill the can with a cast resin prior to the insertion of the die etc., and to locate the can placement station in close proximity to the stations for mounting the die etc.

The invention offers the following advantages. A low-cost plastic can be used for the can. The step of removing the webs and, thus, the device necessary for this purpose are eliminated. The molds for producing the can-shaped housings can be simpler in design and, thus, smaller than the molds used so far. The need for two transfers of the equipped lead-frame reels (assembly station of conventional kind — molds, molds — sandblasting device)

is eliminated. This reduces the above-mentioned total time of passage of the lead frame considerably, e.g., by more than one half. All process steps necessary to manufacture the plastic encapsulation with the die and its leads can be performed in a single assembly facility which does not take up more area than a conventional assembly facility, so that a large number of such assembly facilities can be accommodated in a manufacturing shop as before, because the can placement station can be located above the stations of the conventional assembly facility.

The invention will now be explained in greater detail with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of an embodiment of the semiconductor device according to the invention;

Fig. 2 is an enlarged front view of the embodiment of Fig. 1 without cast-resin filling;

Fig. 3 is a central vertical section through the arrangement of Fig. 1;

Fig. 4 shows an embodiment of a lead frame as used in the invention;

Fig. 5 is a perspective schematic view of an embodiment of an apparatus according to the invention for inserting dice and their leads into can-shaped housings;

Fig. 6 is a schematic view of an embodiment of an assembly facility according to the invention, and

Fig. 7 is a schematic view of an embodiment of part of the stations of the assembly facility of Fig. 6.

The perspective view of the embodiment of Fig. 1 shows a transistor or thyristor in the above-mentioned T0-92 package. The can-shaped housing 1, henceforth called "can" for short, is filled with cast resin 2, which has cured around the finished device. The cast resin is sufficiently liquid at room temperature to be filled into the cans 1. The three leads 3, via which the transistor or thyristor can be connected to the circuit in which it is to be used, project from the cast resin 2.

Fig. 2 shows the internal structure of the embodiment of Fig. 1 in an enlarged view. To achieve this representation, no cast resin has been filled into the can 1 and the synthetic-resin cover 5 (cf. Fig. 7) has been omitted, so that the leads 30, 31, 32 and the die 4 as well as further details can be represented in the drawing.

Each of the two outer leads 31, 32 is provided with a lug 7 which engages the corresponding groove 61, 62 with a slight press fit. The press fit is obtained by suitable choice of the outer dimensions of the lug with respect to the inner dimensions of the grooves in the side-walls. The slight press fit is to prevent the cans from

falling off the lead frame as long as the cast resin has not cured yet.

The groove 61 begins at the opening of the can 1 and extends toward the bottom 1a of the can in a direction perpendicular thereto. In the bottom 1a, the groove 60 runs perpendicularly toward the opposite sidewall, in which the groove 62 extends parallel to the groove 61 up to the opening. It is not necessary for the grooves 61, 60, 62 to form one continuous groove, but they should lie in one plane.

Instead of providing the two outer leads 31, 32 with the lugs 7, it is within the scope of the invention to form the outer leads 31, 32 in a different manner so that they will engage the grooves 61, 62. This can be done, for example, by making the leads 31, 32 wider inside the housing than outside the housing, but this widening need not extend over the entire length of the inner lead ends.

On the inner end of the central lead 30, which has a correspondingly large area, the die 4 is mounted, while each of the other contact areas at the surface of the die are connected to one of the outer leads 31, 32 by a bonding wire. The die 4, the bonding wires, and corresponding portions of the leads are provided with the synthetic-resin cover 5 (cf. Fig. 7). The latter can be formed, for example, by depositing a suitable quantity of synthetic-resin powder which is subsequently cured by being heated, or applying a drop of flowable synthetic resin and then curing it.

In a preferred embodiment of the invention, in a T0-92 package, the hollow space of the can 1 is only so wide in the direction perpendicular to the plane of the inserted leads 3 that the die 4 with the synthetic-resin cover can just be inserted. Then, the areas of the leads facing away from the die rest on the inner surface 1c, which is parallel to the outer segment surface 1b of the T0-92 package, and the grooves 61, 62 run along the transition of this inner surface to the sidewalls of the hollow space.

Fig. 3 shows a central vertical section through the arrangement of Fig. 2, so that it can also be seen how the end portion 38 (cf. Fig. 4) of one of the inner lead ends is fitted in the bottom groove 60.

A part of the lead frame 8 used in the invention is shown in the embodiment of Fig. 4. The leads 3 are combined into lead triplets by being stiffened and firmly interconnected by means of the narrow cross-link and the wide cross-link, which contains sprocket holes whose spacing is equal to the pitch of the lead frame 8. In the area of the inner lead ends 39, the lugs 7, the flat widening 37 of one of the leads - in Fig. 4, this is the outer lead 31, while in Fig. 2 this is the central lead 30 for graphic reasons -, and the end portion 38 are shown.

Fig. 5 is a perspective, schematic view of an embodiment of an apparatus according to the invention for inserting chips and their leads into the can-shaped housings described. This apparatus contains the feed rail 10, which the cans enter with their openings directed upwards. They

may have been aligned in one of the conventional alignment devices, such as a screw conveyor of suitable design. In the case of the T0-92 packages, they are so aligned that their side surfaces slide along one sidewall of the rail 10.

The centering slide 11, which is movable in the longitudinal direction of and perpendicular to the feed rail 10, can grasp a predetermined subset 9 of cans 1 and is disposed at the exit end of the feed rail 10. In Fig. 5, five cans form the subset 9.

Disposed behind the exit opening of the feed rail 10 is the swivelling gripper 12, onto which the subset 9 is pushed by the centering slide 11. According to an advantageous aspect of the invention, each can 1 can be held on the swivelling gripper 12 via one of the suction openings 22. The swivelling gripper 12 is rotatable about its longitudinal axis through, e.g., 90° , so that the cans 11 of the subset 9, which are held on the gripper 12 with their openings directed upwards can be rotated so that the plane of their openings is approximately vertical.

Mounted above the openings of the cans 1 is the cast-resin-metering device 13, which has a number of outlets 14, preferably in the form of outlet tubules, equal to the number of cans of the subset 9, and which fills just as much cast resin into the hollow spaces of the cans 1 that after insertion of the dice, etc., the hollow spaces are full. The spacing of the outlets 14 is equal to the spacing of

the cans. The cast-resin-metering device 13 can be located either above the cans of the subset 9 to be grasped by the centering slide 9 or above the subset held in place by the swivelling gripper 12, the latter alternative being generally preferred because in that case the cans are particularly well fixed before being filled with cast resin.

The lead frame 8, provided with the dice, their bonding wires, and the synthetic resin cover, travels above the swivelling gripper 12 and is temporarily fixed by the hold-down device 15, so that by rotating the swivelling gripper 12, the subset of cans held by the latter can be slipped over the dice, with each can fitting on one die etc.

In a preferred embodiment of the apparatus of Fig. 5, the feed rail 10 has a U-shaped section with the bottom 16, the longer leg 17 and the shorter leg 18. The centering slide 11 is disposed at the shorter leg 18, so that the T0-92 cans rest with their side surfaces against the longer leg 17 and rise above the shorter leg 18, so that they can be grasped by the centering slide 11.

In another preferred embodiment of the apparatus of Fig. 5, the swivelling gripper 12 has a rectangular recess 19 whose vertical surface 20 is flush with the inside wall of the longer leg 17 of the feed rail 10, and whose horizontal surface 21 is flush with the bottom 16. The vertical surface 20 preferably contains the above-mentioned suction openings 22.

Fig. 6 shows a scheme of an assembly facility according to the invention for a plurality of semiconductor devices according to the invention. On one side of the facility, the unequipped lead frame 8 is wound on the reel 81. From there, it moves in the direction indicated by the arrow, passing through the die-mounting station 23, the bonding station 24, the covering station 25, the can placement station 26, and the curing station 27, unless curing is performed at the equipped lead-frame reel. After leaving the curing station 27, the lead frame 88, now equipped with the semiconductor devices, is wound on the reel 82.

Fig. 7 shows the succession of the stations 23...26 of Fig. 6. The lead frame 8, in which the sprocket holes in the wide cross-link have been omitted for simplicity, moves below the individual stations. The die-mounting station 23 contains the pickup device 28 and, if necessary, a conductive-adhesive-metering device which applies a droplet of conductive adhesive to the lead frame before the die 4 is put on. The die 4 is lifted off the above-mentioned diced semiconductor wafer by the rotatably mounted pickup device 28 via the tubule 29, which holds the die by suction and releases it when placing it on the lead frame 8.

The bonding station 24 contains the swivelling holder 41, to which the additional tubule 42 is attached. The bonding wire, which unwinds from a reel (not shown), runs through this tubule and emerges at its tip. By lowering the tubule 42, the bonding wire is pressed on the metal layer of the contact area of the die 4. Attached parallel

to the tubule 42 is the additional tubule 44, through which a reducing agent, such as hydrogen, for reducing the surface of the flat lead end 37 can be applied if this end is made of copper, for example, as is generally the case.

In the covering station 25, the above-mentioned quantity of covering material is applied - in powder or droplet form - to the die 4 mounted on the lead end 37 and to the bonding wires. Finally, the lead frame 8, which is moved step by step from the left to the right (direction of arrow) by means of the sprocket holes shown in Fig. 4, reaches the can placement station 26, an embodiment of which is shown in Fig. 5 and which is indicated only schematically in Fig. 7 by the parts 12, 15 for ease of illustration. The lead frame may then travel on to the curing station 27, which is constituted in the simplest case by a heat or ultraviolet-light source mounted above or below the lead frame.

Finally, the method of manufacturing the plurality of semiconductor devices will be explained. The dice 4 are mounted on the flat lead ends 37, and their contact areas are connected with the other associated lead ends 39. Next, each die 4 is provided with the synthetic-resin cover 5. Then, the subset 9 of the plurality of cans 1 is simultaneously filled with the cast resin 2, and after that, the associated dice 4, together with their lead ends 39, are simultaneously inserted into the cans. The lead frame 8 is then heated to cure the cast resin 2 and, if necessary, to further cure the synthetic-resin cover 5.

The synthetic-resin cover 5 is formed by applying a measured quantity of synthetic-resin powder or a corresponding synthetic-resin drop and then heating it.

Those of ordinary skill in the art will be readily able to modify the invention so that it can also be realized for plastic-package types other than that described with the aid of the embodiment. It is clear to the person skilled in the art that the design of the apparatus according to the invention for placing the cans on the dice etc. is dependent on the shape of the package, and that for other package types, this apparatus must be slightly modified.



Claims

1. Semiconductor device comprising

- a prefabricated plastic can (1) filled with cast resin (2),
- a die (4) which is seated on the inner end of one of several leads (3), said inner end being inserted in the can (1), and which has areas each connected with the inner end of one of the other leads (3), and is provided with a synthetic-resin cover (5),
- grooves (61, 60, 62) in the hollow space of the can (1) which extend, respectively, from the opening of the can along one sidewall toward the bottom (1a) in a direction perpendicular to the bottom (1a), along the latter, and along the other sidewall parallel to said one sidewall, and
- inner ends (39) of the leads (3) so inserted into the cans (1) that each of the outer leads (31, 32) engages the corresponding sidewall groove (61, 62) with a slight press fit, and that end portions (38) of at least one inner lead end (39) engage the bottom groove (60) at least in part.

2. A semiconductor device as claimed in claim 1 wherein at least one lug (7) is provided on those edges of each



of the outer leads (31, 32) which are directed toward the sidewalls.

3. A semiconductor device as claimed in claim 1 or 2 wherein in the plane perpendicular to the plane of the inserted leads (3), the hollow space of the can (1) is only so wide that die (4), leads (3), and synthetic-resin cover (5) are just insertable.

4. Method of manufacturing a plurality of semiconductor devices as claimed in any one of claims 1 to 3, wherein

- the leads (3) of the semiconductor devices are combined to form a lead frame (8) which is electrically and mechanically separated into the leads (3) associated with the individual semiconductor devices only after completion of the encapsulations of the semiconductor devices,

- a die (4) is mounted on an flat end (37) of one of the leads associated therewith, and its contact areas are connected with the ends (39) of the other associated leads,

- each die (4) is then provided with the synthetic-resin cover (5),

- a plurality of cans (1) are provided,

- a subset (9) of the plurality of cans (1) is simultaneously filled with the necessary quantity of cast resin (2), and the associated dice (4), together with their inner lead ends (39), are then inserted simultaneously, and



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- the lead frame (8) is then heated to cure at least the cast resin (2).

5. A method as claimed in claim 4, characterized in that the synthetic-resin cover (5) is formed by applying a synthetic-resin drop or synthetic-resin powder and then heating it.

6. Apparatus for inserting dice (4) and their leads into cans (1) as claimed in claim 4 or 5, comprising

- a feed rail (10) which the cans (1) enter with their openings directed upwards and at whose exit end is disposed a centering slide (11) which is movable in the longitudinal direction of and perpendicular to the feed rail (10) and grasps the subset (9) laterally,

- a swivelling gripper (12) which follows the exit opening of the feed rail (10) and onto which the subset (9) is pushed by the centering slide (11),

- a preferably vertically movable cast-resin-metering device (13) disposed above the openings of the cans (1) and having a number of outlets (14) equal to the number of cans (1) of the subset (9), the spacing of said outlets (14) being equal to that of the cans arranged side by side, and

- a hold-down device (15) which temporarily fixes a section of the lead frame (8) containing at least some dice (4) and is so mounted above the swivelling gripper (12)



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that the subset of cans held by the latter fits on the fixed dice (4) after a swivelling motion.

7. An apparatus as claimed in claim 6, characterized in that the feed rail (10) has a U-shaped section with a bottom (16), a longer leg (17), and a shorter leg (18), and that the centering slide (11) is disposed at the shorter leg (18).

8. An apparatus as claimed in claim 7, characterized in that the swivelling gripper (12) has a rectangular recess (19) whose vertical surface (20) is flush with the inside wall of the longer leg (17), and whose horizontal surface (21) is flush with the bottom (16) of the feed rail (10).

9. An apparatus as claimed in any one of claims 6 to 8, characterized in that the cast-resin-metering device (13) is provided with an outlet tubule.

10. An apparatus as claimed in any one of claims 6 to 9, characterized in that the swivelling gripper (12) has a number of suction openings (12) in the vertical surface (20) which is equal to the number of cans (1) of the subset (9).

11. Assembly facility for a plurality of semiconductor devices as claimed in any one of claims 1 to 3,

- on one side of which an unequipped lead frame (8) is wound on a reel (81) from which it passes through the



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following stations arranged one behind the other in the direction of transport:

-- a die-mounting station (23),

-- a bonding station (24),

-- a covering station (25),

-- a can placement station (26), and

- on the other side of which assembly facility the lead frame (88) equipped with the semiconductor devices is wound on a reel (82).

12. An assembly facility as claimed in claim 11 and comprising a curing station (27) behind the can placement station (26).