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(72) Inventeurs/Inventors:
Yoshitake, Junichi, JP;
Tominaga, Kaoru, JP;
Katayama, Shigeru, JP

(73) Propriétaire/Owner:
MITSUI CHEMICALS INC., JP

(74) Agent: SMART & BIGGAR

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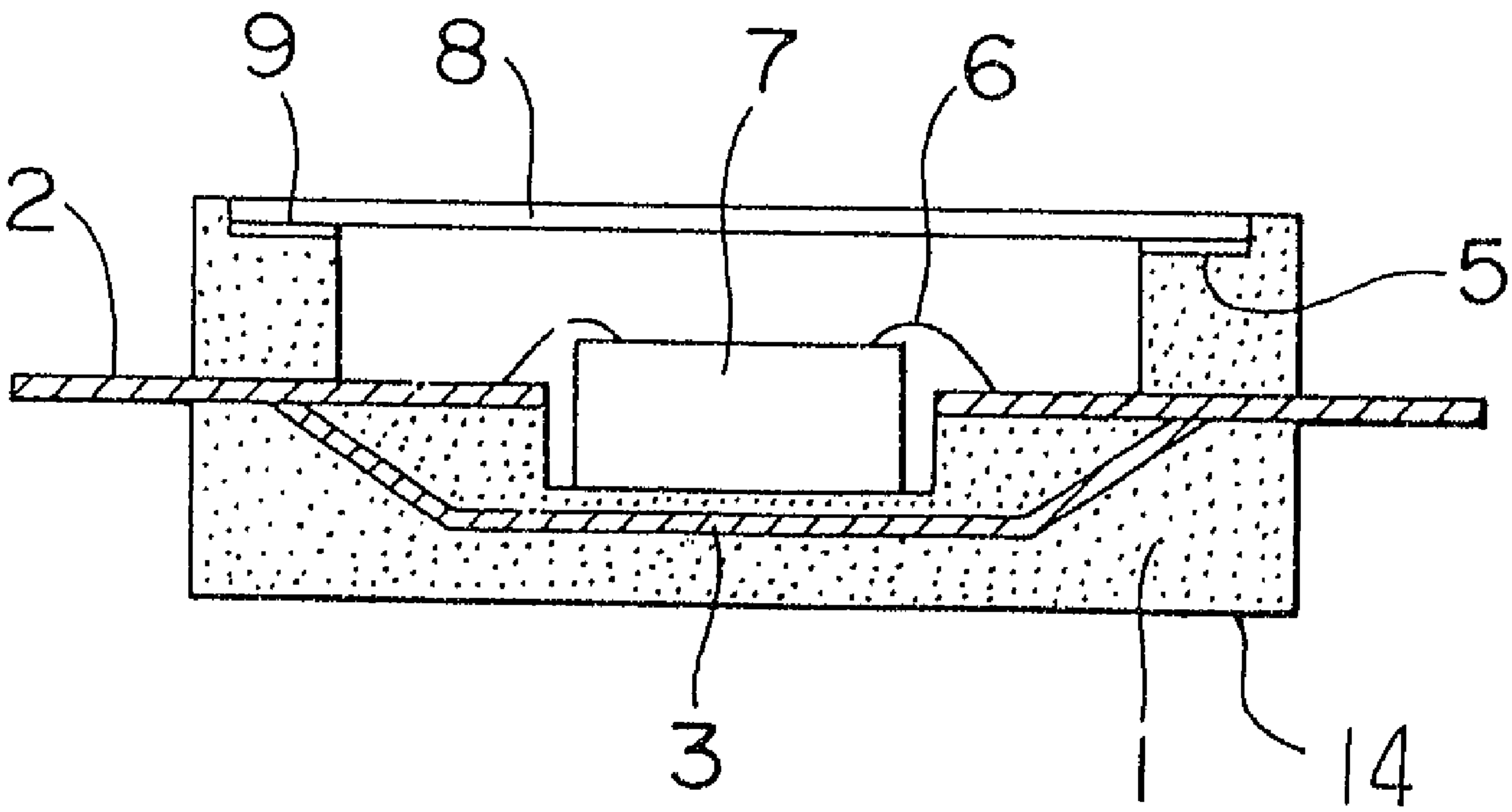

(57) Abrégé/Abstract:
This invention relates to a package construction of a semiconductor device and provides a hollow package for holding a semiconductor device in which a vapour-impermeable moistureproof plate is embedded in a bottom surface thereof or at a position inwardly of the bottom surface to provide increased moisture impermeability of the package.

ABSTRACT OF THE DISCLOSURE

This invention relates to a package construction of a semiconductor device and provides a hollow package for holding a semiconductor device in which a vapour-impermeable moistureproof plate is embedded in a bottom surface thereof or at a position inwardly of the bottom surface to provide increased moisture impermeability of the package.

SEMICONDUCTOR DEVICE AND METHOD FOR MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to a semiconductor device and method for manufacturing the same. More specifically the invention relates to a semiconductor device in which the moisture impermeability of an airtight sealed semiconductor package is increased, and a method of manufacturing the same.

In semiconductor chips such as IC, LSI or VLSI, the highly integrated circuits surface tend to be affected by the changes in ambient temperature or humidity, or fine dust. Further, because a semiconductor chip itself tends to be broken by mechanical vibration or shock it may be situated in a package encasing the semiconductor chip.

The package type may roughly be classed as an airtight seal type or a resin mold type. In the former, the airtight seal type, an airtight space is formed in the cental portion of a package member, and a semiconductor chip is positioned within the airtight space. Ceramics having a high moisture impermeability are generally used as the material for such hollow packages, but synthetic resins which are low in cost and are easier to work.

In a semiconductor device using a hollow package made of synthetic resin, the semiconductor chip is secured to a bonding surface (a chip bonding surface) in a hollow portion by means of adhesives and is electrically connected to a lead frame by means of a bonding wire. Opposite ends of the lead frame connect the inner side and the outer side of a package.

The top surface of the hollow package is airtightly sealed by securing a cover member or lid such as a transparent or opaque synthetic resin plate, a glass plate or the like thereto, by adhesives.

In a case in which a hollow package made of synthetic resin is used, there is the problem that even if the cover member is secured by means of adhesives, a small amount of moisture enters into the package as through passage of time. As a result, electrodes of the semiconductor chip or internal circuit become corroded thus degrading the operation thereof, and eventually rendering it unusable.

Even if the adhesive portion of the cover or the seal portion of the lead frame (which were thought to be entry routes of moisture) are carefully sealed, it was still not possible to prevent entry of moisture over a period of time.

The present inventors have carried out studies to determine the route of entry of the small amounts of moisture which enter an airtightly sealed semiconductor package. At the outset it had been assumed that a route of entry of moisture into the semiconductor package is through the adhesive portion of the cover member or the seal portion of the lead frame. Therefore, tests were carried out to determine whether such assumption was correct.

It was found that the entry of moisture through the adhesive portion of the cover member or the seal portion of the lead frame did not pose much of a problem since various countermeasures can be taken. Unexpectedly it was found that entry of moisture into the semiconductor package principally occurs by moisture passing through the molded body from the lowermost surface of the package, that is, the bottom surface of the hollow package.

The route of entry of moisture into the semiconductor package was tested in the following manner. A package sealed by a transparent cover member is put into a commercially available pressure cooker tester (PCT) and heated and pressurized to a temperature of 121^{o}C, a humidity of 100% RH and a gauge pressure of 1 kg/cm^2 for a definite period of hours, following which it was removed to examine whether condensation had formed caused by moisture having entered internally of a transparent cover member under normal temperature.

Those which showed no condensation representing those having less internal moisture were continued to be heated and pressurized for definite periods of hours until condensation appeared.

Accordingly, in the present invention, the quality of the moisture-proofness of the package was determined by the length of heating and pressurizing time until condensation appeared on the inside of the transparent cover member.

It is an object of the present invention to provide a semiconductor device of an airtight seal type having improved moisture impermeability.

SUMMARY OF THE INVENTION

A feature of the present invention is the provision of a vapour-impermeable moistureproof plate on the bottom surface of a hollow package or at a position inward of said bottom surface.

According to a first embodiment the moistureproof plate comprises an island portion connected to a lead frame through a support lead which is located on the bottom surface of the hollow package or at a position inward of said bottom surface.

The above mentioned support lead serves to accurately fix the position of the island portion. However even if the support lead is served after the molding step the moisture-proofing effect on the semiconductor device is not decreased.

In the molding process the island portion as well as the lead frame itself are positioned beforehand within a mold to provide an integrally molded hollow package by insert molding.

It is preferable that the island portion be connected to the lead frame through the support lead so that the position of the island portion within the semiconductor package can be accurately fixed at the time of molding.

Furthermore, according to the present invention, there is provided a semiconductor device in which said island portion is provided internally of (below) the bonding surface and internally of (above) the bottom surface of the hollow package. More particularly the island is closer to the bottom surface of the hollow package by at least 100μm or more from the bonding surface, and serves to impede entry of moisture into the hollow package.

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Moreover, according to the present invention, after the lead frame having an island portion has been fixed in a predetermined position within a mold, synthetic resin is applied by injection molding or transfer molding, whereby the island portion, the lead portion and the plastic are united into an integral package.

According to a second embodiment the vapour-impermeable moistureproof plate comprises a moistureproof plate formed from a vapour-impermeable plate-like member embedded on the bottom surface of an airtight sealed hollow package or at a position inwardly of the bottom surface.

In this embodiment, since the moistureproof plate is an element separate from the lead frame, the material, size, etc. of the moistureproof plate can be selected without regard to the material or size of the lead frame.

In accordance with the present invention there is provided a semiconductor device having a semiconductor chip mounted on an inner surface of a hollow package molded in situ so as to be airtightly scalded, and formed an island portion comprises a vapor-impermeable moistureproof plate and being provided in an area which is the same size as a bottom surface of the semiconductor chip at a position lower than a bonding surface, characterized in that said island portion is connected on both side of a lead frame by a support lead, and sealed in the hollow package by a process selected from the group injection molding and transfer molding, wherein said island portion is provided close to the bottom surface of the hollow package by at least 100 μm or more from the bonding surface for securing the semiconductor chip.

In accordance with the present invention there is provided a method of manufacturing a semiconductor device comprising the steps of: locating and setting a lead frame and an island portion connected therewith at a predetermined position within a mold; and thereafter applying a synthetic resin by a process selected from the group injection-molding and transfer-molding, thereby the lead frame, the island portion and a follow package are integrated.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 to 3 show a first embodiment of the present invention.

Fig. 1 is a side sectional view showing an example of a hollow package according to the present invention integrated by insert molding.

Fig. 2 is a side sectional view showing an example of an airtight sealed semiconductor device according to the invention.

Fig. 3 is a side sectional view showing a further example of an airtight sealed semiconductor device according to the invention.

Fig. 4 is a top view showing an example of the shapes of a lead frame and an island before insert molding in the first embodiment.

Fig. 5 is a graph showing the result of a pressure cooker test of the first embodiment illustrating the effect of differences in position in which the island is formed.

Figs. 6 and 7 show a second embodiment of the present invention.

Fig. 6 is a side sectional view showing an example of a hollow package of the present invention integrated by insert molding, and

Fig 7 is a side sectional view showing an example of an airtight sealed semiconductor device according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

A semiconductor device according to this invention, which comprises a semiconductor chip with a hollow package, a lid (cover member) and a moistureproof plate, to provide improved moisture impermeability of the airtightly sealed semiconductor package.

The hollow package 1 referred to above is composed of synthetic resin, preferably thermosetting resins such as epoxy resin, polyamide resin (for example polyaminomaleimide, polypyromeritimide), phenol resin, unsaturated polyester resin, silicon resin, etc., or heat resistant thermoplastic resins such as liquid-crystal polymer, polyphenylsulfide resin, polysulfone resin, etc.

Among the above mentioned synthetic resins, epoxy resins such as bisphenol-A type, orthocresol novolak type, glycidyl amine type, etc., are preferred in view of their moldability and moisture-proofness and their ability to form a hollow package by injection or transfer molding, in accordance with this invention.

The moistureproof plate 11, may comprise a vapour-impermeable plate-like member, particularly, those in which material such as metal such as iron, copper, nickel, aluminum, alloys and their oxide, ceramic, glass, etc., are formed into a plate-like member. In a case in which metal such as aluminum, copper and iron, alloys or their oxide which have a heat transfer rate in excess of 0.01 cal/cm sec.^{o}C, are used, not only is moisture impermeability improved but there is also an increased radiation outside the package of heat generated by the semiconductor chip 7, thus assisting the operating stability of the semiconductor element.

In a case in which the moistureproof plate consists of a part of the lead frame, the lead frame is desirably formed of a material selected from the group copper, iron, aluminum or a group comprising an alloy thereof, or preferably 42 alloy or a copper alloy.

The lead frame 2 is, wholly or partly as may be necessary, surface treated for example, by plating with a material such as gold, silver, nickel, solder, etc. A further example of a suitable surface treating material is nickel plating containing no lustering agent. More specifically, saccharin or the like may be added to smooth the plated surface.

(Embodiment 1)

In Fig. 1 which shows a side sectional view of an example of a package for a semiconductor device in which an island portion 3 is formed internally of a bottom surface, the reference numeral 1 designates a hollow package made of synthetic resin, and 2, a lead frame.

The island portion 3 is connected to the lead frame 2 through a support lead 3 and is situated in a lower position than the remainder of the lead frame.

The reference numeral 4 designates a bonding surface on which a semiconductor chip 7 is secured by means of adhesives, and numeral 5 designates a cover adhesive portion for sealing a space in the package.

The hollow package 1 is molded of resins as aforementioned such as epoxy resin, polyamide resin.

The lead frame 2 (including the island portion 3) is formed of a material as aforementioned, preferably 42 alloy or a copper alloy.

Other plate-like material such as a copper plate may be joined to the island portion 3 for improving heat radiation properties. In this manner, the plate-like member such as the copper plate which is joined to the island portion 3 provides not only improved moisture impermeability of the semiconductor device but also produces efficient radiation outside the package of heat generated in the semiconductor chip 7 to maintain the stability of operation of the semiconductor chip 7.

The plate-like member may be of the same size as the island portion 3, or may be of an area larger than the former.

In the present embodiment, the island portion 3 is connected to the lead frame 2 through the support lead 3′ as shown in Fig. 4.

The island portion 3 is integrally formed in the same plane as the lead frame 2 at the time of fabrication as part of the lead frame 2. Thereafter the portion 3 is depressed out of the plane of the lead frame 2 by suitable post-working.

By this means the island portion 3 and the lead frame 2 are formed of the same material. However, in order to improve anticorrosion and radiation properties, the island portion 3 may be partly plated, or another material such as a copper plate may be joined to the island portion 3, as mentioned above.

As described above, the island portion 3 is preferably formed inwardly (in the figure below the bonding surface 4) from the bonding surface 4 and inwardly (in the figure, above the bottom surface 14 of the package) from the bottom surface 14 of the hollow package 1, particularly, closer to the bottom surface 14 by at least 100 μm or more from the bonding surface.

The registration of the upper surface of the island portion 3 with the bonding surface is not preferred since this lowers moisture impermeability.

The position of the island portion 3 is suitably adjusted at the time the lead frame 2 is pressed, for example.

The thickness of the island portion 3 is normally 50 to 1000 μm, preferably, 100 to 500 μm, and is substantially the same size as the bottom surface of the semiconductor chip 7. A larger sized island provides advantages in accordance with the invention.

The lid adhesive portion 5 is preferably provided with a shoulder as shown in order to obtain better sealing effect.

The semiconductor chip 7 is secured to the bonding surface 4 of the hollow package 1, the chip and the lead frame 2 are connected by a bonding wire 6, and thereafter the cover member 8 or lid is adhered to the cover adhesive portion 5 of the package 1 by adhesives such as epoxy group, imide group or acrylic group, to provide an airtight seal.

The bonding wire 6 normally comprises gold or aluminum wire. The cover member 8 or lid may comprise a transparent cover member 8 such as a glass plate, a sapphire plate, a transparent alumina plate, a transparent plastic plate, etc., or translucent or opaque cover members 8 such as a coloured glass plate, a ceramics plate, a coloured plastic plate, etc.

While Fig. 2 shows an example in which the position of the lower surface of the island portion 3 is at the bottom surface of the hollow package, the island portion 3 may be situated more inwardly of the bottom surface of the hollow package.

A semiconductor device according to this embodiment is manufactured in accordance with the following procedure.

The lead frame 2 having the island portion 3 depressed a predetermined distance from other portions is initially set in a predetermined position within the mold, and subsequently, epoxy resin such as bisphenol A type, orthocresol novolak type, glycidyl amine type, etc., is applied by injection or transfer molding.

According to this method, the position of the island portion 3 of the lead frame 2 sealed into the hollow package 1 is fixed by depressing it using a suitable pressing means, for example a press machine, so that its position is accurately predetermined in advance. By this means the process involves a single insertion step at the time of molding thus avoiding difficulties of positioning.

The conditions of insert molding differ with use or different kinds of resins. Where use is made of epoxy resin, pressing and heating are carried out under the general conditions of 10 to 800 kg/cm^2 of pressure, 150 to 200 $^{\circ}$C of temperature, 1 to 5 minutes of time, and post-curing is provided as needed. The lead frame 2 having the depressed island portion 3 is subjected to insert molding whereby the island portion 3 with excellent moisture impermeability is secured with high precision to the bottom surface of the hollow package 1 or to an inner portion therefrom. Accordingly the operating steps are simplified, and in addition, positive positioning can be attained.

The present inventors have conducted experiments as described hereafter in order to measure the level of moisture impermeability of the semiconductor package according to the present embodiment. In these experiments the entry of moisture into the semiconductor package was tested in the following manner:

(Method A for evaluation)

A package sealed by a transparent cover member 8 was placed in a commercially available pressure cooker tester and heated and pressurized for two hours under the conditions of temperature (121^{o}C), humidity (100%RH) and gauge pressure (1kg/cm^{2}), after which it was removed. On the side of the transparent cover member the package was pressed against the hot plate and heated for 15 seconds at 80^{o}C, and thereafter the transparent cover member was pressed against a brass block for 10 seconds at 25^{o}C to examine if condensation caused by moisture which had entered was formed inside the transparent cover member. Those which had no condensation indicated less entered moisture and were judged to present no practical problem. Accordingly, in the present invention, the quality of the moisture impermeability of the package is determined by the length of heating in the pressure cooker tester time until condensation appears inside the transparent cover material.

Experiment 1

A lead frame 2 (thickness:μ250 m) made of 42 alloy subjected to nickel plating with a lustering agent (saccharin) combined having an island portion 3 as shown in Fig. 4 was pressmolded. Only the island portion 3 was depressed and set to a predetermined position within the mold of a transfer molding machine.

Next, molding material of an orthocresol novolak type epoxy resin and phenol novolak curing agent was transferred into the mold under the conditions of 180^{o}C temperature, 120 kg/cm^{2} pressure and 3 minutes time after which it was subjected to post-curing for three hours at 180^{o}C to obtain a molded article (thickness of bottom is 1 mm) as shown in Fig. 1. Subsequently, the cover adhesive portion 5 was coated with epoxy resin to form an adhesive layer 9, to which a cover member 8 made from a transparent glass plate was adhered to seal hollow package 1 in an airtight manner. This hollow package 1 was tested in a pressure cooker tester under the above mentioned conditions. The package was removed every two hours to examine if condensation appeared on the inside of the glass cover member 8.

As the result, no condensation was observed until 12 hours but condensation was recognized first after 14 hours. The results obtained by measuring the difference of moisture impermeability as a result of varying the distance between the package die pad surface (bonding surface 4) and the upper surface of the island portion 3 is indicated by the curve (dotted line marked by △) in Fig. 5. The thickness of the package used (from the bottom surface of the semiconductor chip 7 (bonding surface) to the bottom surface of the package) was 1mm. The time until a blur occurs inside was measured by the same method.

On the other hand, in a package fabricated in the exactly same manner except that an island portion is not incorporated, condensation was recognized in four hours by a similar pressure cooker test.

Experiment 2

An experiment was conducted in a manner similar to that of the aforesaid Experiment 1 except that nickelplated 42 alloy was used without combination with a lustering agent, as the lead frame 2.

The result obtained by measuring the difference of moisture impermeability while varying the distance (t) from the bonding surface 4 to the upper surface of the island portion, is shown by the curve (solid line marked by●) in Fig. 5.

It has been found from the aforesaid results that the preferred position for the island portion 3 is at an inner position from the bonding surface 4, and internally of the bottom surface of the hollow package 1, particularly, closer to the bottom surface by at least 100 μm or more than from the bonding surface.

Experiment 3

An experiment was conducted in a manner similar to that of the aforesaid Experiment 1 except that 42 alloy without applied plating was used as the lead frame. As a result, the same result as the curve marked ● in Fig. 5, was obtained.

(Embodiment 2)

In this embodiment, a moisture-proof plate 11 separate from a lead frame 2 is embedded inwardly from the bottom surface 14 of the hollow package 1 as shown in Fig. 6.

In Fig. 6. the reference numeral 1 designates a hollow package formed of thermosetting resins such as epoxy resin, polyimide resin; 2, a lead frame formed of 42 alloy, copper alloy, etc.; 4, a bonding surface for securing a semiconductor chip; and 5, a cover adhesive portion for sealing a semiconductor device, the cover adhesive portion being provided with a shoulder for providing better seal effect similarly to the aforementioned Embodiment 1. The reference numeral 11 designates a moisture proof plate which is composed of material selected from the aforementioned materials.

Where alloys or their oxides which have a heat transfer rate in excess of 0.01 cal/cm. sec. ^{o}C are used, not only is the moisture impermeability improved but radiation of heat generated by the semiconductor chip 7 is promoted to provide operating stability of the semiconductor element.

The thickness of the moistureproof plate 11 is normally 50 to 1000 μm, preferably, 100 to 500 μm.

The size of the moistureproof plate 11 which is positioned between the bottom surface of the semiconductor chip 7 and the bottom surface of the hollow package, is preferably, as shown in Fig. 6, substantially the same as the bottom surface (lowermost surface) of the hollow package 1.

Preferably, the moistureproof plate 11 is embedded at the bottom surface 14 of the hollow package 1 or inwardly thereof as shown in Fig. 6. Where it is desired to enhance its function as a radiation plate the moistureproof plate 11 may be situated closer to the semiconductor chip 7 (for example, by adjusting the length of a lead member 10).

Furthermore, as shown in Fig. 7 there may be provided a lead member 10 positioned directly below the bonding surface 4 and connected to the moistureproof plate 11. The lead member 10 is preferably formed of a material having a heat transfer rate in excess of 0.01 cal/cm sec ^{o}C. With the provision of the lead member 10, heat generated by the semiconductor chip 7 is transmitted to the moistureproof plate 11 to enhance the radiation effect.

In the manufacture of the device lead frame 2 made of 42 alloy and a moistureproof plate 11 made of copper alloy having a thickness of 250 µm and a heat transfer rate of 0.53 cal/cm. sec. ^{o}C, were inserted in predetermined positions within a mold of a transfer molding machine. Next, a molding material consisting of a novolak type epoxy resin together with curing agent was insert-molded at a temperature of 180^{o}C, a pressure of 80 kg/cm^2 and a time of 2 seconds. Following which the molded material was subjected to post-curing for 3 hours at a temperature of 180^{o}C to obtain a hollow package 1 as shown in Fig. 6. A cover member 8 made from a transparent glass plate was then adhered to the cover adhesive portion 5 of the hollow package 1 by an epoxy resin (adhesive layer 9).

The aforementioned insert molding conditions will differ with the type of resin used. However, with use of epoxy resin, the preferred heat and pressure conditions comprise a pressure of 10 to 500kg/cm^2 temperature of 150 to 200 ^{o}C, and time of 1 to 5 minutes.

The moistureproof plate 11 is subjected to insert molding simultaneously with the lead frame 2 to thereby fix the moistureproof plate 11 at the bottom surface of the hollow package

1 or inwardly therefrom, with high precision. Not only does this simplify this assembly step but it also accurately fixes the position of the moistureproof plate 11 as compared with methods by which the moistureproof plate is adhered.

The airtight sealed package was evaluated under the following conditions (Method B for evaluation). The package was subjected to a pressure cooker tester, to a temperature of 121^{o}C, humidity of 100%RH and gauge pressure of 1kg/cm^2. It was removed every 5 hours and was left under room temperatures for an hour to examine if condensation is observed internally of the glass cover at room temperature. In evaluation Method B this package was not cooled by use of temperatures other than room temperatures as it was at this stage, in evaluation Method A.

As the result, condensation was not observed until 45 hours but recognized first after 50 hours. By contrast, in a package fabricated in a similar manner except that a moisture-proof plate is not incorporated, condensation was recognized in 20 hours using a similar pressure cooker test. Thus the effect of the moistureproof plate was conspicuous.

Thus, according to the present embodiment, the formation of a layer consisting of a vapour-impermeable moistureproof plate 11 on the bottom surface of the hollow package 11 or inwardly therefrom, serves as a barrier against entry of moisture from the bottom surface of the package where a moisture permeability into the semiconductor package is normally highest. Furthermore, by insert molding of the moistureproof plate 11 along with the lead frame 2, the moistureproof plate 11 can be fixed to the inner surface or outer surface of the hollow package 1 with high precision and by simple procedure.

The semiconductor chip 7 with which the invention may be used may consist of a solid image pickup element such as Charge Coupled Device, Metal Oxide Semiconductor or Charge Priming Device. The chip is sealed by the above described hollow package and the lid (cover member 8) is composed of a transparent glass.

When the invention is used with a solid image pickup device, the device features airtightness, vaportightness and high reliability.

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CLAIMS:

1. A semiconductor device having a semiconductor chip mounted on an inner surface of a hollow package molded in situ so as to be airtightly scalded, and formed an island portion comprises a vapor-impermeable moistureproof plate and being provided in an area which is the same size as a bottom surface of the semiconductor chip at a position lower than a bonding surface, characterized in that said island portion is connected on both side of a lead frame by a support lead, and sealed in the hollow package by a process selected from the group injection molding and transfer molding, wherein said island portion is provided close to the bottom surface of the hollow package by at least 100 μm or more from the bonding surface for securing the semiconductor chip.

2. A semiconductor device according to claim 1 wherein said island portion is provided close to the bottom surface of the hollow package by at least 100 μm or more from the bonding surface for securing the semiconductor chip.

3. A semiconductor device according to claim 1, wherein said moistureproof plate is formed of material selected from a group comprising aluminum, copper, iron oxide thereof or alloys whose heat transfer rate is in excess of 0.01 cal/cm.sec.°C.

4. A method of manufacturing a semiconductor device comprising the steps of:

locating and setting a lead frame and an island portion connected therewith at a predetermined position within a mold; and thereafter applying a synthetic resin by a process selected from the group injection-molding and transfer-molding,

thereby the lead frame, the island portion and a follow package are integrated.

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FIG.1

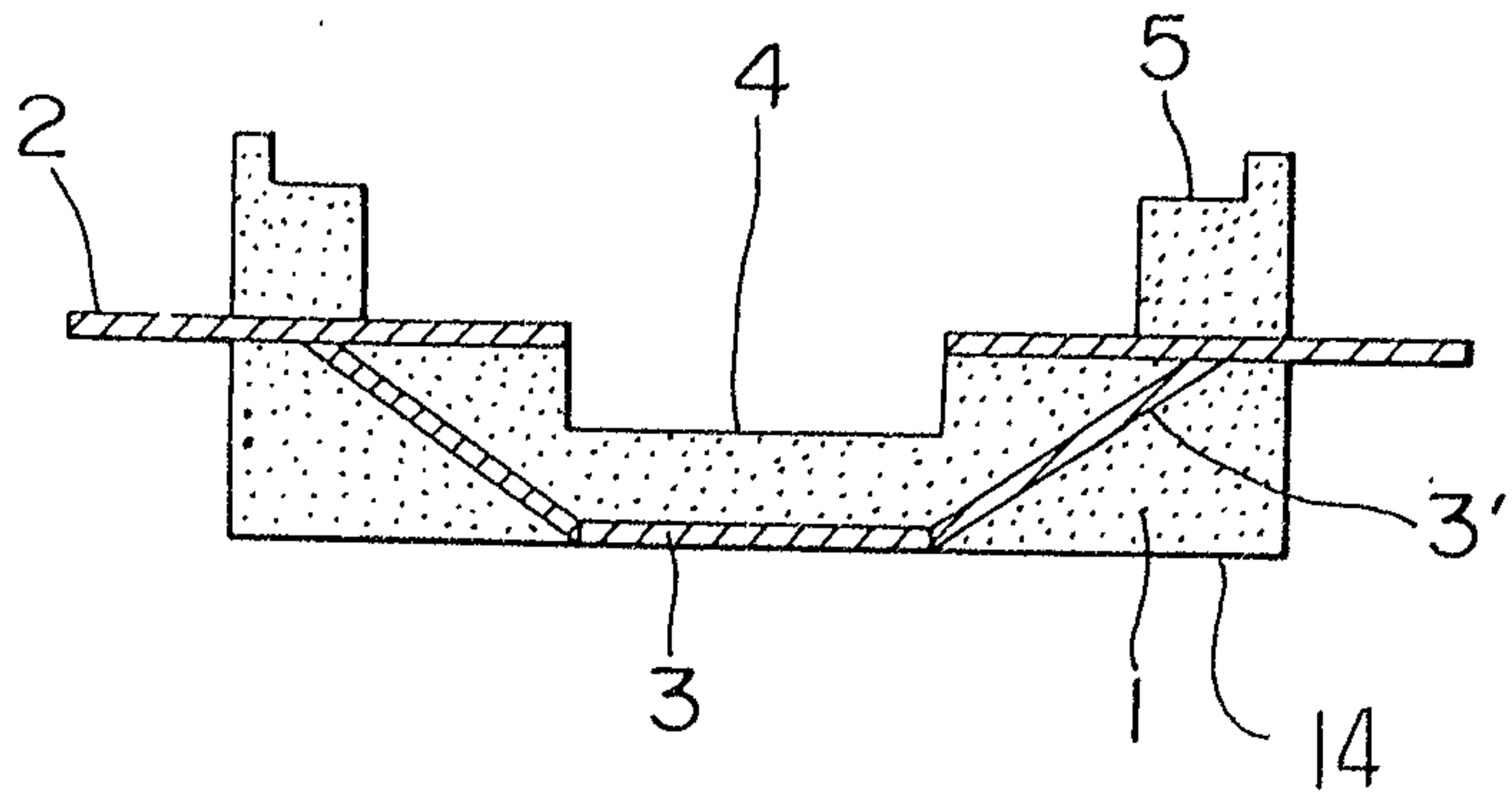

FIG.2

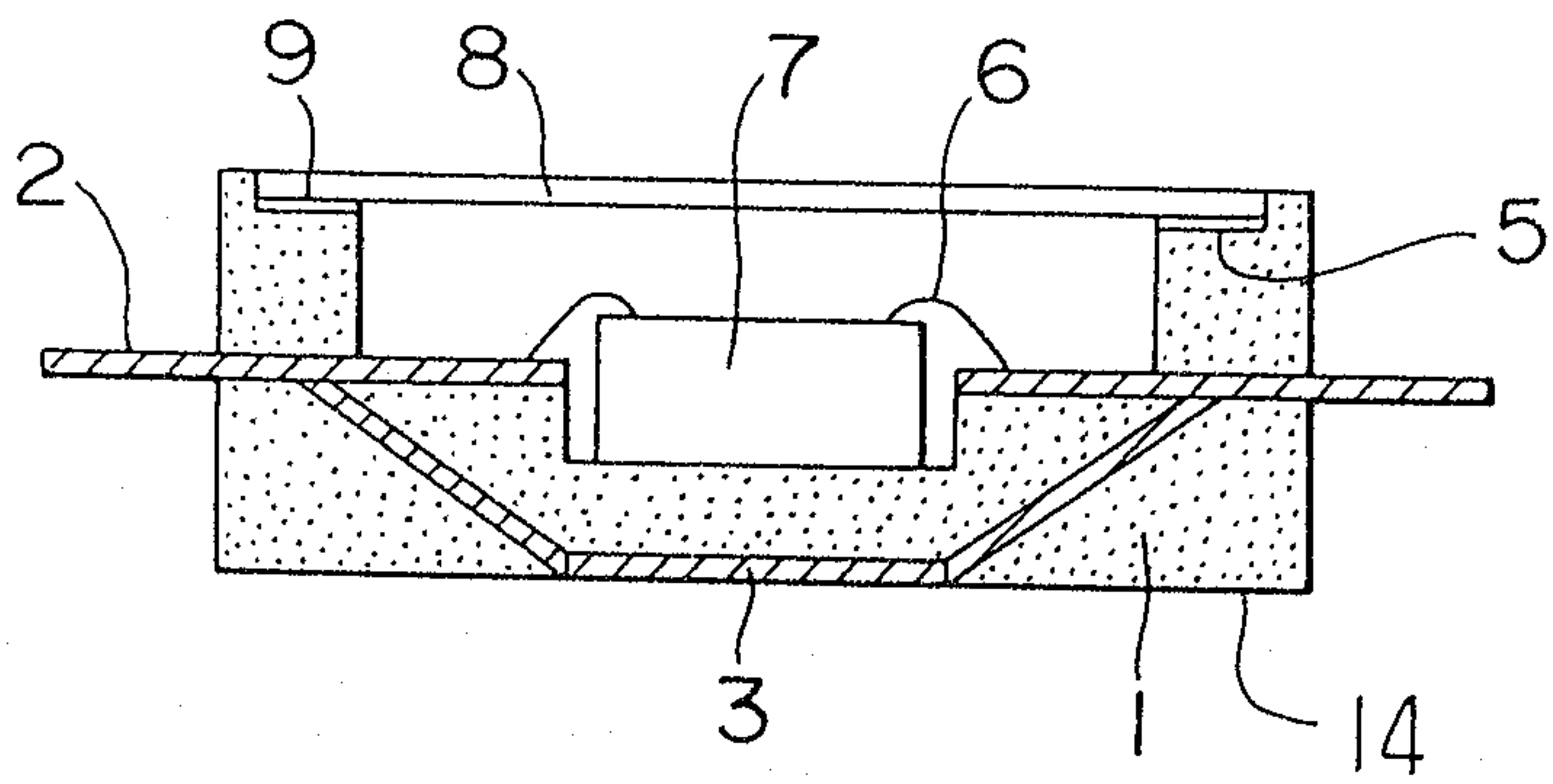

FIG.3

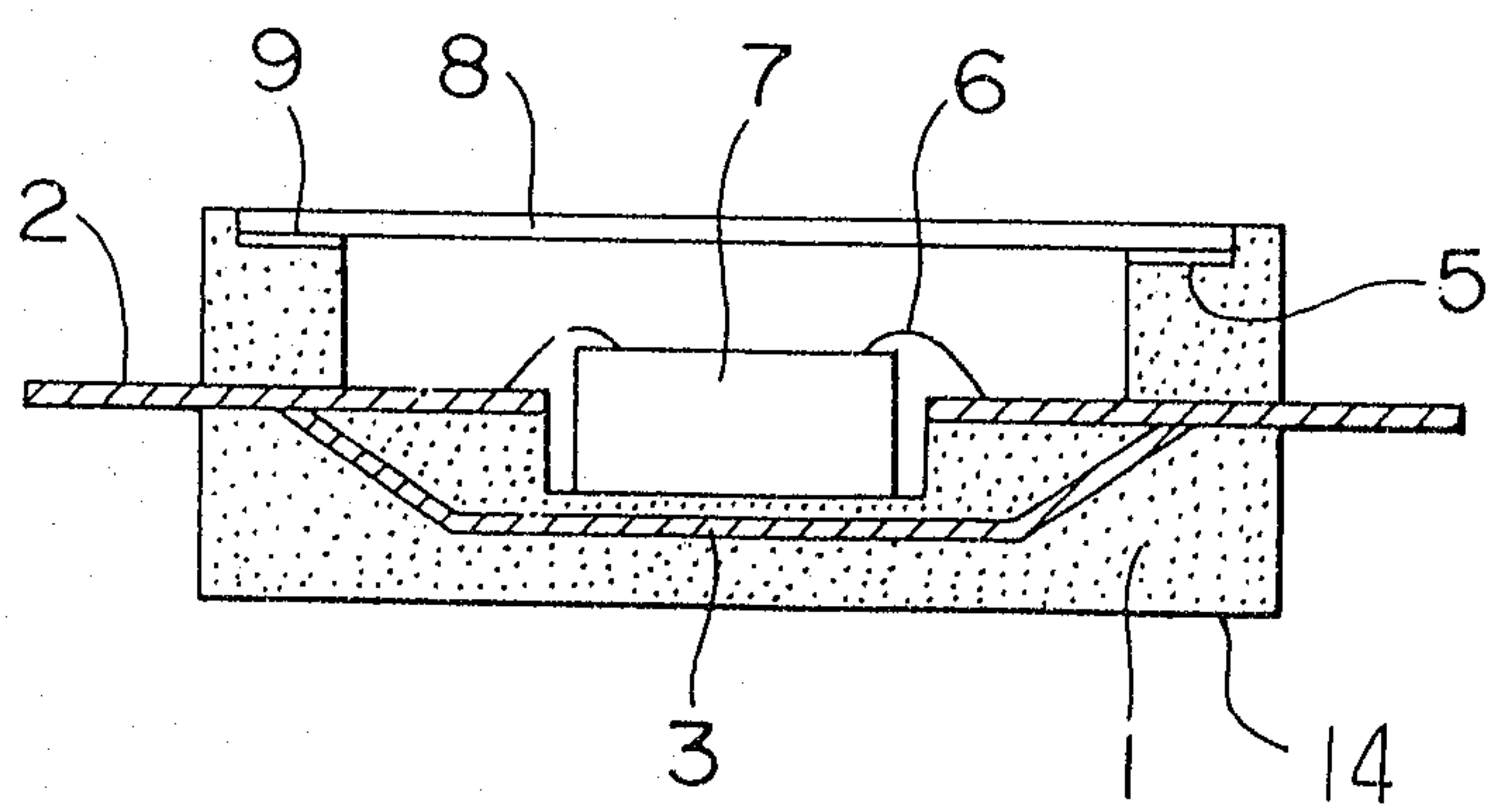

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FIG.4

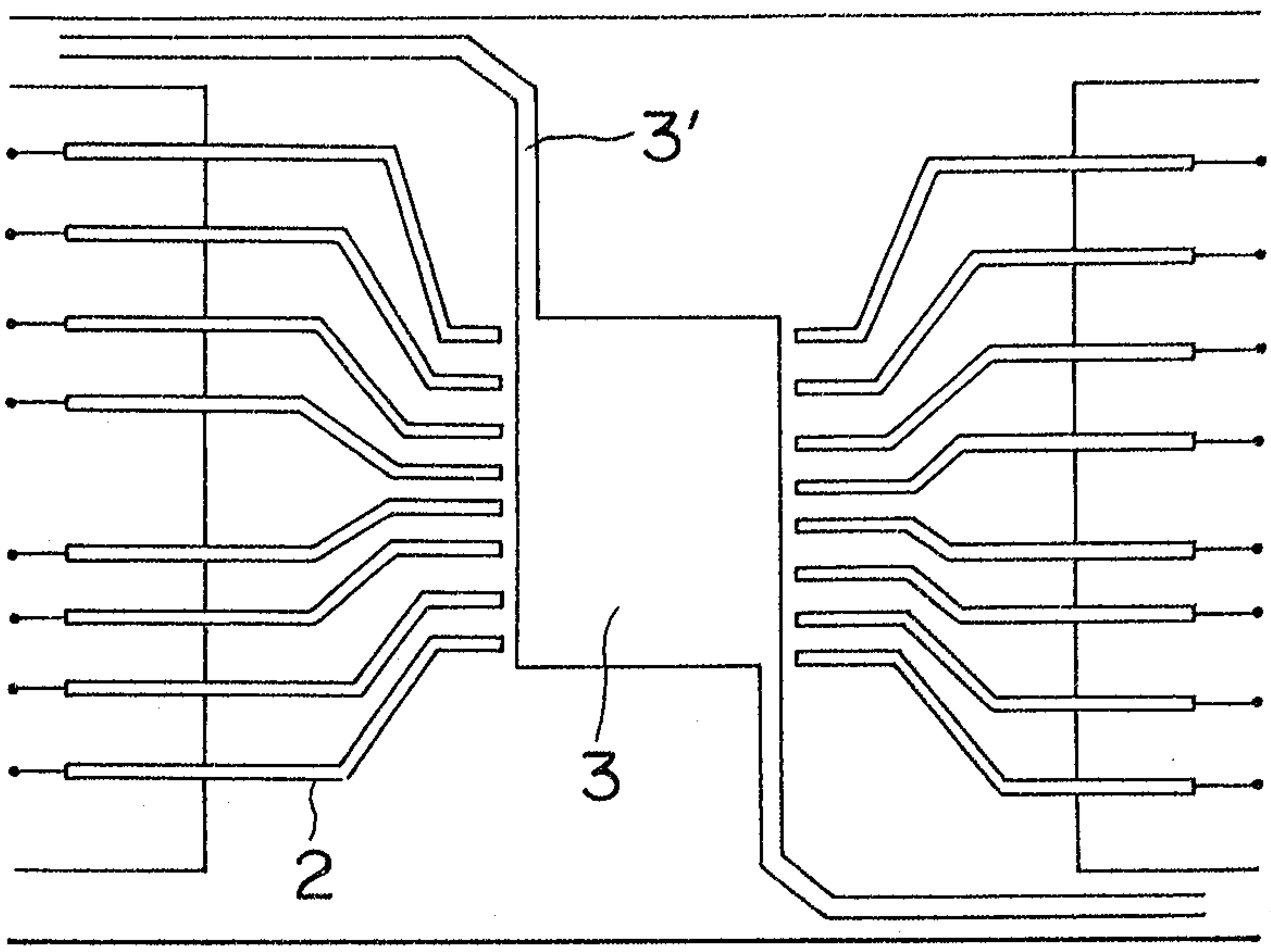

FIG.5

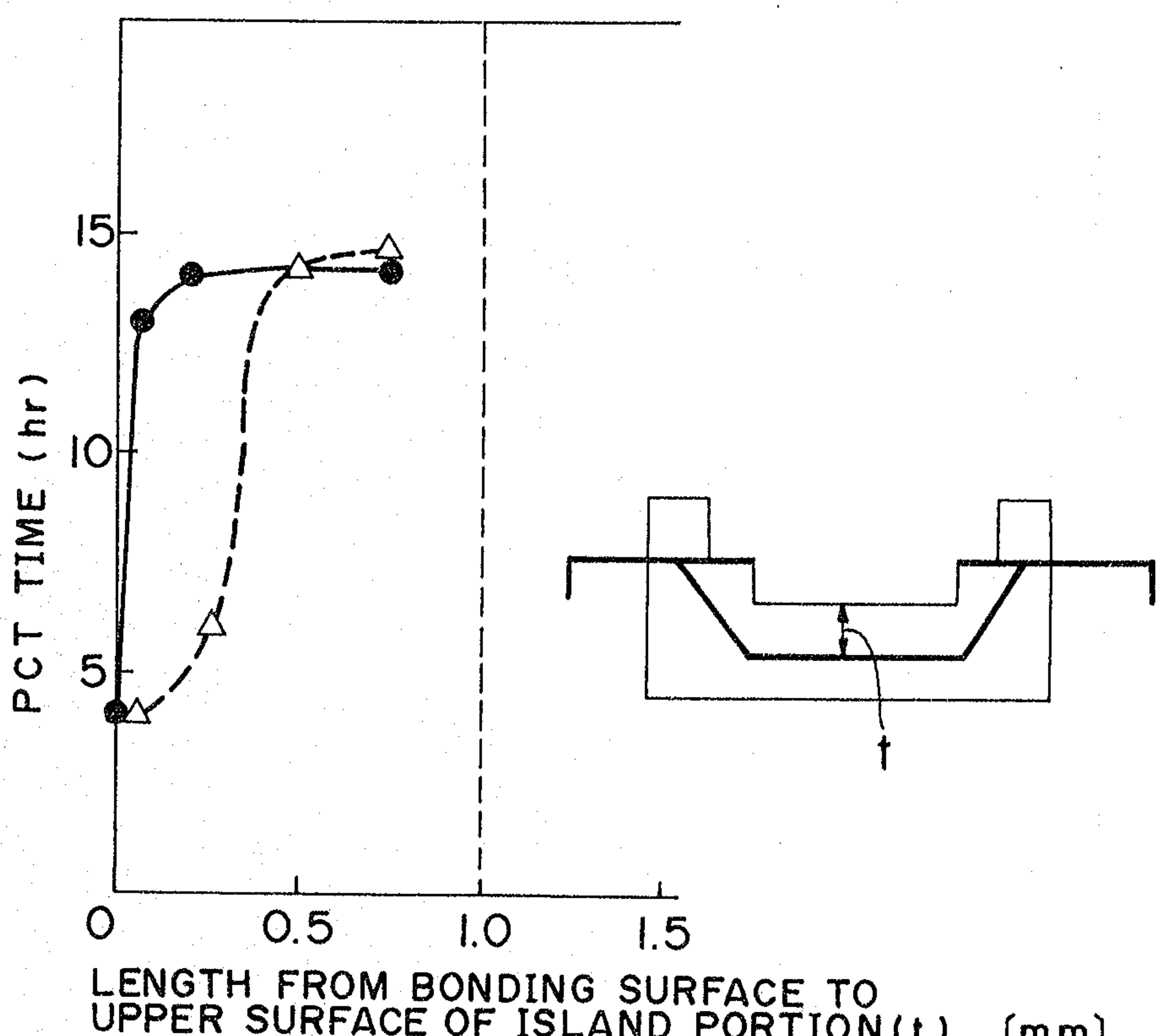

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FIG.6

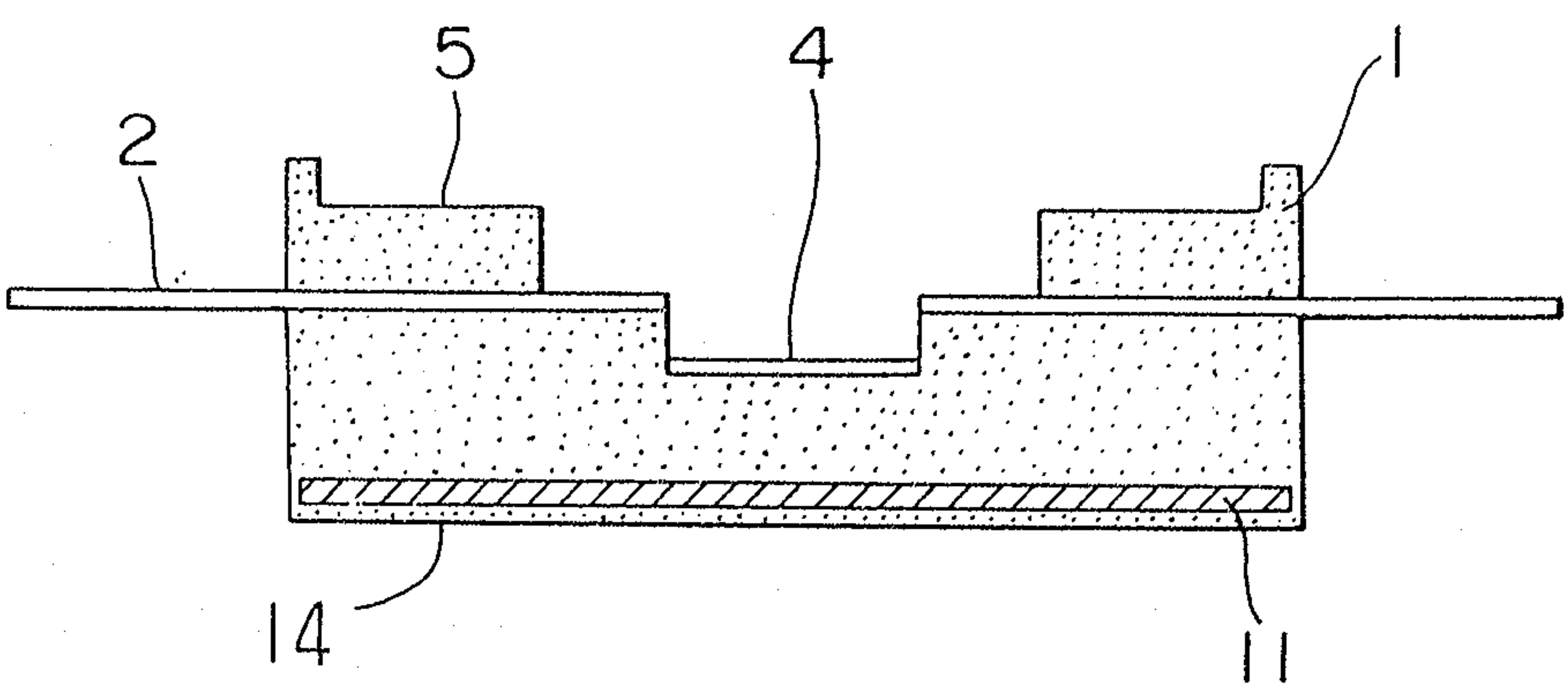
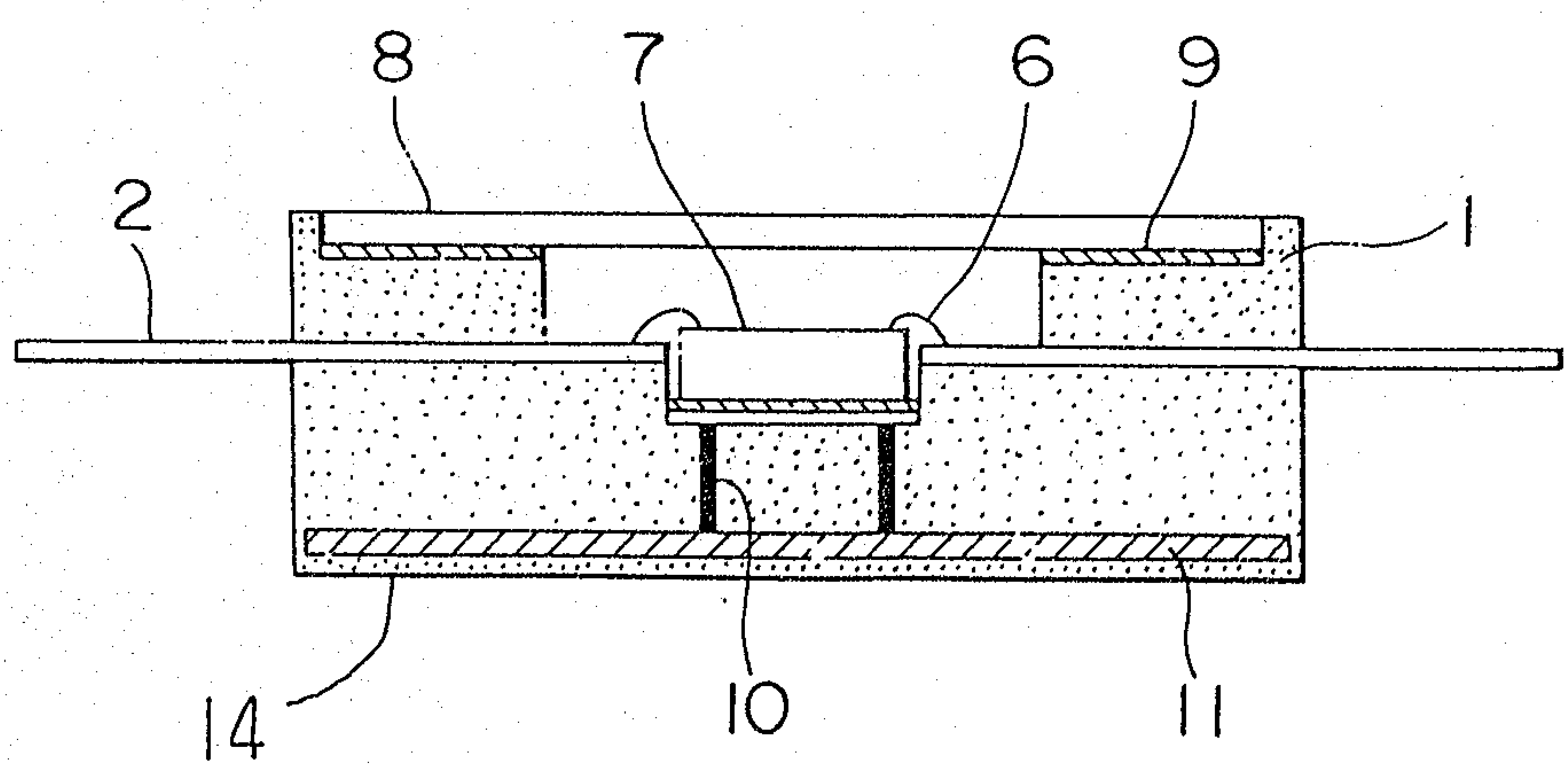


FIG.7



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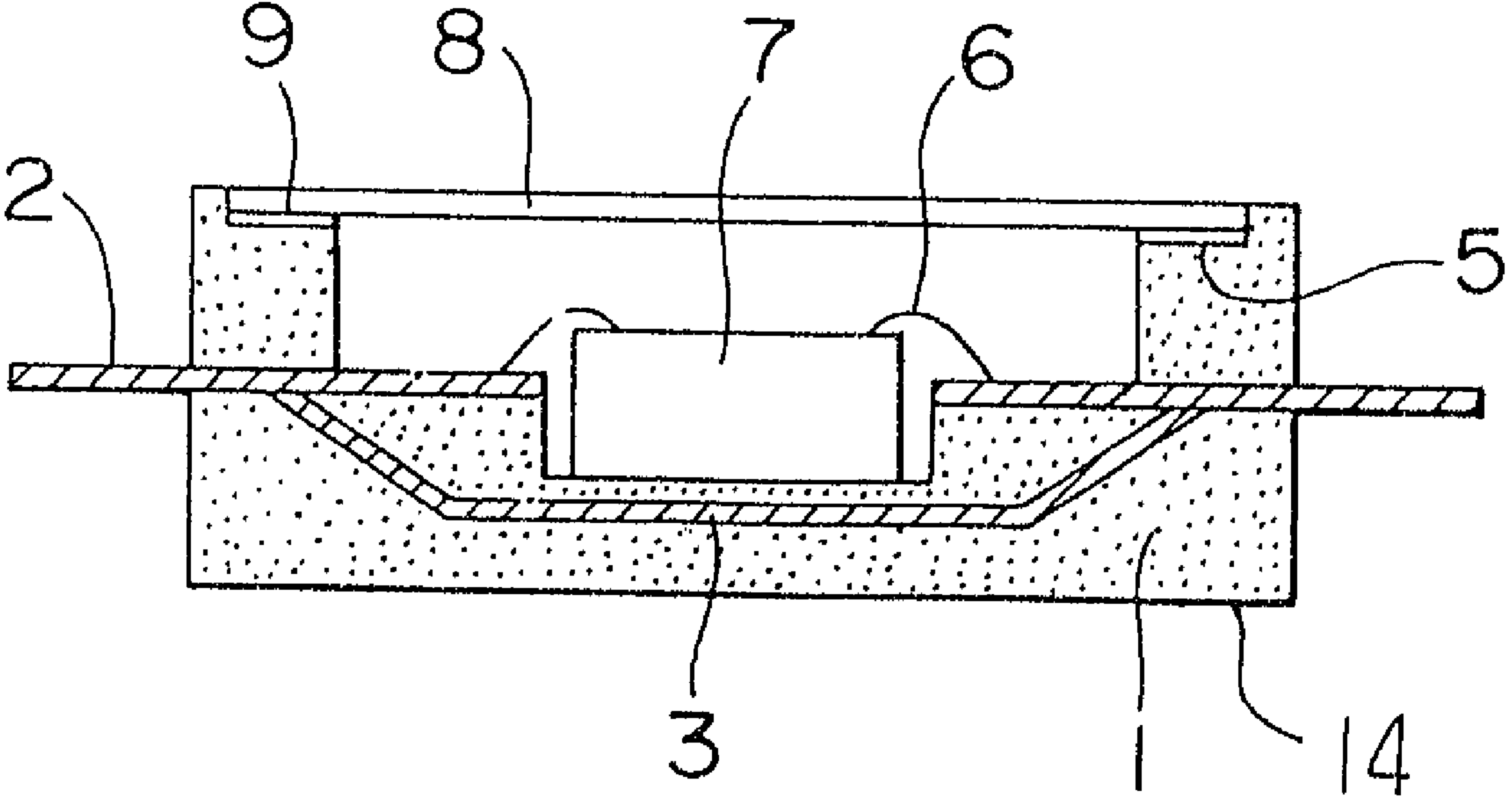
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