Description

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Intermediate base for a semiconductor module, a semiconductor module produced using such an intermediate base, and a method for producing such an intermediate base

The invention relates to an intermediate base for a module having at least one semiconductor component, comprising a flat base body having

- an upper face, on which internal connections are formed for connection to component connecting elements of a semiconductor component,
- a lower face, which is provided with external connections for making contact with a circuit base, and
- through-holes between the upper face and the lower face, whose walls are at least partially metallized, and each make a conductive connection between an internal connection on the upper face and a corresponding external connection on the lower face.

The invention furthermore relates to a semiconductor module, produced using such an intermediate base, and to a method for producing such an intermediate base.

The increasing miniaturization of integrated circuits has led to the problem that an ever greater number of electrical connections need to be accommodated in a very confined space between the actual semiconductor and a circuit base, that is to say a printed circuit board. However, the finer the structures of the semiconductor chip and of the connecting conductors, the greater is the extent to which they are at risk from different expansion levels of the materials involved, in particular of the semiconductor body on the one hand and of the printed circuit board, which is composed of plastic, on the other hand.

The intermediate base or interposer plays a major role in making contact with semiconductor chips, allowing one or more chips to be

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connected to form a module, with which contact is then made on the circuit base.

In the case of what is referred to as BGA (Ball Grid Array) technology, an intermediate base is provided over the area of its lower face with solder studs, which allow surface mounting on a printed circuit board. The solder studs are in this case used firstly as electrical connections and secondly as spacers to compensate for expansion between the different materials, that is to say the intermediate base and the printed circuit board. The semiconductor chip can be mounted on the upper face of the intermediate base, and contact can be made with it, for example, by means of bonding wires. Flip-chip mounting is also known, in which the connections of the unhoused semiconductor are directly connected to conductor tracks on the upper face of the intermediate base. In order to provide expansion compensation between the semiconductor body and the intermediate base in this case, underfilling is generally required for the semiconductor, which involves the necessity for an additional, complicated and expensive process step, which also no longer allows subsequent repair.

In the case of what is referred to as PSGA (Polymer Stud Grid Array) technology, an injection-molded, three-dimensional substrate composed of an electrically insulating polymer is used as the intermediate base, on whose lower face polymer studs are arranged over the surface, which are integrally formed during the injection molding process (EP 0 782 765 B1). These polymer studs are provided with an end surface which can be soldered, and thus form external connections which are connected via integrated conductor runs to internal connections for a semiconductor component which is arranged on the substrate. The polymer studs are used as spacers for the module from a printed circuit board, and are thus able to compensate for different expansion levels between the printed circuit board and the intermediate base. Contact can be made with the semiconductor component on the upper face of the intermediate base via bonding wires; however a form of contact making is also feasible in which the

different thermal coefficients of expansion are compensated for in an analogous manner via polymer studs on the upper face of the intermediate base.

Furthermore, a single-chip module is known from WO 89/00346 A1, in which the injection-molded three-dimensional substrate composed of an electrically insulating polymer has integrally formed polymer studs on the lower face, which are arranged in one row, or in a number of rows, along the circumference of the substrate. One chip is arranged on the upper face of the substrate, and contact is made with it via fine bonding wires and conductor tracks, which are then themselves connected via plated-through holes to the external connections formed on the lower-face studs. In this embodiment, the intermediate base has a relatively large extent.

The aim of the present invention is to provide an intermediate base for a semiconductor module of the type mentioned initially, and a production method for such an intermediate base and such a module, in which contact can be made directly with the semiconductor component without any underfilling on the intermediate base, and contact can be made with the intermediate base on a circuit base without any additional measures, and in which the different coefficients of expansion of the materials that are used do not have any apparent disadvantageous effect. In this case, the semiconductor component together with the intermediate base is intended to produce a module with a very compact physical form.

According to the invention, the first part of the object is achieved by an intermediate base for a module having at least one semiconductor component, comprising a flat base body having

- an upper face, on which internal connections are formed for connection to component connecting elements of a semiconductor component,
- a lower face, which is provided with external connections for making contact with a circuit base, and

- through-holes between the upper face and the lower face, whose walls are at least partially metallized, and each make a conductive connection between a contact point on the upper face and a corresponding external connection on the lower face, with
- the walls of the through-holes being at least partially exposed in the region of the lower face of the base body by means of annular notches which are incorporated adjacent to their circumferential edge, and forming freestanding studs as external connections.

The production of the studs by means of notches on the lower face of the intermediate base as envisaged according to the invention results in them being arranged recessed in the lower-face surface and not projecting, or only their metallization layer projecting, above this surface. Nevertheless, they are able to adsorb and to compensate for temperature-dependent different expansion levels of the intermediate base on the one hand and of a circuit base on the other hand. Contact is made via a short route through the metallized holes which run within the polymer studs to the upper face of the intermediate base, where the semiconductor component or else a number of semiconductor components is or are arranged, and contact is made with the internal connections.

The through-holes are preferably formed concentrically within the studs, so that the latter have a tubular or chimney-like configuration. However an eccentric arrangement between the through-holes and studs is also feasible, so that the latter approximately have the form of a tubular segment.

A particularly compact construction can be achieved if the intermediate base according to the invention is formed by a film composed of a plastic material whose coefficient of expansion is approximately the same as that of the semiconductor component, generally silicon. In this case, the semiconductor component can be placed

with its component connecting elements directly onto the internal connections on the upper-face end of the through-holes, and can be made contact with, which means that no connecting conductors whatsoever in the form of bonding wires or conductor tracks are required on the upper face of the intermediate base. Compensation for different thermal coefficients of expansion is then essentially required only between the intermediate base and the circuit base, and this compensation is provided via the polymer studs, which are provided according to the invention, in the lower face area of the intermediate base.

A film composed of LCP (Liquid Crystal Polymer) or a material with similar thermal expansion characteristics is particularly highly suitable for use as the material for the intermediate base. This material is described, for example, in the journal Advancing Microelectronics, July/August 1998, pages 15 to 18.

In one preferred refinement, the external connecting elements are formed by a metal layer on the outer rim of the studs, which is in the form of a continuation of the metallization in the through-holes. This can be provided with an additional solder layer; the through-holes in the interior of the studs can also be filled with solder material.

In one particularly advantageous refinement of the invention, the internal connections are each only in the form of a continuation (which covers the upper-face opening of the respective through-hole) of the metallization on the inner walls of the through-holes. In this case, this metallization layer which forms the internal connections is applied directly to the component connecting elements of the already fitted semiconductor component, through the through-holes from the lower face of the intermediate base.

The method according to the invention for producing a connecting base for at least one semiconductor component comprises the following steps:

- the connecting side of a semiconductor component is fixed on the upper face of a flat base body such that its component connections rest on the upper face of the base body;
- through-holes are drilled through the base body from the lower face as far as the upper face in order to expose the component connecting elements of the semiconductor component;
- the inner walls of the through-holes and the exposed contact surfaces of the semiconductor component are coated with a metal layer at the same time as at least part of the lower face of the base body; and
- the rim of the holes on the lower face of the base body is at least partially exposed by means of a circumferential notch.

The annular notches for exposing the hole rims are preferably produced in the same way as the holes for the through-holes, by means of laser processing. In this case, further laser structuring for a conductor track structure can be carried out at the same time on the lower face of the base body. During this process step, those metal surfaces which are not required are removed, and the remaining metal surfaces are provided with an additional metal layer. In order to produce a greater thickness, additional solder layers (using tin-lead) can be applied to these metal structures for soldering, so that there is no need for a process for paste printing.

However, a somewhat different method sequence is also feasible, in which the studs on the lower face of the base body are produced even before the connection to the semiconductor component. In this case, the studs can be produced both by laser structuring and by stamping on the lower face of the base body. In this case, the semiconductor

component would be fitted onto the base body provided with the studs, and the drilling of the through-holes would then be carried out from the lower face, through the already preformed studs, to the upper face of the base body, followed by subsequent metallization.

The invention will be explained in more detail in the following text using exemplary embodiments and with reference to the drawing, in which:

Figures 1 to 4 show, schematically, the individual phases in the production of an intermediate base according to the invention, in conjunction with a semiconductor component,

Figure 5 shows a perspective view, corresponding to Figure 4, of the lower face of a cutaway intermediate base, and

Figure 6 shows, schematically, the mounting of a semiconductor module according to the invention on a printed circuit board.

Figures 1 to 4 show the production of an intermediate base according to the invention, in which case the intermediate base has already been connected to the semiconductor component, and has made contact with it, during its production and processing. The intermediate base 1 has a base body 10 which is formed from an LCP film with a similarly low coefficient of expansion to that of the semiconductor component. As is known, the thermal coefficient of expansion of LCP is similar to that of silicon, so that such a base body can be connected directly to a semiconductor without any risk of different expansion when subjected to thermal loads. As is shown in Figure 1, the base body 10 is connected via an intermediate adhesive layer 3 to a semiconductor chip 2, whose component connecting elements, in the form of metal pads 21, face the base body 10. The adhesive layer 3 may have a thickness of 25 to 50 µm for example, while the LCP film which forms the base body 10 may, for example, have a thickness of 100 to 200 µm. It is also feasible to use a multilayer film, in which case a conductor track structure can also be provided between the layers.

In a further process step, as shown in Figure 2, through-holes 11 are drilled from the lower face 10a of the base body to the upper face of the base body 10, to be precise such that they each meet one of the flat component connecting elements 21. These connecting elements are thus exposed. The drilling process is carried out using a laser drilling method, with the laser beam being set such that the component connecting elements 21 are not removed.

In the next process step, the inner walls of the through-holes 11 are provided entirely, or at least partially, with a metal layer 12, with this metal layer also being deposited on the exposed component connecting elements 21, without any discontinuity. The semiconductor chip 2 thus makes direct contact with the intermediate base. The application of the metallization 12 also allows the other areas of the lower face 10a of the base body 10 to be entirely or partially covered with a metal layer.

As is also shown in Figure 4, annular notches 14 are now incorporated around each of the through-holes 11, in each case producing chimney-like studs 15 which are arranged recessed in the base body 10, so that they do not project beyond the lower face 10a. The rims of the studs are already covered with the metal layer 12, as a result of the previous metallization process, and can thus be used directly as external connections for making contact on a printed circuit board. The depth of the notches 14 is governed by the required thermal load capacity, since these studs 15 can now absorb and compensate for the loads that occur in the event of different thermal expansion of the intermediate base 1 with, firstly, the semiconductor chip 2 seated on it and, secondly, a printed circuit board.

The notches 14 are ideally arranged concentrically with respect to the through-holes 11, so that the studs have a symmetrically tubular shape. However, it is also feasible, for specific reasons or as a

result of dimensional discrepancies, for a notch 16 (Figure 4) to be located eccentrically with respect to the corresponding through-hole 11, thus resulting in a stud 17 which is cut on one side, in the form of an annular segment.

At the same time that the notches 14 are incorporated, a desired conducting structure can also be produced on the lower face of the base body 10 by laser processing during the same process step. In this case, those metal surfaces which are not required can be removed, and the remaining metal surfaces can be provided with an additional metal coating. Solder materials can be applied to the rims of the studs, which are used as external contacts 18, in order, in particular, to achieve a greater metal thickness.

Figure 6 shows how a module according to the invention makes contact with an intermediate base 1 and a semiconductor chip 2 on a printed circuit board 4, with the external contacts 18 each being reinforced by a solder layer 19 composed of tin-lead. Figure 6 also shows that the tin-lead alloy 19 also fills one of the through-holes 11.

Patent Claims

1. An intermediate base for a module having at least one semiconductor component (2,), comprising a flat base body (10) having
   - an upper face, on which internal connections (22) are formed for connection to component connecting elements (21) of a semiconductor component (2),
   - a lower face (10a), which is provided with external connections (18) for making contact with a circuit base (4), and
   - through-holes (11) between the upper face and the lower face, whose walls (12) are at least partially metallized, and each make a conductive connection between an internal connection (22) on the upper face and a corresponding external connection (18) on the lower face,

   with
   the walls of the through-holes (11) being at least partially exposed in the region of the lower face (10a) of the base body (10) by means of annular notches (14; 16) which are incorporated adjacent to their circumferential edge, and forming freestanding studs (15; 17) as external connections (18).

2. The intermediate base as claimed in claim 1, characterized in that the studs (15) are designed to be tubular by means of concentric annular notches (14).

3. The intermediate base as claimed in claim 1, characterized in that the studs (17) are designed to be approximately in the form of tubular segments, by means of eccentric, approximately annular notches (16).

4. The intermediate base as claimed in one of claims 1 to 3, characterized in that a film composed of a plastic material

whose coefficient of expansion is approximately the same as that of the semiconductor component (2) is used as the base body.

5. The intermediate base as claimed in claim 4, characterized in that a film composed of LCP (Liquid Crystal Polymer) is used as the base body (10).

6. The intermediate base as claimed in one of claims 1 to 5, characterized in that the external connections (18) are in the form of a metal layer on the outer rim of the studs (15; 17).

7. The intermediate base as claimed in claim 6, characterized in that the external connecting elements have an additional solder layer (19).

8. The intermediate base as claimed in one of claims 6 or 7, characterized in that the through-holes (11) are at least partially filled with solder material (19).

9. The intermediate base as claimed in one of claims 1 to 8, characterized in that the internal connections (22) on the upper face of the base body (10) are formed by a metal layer on the component connecting elements (21) of a semiconductor component which is connected to this surface, with the metal layer (12) continuously covering both the walls of the through-holes and the contact surface of the component connecting element (21) which faces the through-holes.

10. A semiconductor module, formed by a semiconductor chip which is connected to an intermediate base as claimed in one of claims 1 to 9.

11. A method for producing an intermediate base as claimed in one of claims 1 to 9 for at least one semiconductor component, comprising the following steps:
- the connecting side of a semiconductor component (2) is fixed on the upper face of a flat base body (10) such that its connecting contact elements rest on the upper face of the base body (10);
- holes (11) are drilled through the base body (10) from the lower face (10a) as far as the upper face in order to expose the component connecting elements (21) of the semiconductor component (2);
- the inner walls of the through-holes (11) and the exposed surfaces of the component connecting elements (21) are coated with a metal layer (12); and
- the rim of the through-holes (11) on the lower face of the base body (10) is in each case exposed by means of a circumferential notch (14; 16).

12. The method as claimed in claim 10, characterized in that the notches (14; 16) for exposing the hole rims are produced by laser processing.

13. The method as claimed in claim 11, characterized in that the notches are produced by stamping the lower face of the base body (10), in that the semiconductor component (2) is then fitted onto the upper face of the base body (10), and in that the through-holes (11) are then drilled from the lower face and, finally, the inner walls of the through-holes and the exposed component connecting elements of the semiconductor component are coated with the metal layer (12).

14. The method as claimed in one of claims 11 to 14, characterized in that a metal layer (13) which is applied to the lower face of the base body (10) is partially removed by

laser processing in order to produce a conductor track structure.

15. The method as claimed in one of claims 11 to 14, characterized in that at least the rims of the studs (15) are provided with solder metallization.