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(19)

(54) IMPROVEMENTS IN AND RELATING TO INSULATING FOILS HAVING CONDUCTIVE PATTERNS THEREON

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, 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 a flexible electrically insulating foil on which a pattern of conductive tracks is situated to which at least one electrical component, for example, a semiconductor circuit element, can be connected. A semiconductor circuit element may be, for example, a planar transistor or an integrated semiconductor device.

Such a flexible insulating foil having a pattern of conductive tracks to which an integrated semiconductor circuit is connected, is described in "Proceedings of the Electronic Conference"—IEEE, 1967, pp. 283—290. Thus it is known that an electrical component, particularly an integrated semiconductor circuit, can be rapidly provided with flexible connection conductors by means of a flexible insulating foil comprising a pattern of conductive tracks. Owing to the flexibility of the foil, the contact places of the component and/or a support for the component need not be situated exactly in a flat plane. Furthermore a number of electrical components can be connected to the pattern, for which purpose electric connections may be incorporated between the components in the pattern of conductive tracks.

A difficulty in the application of known foils of the said type is that an undesirable shortcircuit between the pattern and a part of the electronic component, for example, the edge of the semiconductor body of an integrated semiconductor circuit or a conductive track on the surface insulating layer on the semiconductor body of an integrated semiconductor circuit, can easily occur. In this respect it has already been suggested to provide the insulating foil with an aperture (see the above cited literature) in which conductive tracks provided on the foil project over the edge of the aperture and the projecting parts of the conductive tracks are secured to an integrated semiconductor circuit, said parts being bent in such manner and the foil being connected to a support with respect to the integrated circuit in such manner that shortcircuit with the edge of the semiconductor body of the integrated circuit is avoided. This is a complicated solution which considerably reduces the advantages of the use of a flexible foil.

According to the invention there is provided a flexible electrically insulating foil on which a pattern of conductive tracks is situated at least at one side of the foil, said pattern comprising a plurality of contact places, at least some of said plurality of contact places being suitable for the connection on the foil of at least one electrical component to the pattern, an insulating layer of a photolacquer being present on the pattern and on the foil, said photolacquer layer covering the pattern and at least the corresponding side of the foil with the exception of the contact places, the side of the photolacquer layer situated opposite to the side adjoining the pattern and the foil being free from conductive tracks.

The photolacquer layer, which need not have a disturbing influence on the flexibility of the foil, prevents undesirable shortcircuits of the conductive tracks with an electrical component and/or component support to be connected to the pattern.

Furthermore, contact places of a component which are not situated near the edge of a surface of a component can, without objection, be connected to contact places of the pattern of conductive tracks, and the insu-

lated conductive tracks can cross a component between said component and the electrically insulating foil.

The photolacquer may be applied to the foil, for example, by dipping or spraying, after which the desired parts are removed by exposure and development. In this manner, the photolacquer layer is obtained in a particularly simple manner. The photolacquer used may be any photolacquer conventionally used in semiconductor technology for photoresist methods.

In a preferred form the contact places of the pattern of conductive tracks have been thickened by means of a metal layer. This promotes the making of good electrical connections to the pattern. Such a metal layer may be, for example, a layer of solder or a metal layer which is better suited for ultrasonic welding thereto or thermocompression bonding thereto than the metal of which the pattern consists. An advantage of the photolacquer layer is that when applying the metal layer, said photolacquer layer may be used as a mask. The metal layer may be provided, for example, electrolytically. If the photolacquer layer should not be present, a metal layer could be provided only in a simple manner, for example, electrolytically, over the whole pattern which would render the foil provided with the pattern less flexible or would require an etching method so as to restrict the metal layer to the contact places.

The foil and the photolacquer layer may be transparent, the foil consisting of a synthetic resin. The thickness of the foil preferably is maximally 75 μm, the thickness of the pattern 25 μ and the thickness of the photolacquer layer 5 μm. The foil preferably is as thin as possible and hence as flexible as possible. In the case of a very flexible foil, the contact places of an electrical component and a component support to be contacted need not be situated in one flat plane since a bend in the foil can hardly exert any force on a connection place. Furthermore, in the case of ultrasonic welding, a thin foil consumes hardly any energy, so that welding in this manner of an electrical component to the pattern can more readily be performed. Foils having thicknesses of approximately 50, 25 and 12 μm have proved to be successful. For similar reasons the pattern and the photolacquer layer preferably are very thin. The foil and the photolacquer layer preferably are transparent so as to visually aid orientation of the pattern contact places on the contact places of an electrical component.

A number of equal patterns of conductive tracks may be situated on the flexible insulating foil, said patterns being provided with an insulating layer of a photolacquer which covers the patterns with the exception of a number of contact places of the patterns. This is of importance for mass production of electrical devices comprising electrical components connected on a flexible foil carrier. After connecting electrical components, for example integrated semiconductor devices, capacitors and resistors, to the patterns, the foil may be subdivided, electrical devices being obtained each comprising a foil having a pattern of conductive tracks to which at least one electrical component is connected.

By use of the foil in accordance with the invention an integrated semiconductor device may be provided with flexible electrical connection conductors in a cheap and efficacious manner. In a preferred form of a flexible insulating foil in accordance with the invention the pattern of conductive tracks comprises a group of contact places situated close to each other and providing for the connection of an integrated semiconductor device to the pattern, each contact place of the group being connected, *via* a conductive track, to a further contact place which is situated outside the group and which is larger than the each of the contact places of the group. The contact places of the group as well as the contact places of an integrated semiconductor device usually have dimensions smaller than 150 μm$\times$150 μm. Further conductive connections to the larger contact places can easily be made.

The flexible electrically insulating foil provided with pattern of conductive tracks and the photolacquer layer can be marketed separately, the electrical component or components being connected on the foil to the pattern by the users themselves.

According to a further aspect of the invention there is provided a flexible insulating foil in accordance with the invention and at least one electrical component connected on the foil to the pattern of conductive tracks. The flexible electrically insulating foil may have connected thereto an integrated semiconductor device comprising semiconductor circuit elements provided in a semiconductor body, said body having an insulating surface layer carrying contact places of the device, the contact places of the device being connected to contact places of the pattern of conductive tracks.

Embodiments of the invention will now be described in greater detail, by way of example, with reference to the accompanying diagrammatic drawings, in which:—

Figure 1 is a diagrammatic plan view of a part of an embodiment of a flexible electrically insulating foil in accordance with the invention;

Figure 2 is a diagrammatic cross-sectional view, taken on the line II—II in Figure 1, in which the foil is shown connected to an integrated semiconductor device, of which a part is shown diagrammatically;

Figure 3 diagrammatically shows a second

embodiment of a flexible insulating foil in accordance with the invention.

Figures 1 and 2 show a part of a flexible insulating foil 1 on which a pattern A of conductive tracks 2 is situated to which an integrated semiconductor device can be connected. The foil 1 and the pattern 2 are covered with an insulating layer 3 of a photolacquer of which the side situated opposite to the side which adjoins the foil 1 and the pattern 2 is free from conductive tracks. The photolacquer layer does not cover parts called the contact places 4 and 5 of the pattern.

In the present example, a number of identical patterns are provided on the foil 1, of which patterns only one (A) is shown entirely and two (B and C) are shown partly for reasons of simplicity. All the patterns are covered by the photolacquer layer 3 with the exception of their contact places. The parts of the pattern covered by the photolacquer layer 3 are denoted by broken lines in Figure 1.

The flexible insulating foil 1 consists of a transparent synthetic resin, for example, a polyimide, and has a thickness of maximally 75 μm, for example, a thickness of 25 μm. The patterns A, B and C of conductive tracks can be provided on the foil in any conventional manner, for example photochemically, as is described in our British Patent Specification No. 1,092,607, in which the patterns consist at least mainly of copper. The patterns have a thickness of less than 25 μm, for example, a thickness of approximately 5 μm. In the above-mentioned known method, the patterns are usually given the desired thickness electrolytically, for example, by depositing copper, for which it is desirable that the patterns electrically should form one assembly. Conductive tracks 6 are therefore provided to interconnect the patterns electrically.

The photolacquer may be applied to the foil to form the layer 3 by spraying and then be exposed and developed, the parts which cover the contact places 4 and 5 being removed. The photolacquer used may be any photolacquer conventionally used in semiconductor technology for photoresist treatments. Many conventional photolacquers are electrically insulating and transparent. The photolacquer layer has a thickness smaller than 5 μm, for example, a thickness of approximately 3 μm. The provision of such a photolacquer layer is particularly simple.

The contact places 4 and 5 of the patterns have been thickened and this is shown in Figure 2 for the one contact place 4. The thickening may be obtained, for example, electrolytically, and consists of a layer of solder. Alternatively, for example, when it is desired to make the connection to the contact places by ultrasonic welding a metal layer may be provided which is more suitable for ultransonic welding thereto than the metal of the patterns. When the thickening layer used is of solder, since only the contact places 4 and 5 are provided with a layer of solder, the flexibility of the foil comprising patterns is substantially not reduced. During the provision of the layer of solder, the photolacquer layer 3 serves as a mask.

The conductive tracks 2 of the patterns A, B and C are to be used as flexible supply conductors for integrated semiconductor devices. For that purpose, a pattern A of conductive tracks 2 comprises a group of contact places 4 situated close to each other so as to be able to connect an integrated semiconductor device to the pattern A, each contact place 4 being connected, via a conductive track 2, to a contact place 5 which is situated outside the group of contact places 4 and which is larger than each of the contact places 4 of the group. The contact places 4, for example, have diameters of 100 μm and the contact places 5 have dimensions of 800 μm$\times$400 μm. The tracks 2 have a length of approximately 2 mm.

A conventional integrated semiconductor device can be connected to the contact places 4 (only one contact place 4 is shown in cross-section in Figure 2), comprising a body 7 which consists partly of the semiconductor material 8 in which semiconductor circuit elements (not shown) are provided in any conventional manner and which comprises an insulating surfaces layer 9, on which contact places 10 of the integrated semiconductor device are provided so as to be situated in the same manner relative to each other and approximately equally as large as the contact places 4 (in Figure 2 only one contact place 10 is shown), the contact places 4 being connected to the contact places 10. The connection is produced by soldering. However, the use of ultrasonic welding is also possible. In Figure 1, the location of the integrated semi- broken line 11. Since the foil 1 as well as the photolacquer layer 3 may be transparent, the foil contact places can simply be oriented visually onto the contact places 10 of the integrated semiconductor device.

It has been found that in the absence of the photolacquer layer 3, a shortcircuit can easily occur between the edge of the semiconductor material denoted by an arrow or semiconductor crystal 8 and the tracks 2. This is often due to the fact that the insulating layer 9 does not exactly reach up to said edge. The layer of photolacquer 3 prevents such a short-circuit.

When integrated semiconductor circuits have been connected to the patterns A, B and C, the foil 1 is subdivided along the lines 12, the conductive tracks 5 not associated with the patterns being separated from the patterns. Integrated semiconductor devices are thus obtained which have been provided with flexible connection conductors in a rapid and

cheap manner and which cannot form an undesirable shortcircuit with the integrated semiconductor device.

The foil may also be first subdivided, after which an integrated semiconductor device can be provided on each resulting foil. For mass production, however, the reverse sequence is to be preferred.

The foil may comprise patterns to which a number of semiconductor circuit elements and/or other electrical components, for example, capacitors and resistors, can be connected. Figure 3 diagrammatically shows such a pattern of conductive tracks to which two integrated semiconductor devices and a further electrical component, for example, a capacitor, can be connected. The location for the integrated semiconductor devices is denoted by 21 and 22 and that of the capacitor by 23. The pattern consists of the conductive tracks 24 to 30 and contact places 31 to 36. The pattern is covered with an insulating layer of a photolacquer which does not cover said contact places.

The tracks 24 with their contact places 36 and 32 or 36 and 33 correspond to the tracks 2 with their contact places 4 and 5 shown in the preceding embodiment.

When the contact places of an integrated semiconductor device are connected to the contact places 31 and 32, the conductive track 30 forms an electrical connection between two parts of said semiconductor device. As the track 30 is covered with an insulating layer of a photolacquer, said track cannot give rise to an undesirable shortcircuit with conductive tracks provided on the integrated semiconductor device. For the same reason the track 26 may cross the integrated semiconductor device which is connected to the contact places 33 and the track 27 may cross the electrical component which is connected to the contact places 34 and 35.

The tracks 25 form electrical connections between the semiconductor circuit elements which are connected to the contact places 32 and 33.

A foil in accordance with the invention having connected thereto one or more electrical components may be mounted and/or incorporated in an electrical device in any conventional manner.

Many variations are possible to those skilled in the art within the scope of this invention as defined in the appended claims. The connection between a contact place of a pattern and a contact place of an electrical component need not be a soldered joint or a connection obtained by ultrasonic welding, but alternatively may be, for example, a connection obtained by thermo-compression bonding. The foil may be provided with a pattern of conductive tracks, to which more electrical components can be or are connected than is shown in the examples. The electrical components may comprise, for example, planar transistor bodies. The foil may be provided on two sides with a pattern of conductive tracks covered by an insulating layer of a photolacquer with the exception of the contact places. The flexible insulating foil, which preferably is transparent, may consist, for example, of polyethylene terephthalate instead of a polyimide. Resistance elements in the form of a metal layer can also be connected on the foil.

WHAT WE CLAIM IS:—

1. A flexible electrically insulating foil on which a pattern of conductive tracks is situated at least at one side of the foil, said pattern comprising a plurality of contact places, at least some of said plurality of contact places being suitable for the connection on the foil of at least one electrical component to the pattern, an insulating layer of a photolacquer being present on the pattern and on the foil, said photolacquer layer covering the pattern and at least the corresponding side of the foil with the exception of the contact places, the side of the photolacquer layer situated opposite to the side adjoining the pattern and the foil being free from conductive tracks.

2. A flexible insulating foil as claimed in Claim 1, wherein the contact places of the pattern of conductive tracks have been thickened by means of a metal layer.

3. A flexible insulating foil as claimed in any of the preceding Claims, wherein the foil and the photolacquer layer are transparent and the foil consists of a synthetic resin.

4. A flexible insulating foil as claimed in any of the preceding Claims, wherein a number of equal patterns of conductive tracks is situated on the foil, said patterns being provided with a photolacquer layer which covers the patterns with the exception of the contact places of the patterns.

5. A flexible insulating foil as claimed in any of the preceding Claims, wherein the pattern of conductive tracks comprises a group of contact places situated close together and providing for the connection of an integrated semiconductor device to the pattern, each contact place of the group being connected, *via* a conductive track, to a further contact place which is situated outside the group and which is larger than each of the contact places of the said group.

6. A flexible insulating foil as claimed in any of Claims 1 to 5 and at least one electrical component connected on the foil to the pattern of conductive tracks.

7. A flexible insulating foil as claimed in any of Claims 1 to 5, having connected thereto an integrated semiconductor device comprising semiconductor circuit elements provided in a semiconductor body, said semiconductor body having an insulating surface layer

cheap manner and which cannot form an undesirable shortcircuit with the integrated semiconductor device.

The foil may also be first subdivided, after which an integrated semiconductor device can be provided on each resulting foil. For mass production, however, the reverse sequence is to be preferred.

The foil may comprise patterns to which a number of semiconductor circuit elements and/or other electrical components, for example, capacitors and resistors, can be connected. Figure 3 diagrammatically shows such a pattern of conductive tracks to which two integrated semiconductor devices and a further electrical component, for example, a capacitor, can be connected. The location for the integrated semiconductor devices is denoted by 21 and 22 and that of the capacitor by 23. The pattern consists of the conductive tracks 24 to 30 and contact places 31 to 36. The pattern is covered with an insulating layer of a photolacquer which does not cover said contact places.

The tracks 24 with their contact places 36 and 32 or 36 and 33 correspond to the tracks 2 with their contact places 4 and 5 shown in the preceding embodiment.

When the contact places of an integrated semiconductor device are connected to the contact places 31 and 32, the conductive track 30 forms an electrical connection between two parts of said semiconductor device. As the track 30 is covered with an insulating layer of a photolacquer, said track cannot give rise to an undesirable shortcircuit with conductive tracks provided on the integrated semiconductor device. For the same reason the track 26 may cross the integrated semiconductor device which is connected to the contact places 33 and the track 27 may cross the electrical component which is connected to the contact places 34 and 35.

The tracks 25 form electrical connections between the semiconductor circuit elements which are connected to the contact places 32 and 33.

A foil in accordance with the invention having connected thereto one or more electrical components may be mounted and/or incorporated in an electrical device in any conventional manner.

Many variations are possible to those skilled in the art within the scope of this invention as defined in the appended claims. The connection between a contact place of a pattern and a contact place of an electrical component need not be a soldered joint or a connection obtained by ultrasonic welding, but alternatively may be, for example, a connection obtained by thermo-compression bonding. The foil may be provided with a pattern of conductive tracks, to which more electrical components can be or are connected than is shown in the examples. The electrical components may comprise, for example, planar transistor bodies. The foil may be provided on two sides with a pattern of conductive tracks covered by an insulating layer of a photolacquer with the exception of the contact places. The flexible insulating foil, which preferably is transparent, may consist, for example, of polyethylene terephthalate instead of a polyimide. Resistance elements in the form of a metal layer can also be connected on the foil.

WHAT WE CLAIM IS:—

1. A flexible electrically insulating foil on which a pattern of conductive tracks is situated at least at one side of the foil, said pattern comprising a plurality of contact places, at least some of said plurality of contact places being suitable for the connection on the foil of at least one electrical component to the pattern, an insulating layer of a photolacquer being present on the pattern and on the foil, said photolacquer layer covering the pattern and at least the corresponding side of the foil with the exception of the contact places, the side of the photolacquer layer situated opposite to the side adjoining the pattern and the foil being free from conductive tracks.

2. A flexible insulating foil as claimed in Claim 1, wherein the contact places of the pattern of conductive tracks have been thickened by means of a metal layer.

3. A flexible insulating foil as claimed in any of the preceding Claims, wherein the foil and the photolacquer layer are transparent and the foil consists of a synthetic resin.

4. A flexible insulating foil as claimed in any of the preceding Claims, wherein a number of equal patterns of conductive tracks is situated on the foil, said patterns being provided with a photolacquer layer which covers the patterns with the exception of the contact places of the patterns.

5. A flexible insulating foil as claimed in any of the preceding Claims, wherein the pattern of conductive tracks comprises a group of contact places situated close together and providing for the connection of an integrated semiconductor device to the pattern, each contact place of the group being connected, *via* a conductive track, to a further contact place which is situated outside the group and which is larger than each of the contact places of the said group.

6. A flexible insulating foil as claimed in any of Claims 1 to 5 and at least one electrical component connected on the foil to the pattern of conductive tracks.

7. A flexible insulating foil as claimed in any of Claims 1 to 5, having connected thereto an integrated semiconductor device comprising semiconductor circuit elements provided in a semiconductor body, said semiconductor body having an insulating surface layer

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carrying contact places of the device, the contact places of the device being connected to contact places of the pattern of conductive tracks.

9. A flexible insulating foil, substantially as herein described with reference to the accompanying drawings.

10. An assembly of a flexible insulating foil and an integrated semiconductor device substantially as herein described with reference to Figures 1 and 2 or Figure 3 of the accompanying drawings.

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