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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN AND RELATING TO FORMING ELECTRICALLY-CONDUCTIVE SOLDER-CONNECTIONS BETWEEN CURRENT-CONDUCTORS ON A SUBSTRATE AND CONDUCTOR-TRACKS OF AN INSULATING FLEXIBLE FOIL

(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 method of forming electrically-conductive solder-connections between current-conductors on a substrate and conductor-tracks exposed on one side of an insulating flexible foil, to which conductor-tracks is connected an electrical element carried by the foil. The invention further relates to assemblies, particularly but not exclusively, semiconductor devices made using such a method.

It is known to form an electrically-conductive solder-connection between current-conductors on a substrate such as a mounting panel and conductor-tracks exposed on one side of an insulating flexible foil, to which conductor-tracks is connected an electrical element, for example a semiconductor device body, carried by the foil. In such a known method, the foil is positioned on the substrate such that exposed terminal-portions of the conductor-tracks on the said one side of the foil are face-down on, and are aligned relative to, solder-coated portions of the current-conductors of the substrate. The solder-connections are then formed by heating. Such a method has several disadvantages. The soldered joint is comparatively weak. Furthermore it is not possible for current-conductors of the mounting panel to extend generally beneath the foil owing to possible short-circuit with the conductor-tracks on the foil. The wiring layout pattern of the current-conductors must thus be adapted to accommodate the foil, and this is often

difficult and sometimes even impossible. In order to mitigate this latter drawback, the foil can be enveloped in insulating synthetic material, but this involves a considerable price increase of the semiconductor device.

According to the present invention there is provided a method of forming electrically-conductive solder-connections between current-conductors on a substrate and conductor-tracks exposed on one side of an insulating flexible foil, to which conductor-tracks is connected an electrical element carried by the foil, in which the foil is positioned on the substrate such that exposed terminal-portions of the conductor-tracks adjacent the foil edge are present on the side of the foil facing away from the substrate and are aligned with solder-coated portions of current-conductors of the substrate, a heated element is placed on the solder-coated portion of at least one current conductor adjacent the foil edge to melt the solder, the end of the heated element is moved to above the exposed terminal portion of the associated conductor track to wet the said exposed terminal portion with molten solder from the current-conductor, and after a further upward movement, the molten solder is detached from the heated element to form a hill of solder between the current-conductor and the conductor-track, the solder connections being made in this manner either separately or in a group.

Such a method results in very rigid connections between the foil and the substrate. The hill of solder is readily obtained; the vertical cross-section of the hill of solder determines the strength of the joint. Only a conventional amount of solder is needed on the current conductors, for example a normal quantity obtained by solder-dipping is amply sufficient. The height of the hill of solder depends inter alia upon the temperature and the rate of movement of the heated element so that said height is adjust-

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able within certain limits. The additional advantage of the method is that the soldering is visible. It is also possible for current-conductors of the substrate to extend below the foil. Since the conductor-tracks are exposed on the side of the foil facing uppermost, the possibility of short-circuit is excluded. Thus less restriction is placed on the layout of the pattern of the current conductors on the substrate.

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

Figure 1 is a plan view of a substrate having a foil secured thereto;

Figure 2 shows the soldered joint between a conductor-track of the foil and a current-conductor of the substrate;

Figure 3 shows a manufacturing step for the soldering of the joint, in accordance with the present invention, and

Figure 4 shows the connected foil and substrate and a cooling member.

In the embodiment now to be described there is provided a flexible insulating foil 1 having metal conductor tracks 2 entirely exposed on one side thereof. The foil may be, for example, a polyimide. Its thickness is, for example, 25 microns, the thickness of the conductor tracks being 7 microns. The upper side of the conductor tracks is provided with a readily solderable metal layer. An electrical element in the form of a semiconductor device body 3 is connected to the inner ends of the conductor tracks 2. The semiconductor device body comprises, for example, an integrated circuit and is provided with metal contacts 4. The connection of the semiconductor element 3 is carried out by soldering contacts 4 to the conductor tracks 2.

A substrate 5 of an insulating material carries current conductors 6. The substrate 5 may be, for example, a printed circuit mounting panel or a ceramic plate on which current conductors are provided by thick-film technology. The current conductors 6 are provided with a layer of solder, for example, a layer of lead-tin, and this may be achieved by solder-dipping.

The side of the flexible foil 1 not carrying conductor tracks is placed on the substrate 5, as shown in Figure 3. The terminal-ports of the conductor tracks 2 adjacent the foil edge are aligned relative to corresponding current conductors 6 on the substrate 5. Figure 2 shows that the current conductors 6 are present slightly beneath the foil 1, to allow a sufficient manufacturing tolerance in locating the foil on the substrate. Such an overlap is not necessary for a good connection.

A separate operation may be used to make each conductive solder-connection between the conductor tracks 2 and the

current conductors 6. However, for a manufacturing process, it is more advantageous to simultaneously form all the connections on one or both longitudinal sides of the foil. The method of connecting is carried out as follows.

A heated element 7 (Figure 3) is placed on the current conductors 6, adjacent a longitudinal side of the foil. The heated element 7 operates as a soldering iron; solder on the current conductors 6 where contacted by the end of the element 7 melts and accumulates around the element 7. The end of the element 7 is now moved to above the ends of the conductor tracks 2, for example to the place A as is denoted in Figure 3 by broken lines, and carries with it molten solder. This solder flows over the ends of the current conductors to the conductor-tracks of the foil 1. This is facilitated in that the upper layer of the conductor tracks consists of a readily solderable metal, for example gold, which is readily wetted by solder. When the end of the soldering element 7 is further moved upwards (as shown by the broken lines from A to B in Figure 3) the solder will detach from the element 7 and in the solidified state constitutes a hill 8 of solder as is shown in Figure 2. Dependent upon the temperature of the soldering element 7 and on the speed of moving the element 7, the top of the hill of solder may be more pointed than is shown in Figure 2. The largest height of the hill of solder lies just near the edge of the foil, so that the joint has a maximum strength. The resulting hills 8 of solder constitute a mechanically strong and electrically excellent conducting joint between the current conductors 6 and the conductor tracks 2.

Figure 4 is a side elevation of a substrate 5 having a foil 1 secured thereto in which a cooling member 10 is secured to the rear side of the semiconductor device body 3. The current conductors on the substrate are again denoted by 6 and the hills of solder by 8. These hills of solder 8 are formed as hereinbefore described with reference to Figures 1 to 3. Viewed in the direction normal to the plane of the drawing, the cooling member 10 is narrower than the foil so that the soldered joints can be readily provided after the provision of the cooling member 10. The cooling member has depressed portions 11 which bear against the top of the foil 1 to secure the foil 1 against the cooling member 10. In the unit thus formed, a large power can be developed in the semiconductor device body 3, while the cooling member 10 also provides mechanical protection.

WHAT WE CLAIM IS:—

1. A method of forming electrically-conductive solder-connections between



able within certain limits. The additional advantage of the method is that the soldering is visible. It is also possible for current-conductors of the substrate to extend below the foil. Since the conductor-tracks are exposed on the side of the foil facing uppermost, the possibility of short-circuit is excluded. Thus less restriction is placed on the layout of the pattern of the current conductors on the substrate.

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

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Figure 4 shows the connected foil and substrate and a cooling member.

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A substrate 5 of an insulating material carries current conductors 6. The substrate 5 may be, for example, a printed circuit mounting panel or a ceramic plate on which current conductors are provided by thick-film technology. The current conductors 6 are provided with a layer of solder, for example, a layer of lead-tin, and this may be achieved by solder-dipping.

The side of the flexible foil 1 not carrying conductor tracks is placed on the substrate 5, as shown in Figure 3. The terminal-ports of the conductor tracks 2 adjacent the foil edge are aligned relative to corresponding current conductors 6 on the substrate 5. Figure 2 shows that the current conductors 6 are present slightly beneath the foil 1, to allow a sufficient manufacturing tolerance in locating the foil on the substrate. Such an overlap is not necessary for a good connection.

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WHAT WE CLAIM IS:—

1. A method of forming electrically-conductive solder-connections between

current-conductors on a substrate and conductor-tracks exposed on one side of an insulating flexible foil, to which conductor-tracks is connected an electrical element
5 carried by the foil, in which the foil is positioned on the substrate such that exposed terminal-portions of the conductor-tracks adjacent the foil edge are present on the side of the foil facing away from the sub-
10 strate and are aligned with solder-coated portions of current-conductors of the substrate, a heated element is placed on the solder-coated portion of at least one current conductor adjacent the foil edge to melt the
15 solder, the end of the heated element is moved to above the exposed terminal portion of the associated conductor track to wet the said exposed terminal portion with molten solder from the current-conductor,
20 and after a further upward movement, the molten solder is detached from the heated element to form a hill of solder between the current-conductor and the conductor-track, the solder connections being made in this
25 manner either separately or in a group.

2. A method as claimed in Claim 1, in which electrically-conductive solder-connections are simultaneously formed between several conductor-tracks and their
30 corresponding current-conductors.

3. A method as claimed in Claim 1 or Claim 2, in which the electrical element is a

semiconductor device body mounted on the side of the foil remote from the substrate.

4. An assembly comprising a substrate and an insulating flexible foil with electrically-conductive solder-connections formed between the current-conductors and conductor-tracks using a method as claimed in any of the preceding Claims.

5. A method of forming electrically-conductive solder-connections between current-conductors on a substrate and conductor-tracks on an insulating flexible foil, substantially as herein described with reference to Figures 1, 2 and 3 of the accompanying drawing.

6. A semiconductor device comprising a semiconductor device body, an insulating flexible foil and a substrate, substantially as herein described with reference to Figures 1 and 2 of the accompanying drawing.

7. A semiconductor device comprising a semiconductor device body, an insulating flexible foil, a substrate and a cooling member, substantially as herein described with reference to Figure 4 of the accompanying drawing.

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