

PATENT SPECIFICATION

(11)

1 237 099

DRAWINGS ATTACHED

- (21) Application No. 42135/68 (22) Filed 4 Sept. 1968
(31) Convention Application No. 682 193 (32) Filed 13 Nov. 1967 in
(33) United States of America (US)
(45) Complete Specification published 30 June 1971
(51) International Classification H 01 L 1/14
(52) Index at acceptance
H1K 312 422 441 442 453 459 469 477 483 490 520 52Y
530 54Y



(54) METHOD OF MAKING ELECTRICAL CONTACT TO ONE OR MORE SEMICONDUCTOR COMPONENTS

(71) We, FAIRCHILD CAMERA & INSTRUMENT CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America of 5 300 Robbins Lane, Syosset, Long Island, New York, United States of America, 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 an electrical connection to a semiconductor chip.

15 Integrated circuits require external electrical connections for the purpose of supplying power, for the purpose of interconnecting a number of circuits together, and for various other purposes. To 20 provide for such connections a number of areas of conductive material (e.g. aluminum film), referred to as pads, are associated with each circuit. These pads are usually placed around the perimeter of the circuit to allow maximum density and flexibility of interconnection of the components of the circuit. Each pad provides sufficient area so that a conventional lead wire may be connected to it by a common 25 bonding technique such as ultrasonic bonding or thermocompression bonding.

In the prior art as stated, the pads have been located outside the area occupied by the circuit components. Such location of 35 the pads substantially increases the total area of the integrated circuit limiting the maximum component density obtainable. The number of circuits that may be batch processed in a single operation by such 40 fabrication equipment as diffusion furnaces and photo-graphic masking jigs is, in part, determined by the area of each integrated circuit. Thus, the increase in area of an integrated circuit attributable 45 to the pad area decidedly limits integrated

circuits production output.

Another disadvantage of such prior art methods is that the pad area does not contain any underlying circuit components. This is because pressure is required to 50 bond the wires to the pad itself which pressure might damage underlying components. Thus, the area on which the pads are located is employed strictly as a support in prior art methods. In some arrangements the pad area may occupy as 55 much as 40% of the integrated circuit.

One prior art method eliminates a large amount of the pad area waste by providing conductive pads that may be folded 60 over onto the substrate. This method has the disadvantage that the bonding of electrical connections must be carefully controlled as too much pressure damages underlying substrates or components. Such 65 a method also requires an extra layer of insulating material.

The subject invention reduces the area required for an integrated circuit and provides a batch method for bonding a 70 lead to an integrated circuit. This enables an electrical connection to be made to an integrated circuit without further wiring or other electrical connection.

According to one aspect of the invention, a method of forming an electric connection to a semiconductor device comprises the steps of forming at least one 75 conductive contact area on the surface of the device and depositing a first layer of conductive selectively adhering material over said contact area and a portion of said surface, said material adhering to said contact area but not adhering to said 80 device surface.

According to another aspect of the invention, an extended beam device comprises a semiconductor chip having at least one component therein defining an 85 element of an electrical circuit, a conduc-

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tive pad associated with said chip, said conductive pad making contact with said component in said semiconductor chip and a conductive beam comprising an extending finger of a first material, said finger being superimposed upon said conductive pad and adhering thereto, and non-adhering to the surface of said chip, said finger extending from said conductive pad and on to the surface of said semiconductor chip and extending longitudinally beyond the edge of said chip, and a layer of a second material imposed upon said finger of said first material and coincident therewith, said layer adhering to said finger of said first material and forming a laminate therewith.

According to a further aspect of the invention, in a structure comprising a semiconductor chip having at least one component therein defining an element of an electrical circuit, with electrical leads contacting the components in said chip, each of said electrical leads comprising a conductive pad making contact with a component in said chip and a conductive beam contacting said conductive pad, said beam comprising an extended finger of conductive material superimposed on, and adhering to, said conductive pad, while extending across, but non-adhering to, the surface of said chip, said finger extending longitudinally beyond the edge of said chip.

One of the advantages of the invented method is that devices may be placed directly under the contact pad or area. Heretofore the dangers of excess strain on the device during bonding prohibited this. However, in the present invention external connection is made to extended conductive fingers or beams and no pressure is placed on the contact pads themselves. Hence, more usable area is to be had for the same chip size. The contact pads may be made smaller as they are no longer required to have a size sufficient to receive a wire.

Another advantage of the present invention is that all external leads may be bonded at once. It is no longer necessary to bond contact wires to individual pads. Furthermore, the extended beams may be formed from simple metal system by vacuum evaporation requiring no etching or other processing step.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with future objects and advantages thereof will be better understood from the following description considered in connection with the accompanying drawing in which a present preferred embodiment of the invention

is illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

Brief Description of the Drawings

FIGURES 1A to 1D illustrates in diagrammatic form the method of providing extended beam leads on a substrate or device surface;

FIGURE 2 is a top view in diagrammatic form of two neighboring device chips having multiple extended beam leads; and

FIGURE 3 is a perspective of a beam lead on a device chip.

Description of the Preferred Embodiment

The extended beam lead technique of providing electrical connections to semiconductor devices is equally applicable to single discrete devices as well as integrated circuits. In the preferred embodiment of the invention the extended beam lead and the process relating thereto is described in connection with an integrated circuit.

Referring now to FIGURE 1A, there is provided a substrate or device 10 which may be a monolithic silicon chip having a scribe line 14 thereon for separating the chip into two or more devices. A passivating or protective layer 13 such as SiO_2 may cover the surface of the device 10. To connect a number of circuits together and to connect one device to another device, a conductive contact or pad 12 is associated with one of the circuits or components 15 which is formed in accordance with well known techniques as described in U.S. Patent 2,981,877. The pad 12 is placed directly over and in electrical contact with component 15 via an aperture in layer 13. The pad 12 may conveniently be two mils wide by two mils long and made of aluminum. (Prior art conductors usually employ pad 5 x 5 mils in order to receive a wire). Any suitable conductive material, however, may be used as pad 12. The forming of a device and pad as shown in FIGURE 1A is by conventional techniques. Normally a discrete device or integrated circuit has a plurality of regions on which conductive pads are positioned and to which extended beam leads in accordance with this invention may be simultaneously formed. For simplicity, the description proceeds primarily with reference to the formation of a beam lead to the single illustrated conductive pad 12.

Next, a layer of material which is selectively adhering is deposited in a pattern on device 10. To accomplish this a mask is placed over the device and is oriented

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and held down firmly in close contact to the surface of the device. The mask has a cutout extending over and coinciding with contact pad 12 which in configuration resembles a finger, and which has a width at one end about the same as the pad itself. The finger cutout extends over the scribe line 14 and over to an adjoining device 10A (FIGURE 2). Thus, the cutout in the mask coincides with aluminum pad 12 and extends therefrom over the protective layer 13.

With the mask in place, the depositing of the selectively adhering material is performed (FIGURE 1B). Typically this may be done by a flash evaporation of silver in well known vacuum depositing equipment. The silver may be deposited to a thickness of no less than 500 Å to form layer 16 (FIGURE 1B). The layer 16 has the property of non-adherence to SiO₂ and of adhering strongly to the pad 12. In addition it is preferred that layer 16 act as a conductor.

With the mask still in place, a second layer 18 is evaporated to a thickness which may be about 25 microns (FIGURE 1C). The second layer 18 is deposited over layer 16. The second layer 18 has the property of adhering well to the first layer and of acting as a conductor when in contact with the first layer. The layer 18 which adheres to layer 16, is a conductive material that is deposited to a predetermined thickness (e.g., no less than 25 microns) to provide additional mechanical strength to the extended beam 20 (FIGURE 3).

In one preferred embodiment of the present process invention, the first layer 16 is silver and the second layer 18 is aluminum. Of course, a combination of any two suitable materials may be used or a single material may be used. For example, silver alone may be used for certain applications. The only requirement is that the material adjacent device 10 adhere well to the pad 12 but not adhere to protective layer 13. In certain applications a protective layer may not be used. Thus, the first and second layers are selected (1) for their adhesion to each other, and (2) for the non-adhesion of the first metal to the device surface, (3) for their electrical characteristics, such as resistance, and (4) for their strength characteristics. It should be noted that when aluminum is deposited over silver the banded aluminum-silver beam has a low electrical resistance, good strength, adhesion to the contact pad and non-adhesion to the device surface. Other material that may be employed as a substitute for aluminum are chromium, platinum, titanium, molybdenum and gold;

other materials that may be used rather than silver (non-adhering to device surface) are gold, antimony and others. It should be understood that the various forms of vacuum deposition, plating and other techniques for forming thin layers of conductive material may be employed.

If several or more devices are treated at the same time, as shown in FIGURE 2, when the mask is removed the resultant pattern is represented by a plurality of discrete interdigitated fingers comprising sets 20 and 20A. The fingers of each set extend over the scribe line 14 onto the adjacent devices. The shape of the fingers accommodate the interdigitation.

It is within the scope of the invention to form the layers 16 and 18 by photoengraving processes such as mentioned in previously referred to U.S. Patent 2,981,877. In addition, it is not necessary that 16 be coincident with layer 18 over the entirety of layer 18. This will be further explained later in the description.

Next, the wafer is backside scribed and the devices separated by mechanical pressure (FIGURE 1D). These devices are brittle and break at the scribe line 14. This scribing and breaking results in the forming of extended beams 20 which easily separate from the surface of the adjacent device since there is poor adhesion between the first layer 16 and the device oxide surface 13 over which they extend. Thus, the first layer deposited serves as a release agent for the extended beam. It should be noted, however, that the first layer (e.g., silver) has excellent adhesion to contact pad 12 and the layer 18, thereby forming an integral extended beam which has good electrical and mechanical properties. At this point it can be seen that it is only necessary that layer 16 be deposited over surfaces that are to be separated from the lead. For example, insofar as device 10 is concerned layer 16 need only be deposited on device 10a. This enables a minimum of silver to be employed and enables a better mechanical support. This also facilitates the forming of contact 12 and layer 18 simultaneously.

The resulting structure (FIGURES 1D and 3) has extended beams which are connected to the contact pads which are arranged across the width and length of a chip. These extended beams then extend beyond the edge of the chip and away from the area of scribe line 14 which marks the boundary of a device. The masking scheme can be designed to alternate the positions of the pads on neighbouring devices so that the extended lead from a pad on one device falls between two adjacent pads on the neighbouring device. Such a design is shown in

FIGURE 2.

The length of the extended leads 20 should be such that the leads overhang the edge of the chip by about 5 mils or more to facilitate other connections. The extended leads have the required mechanical strength when 5 mil in length and when used on a 2 x 2 mil conductive pad. When the metallization mask has been removed and the wafer is back side scribed the chip is ready for connection by means of the extended beams to another adjacent device or circuit, the beams serving the same function as a conventional connecting wire.

It is apparent from the foregoing that the heretofore described process and device has many advantages. One such advantage with respect to extended leads is that all leads may be bonded at once thus eliminating the need for bonding individual wires to each conductive pad. No new processing technology is involved in processing the leads other than the standard techniques of metal evaporation plating etc.

Another significant advantage of the present invention is that devices may now be placed directly under the pad. Heretofore, the danger of excess strain on the device during bonding prohibited this. Where leads extend off the pads, bonding pressures do not affect the components underlying the conductive pads. Thus more usable area is to be had for the same chip size. Higher densities of pads are also possible. If, for example, a 2 x 2 mil pad on 5 mil centres is selected, then a 75 x 75 mil chip can accommodate 60 pads with extended leads. Extended leads also are very economical and lend themselves to mass production.

The method of this invention has been described with contact pad 12 first deposited over an aperture in protective layer 13, and then layer 16 deposited over layer 13 and pad 12. In an alternative embodiment, layer 16 of conductive material is first deposited on protective layers 13 and then contact pad 12 is formed. Next, as in the previous embodiment conductive layer 18 is deposited over the exposed portions of layers 16 and the top of contact pad 12.

WHAT WE CLAIM IS:—

1. A method of forming an electric connection to a semiconductor device comprising the steps of forming at least one conductive contact area on the surface of the device and depositing a first layer of conductive selectively adhering material over said contact area and a portion of said surface, said material adhering to said contact area but not adhering to said device surface.

2. The method of claim 1 including the additional steps of depositing a second layer of conductive material over said first layer to adhere thereon and coinciding therewith, and separating a portion of said device underlying a portion of said layers.

3. The method of claim 2 wherein said separating is accomplished by back-scribing said device.

4. The method of claim 3 wherein said first and second layers are formed into a lead having a predetermined configuration by vacuum depositing said layers via a mask.

5. The method of claim 1, 2, 3 or 4 wherein said device is a semiconductor device having a protective coating over at least one surface with openings in said coating to expose the surface, contact being made with said semiconductor material through said openings, and said first layer is deposited over at least a portion of said protective coating.

6. The method of claim 6 wherein said first layer is deposited on the surface of said device and on said contact area to a thickness of no less than 500 angstroms and said second layer is deposited over said first layer and adhering thereto, said second layer being deposited to a thickness of no less than 25 microns.

7. The method of claim 6 wherein said first layer is silver and wherein said second layer is aluminium.

8. The method of claim 6 wherein said first layer is deposited and then at least one conductive contact area is formed with said contact area extending over said first layer.

9. An extended beam device comprising a semiconductor chip having at least one component therein defining an element of an electrical circuit, a conductive pad associated with said chip, said conductive pad making contact with said component in said semiconductor chip and a conductive beam comprising an extending finger of a first material, said finger being superimposed upon said conductive pad and adhering thereto, and non-adhering to the surface of said chip, said finger extending from said conductive pad and on to the surface of said semiconductor chip and extending longitudinally beyond the edge of said chip, and a layer of second material imposed upon said finger of said first material and coincident therewith, said layer adhering to said finger of said first material and forming a laminate therewith.

10. The extended beam device as defined in claim 9 wherein said first material is silver and said second material is aluminium.

FIGURE 2.

The length of the extended leads 20 should be such that the leads overhang the edge of the chip by about 5 mils or more to facilitate other connections. The extended leads have the required mechanical strength when 5 mil in length and when used on a 2 x 2 mil conductive pad. When the metallization mask has been removed and the wafer is back side scribed the chip is ready for connection by means of the extended beams to another adjacent device or circuit, the beams serving the same function as a conventional connecting wire.

It is apparent from the foregoing that the heretofore described process and device has many advantages. One such advantage with respect to extended leads is that all leads may be bonded at once thus eliminating the need for bonding individual wires to each conductive pad. No new processing technology is involved in processing the leads other than the standard techniques of metal evaporation plating etc.

Another significant advantage of the present invention is that devices may now be placed directly under the pad. Heretofore, the danger of excess strain on the device during bonding prohibited this. Where leads extend off the pads, bonding pressures do not affect the components underlying the conductive pads. Thus more usable area is to be had for the same chip size. Higher densities of pads are also possible. If, for example, a 2 x 2 mil pad on 5 mil centres is selected, then a 75 x 75 mil chip can accommodate 60 pads with extended leads. Extended leads also are very economical and lend themselves to mass production.

The method of this invention has been described with contact pad 12 first deposited over an aperture in protective layer 13, and then layer 16 deposited over layer 13 and pad 12. In an alternative embodiment, layer 16 of conductive material is first deposited on protective layers 13 and then contact pad 12 is formed. Next, as in the previous embodiment conductive layer 18 is deposited over the exposed portions of layers 16 and the top of contact pad 12.

WHAT WE CLAIM IS:—

1. A method of forming an electric connection to a semiconductor device comprising the steps of forming at least one conductive contact area on the surface of the device and depositing a first layer of conductive selectively adhering material over said contact area and a portion of said surface, said material adhering to said contact area but not adhering to said device surface.

2. The method of claim 1 including the additional steps of depositing a second layer of conductive material over said first layer to adhere thereon and coinciding therewith, and separating a portion of said device underlying a portion of said layers.

3. The method of claim 2 wherein said separating is accomplished by back-scribing said device.

4. The method of claim 3 wherein said first and second layers are formed into a lead having a predetermined configuration by vacuum depositing said layers via a mask.

5. The method of claim 1, 2, 3 or 4 wherein said device is a semiconductor device having a protective coating over at least one surface with openings in said coating to expose the surface, contact being made with said semiconductor material through said openings, and said first layer is deposited over at least a portion of said protective coating.

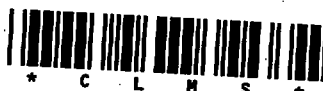
6. The method of claim 6 wherein said first layers is deposited on the surface of said device and on said contact area to a thickness of no less than 500 angstroms and said second layer is deposited over said first layer and adhering thereto, said second layer being deposited to a thickness of no less than 25 microns.

7. The method of claim 6 wherein said first layer is silver and wherein said second layer is aluminium.

8. The method of claim 6 wherein said first layer is deposited and then at least one conductive contact area is formed with said contact area extending over said first layer

9. An extended beam device comprising a semiconductor chip having at least one component therein defining an element of an electrical circuit, a conductive pad associated with said chip, said conductive pad making contact with said component in said semiconductor chip and a conductive beam comprising an extending finger of a first material, said finger being superimposed upon said conductive pad and adhering thereto, and non-adhering to the surface of said chip, said finger extending from said conductive pad and on to the surface of said semiconductor chip and extending longitudinally beyond the edge of said chip, and a layer of second material imposed upon said finger of said first material and coincident therewith, said layer adhering to said finger of said first material and forming a laminate therewith.

10. The extended beam device as defined in claim 9 wherein said first material is silver and said second material is aluminium.



11. In a structure comprising a semiconductor chip having at least one component therein defining an element of an electrical circuit, with electrical leads contacting the components in said chip, each of said electrical leads comprising a conductive pad making contact with a component in said chip, and a conductive beam contacting said conductive pad, said beam comprising an extended finger of conductive material superimposed on, and adhering to, said conductive pad, while extending across, but non-adhering to the surface of said chip, said finger extending longitudinally beyond the edge of said chip.

12. The method of making the structure of claim 9 comprising the steps of forming at least one conductive contact area on the surface of a semiconductor chip, then, with respect to each contact area, depositing on said chip selected

layers of conductive, selectively adhering material, said material overlying and adhering to said contact area, and overlying but not adhering to said chip surface, and separating from said layers of conductive material a portion of said chip underlying said first layer, leaving part of said conductive material extending beyond the edge of the remaining semiconductor chip.

13. The method of forming an electrical connection to a semiconductor device substantially as described.

14. An extended beam device substantially as described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed. 1971
Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY from which copies may be obtained.

