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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method for Alloying Contacts to Semi-conductor Devices

We, TEXAS INSTRUMENTS INCORPORATED, 13500 North Central Expressway, Dallas, Texas, United States of America, a corporation organized and existing under the laws of the State of Delaware, 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 electrical contacts for semiconductor devices, and more particularly to a technique for alloying a deposited metal contact to the surface of a semiconductor body.

In the manufacture of transistors, it is quite common to deposit a thin film of metal onto selected areas of a transistor wafer to which ohmic contact is to be made. The wafers are then heated to alloy the deposited material with the monocrystalline semiconductor wafer, the heating ordinarily being done either in an alloying furnace or by placing the wafers on a strip heater. In either case, it is difficult to control the degree of heating. To produce an optimum alloyed contact, it is preferable to heat only to an extent necessary to fuse a thin region, adjacent the bottom surface of the deposited material, with the top surface of the wafer, and then to cool rapidly to avoid further alloying. This is not possible when an alloying furnace is used since the entire wafer assemblies are heated, resulting in a considerable time lag in removing the heat source and cooling the devices. Likewise, a strip heater has considerable thermal inertia and necessitates heating the entire wafer by conduction.

The object of the invention is to provide a method of alloying a metal contact to a semiconductor body.

The present invention is a method for alloying at least one metal contact to a semiconductor body comprising placing an amount of metal in contact with the semiconductor body and subjecting the body and the amount of metal to infrared radiation from one or more infrared lamps.

Conductive material may be deposited in a selected pattern on the surface of a semiconductor wafer, then the wafer is placed on a heat-conductive support in vacuum under an overhead heat source, preferably a bank of quartz infrared tubes. The infrared tubes are excited for a few seconds, heating the deposited metal by radiant infrared and fusing the bottom surface of the deposited material to the surface of the wafer. The semiconductor material, typically silicon, would be transparent to infrared and so would be heated very little. As soon as the infrared tubes are cut off, the wafers and contacts cool rapidly due to the heat sink and the fact that the tubes have little thermal inertia. Since silicon is transparent to infrared, the alloying may be provided by radiation from the wafer face opposite the deposited contacts, producing even more rapid alloying.

The novel features and advantages of this invention will become readily apparent from the following detailed description of a preferred embodiment of the invention when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a side view in elevation of apparatus for practicing the method of this invention;

Fig. 2 is an end view in elevation of the apparatus of Fig. 1;

Fig. 3 is a greatly enlarged pictorial view in section of a small portion of one of the semiconductor wafers of Figs. 1 and 2 in the active area; and

Fig. 4 is a further enlarged sectional view of a portion of the device of Fig. 3 after alloying.

With reference to Figs. 1 and 2, apparatus for alloying contacts according to this inven-

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tion is illustrated. A plurality of wafers 10 of semiconductor material ~~is~~ are disposed on a heat sink support member 11 such as a block or sheet of aluminium or quartz. A bank of infrared tubes 12 is mounted above the base member 11 by a suitable support (not shown). Preferably, these are quartz tubes. These lamps 12 may be suitably mounted on one-half inch centers about one-half inch from the base member 11. The entire assembly is mounted in an evacuable chamber so that a vacuum may be provided during the alloying step.

Each of the wafers 10 may have a large number of double-diffused transistors formed therein with each of the transistors being of the type illustrated in Fig. 3. The bulk of the wafer 10 may be n-type silicon and provides the collector region for each of the many transistors, while base and emitter regions 14 and 15 would be provided by P- and N-type diffusions, respectively. Emitter and base contacts are provided by evaporating pairs of parallel stripes 16 and 17 of aluminium, typically one by three mils in area spaced one-half mil apart and 6000 to 8000 Å thick. This technique for evaporation of the metal stripes is widely utilized and is described in the prior art. Masking and selective etching may be used to properly position the stripes 16 and 17. Each of the wafers 10 may have perhaps one hundred pairs of the stripes 16 and 17 thereon at spaced positions, and after the alloying step the wafers would be sawed into as many separate transistors.

The wafers 10 are placed on the heat conductive base member 11 in an evacuable chamber such as under a bell jar which is connected to vacuum pump system. The pressure is lowered to about 1 micron Hg for the duration of the alloying process. Of course, any inert atmosphere may be suitable. The infrared tubes are energized by applying AC power thereto for at least three to four seconds. The assembly cools rapidly when the tubes are de-energized since the thermal inertia of the tubes is small and the support members are heated very little.

The deposited stripes 16 and 17 may be either on top of the wafers in Figs. 1 and 2, or underneath the wafers, since silicon is relatively transparent to infrared. In fact, alloying is even more rapid for aluminium on silicon when the contact material is farthest from the heat source compared to when the contacts are between the heat source and the wafer. For example, very similar alloys are obtained in 10 seconds with the contacts on top and 5 seconds with the contacts on the bottom. This may be attributed to the fact that infrared rays striking the metal surface first tend to be reflected while those striking the semiconductor metal interface first tend to be absorbed.

The amount of deposited material which is actually fused or alloyed with the semiconductor material is preferably a very small percentage of the stripe thickness. As illustrated in Fig. 4, which is not to scale, only a thin layer of the bottom surface of the stripe 17 is fused with the silicon wafer. The exact degree and depth of alloy may be accurately controlled by varying the power applied to the IR tubes, the distance between the IR tubes and the work, or the time of exposure to the heat source.

WHAT WE CLAIM IS:—

1. A method for alloying at least one metal contact to a semiconductor body comprising placing an amount of metal in contact with the semiconductor body and subjecting the body and the amount of metal to infrared radiation from one or more infrared lamps.

2. A method as claimed in claim 1, wherein at least a portion of the amount of metal is placed on a surface of the semiconductor body in the form of a layer.

3. A method as claimed in claim 1, wherein at least a portion of the amount of metal is placed on a surface of the semiconductor body in the form of one or more metal strips.

4. A method as claimed in any of claims 1 to 3, wherein at least a portion of the metal placed on the semiconductor body is aluminium.

5. A method as claimed in any of claims 1 to 4, wherein the bulk of the semiconductor body is maintained below the alloying temperature.

6. A method as claimed in claim 5, wherein the bulk of the semiconductor body is maintained below the alloying temperature by placing the body on a heat conductive member.

7. A method as claimed in any of claims 1 to 6, wherein the body and the amount of metal is subjected to the infrared radiation in a vacuum.

8. A method as claimed in any of claims 1 to 7, wherein the semiconductor body is placed so that one surface thereof is adjacent the one or more infrared lamps and at least a portion of the amount of metal is placed on a surface of the body shaded from the one or more infrared lamps by the body.

9. A method as claimed in any of claims 1 to 7, wherein the semiconductor body is placed so that one surface thereof is adjacent the one or more infrared lamps and at least a portion of the amount of metal is placed on said one surface.

10. A method as claimed in any of claims 1 to 9, wherein the step of subjecting the body and the amount of metal to infrared radiation is accomplished by subjecting the body and the amount of metal to infrared radiation from one or more quartz infrared tubes.

11. A method as claimed in any of claims

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tion is illustrated. A plurality of wafers 10 of semiconductor material ~~is~~ disposed on a heat sink support member 11 such as a block or sheet of aluminium or quartz. A bank of infrared tubes 12 is mounted above the base member 11 by a suitable support (not shown). Preferably, these are quartz tubes. These lamps 12 may be suitably mounted on one-half inch centers about one-half inch from the base member 11. The entire assembly is mounted in an evacuable chamber so that a vacuum may be provided during the alloying step.

Each of the wafers 10 may have a large number of double-diffused transistors formed therein with each of the transistors being of the type illustrated in Fig. 3. The bulk of the wafer 10 may be n-type silicon and provides the collector region for each of the many transistors, while base and emitter regions 14 and 15 would be provided by P- and N-type diffusions, respectively. Emitter and base contacts are provided by evaporating pairs of parallel stripes 16 and 17 of aluminium, typically one by three mils in area spaced one-half mil apart and 6000 to 8000 Å thick. This technique for evaporation of the metal stripes is widely utilized and is described in the prior art. Masking and selective etching may be used to properly position the stripes 16 and 17. Each of the wafers 10 may have perhaps one hundred pairs of the stripes 16 and 17 thereon at spaced positions, and after the alloying step the wafers would be sawed into as many separate transistors.

The wafers 10 are placed on the heat conductive base member 11 in an evacuable chamber such as under a bell jar which is connected to vacuum pump system. The pressure is lowered to about 1 micron Hg for the duration of the alloying process. Of course, any inert atmosphere may be suitable. The infrared tubes are energized by applying AC power thereto for at least three to four seconds. The assembly cools rapidly when the tubes are de-energized since the thermal inertia of the tubes is small and the support members are heated very little.

The deposited stripes 16 and 17 may be either on top of the wafers in Figs. 1 and 2, or underneath the wafers, since silicon is relatively transparent to infrared. In fact, alloying is even more rapid for aluminium on silicon when the contact material is farthest from the heat source compared to when the contacts are between the heat source and the wafer. For example, very similar alloys are obtained in 10 seconds with the contacts on top and 5 seconds with the contacts on the bottom. This may be attributed to the fact that infrared rays striking the metal surface first tend to be reflected while those striking the semiconductor metal interface first tend to be absorbed.

The amount of deposited material which is actually fused or alloyed with the semiconductor material is preferably a very small percentage of the stripe thickness. As illustrated in Fig. 4, which is not to scale, only a thin layer of the bottom surface of the stripe 17 is fused with the silicon wafer. The exact degree and depth of alloy may be accurately controlled by varying the power applied to the IR tubes, the distance between the IR tubes and the work, or the time of exposure to the heat source.

WHAT WE CLAIM IS:—

1. A method for alloying at least one metal contact to a semiconductor body comprising placing an amount of metal in contact with the semiconductor body and subjecting the body and the amount of metal to infrared radiation from one or more infrared lamps.

2. A method as claimed in claim 1, wherein at least a portion of the amount of metal is placed on a surface of the semiconductor body in the form of a layer.

3. A method as claimed in claim 1, wherein at least a portion of the amount of metal is placed on a surface of the semiconductor body in the form of one or more metal strips.

4. A method as claimed in any of claims 1 to 3, wherein at least a portion of the metal placed on the semiconductor body is aluminium.

5. A method as claimed in any of claims 1 to 4, wherein the bulk of the semiconductor body is maintained below the alloying temperature.

6. A method as claimed in claim 5, wherein the bulk of the semiconductor body is maintained below the alloying temperature by placing the body on a heat conductive member.

7. A method as claimed in any of claims 1 to 6, wherein the body and the amount of metal is subjected to the infrared radiation in a vacuum.

8. A method as claimed in any of claims 1 to 7, wherein the semiconductor body is placed so that one surface thereof is adjacent the one or more infrared lamps and at least a portion of the amount of metal is placed on a surface of the body shaded from the one or more infrared lamps by the body.

9. A method as claimed in any of claims 1 to 7, wherein the semiconductor body is placed so that one surface thereof is adjacent the one or more infrared lamps and at least a portion of the amount of metal is placed on said one surface.

10. A method as claimed in any of claims 1 to 9, wherein the step of subjecting the body and the amount of metal to infrared radiation is accomplished by subjecting the body and the amount of metal to infrared radiation from one or more quartz infrared tubes.

11. A method as claimed in any of claims

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1 to 10, wherein the amount of metal is placed in contact with a body made of silicon.

12. A method for alloying one or more metal contacts to a semiconductor body substantially as hereinbefore described.

13. A semiconductor device substantially as hereinbefore described with reference to Figs. 3 and 4 of the accompanying drawing taken either singly or in combination.

14. A semiconductor device when made by the method as claimed in any of claims 1 to 12.

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