Dec. 14, 1965 ETSUYUKI MATSUURA ETAL 3,223,820

METHOD OF OHMICALLY CONNECTING FILAMENT TO SEMICONDUCTING MATERIAL

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Fig. 1

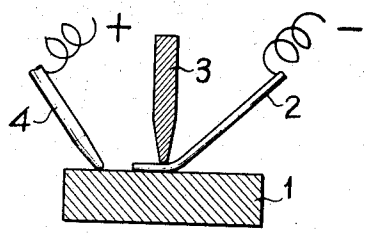
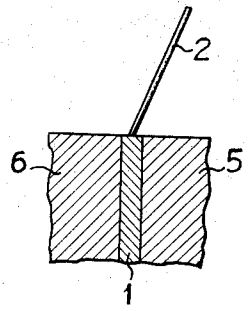


Fig. 2



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METHOD OF OHMICALLY CONNECTING FILAMENT TO SEMICONDUCTING MATERIAL

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This invention relates to improvements of a method of ohmically connecting filaments to semiconducting material of the group consisting of silicon and germanium.

With the recent development of the electronic industry, the demand of very small transistors made of silicon or germanium has increased and it is required to connect filaments to such semiconducting materials in a perfectly ohmic state. However, such requirement cannot be met with any conventional method. That is to say, there has been used a method wherein an alloy of gold-lithium or any other alloy is placed on a very clean surface of silicon and is heated at about 400 to 800° C. for about one hour to form an alloy on the surface of silicon and a filament is soldered to the alloy or a method wherein a metallic filament is erected on a surface of silicon and a high voltage is applied thereto to fuse the filament by high voltage spark discharge. However, in the former, there are defects that not only a bad influence will be given to the silicon by the heating at the time of making the alloy but also the alloy will flow widely, the connecting part will become wide and a mass of solder will be left and further a long time is required in the operation. In the latter, the connecting part will be formed of an alloy bearing the silicon and metal oxide as made when electricity is discharged at the tip of the filament and will be therefore mechanically weak, the tip of the filament will be expanded in the electric discharge and therefore it is impossible to make a very small connecting point. Thus, in either of the conventional methods, no perfect ohmic connection can be hoped for. There has been suggested another method wherein silicon is mounted on a heating base and is heated in its entirety to 400 to 500° C. and a filament is erected in a part to which is the filament to be connected and is pressed and connected by means of a pressing rod. In such method, there are defects that the entire silicon will be heated, therefore impurities and rearrangement of atoms and bad influence to the surface state will be produced and the silicon will be denatured.

The present invention is suggested to eliminate the above mentioned defects.

A principal object of the present invention is to provide a method of enabling ohmic connection of filaments to semiconducting group material consisting of silicon and germanium, said connection being ohmic not only at the room temperature but also even at the liquid helium temperature.

Another object of the present invention is to provide a method of enabling connection of a high mechanical strength.

A further object of the present invention is to provide a method wherein the point of contact of a semiconducting material with a filament is only locally heated without heating the entire semiconducting material to which the filament is to be connected and therefore said semiconducting material is not likely to be denatured by the connection of the filament.

Still another object of the present invention is to provide a method wherein a filament can be perfectly ohmic connected even to a very fine area.

The present invention relates to a method of ohmically connecting leads wherein a metallic filament is placed on a surface of a semiconducting material and, while said

metallic filament is pressed against said semiconducting material with a pressure wedge and a current supplier as the other electrode is kept in contact with said material, an electric current is passed from said current supplier through said semiconducting material to said filament so that the metallic filament may be ohmically connected to the semiconducting material.

FIGURE 1 is a magnified vertically sectioned view showing an embodiment of the method of the present invention.

FIGURE 2 is a magnified vertically sectioned view showing a product to which is applied the method of the present invention.

The method of the present invention shall now be explained with reference to the accompanying drawings.

In FIGURE 1, **1** is silicon, **2** is a metallic filament such as, for example, of gold or its alloy, **3** is a nonconductive pressure wedge in the form of a quartz rod and **4** is a current supplier as the other electrode made of a high melting point metallic material such as, for example, an iron or tungsten wire and kept in contact with the silicon. In connecting the metallic filament, the metallic filament **2** is brought into contact with the surface of the silicon **1** and, while said metallic filament **2** is pressed against the silicon **1** with the pressure wedge **3**, a direct or alternating electric current is passed from the current supplier **4** kept in contact with said silicon **1** to the metallic filament **2** so that the metallic filament **2** may fuse to the silicon **1**.

FIGURE 2 shows another embodiment in which **1** is silicon, **5** and **6** are p-n-p junction area said n-type silicon **1** between them and **2** is a metallic filament fused to the silicon **1**. According to the present invention, it is possible to connect a metallic filament even to a very small part. Therefore, the metallic filament can be perfectly connected even to such limited very fine base as is shown in FIGURE 2.

An example of experiment of the present invention shall be given in the following.

A gold wire 0.2 mm. in diameter was used for a metallic filament. A force was applied to a silicon base with a weight of 100 g. of a pressure wedge. The distance between the current supplier and metal filament was made 0.1 to 1 mm. An alternating current of 50 or 60 cycles/second or a direct current of a voltage of 20 to 60 volts was passed between the metallic filament and current supplier. Thus the metallic filament could be connected to the silicon base in 0.1 to 1 second. In such case, the thickness of the silicon base had nothing to do with the above mentioned conditions.

According to the present invention, it is possible to connect a metallic filament even to a very small part and, as the metallic filament is pressed while it is being fused, the voltage of the electric source may be low. The connecting part is heated by passing electricity so locally as to cause no bad influence to the silicon. Further, the connecting part can be freely adjusted so as to be larger or smaller. No oxide will be produced in the connecting part and therefore no bad influence will be thereby caused to silicon or germanium. The mechanical strength of the connecting part will be so high that the filament will not separate from the connecting part even if it is pulled.

When the surface of silicon or germanium is of the n-type, a quinquevalent element such as antimony (Sb) may be deposited by vacuum-evaporation on the surface and, when it is of the p-type, a trivalent element such as indium (In) may be deposited by vacuum-evaporation on the surface and then the filament may be connected by the above mentioned method. After all according to the above mentioned method, it is possible to perfectly ohmically connect filaments to any high resistance silicon and germanium.

What is claimed is:

1. A method of ohmically connecting leads to semiconducting materials comprising placing a conductive filament on a surface of a semiconducting material of the group consisting of silicon and germanium, pressing said filament against said semiconducting material with a pressure wedge consisting of quartz, pressing a current supplier against said semiconducting material and passing an electric current from said current supplier through said semiconducting material to said filament whereby said filament fuzes and becomes connected to said semiconducting material.

2. A method of ohmically connecting leads to semiconducting materials according to claim 1 wherein a quinquevalent metallic element is evaporation-deposited on the surface of n-type silicon or geraminum and then the filament is connected to the surface.

3. A method of ohmically connecting leads to semiconducting materials according to claim 1 wherein a trivalent metallic element is evaporation-deposited on the surface of p-type silicon or germanium and then the filament is connected to the surface.

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