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ELECTRICALLY SEMICONDUCTIVE CRYSTALLINE BODY

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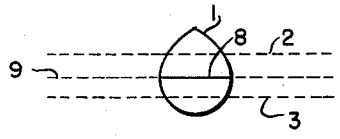

FIG. 1

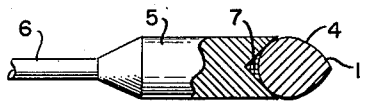

FIG. 2

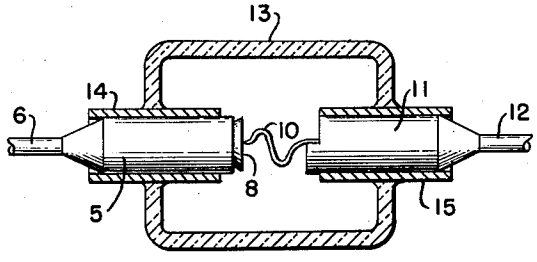

FIG. 3

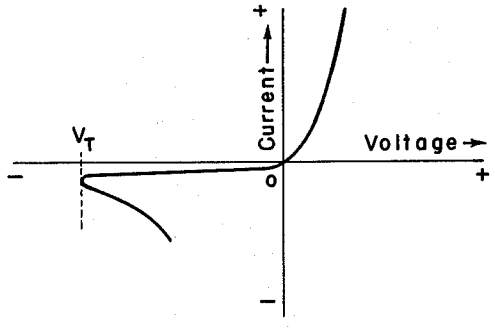

FIG. 4

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ELECTRICALLY SEMICONDUCTIVE CRYSTALLINE BODY

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Claims priority, application Great Britain October 6, 1950

4 Claims. (Cl. 317—236)

This invention relates to methods of producing electrically semiconductive crystalline bodies for use in electrical crystal-contact devices. The invention is concerned in particular with electrical crystal-contact devices including semiconductive germanium elements prepared by a method including steps described in British Patent No. 635,385, which corresponds to copending U. S. application of Ronald W. Douglas, Serial No. 56,943, filed October 28,1948, and entitled "Improvements in or Relating to Methods of Manufacturing Crystal Contact Devices," now abandoned. It is to be understood that in the present specification and claims, the terms "germanium" and "germanium element" are intended to mean germanium of high purity with or without small quantities of added impurities.

In the above-identified British patent there is described a method of preparing a semiconductive element in which a small quantity of material such as germanium is fused on a refractory support in a suitable inert atmosphere or in vacuo to provide upon solidification a germanium element in the form of a globule. Upon cooling the element solidifies in this form due to the surface tension of the germanium material, and thus the possible size of elements which may be produced in this way is limited, the maximum size having a diameter of the order of 2.5 millimeters and therefore a mass of the order of 45 milligrams. It has been found that globules prepared in this manner usually do not solidify in a perfectly spherical form but each has an outwardly projecting spike, the spike being formed from the germanium material which is last to solidify, and usually projects upwards when the globule is formed.

After the globule is formed, it is preferably mounted on a metallic support and is then provided with a contact surface by removing part of the globule, for example by grinding. When a metallic contact member or electrical conductor is brought into small-area contact with this surface, the contact exhibits at least one desirable electrical characteristic, that is, it has a high turnover voltage signifying that the current flow through the reverse impedance of the globule increases only slightly as an increasing negative voltage is applied across that impedance. In certain applications of the crystal-contact devices, it is desirable that the absolute magnitude of the turnover voltage should be as great as possible.

If globules of the type just mentioned are used, and the crystal-contact devices are made up in a random manner without reference to the position of the contact point or points relative to the spike, it has been found that when a large group of devices are tested which use such globules prepared from a uniform batch of germanium material, the electrical characteristics of the contacts exhibit considerable numerical variation over the group although their general form is the same for the whole of the group. In particular, where globules of germanium of high purity are used, the average value of the turnover voltage exhibited by the contacts, taken over the whole group of devices, is in general considerably lower than the highest values of turnover voltage found among the group.

It is an object of the present invention, therefore, to provide a new and improved method of producing an electrically semiconductive crystalline body for use in an electrical crystal-contact device.

It is another object of the invention to provide a new and improved method of producing electrical crystal-contact devices, individual ones of which have electrical characteristics which do not vary greatly from the characteristics of a group of such devices.

It is a further object of the invention to provide new and improved bodies of germanium for use in electrical crystal-contact devices to impart a high average value of turnover voltage to a group of such devices.

In accordance with the invention, a method of producing an electrically semiconductive body for use in an electrical crystal-contact device comprises fusing in an inert atmosphere a sufficient quantity of electrically semiconductive crystalline material effective in its fused state by virtue of surface tension of the aforesaid material to produce a fluid globule, cooling the globule whereby there is formed thereon upon solidification an outwardly projecting spike having a higher concentration of impurities than the remainder of the aforesaid body, and removing the spike to form on the body, a contact surface lying in a plane substantially perpendicular to the direction of projection of the aforesaid spike for engagement with an electrical conductor.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

One method of performing the invention will now be described, by way of example, with reference to the accompanying drawing, in which Fig. 1 represents diagrammatically an electrically semiconductive crystalline body in the form of a globule; Fig. 2 is a view, partly in section, illustrating a stage in the manufacture of a crystal-contact device provided with a semiconducting crystalline element; Fig. 3 is a longitudinal sectional view of a completed crystal-contact device; and Fig. 4 is a graph representing the electrical characteristic of a contact between an electrically semiconductive crystalline body and a metallic contact member in small-area contact with the body.

Referring now to Fig. 1, there is represented an electrically semiconductive crystalline body in the form of a globule of high purity material such as germanium, this globule being produced by the method described in the above-identified British patent. In accordance with that method, small quantities of germanium such as germanium powder are fused in small holes or depressions in a carbon block to produce upon solidification globules having a diameter of about 1.6 millimeters and a mass of about 12 milligrams.

As represented in Fig. 2 of the present drawing, each globule 4 is mounted with its spike 1 projecting outwards on an electrical conductor or metal stub 5 which is provided with a conducting wire 6, the globule 4 first being nickel-plated and then being soldered in a recess 7 formed in the end of the stub 5.

In accordance with the present invention, the spiked part of the globule 4 is then ground away to form a contact surface 8 (see Fig. 1) which is preferably flat, the surface lying in a plane 9 preferably being substantially perpendicular to the direction of projection of the spike 1 and positioned in the central portion or half of the length of the original globule 4 in the direction of projection of the spike 1, that is between the planes 2 and

3 shown in Fig. 1. The contact surface 8 is then etched, and the stub 5 is assembled to form part of the crystal-contact device represented in Fig. 3. The germanium element formed from the globule 4 is arranged to cooperate with a metallic contact member in the form of a pointed tungsten wire 10 which is in point contact with the contact surface 8 and is supported by a metal stub 11 provided with a conducting wire 12, the element and the wire 10 being housed in a glass envelope 13 sealed in a well-known manner to metal tubes 14 and 15 in which the stubs 5 and 11 are secured as by soldering. British Patent No. 616,065 describes a particular method of forming a crystal-contact device of the type represented in Fig. 3 of the drawing.

The contact between the germanium element and the wire 10 exhibits an electrical characteristic of the form represented in Fig. 4, and it is found that the average value of the turnover voltage V_T taken over a group of rectifiers manufactured by the method described above is considerably higher than the average value obtained for a group of rectifiers made up without reference to the position of the contact point in the original globule 4.

It is believed that the improved results obtained by using the present invention may be explained in the following manner. When a globule of material such as germanium solidifies, the concentration of impurities in the germanium is not uniform throughout the globule, owing to the fact that the impurities are more soluble in liquid germanium than solid germanium and the fact that the whole of the globule does not solidify simultaneously. In particular, the concentration of impurities will be higher in the spiked part of the globule than in the rest of the globule since this part is the last to solidify. Thus when part of the globule is removed to form a contact surface, the concentration of the impurities at the contact point will vary with the position of the contact point in the globule. The electrical characteristic of any particular contact will depend on the concentration of the impurities at the contact point and therefore on the position of the contact point in the globule. Thus by insuring that the contact point or points is or are positioned in the central half of the length of the original globule in the direction of projection of the spike 1, that is between the planes 2 and 3 shown in Fig. 1, greater uniformity in the electrical characteristics of the contacts may be attained. This may be conveniently achieved in accordance with the invention by mounting the globule with the spike 1 projecting outwards and then removing the spiked part of the globule to form the contact surface. Furthermore, it is found that the average turnover voltage obtainable over a group of devices is at a maximum when the contact points are positioned between the planes 2 and 3, and shows a comparatively small variation between these limits.

It will be appreciated that the present invention has utility not only in the manufacture of crystal diodes but also in the manufacture of electrical crystal-contact devices having two or more conductors in contact with the semiconducting element.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A method of producing an electrically semiconductive crystalline body for use in an electrical crystal-contact device comprising: fusing in an inert atmosphere a quantity of germanium not greater than 45 milligrams effective in its fused state by virtue of surface tension of said germanium to produce a fluid globule; cooling said globule whereby there is formed thereon upon solidification an outwardly projecting spike having a higher concentration of impurities than the remainder of said body; securing an electrical conductor to a portion of said cooled globule adjacent said spike; cutting a slab from said body which includes said spike and which is substantially perpendicular to the direction of projection of said spike to form on said body a contact surface for engagement with an electrical conductor; and etching said contact surface.

2. A method of producing an electrically semiconductive crystalline body for use in an electrical crystal-contact device comprising: fusing in an inert atmosphere a sufficient quantity of electrically semiconductive crystalline material effective in its fused state by virtue of surface tension of said material to produce a fluid globule; cooling said globule whereby there is formed thereon upon solidification an outwardly projecting spike having a higher concentration of impurities than the remainder of said body; and removing said spike to form on said body a contact surface lying in a plane substantially perpendicular to the direction of projection of said spike for engagement with an electrical conductor.

3. A method of producing an electrically semiconductive crystalline body for use in an electrical crystal-contact device comprising: fusing in an inert atmosphere a sufficient quantity of electrically semiconductive crystalline material effective in its fused state by virtue of surface tension of said material to produce a fluid globule; cooling said globule whereby there is formed thereon upon solidification an outwardly projecting spike having a higher concentration of impurities than the remainder of said body; and removing said spike by grinding to approximately the central portion of said cooled globule to form on said body a contact surface lying in a plane substantially perpendicular to the direction of projection of said spike for engagement with an electrical conductor.

4. A method of producing an electrical crystal-contact device comprising: fusing in an inert atmosphere a sufficient quantity of electrically semiconductive crystalline material effective in its fused state by virtue of surface tension of said material to produce a fluid globule; cooling said globule whereby there is formed thereon upon solidification an outwardly projecting spike having a higher concentration of impurities than the remainder of said body; securing an electrical conductor to a portion of said cooled globule adjacent said spike; removing said spike by grinding to approximately the central portion of said cooled globule and in a plane to form a contact surface lying in a plane substantially perpendicular to the direction of projection of said spike for engagement with an electrical conductor; and bringing at least one electrical conductor into small-area contact with said contact surface.

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