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[54] **DEVICE FOR THE DIFFUSION OF DOPING MATERIAL**

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[52] **U.S. Cl.** **118/48**
[51] **Int. Cl.** **C23c 13/08**
[58] **Field of Search** .... 118/48–49.5; 117/106 R, 106 A, 106 C, 107, 107.2 R; 148/175, 174

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[57] **ABSTRACT**

A device used for receiving semiconductor discs and doping material during a diffusion process which includes a heating step to diffuse the doping material into the semiconductor disc characterized by the semiconductor disc being arranged in small tubes formed of the same semiconductor material which small tubes are disposed in a larger tube formed of the same semiconductor material and containing the source of doping material. The small tubes are opened at least at one end which receives a supporting member to hold the disc in the proper position in the small tubes and the supporting member has a diameter less than the inner diameter of the tube and is formed of the same semiconductor material.

8 Claims, 3 Drawing Figures

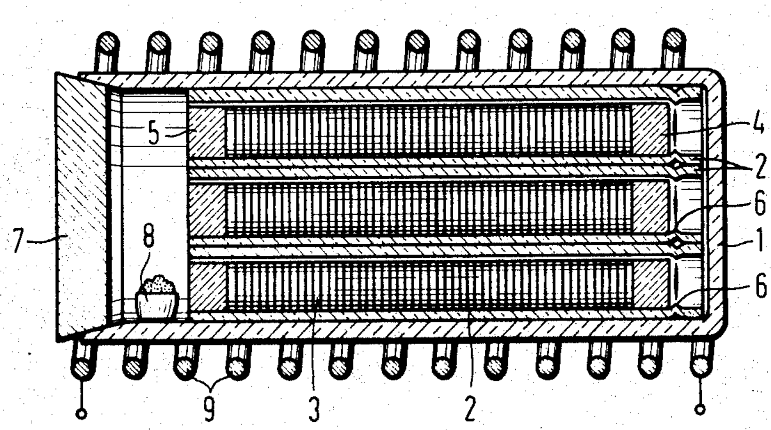


Fig.1

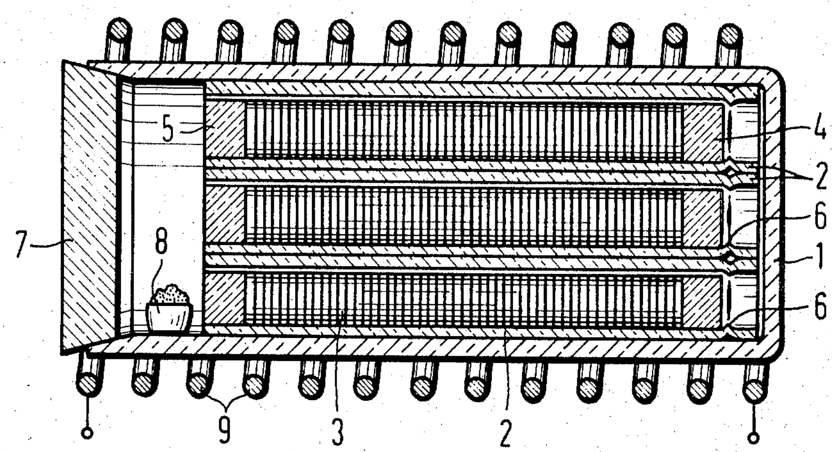


Fig.2

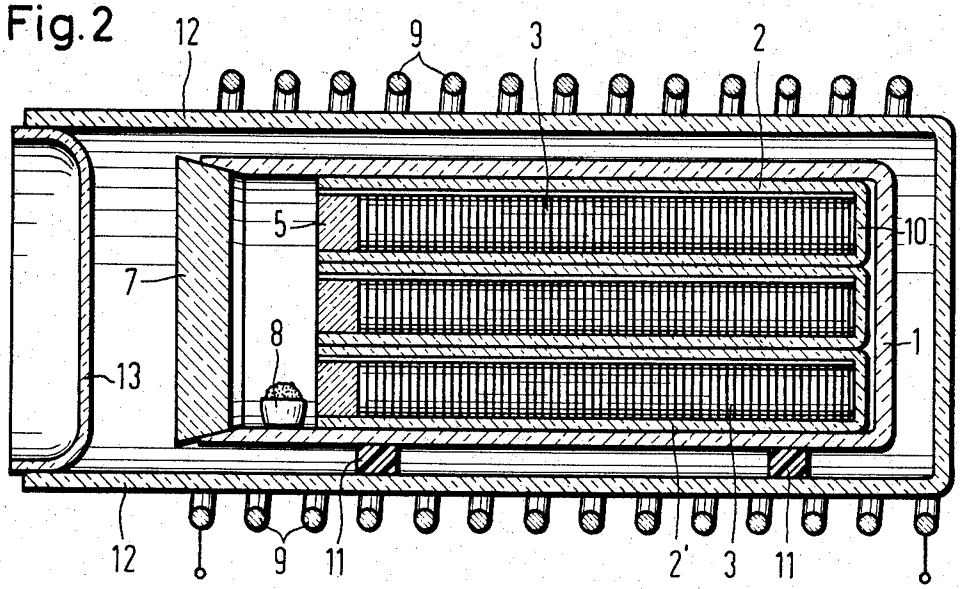
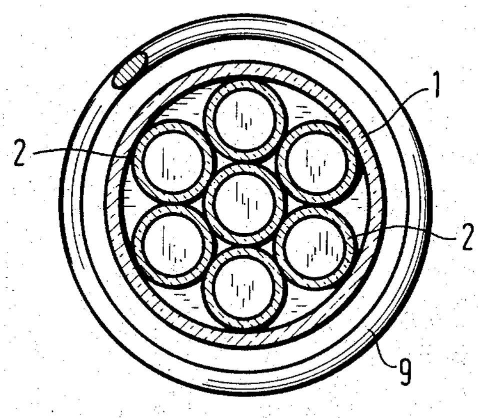


Fig.3



DEVICE FOR THE DIFFUSION OF DOPING MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to a device for use in a process of diffusing a doping material into a semiconductor disc.

2. Prior Art

To properly dope semiconductor discs, it has been suggested to place the semiconductor disc in a quartz tube or ampoule with a source of the doping material. The ampoule or tube is evacuated and closed. To diffuse the doping material into the semiconductors, the quartz tube is heated to a diffusion temperature. However, contact of the semiconductor discs with the quartz ampoule may lead to unwanted impurities being diffused into the semiconductor disc.

An improvement on this device was described in the German Patent No. 1,521,494. The German patent described a device which had a vertically positioned tube which had at least the interior made of a semiconductor material. The semiconductor discs of the same semiconductor material were stacked in the tube, and then the tube was evacuated by being placed in a chamber which was connected to a vacuum pump. The chamber was situated in a diffusion oven which heated the semiconductor discs to a temperature which was required for diffusion of the doping material into the semiconductor disc. This device had considerable advantages over the use of a quartz tube or ampoule. One of these advantages is that a tube made of semiconductor material can endure substantially higher temperatures than the quartz tube. Thus, the diffusion can be carried out with a higher temperature than when using a quartz tube, and the diffusion process is accelerated. Another advantage is that, if the semiconductor discs come into contact with the walls of the tube made of semiconductor material, they do not become contaminated with undesirable impurities.

Because of the high temperature required during the diffusion process, the process requires special care. Since the process takes place in a temperature range at which the semiconductor discs may have plastic characteristics, the discs must be kept free from the application of mechanical forces. If during the heating process, a mechanical force is applied to the discs, it will cause stresses and displacement in the crystal structure which displacement adversely affects the electrical characteristics of the finished semiconductor component. In the case of the known devices, the semiconductor discs are kept free from the application of mechanical forces by preferably providing the semiconductor tube with a diameter which is only a little larger than the diameter of the semiconductor discs. Thus, the semiconductor discs are supported and cannot be tilted or jammed, regardless of the position of the tube. However, if the semiconductor discs have a diameter which is substantially smaller than the semiconductor tube, they are not supported in an exact position and may tilt or be jammed in the tube. Tilting or jamming of semiconductor discs will apply a mechanical force thereto and cause the undesirable displacement in the crystal structure. In addition, small semiconductor discs are very difficult to handle, which prevents careful positioning of the small discs in the heating tube.

SUMMARY OF THE INVENTION

The present invention is directed to a device for use in a process of diffusing doping material into semiconductor discs which enable performing the diffusion process on semiconductor discs of any size without applying undesirable mechanical forces thereto. The device utilizes several small tubes made of the same semiconductor material as the semiconductor discs which tubes have an inner diameter which is only slightly larger than the diameter of the semiconductor discs. The semiconductor discs are arranged in the tubes which have at least one end open and held in the desired position therein by a supporting member made of the same semiconductor material, which member has a diameter less than the inner diameter of the tube. Each of the small tubes is then arranged in a large tube which contains the doping material and is also formed of the same semiconductor material and which larger tube is evacuted and sealed before the heating step of the diffusion provess. In one embodiment of the invention, the smaller tubes are open at each end with one end provided with a constriction to hold the supporting member disposed at the one end in the tube. In another embodiment, one end of the smaller tubes is closed so that only one supporting member is used. Preferably, the wall thickness for the small tubes, and the large tube which receives the small tubes, is in a range of 1 to 5 millimeters. The device can be utilized either in a horizontal position or in a vertical position during the diffusion process.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal section through an embodiment of the device of the present invention;

FIG. **2** is a longitudinal cross-section through another embodiment of the device of the present invention; and

FIG. **3** is a transverse cross-section of the embodiment illustrated in FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles of the present invention are particularly useful when incorporated in a device illustrated in FIG. **1**. The device utilizes a tube **1** having a large diameter which receives a plurality of smaller tubes **2** which are arranged in a parallel manner inside the tube **1**. Each of the tubes **2** receives a plurality of the semiconductor discs **3** which are held in a stack configuration therein, as illustrated, by supporting members **4** and **5** disposed at each end of the tubes **2**. One end of each of the tubes **2** is provided with a constriction **6** to provide a portion of the tube **2** with an inner diameter less than the diameter of the supporting member or disc **4** to hold the member **4** in the tube.

The large tube **1**, each of the inner tubes **2**, and each of the supporting members **4** and **5** are formed of the same semiconductor material as the semiconductor disc **3**. The smaller tubes **2** are selected to have an inner diameter slightly larger than the diameter of the disc **3**. The supporting members **4** and **5** have an inner diameter substantially the same as the disc **3** and slightly smaller than the inner diameter of the tubes **2** to allow the gaseous doping material to flow into the tubes **2**. The supporting members **4** and **5** have a thickness which is several times the thickness of the disc **3**.

After loading the discs **3** and supporting members **4** and **5** in the tubes **2**, the tubes **2** are placed in the large diameter tube **1**. A source of doping material in a container **8** is placed inside the large tube **1** but outside of the smaller tubes **2**. The interior of the tube **1** and the tubes **2** are evacuated, and the tube **1** is closed with a gas-tight seal formed by a closure member or plug **7** which should consist of the same semiconductor material as the tube **1** to form a gas-tight chamber.

To perform the diffusion process with the device of the invention, the sealed tube **1** is placed in a heating coil **9** and heated to the desired diffusion temperature. At the diffusion temperature, the doping material in the container **8** will evaporate and diffuse into the semiconductor disc **3**. If the semiconductor disc **3** consists of silicon, the device is heated to a temperature range of 1,050° and 1,250° C. If this temperature is maintained for 24 hours, a penetration depth of 10μ into the semiconductor discs **3** is achieved depending on the doping material.

The tubes **2** have a diameter of 8 to 25 millimeters depending on the diameter of the semiconductor disc **3** and a length of between 200 and 400 millimeters. The wall thickness of the tubes **2** is in a range of 1 to 5 millimeters and the wall thickness of the outer large diameter tube is also in the range of 1 to 5 millimeters in thickness.

As illustrated in FIG. **3**, the tube **1** is completely filled with the smaller tubes **2**. However, the complete filling or packing of the tube **1** with the smaller tubes **2** is not necessary although it enables the treating of a maximum number of discs **3** in the diffusion oven during the diffusion process.

An embodiment of the invention is illustrated in FIG. 2 and all of the parts which are the same have the same element numbers. The difference is in the structure of the smaller tubes **2'** which are closed at one end by a base plate **10** which is illustrated as being an integral portion of the tubes **2**. The other end of the tubes **2'** is opened and, as in the previously described embodiment, a supporting member or disc **5** is provided to hold the semiconductor disc **3** in the desired position.

In the embodiment of this figure, the sealed outer tube **1** is arranged in a quartz ampoule **12** which after evacuation is sealed by melting a quartz plug **13** to form a seal. As illustrated, the semiconductor tube **1** is positioned in the quartz ampoule **12** and rests on supports **11**. By providing a second outer sealed envelope formed by the sealed ampoule **12**, it guarantees that neither air nor damaging gases can reach the semiconductor disc **3** during the diffusion process.

During the diffusion process, the diffusion temperature causes the quartz to become soft and it is compressed onto tube **1** by the ambient air pressure applied to its outer surface. Since the tube **1** of semiconductor material, such as silicon, which tube has a wall thickness of approximately 1 millimeter, is mechanically stable even at the diffusion temperature, it will resist deformation by the ambient air pressure. Thus, the semiconductor discs **3** are protected against the application of mechanical forces. At the completion of the diffusion process, the quartz tube **12** and the tube **1** are opened and the tubes **2'** containing the doped semiconductor discs **3** are removed. Since the tube **1** was not deformed, it may be used again for subsequent diffusion processes.

The present invention is particularly suited for the diffusion of semiconductor discs made of silicon. It may also be used for the diffusion of semiconductor discs consisting of germanium or of compounds formed from sub-groups III-A, VII-B or II-A, VI-B.

The invention also has the advantage of enabling the use of a diffusion oven, which was designed for the diffusion of large diameter semiconductor discs, to be used for treating small diameter semiconductor discs in a diffusion process. Since the application of mechanical forces to the semiconductor discs is practically excluded, semiconductor discs which were free of displacement in the crystal structure before the diffusion process maintain this condition even after diffusion. In addition, there is the advantage that due to the relation of the diameter to the length of the device, a good temperature constant is achieved along the entire length of the tubes. Otherwise, in the case of long tubes of a small diameter, there might be the danger that the temperature of the tubes differ at certain points due to other radiation characteristics.

Although various minor modifications may be suggested by those versed in the art, it is to be understood that I wish to employ within the scope of the patent granted hereon all such modifications that reasonably and properly come within the scope of my contribution to the art.

I claim:

1. A device for use in a process of diffusing doping material into discs of semiconductor material, the device comprising a plurality of small tubes, each tube having at least one open end and being of the same semiconductor material as the discs, each of said small tubes having an inner diameter slightly larger than the diameter of the discs which are to be received therein, a supporting member disposed in each open end of each of the tubes to maintain the position of semiconductor disc arranged therein, each of said supporting members being of the same semiconductor material as the disc and having a thickness several times thicker than the disc, each of said supporting members having a diameter smaller than the inner diameter of the small tubes to enable a doping material during a diffusion process to flow by the supporting members for diffusion into the semiconductor discs, and a large tube of the same semiconductor material as the discs and having a diameter to receive a plurality of said small tubes, said large tube having a closure member for forming the interior of the tube as a gas-tight chamber with the small tubes and a source of doping material disposed therein, so that during the diffusion process the discs are free from the application of mechanical forces thereto.

2. A device according to claim **1**, wherein each of the small tubes is opened at both ends.

3. A device according to claim **2**, wherein each of the small tubes at one end is provided with a constriction to maintain the supporting member disposed at said one end in said tube.

4. A device according to claim **1**, wherein each of the small tubes has one end closed.

5. A device according to claim **1**, wherein the doping material source is disposed within the large tube and outside of the small tubes.

6. A device according to claim **1**, wherein the outer tube and the small tubes are disposed in horizontal position during a heating of the diffusion process.

7. A device according to claim 1, wherein the large tube and the small tubes disposed therein are arranged in a vertical position during a heating step of the diffusion process.

8. A device according to claim 1, wherein the large tube and the small tubes have a wall thickness in a range of 1 to 5 millimeters.

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