June 19, 1956 E. G. SHOWER 2,751,527

SEMICONDUCTOR DEVICES

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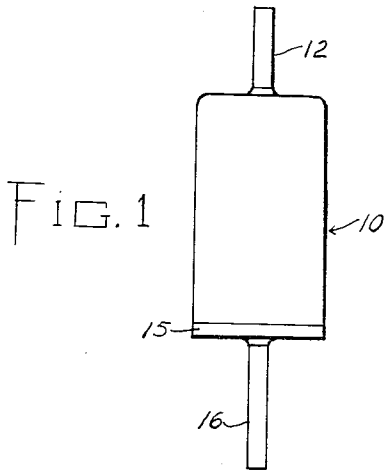


Fig. 1

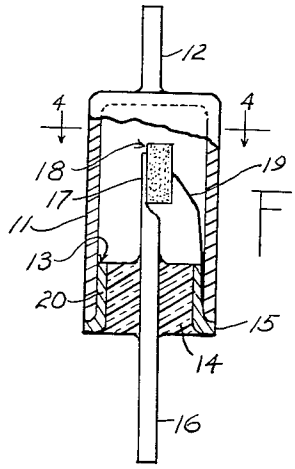
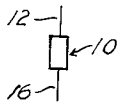


Fig 2.

Fig 5.



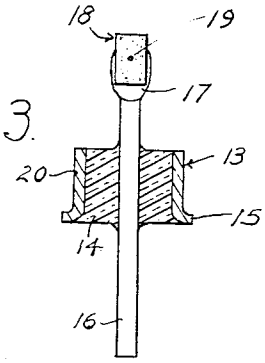


Fig. 3.

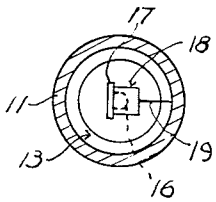


Fig. 4

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SEMICONDUCTOR DEVICES

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5 Claims. (Cl. 317—234)

This invention relates to semiconductor devices and more especially to devices of the asymmetric metal-to-crystal kind, such for example as crystal diodes, transistors, and the like.

The invention has for its principal object to provide a novel mount construction for such devices as crystal diodes and transistors, which mount lends itself readily to automatic assembly techniques.

Another object of the invention is to provide a simplified metal-to-glass mount for a diode or transistor which mount can be manufactured economically to form a complete single ended unit which can be sealed to a tubular metal bulb or envelope.

A feature of the invention relates to a device such as a crystal diode, transistor, or the like, which is provided with a metal enclosing bulb having integrally attached external circuit connecting wires extending from opposite ends of the device, and wherein the electrodes of the diode or transistor form part of a unitary prefabricated mount.

Another feature relates to a crystal diode or transistor mount comprising a metal eyelet through which is insulatingly sealed, a rigid metal rod or wire, the inner end of which is flattened to provide a support and electrical contact with one surface of a semiconductor crystal wafer element, the opposite surface of the element being directly connected to the eyelet whereby a single prefabricated mount is provided for telescopic assembly within a tubular metal bulb.

A further feature relates to the novel organization, arrangement and relative location and interconnection of parts which cooperate to provide a rugged and more economically manufactured device of the crystal diode or transistor kind.

Other features and advantages not particularly enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing, which shows by way of example one preferred embodiment,

Fig. 1 is an external plan view of the finished device according to the invention;

Fig. 2 is a view similar to that of Fig. 1 with part of the enclosing metal bulb broken away to show the interior of the mount more clearly;

Fig. 3 is a side view of the mount of Fig. 2;

Fig. 4 is a sectional view of Fig. 2 taken along the line 4—4 thereof and viewed in the direction of the arrows;

Fig. 5 is a plan view to scale of an actual device made according to the invention.

Various forms of semiconductor devices, such as crystal diodes, transistors, and the like, have been manufactured heretofore, but such devices, in general, have not been adapted readily for automatic assembly. This is particularly true where the device is of the metal bulb or envelope kind having a pair of integral contact wires extending in opposite directions therefrom. In the manufacture of such semiconductor devices, one of the essential steps is the etching and rinsing of the semiconductor crystal

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before and after it is bonded to its contact wire and to its support. For example, in the bonded wire-to-crystal form of transistor, the end of the wire may be carefully welded to the appropriate point on the crystal surface, as described for example in my copending application Serial No. 338,015, filed February 20, 1953. This operation requires that the crystal surface be etched before the bonding and the crystal and bonded junction must be rinsed in a suitable rinsing solution. When the device is of the so-called double ended kind, it has been necessary heretofore to assemble the metal bulb over the mount in order to make the necessary double ended contact. Therefore, with such an arrangement, it is not possible to rinse the bonded junction after the mount has been completed and tested. In fact, with such prior known devices, the testing has usually been necessary after the completion of the device, that is after the metal bulb has been sealed to the mount. The above disadvantages are overcome in accordance with the present invention.

Referring to the drawing, the semiconductor device according to the invention comprises a completely closed container **10**. This container **10** may comprise a cylindrical cup-shaped metal member **11** which is integrally closed off at its upper end. Attached externally to said upper end is a suitable circuit connection wire **12**, for example of soft steel. The opposite end of the member **11** is hermetically sealed by a glass-metal eyelet consisting of the metal eyelet member **13** and the glass bead **14**. The glass bead **14** is hermetically sealed to the inner wall of the metal eyelet. The eyelet **13** has a lateral flange **15** which can be welded or otherwise hermetically sealed to the lower end or lip of the metal cup **11**.

Passing centrally through the glass bead **14** and hermetically sealed thereto is a round metal wire **16**. Preferably, but not necessarily, the wire **16** is of a metal or alloy which has substantially the same coefficient of thermal expansion as does the glass **14**.

The inner end of the wire **16** is flattened to provide a spade-like support **17** to which can be attached by any well known conductive cement or by a plating bond, any well known semi-conductor crystal material such as the wafer **18**. Suitably welded or bonded to the opposite surface of wafer **18** is a flexible conductor **19**, the free end of which is wedged between the vertical wall **20** of the metal eyelet and the inner wall of the metal bulb **11**. The conductor **19** can be bonded to the crystal wafer **18** prior to assembly of the wafer on the spade **17**. If desired, the free end of conductor **19** can be soldered or welded to the wall **20** of the metal eyelet prior to the assembly of the metal bulb **11** on the eyelet. Thus, the elements **13**, **14**, **16–19** form a unitary mount wherein the connections to the opposite sides of the crystal wafer **18** are at the same end of the mount. The previously etched wafer **18** can then be rinsed in any suitable rinsing solution merely by inverting the mount from the position shown in Fig. 3 so as to dip the spaded end carrying the crystal wafer **18** into the rinsing solution. When the device has been completely rinsed and processed in accordance with techniques well known in the transistor and crystal diode arts. It can then be tested prior to assembly of the bulb **11** over the mount. After the completion of the testing, the bulb **11** is telescoped over the eyelet **13** and soldered or welded to the flange **15** to form a completely closed and hermetically sealed unit.

It will be understood, of course, that the drawing shows the finished unit in highly magnified form and the drawing is not intended to be dimensionally in proportion. For example, in one particular device that was made according to the invention, the overall length of the bulb **11** was approximately ⅕ of an inch with a diameter of approximately ⅛ of an inch. The wire **16** had a diameter of approximately 1/60 of an inch. The wafer **18** had a length

of approximately 1/20 of an inch, a width of approximately 1/25 of an inch, and a thickness of the order of a few thousandths of an inch. Fig. 5 shows the actual dimensions of a device made in accordance with the invention.

While it is not necessary to produce a vacuum within the device, in any case where a vacuum or a gas filling is required within the device, the interior thereof may be evacuated or gas filled in any well known manner.

From the foregoing it will be seen that in view of the simplicity of the device and the manner of assembling and supporting the various elements, the device is particularly well suited to automatic assembly.

Various changes and modifications may be made in the disclosed embodiment without departing from the spirit and scope of the invention.

What is claimed is:

1. A semiconductor device comprising, a semiconductor crystal, a conductor having one end in contact with a surface of said crystal, a glass-beaded metal eyelet comprising a cylindrical metal wall member surrounding a glass bead hermetically sealed thereto, another conductor hermetically sealed through the glass of said eyelet, said crystal being attached directly to the inner end of said other conductor, the free end of the first mentioned conductor being in electrical contact with the metal wall member of said eyelet, and a metal enclosing bulb sealed to the rim of said eyelet.

2. A semiconductor device comprising, a mount consisting of a glass bead, a conductor hermetically sealed through said bead, a cylindrical metal eyelet surrounding said bead and hermetically sealed thereto, said conductor having a spade-like portion, a semiconductor wafer seated on and conductively united to said spade-like portion, another conductor having one end bonded to the surface of said wafer and the other end in electrical contact with said eyelet, and a metal cup-like bulb sealed to said eyelet to provide a hermetic enclosure for the semiconductor.

3. A semiconductor device comprising, a mount consisting of a glass-beaded metal eyelet, a first conductor sealed through the glass of said eyelet and having a flattened spade-like end, a semiconductor crystal wafer fastened to said spade-like end, said spade-like end serving as the base electrode for said semiconductor, a fine wire having one end integrally bonded to said wafer on a surface opposite to the surface attached to said spade-like base, and an inverted metal cup telescoped over said eyelet and hermetically sealed thereto, the opposite end of said fine wire being electrically bonded to said metal eyelet and in electrical contact with said cup-like member.

4. A semiconductor device according to claim 3, in which the said free end of said fine wire is integrally bonded to said metal eyelet, said metal eyelet having a peripheral flange to which the said cup-like member is hermetically and conductively sealed.

5. A semiconductor device according to claim 3 in which said cup-like member has integrally attached thereto a circuit connection wire which extends outwardly of the device in a direction opposite to that in which the first conductor extends outwardly of the beaded eyelet.

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