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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Header for Semiconductor Device

We, TEXAS INSTRUMENTS INCORPORATED, of 6000 Lemmon Avenue, 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 improvements in semiconductor devices and to an improved header design for use in fabrication of transistor devices of the PN junction type.

The deleterious effects on transistors operated at high temperatures has emphasized the need for efficient and effective heat dissipation to increase the power handling capabilities of the device. It has been found, for example, in the use of germanium, one type of semiconductor material used for transistors, that the temperature of the transistor junction should not exceed about 80—100 degrees C. under operating conditions. Thus, a relatively low temperature differential must be maintained between the transistor junction and the outside ambient.

Heretofore, one solution of the heat dissipation problem has been to encase the semiconductor element in a metallic container filled with oil, grease, or mixtures of various desicants and oil or other liquids to provide good thermal conduction. This arrangement has generally proved unsatisfactory for the reason that the heat dissipation afforded is usually inadequate and perhaps more important, the liquids often detrimentally affect the surface states of the semiconductor crystals.

An alternative solution to the problem of thermal dissipation of the transistor has been to connect devices to the crystal to establish a good thermal path from the crystal to a large radiating surface whereby the heat generated in the operation of the device may be dissipated to the outside ambient. These devices have been satisfactory in many instances particularly where the power requirement of the transistor is not high. The transistor device of the present invention is of this general type, but a number of advantages have been realized through the incorporation of an improved header design which provides for an efficient thermal path for conduction of heat from the transistor junction to the encapsulating can which may have a heat sink attached thereto.

Another problem encountered in transistor fabrication is that of maintaining chemical cleanliness of the crystal and its environment. Transistor action is extremely sensitive to crystal surface conditions and reliability may be considerably affected by undesirable chemical impurities in that vicinity. In bonding operations and, in fact, in all fabrication steps in manufacturing a well-designed transistor, great care must be exercised to avoid contamination and entrapment of impurities.

An object of the device to provide an improved transistor header design embodying the use of clad materials to provide a path of high thermal conductivity between the junction and can via the base electrode and header.

According to the present invention we provide a semiconductor device, a header unit comprising a clad metal shell, insulating material filling said shell and a clad metal tab integral with said shell and forming an electrode.

The features of the present invention will become more fully apparent from the following description when taken in conjunction with the accompanying drawing in which:—

Fig. 1 is a vertical sectional view of the improved header design;

Fig. 2 is a plan view of the header of Fig. 1;

Fig. 3 is a detail in section showing the connection between one of the electrical leads and the metallic portion of the header; and

[*Price* 4s. 6d.]

Fig. 4 is a detail similar to Fig. 3 showing another variation.

Referring now to Fig. 1, the header assembly includes a dish-shaped metal shell 10 defining circular apertures 14 and 16 and having an out-turned annular flange 12. The space within the shell 10 is filled with a suitable insulating material 18 such as glass which also extends into and fills the circular apertures 14 and 16. Electrical lead wires, 20 and 22, extend through the insulating material 18 and through the apertures 14 and 16 in shell 10. The insulating material 18 forms bushings for the leads as they pass through apertures 14 and 16 and the leads are thereby insulated from electrical contact with the shell 10.

A third electrical lead 24 passes into the insulating material 18 and is soldered or welded to the inside of the shell 10 as best shown in Fig. 3.

Integral with the metal shell 10 and projecting upwardly therefrom is a tab 30 forming an electrode. The tab 30 is preferably punched and bent from the metal shell 10 and may be cut-out along its upper edge as shown at 32 to facilitate mounting of the semiconductor crystal.

Metal shell 10 is of clad construction; that is it comprises a thin vineer of metal on a dissimilar metal, and thus consists of an inner layer 10*b* which is a metal having thermal expansion properties similar to those of the insulating material 18 and an outer layer 10*a* which is a metal of high thermal conductivity. A clad metal construction which has been found especially suitable is a shell in which the inner layer is an alloy of iron, nickel and cobalt produced commercially by the Driver-Harris Company of Harrison, New Jersey, under the trade name Kovar, and the outer layer is copper. Kovar is used quite extensively for glass-to-metal seals due to its coefficient of thermal expansion which matches that of certain types of glass compounds. The term clad metal refers to a metal having a thin vineer of a dissimilar metal thereon.

The header for semiconductor devices fabricated of clad metal which is the subject of the invention affords many advantages and improvements over existing header types. Perhaps the most obvious of these advantages is the possibility of obtaining a seal between the insulating material 18 and the shell 10 while simultaneously providing an excellent thermal path between transistor element and the can in which it is encased via the shell 10.

As will be appreciated by those skilled in the art, the seals around the external electrical leads and also between the metal shell and insulating material are of major significance in the maintenance of the internal environment of the device because they determine the leak rate into and out of the device. As has already been stated, Kovar-to-glass seals have proven to be excellent for this purpose. Thus, by making the inner layer 10*b* of metallic shell 10 and the electrical leads of Kovar or some other material having thermal expansion properties which match closely those of the insulating material utilized a very excellent seal is obtained.

In order to provide a good thermal path from the crystal junction to the can or heat sink, a metal having a high thermal conductivity can most advantageously be used in the construction of the metal shell 10. The thermal conductivity of copper defined as calories transmitted per second through a plate one centimetre thick across an area of one square centimetre for a temperature difference of 1 degree C. if 0.918 as compared to 0.046 for Kovar. Thus, for example, by using copper as the outer layer 10*a* clad on an inner layer 10*b* of Kovar, a header which possesses excellent heat dissipation characteristics as well as providing tight and rugged seals around the external leads may be fabricated.

This clad construction is also quite significant in that varying heat dissipation requirements can be met by varying the proportionate thickness of the inner and outer metallic layer of the shell 10 without changing the over-all thickness of the shell or its physical configuration. This presents a very real advantage in designing to meet industrial specifications covering the allowable internal temperature differential (junction to case). For a given allowable internal temperature differential, the proportions of the thickness of the outer layer metal to the thickness of the inner layer metal which must be utilized may be easily determined by known analytical techniques. The only variation in design which is required to meet different internal temperature differential requirements within device design limitations, is the relative thickness of the two metal layers 10*a* and 10*b*. The over-all thicknesses of the metal shell need not be varied. A practical upper limit on the proportion of the thickness of the outer and inner metal layers would be set by the allowable deformation of the shell with temperature changes to preclude damage to the metal-to-glass seals.

A further advantage of the header for semiconductor devices accrues from the integral tab feature. Tab 30 is formed by punching it out of the metal shell 10 and bending it into an upright position. It is thus not necessary to weld or braze a tab element to the metal shell of the header. Because of the accompanying entrapment of impurities and inherent chemical uncleanliness of such welding or brazing operations, the elimination of these operations is highly desirable in transistor fabrication.

Following construction of the header for

semiconductor devices, as thus far described, a suitable finish (i.e. plating with gold or other metals) may be applied to the outer layer 10*a* of the clad material shell to provide adequate protection during processing the device and resistance to the action of chemical or electrolytic etching procedures. Alternatively, an additional clad layer may be provided to provide, in turn, the desired protective properties. Also the leads 20 and 22 may be either tin or gold-plated to provide for soldering to the transistor element in accordance with techniques well known in the art and lead 24 may be connected to the shell by means of solder 34.

It will be appreciated that still greater improvements in reliability are achieved through the use of a clad chemically resistant metal layer covering the copper clad. The use of this upper clad layer is considered to be superior to otherwise coated (and in particular plated) protective metal layers. Plating has the drawback of producing a coating having microscopic voids and inclusion of impurities (plating solution) notably by entrapment. Cladding, on the other hand, avoids these difficulties. A top clad of nickel or gold would serve as a suitable chemically resistant metal layer.

Fig. 4 illustrates a variation in the header arrangement, the header comprising a copper-Kovar clad 10 having a projection 60 therein of a configuration similar to tab 30. The variation of Fig. 4 may also include an outer clad of a chemically resistant metal layer such as nickel or gold in order to obtain improved reliability. The structure illustrated is particularly advantageous as all surfaces may be covered by a clad layer of chemically resistant material.

Although the arrangements described hereinabove is considered preferred embodiments of the invention, it will be appreciated that other arrangements are possible which do not depart from the novel concepts herein taught. For example, although reference by way of example has been made to the use of Kovar and copper as materials from which the clad material shell may be fabricated, any two or more metals or alloys may be used in any proportionate thickness so as to impart to the header those properties which are especially desired, or to effect material economies within technical specification requirements.

WHAT WE CLAIM IS:—

1. In a semiconductor device, a header unit comprising a clad metal shell, insulating material filling said shell and a clad metal tab integral with said shell and forming an electrode.

2. In a semiconductor device, the combination of a tab and a header connected integrally to said tab, said header comprising a metallic shell formed of Kovar clad with copper and insulating material filling said shell.

3. In a semiconductor device, a header unit comprising insulating material, a metallic shell partially surrounding said insulating material and bonded thereto, said metallic shell having an inner metallic layer which possesses substantially the same coefficient of thermal expansion as said insulating material bonded to said insulating material and having an adjacent layer of metal clad to said inner layer, which adjacent layer of metal is characterized by high thermal conductivity, a plurality of circular apertures in said shell for accommodating the lead wires of said transistor device, and lead wires passing through said insulating material and through said circular apertures.

4. A header unit for a transistor device comprising a dish-shaped metal shell, insulating material enclosed within said shell, a pair of lead wires passing through said insulating material and said shell, a third lead wire passing through said insulating material and connected to said shell, and a metallic tab integral with said shell and projecting outward therefrom to form one electrode for the wafer of said transistor device, said dish-shaped metal shell having apertures in one surface thereof through which said pair of lead wires pass and having an inner layer of metal having substantially the same coefficient of thermal expansion of said insulating material and an intermediate layer of metal whose thermal conductivity is higher than that of said inner layer, and further having an etch resistant metallic plating superimposed upon said intermediate layer, said insulating material being bonded to said inner layer of said metallic shell and forming insulating bushings in said apertures in said shell through which said pair of lead wires pass.

5. A header unit for a transistor device as claimed in Claim 4 in which said insulating material is glass, said inner layer of said metallic shell is Kovar, and said intermediate layer of said metallic shell is copper.

6. In a semiconductor device, a header unit comprising insulating material, a metallic shell partially surrounding said insulating material and bonded thereto, said metallic shell having a first inner metallic layer which possesses substantially the same coefficient of thermal expansion as said insulating material bonded to said insulating material, a second inner layer of metal of high thermal conductivity clad to said first inner layer and an outer layer of a metal possessing qualities of chemical resistance, to the action of various electrolytic and chemical etching processes commonly employed in fabrication of semiconductor devices clad to said second inner layer, a plurality of circular apertures in said shell for accommodating the lead wires of said semiconductor device, and lead wires passing through said insulating material and through said circular apertures.

7. A header unit for a semiconductor device as claimed in Claim 6 in which said

semiconductor devices, as thus far described, a suitable finish (i.e. plating with gold or other metals) may be applied to the outer layer 10*a* of the clad material shell to provide adequate protection during processing the device and resistance to the action of chemical or electrolytic etching procedures. Alternatively, an additional clad layer may be provided to provide, in turn, the desired protective properties. Also the leads 20 and 22 may be either tin or gold-plated to provide for soldering to the transistor element in accordance with techniques well known in the art and lead 24 may be connected to the shell by means of solder 34.

It will be appreciated that still greater improvements in reliability are achieved through the use of a clad chemically resistant metal layer covering the copper clad. The use of this upper clad layer is considered to be superior to otherwise coated (and in particular plated) protective metal layers. Plating has the drawback of producing a coating having microscopic voids and inclusion of impurities (plating solution) notably by entrapment. Cladding, on the other hand, avoids these difficulties. A top clad of nickel or gold would serve as a suitable chemically resistant metal layer.

Fig. 4 illustrates a variation in the header arrangement, the header comprising a copper-Kovar clad 10 having a projection 60 therein of a configuration similar to tab 30. The variation of Fig. 4 may also include an outer clad of a chemically resistant metal layer such as nickel or gold in order to obtain improved reliability. The structure illustrated is particularly advantageous as all surfaces may be covered by a clad layer of chemically resistant material.

Although the arrangements described hereinabove is considered preferred embodiments of the invention, it will be appreciated that other arrangements are possible which do not depart from the novel concepts herein taught. For example, although reference by way of example has been made to the use of Kovar and copper as materials from which the clad material shell may be fabricated, any two or more metals or alloys may be used in any proportionate thickness so as to impart to the header those properties which are especially desired, or to effect material economies within technical specification requirements.

WHAT WE CLAIM IS:—

1. In a semiconductor device, a header unit comprising a clad metal shell, insulating material filling said shell and a clad metal tab integral with said shell and forming an electrode.

2. In a semiconductor device, the combination of a tab and a header connected integrally to said tab, said header comprising a metallic shell formed of Kovar clad with copper and insulating material filling said shell.

3. In a semiconductor device, a header unit comprising insulating material, a metallic shell partially surrounding said insulating material and bonded thereto, said metallic shell having an inner metallic layer which possesses substantially the same coefficient of thermal expansion as said insulating material bonded to said insulating material and having an adjacent layer of metal clad to said inner layer, which adjacent layer of metal is characterized by high thermal conductivity, a plurality of circular apertures in said shell for accommodating the lead wires of said transistor device, and lead wires passing through said insulating material and through said circular apertures.

4. A header unit for a transistor device comprising a dish-shaped metal shell, insulating material enclosed within said shell, a pair of lead wires passing through said insulating material and said shell, a third lead wire passing through said insulating material and connected to said shell, and a metallic tab integral with said shell and projecting outward therefrom to form one electrode for the wafer of said transistor device, said dish-shaped metal shell having apertures in one surface thereof through which said pair of lead wires pass and having an inner layer of metal having substantially the same coefficient of thermal expansion of said insulating material and an intermediate layer of metal whose thermal conductivity is higher than that of said inner layer, and further having an etch resistant metallic plating superimposed upon said intermediate layer, said insulating material being bonded to said inner layer of said metallic shell and forming insulating bushings in said apertures in said shell through which said pair of lead wires pass.

5. A header unit for a transistor device as claimed in Claim 4 in which said insulating material is glass, said inner layer of said metallic shell is Kovar, and said intermediate layer of said metallic shell is copper.

6. In a semiconductor device, a header unit comprising insulating material, a metallic shell partially surrounding said insulating material and bonded thereto, said metallic shell having a first inner metallic layer which possesses substantially the same coefficient of thermal expansion as said insulating material bonded to said insulating material, a second inner layer of metal of high thermal conductivity clad to said first inner layer and an outer layer of a metal possessing qualities of chemical resistance, to the action of various electrolytic and chemical etching processes commonly employed in fabrication of semiconductor devices clad to said second inner layer, a plurality of circular apertures in said shell for accommodating the lead wires of said semiconductor device, and lead wires passing through said insulating material and through said circular apertures.

7. A header unit for a semiconductor device as claimed in Claim 6 in which said

insulating material is glass, said first inner layer of said metallic shell is Kovar, said second inner layer of high thermal conductive layer is copper, and said outer layer of chemically resistant material is nickel.

8. A header unit for a semiconductor device as claimed in Claim 7 except that said outer layer of chemically resistant material is gold.

9. A header unit as claimed in Claim 6, having a projection formed in said metallic shell.

10. A header for a semiconductor device as hereinbefore described with reference to Figs. 1 to 3, or Fig. 4, of the accompanying drawing.

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