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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Diode Structure

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:—

The present invention relates to a diode structure and more particularly to a diode structure wherein the contact with the diode is made in a surer fashion with less danger of shorting.

In the fabrication of semiconductor diodes, one technique in favour involves making contact to one side of the diode by means of a ribbon. A ribbon has been found superior to a wire in some respects for making contact to the diode. As a ribbon presents a fairly wide surface to the diode, it is to all intents and purposes self-positioning. A wire, on the other hand, must be positioned with great care since its end is usually shaped to a fine point. A ribbon also has the advantage of greater strength due to its bulk. A further advantage of using a ribbon is that a more positive pressure contact can be had since it is possible to develop greater bias also due to the bulk of the ribbon. Various configurations have been used for the ribbon, such as bending the ribbon into an S-shape or a C-shape. In both cases, the purpose of the shape is to impart resiliency to the ribbon to insure positive pressure contact.

It has been discovered, however, that since the ribbon tends to contact the diode over a large area due to its planar form, it can conceivably short out the diode. This problem has arisen, particularly in the fabrication of mesa diode structures. This type of semiconductor diode is made by forming a diffused PN junction in one face of a wafer of semiconductor material. Next, a small area of the face is masked and the remainder of the face is removed to a depth below the junction line. This leaves remaining only that portion of the original face that was masked. This portion now stands out or projects as a mesa. The diffused junction is, of course, located in the mesa and consequently, the cross-sectional area of the junction is substantially the same as the cross-sectional area of the mesa. The big advantage of this type of construction is the fact that the small cross-sectional area of the junction will impart high frequency characteristics to the ultimate device. The fact that the junction and the mesa are correlated provides an excellent control of the cross-sectional area of the junction.

In structures of the mesa type, where one side of the diode is contained in a mesa that projects slightly above the surface of the wafer and the other side of the diode is constituted by the entire remaining part of the wafer, difficulties have been experienced in making contact to that portion of the diode that is contained in the mesa. It is to be appreciated in this regard that the mesa does not project more than about one to two mils above the surface of the wafer. Consequently, when attempting to make contact to a structure of this type by a ribbon of any width whatsoever, there is always the danger that the ribbon will contact the mesa on one edge and the remaining portion of the ribbon will bend or somehow contact the remaining portion of the wafer. The net effect of this is to short out the diode. This condition could be brought about during application of the ribbon contact or after the diode has been completely fabricated and encapsulated and is subjected to some sort of shock or jostling. In either event, the diode would be a reject. It is to solve this very serious and frequently costly problem that the present invention was conceived.

The present invention is a diode structure comprising a housing enclosing a diode wafer

[*Price 4s. 6d.*]

containing a PN junction and having an electrode in electrical contact with each of its opposite faces, one said electrode being a ribbon defining only in a restricted area where in electrical contact with the face of the wafer a three-dimensional curved surface that is curved in two directions normal to each other, a wire being directly connected to said ribbon within the housing and at some spacing from the contact with the wafer.

Embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, in which:

Fig. 1 portrays in section a diode configuration of the present invention;

Fig. 2 portrays in a section taken normal to the section of Fig. 1, the same diode configuration; and

Figs. 3 to 5 illustrate alternative shapes for a whisker ribbon demonstrating the versatility of the invention.

A preferred embodiment of the diode structure of the present invention is shown in Figs. 1 and 2. The diode structure shown is characterized by a narrow elongated ribbon such as a whisker ribbon such that shorting of the diode is prevented and danger thereof is eliminated. Referring particularly to Figs. 1 and 2 of the drawings, the reference numeral 10 refers to a glass sleeve. Attached to one end of the glass sleeve 10 is a metal plug 12 which forms a suitable glass-to-metal hermetic seal. The plug 12 can be comprised of molybdenum or may be comprised of a material, such as Kovar (Registered Trade Mark) which is a nickel-iron-cobalt alloy having the characteristic that its thermal coefficient of expansion matches that of a hard glass sold commercially under the trade name Corning Works Glass 7052. This material further has the distinction of forming an hermetic seal with this glass. A suitable diode lead wire 14 is affixed at one of its ends to the outer face of the metal plug 12. Mounted on the inner-face of the metal plug 12 is a conventional mesa diode 16 with the mesa portion thereof being identified by the reference numeral 18. It will be appreciated that suitable contacts, composed for example of nickel or gold, will be present on the top of the mesa 18 and the bottom face of the diode.

A glass bead 20 is sealed with the other end of the glass sleeve 10 and forms an hermetic seal therewith. Glass sleeve 10 and glass bead 20 are composed of a hard glass as above identified. The glass bead 20 is sealed onto a lead or wire 22 composed of Kovar. The Kovar wire 22 terminates at the outer extremity of the glass bead 20 and is welded, as indicated by the reference numeral 24, to one end of a suitable lead wire 26. This latter wire may be comprised of Dumet which is a nickel-iron alloy having a copper coating thereon. It is thus apparent that the glass sleeve 10, the metal plug 12, wire 22 and the glass bead 20 constitute a complete hermetically sealed enclosure. The end of the wire 22, contained within the glass sleeve 10, has affixed to it a C-shaped ribbon 30. The outside surface of one leg of the ribbon 30 is attached to the end surface of the wire 22. The outside surface of the other leg 32 of the ribbon 30 is stamped to define a spherical surface and also is roughened. This leg 32 pressure-contacts the mesa 18 of the diode 16. From the foregoing description it is evident that the leg 32 of the C-shaped whisker ribbon 30 is one diode electrode and the metal plug 12 is the other diode electrode.

Although the whisker ribbon can be composed of any suitable material, it is preferred that it be composed of some high temperature alloy that will not oxidize. Typical examples of materials that can be used for the ribbon are platinum-tungsten alloys and platinum clad nickel.

The surface of leg 32 can be roughened in several ways including sand blasting, embossing by rolling to produce a coarse microfinish surface, chemical etching, and rolling on a female die characterized by a myriad of pyramids to name a few.

In the specific preferred example (Figs. 1 and 2), the whisker ribbon has been shown as C-shaped. There are other shapes which can be employed. Some of these are illustrated in Figs. 3 to 5. As shown in Fig. 3, the whisker ribbon 50 is S-shaped and is attached to the end of a wire 52. The region 54 of whisker 50 that contacts the mesa of diode 56 is stamped in a restricted area only to present a spherical surface to the mesa. This surface is roughened as previously described. In Fig. 4, the whisker ribbon 60 is in the shape of a 5. The flag portion of the ribbon 60 is attached to a wire 62 and the portion 64 that contacts the mesa of diode 66 is stamped in a restricted area only to present a spherical surface to the mesa. This surface is roughened. In Fig. 5, the ribbon 70 is a closed loop and is attached to a wire 72. Diametrically opposite to the wire 72, the ribbon is stamped in a restricted area only to define a spherical surface 74 that is roughened. Surface 74 contacts the mesa of diode 76.

The surface of the ribbon that contacts the diode has been described as spherical but it can be any three-dimensional curved surface, such as, an ellipsoidal surface or a paraboloidal surface. By this means it is possible to gain all the advantages of using a wire, and preserve all the advantages of using a ribbon since the contact between the ribbon and the diode will be in the nature of a point contact regardless of which point on the ribbon actually contacts the mesa of the diode.

WHAT WE CLAIM IS:—

1. A diode structure comprising a housing

containing a PN junction and having an electrode in electrical contact with each of its opposite faces, one said electrode being a ribbon defining only in a restricted area where in electrical contact with the face of the wafer a three-dimensional curved surface that is curved in two directions normal to each other, a wire being directly connected to said ribbon within the housing and at some spacing from the contact with the wafer.

Embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, in which:

Fig. 1 portrays in section a diode configuration of the present invention;

Fig. 2 portrays in a section taken normal to the section of Fig. 1, the same diode configuration; and

Figs. 3 to 5 illustrate alternative shapes for a whisker ribbon demonstrating the versatility of the invention.

A preferred embodiment of the diode structure of the present invention is shown in Figs. 1 and 2. The diode structure shown is characterized by a narrow elongated ribbon such as a whisker ribbon such that shorting of the diode is prevented and danger thereof is eliminated. Referring particularly to Figs. 1 and 2 of the drawings, the reference numeral 10 refers to a glass sleeve. Attached to one end of the glass sleeve 10 is a metal plug 12 which forms a suitable glass-to-metal hermetic seal. The plug 12 can be comprised of molybdenum or may be comprised of a material, such as Kovar (Registered Trade Mark) which is a nickel-iron-cobalt alloy having the characteristic that its thermal coefficient of expansion matches that of a hard glass sold commercially under the trade name Corning Works Glass 7052. This material further has the distinction of forming an hermetic seal with this glass. A suitable diode lead wire 14 is affixed at one of its ends to the outer face of the metal plug 12. Mounted on the inner-face of the metal plug 12 is a conventional mesa diode 16 with the mesa portion thereof being identified by the reference numeral 18. It will be appreciated that suitable contacts, composed for example of nickel or gold, will be present on the top of the mesa 18 and the bottom face of the diode.

A glass bead 20 is sealed with the other end of the glass sleeve 10 and forms an hermetic seal therewith. Glass sleeve 10 and glass bead 20 are composed of a hard glass as above identified. The glass bead 20 is sealed onto a lead or wire 22 composed of Kovar. The Kovar wire 22 terminates at the outer extremity of the glass bead 20 and is welded, as indicated by the reference numeral 24, to one end of a suitable lead wire 26. This latter wire may be comprised of Dumet which is a nickel-iron alloy having a copper coating thereon. It is thus apparent that the glass sleeve 10, the metal plug 12, wire 22 and the glass bead 20 constitute a complete hermetically sealed enclosure. The end of the wire 22, contained within the glass sleeve 10, has affixed to it a C-shaped ribbon 30. The outside surface of one leg of the ribbon 30 is attached to the end surface of the wire 22. The outside surface of the other leg 32 of the ribbon 30 is stamped to define a spherical surface and also is roughened. This leg 32 pressure-contacts the mesa 18 of the diode 16. From the foregoing description it is evident that the leg 32 of the C-shaped whisker ribbon 30 is one diode electrode and the metal plug 12 is the other diode electrode.

Although the whisker ribbon can be composed of any suitable material, it is preferred that it be composed of some high temperature alloy that will not oxidize. Typical examples of materials that can be used for the ribbon are platinum-tungsten alloys and platinum clad nickel.

The surface of leg 32 can be roughened in several ways including sand blasting, embossing by rolling to produce a coarse microfinish surface, chemical etching, and rolling on a female die characterized by a myriad of pyramids to name a few.

In the specific preferred example (Figs. 1 and 2), the whisker ribbon has been shown as C-shaped. There are other shapes which can be employed. Some of these are illustrated in Figs. 3 to 5. As shown in Fig. 3, the whisker ribbon 50 is S-shaped and is attached to the end of a wire 52. The region 54 of whisker 50 that contacts the mesa of diode 56 is stamped in a restricted area only to present a spherical surface to the mesa. This surface is roughened as previously described. In Fig. 4, the whisker ribbon 60 is in the shape of a 5. The flag portion of the ribbon 60 is attached to a wire 62 and the portion 64 that contacts the mesa of diode 66 is stamped in a restricted area only to present a spherical surface to the mesa. This surface is roughened. In Fig. 5, the ribbon 70 is a closed loop and is attached to a wire 72. Diametrically opposite to the wire 72, the ribbon is stamped in a restricted area only to define a spherical surface 74 that is roughened. Surface 74 contacts the mesa of diode 76.

The surface of the ribbon that contacts the diode has been described as spherical but it can be any three-dimensional curved surface, such as, an ellipsoidal surface or a paraboloidal surface. By this means it is possible to gain all the advantages of using a wire, and preserve all the advantages of using a ribbon since the contact between the ribbon and the diode will be in the nature of a point contact regardless of which point on the ribbon actually contacts the mesa of the diode.

WHAT WE CLAIM IS:—

1. A diode structure comprising a housing

* C L M S *

enclosing a diode wafer containing a PN junction and having an electrode in electrical contact with each of its opposite faces, one said electrode being a ribbon defining only in a restricted area where in electrical contact with the face of the wafer a three-dimensional curved surface that is curved in two directions normal to each other, a wire being directly connected to said ribbon within the housing and at some spacing from the contact with the wafer.

2. A diode structure according to claim 1, in which said ribbon is C-shaped.

3. A diode structure according to either preceding claim, wherein said surface is spherical.

4. A diode structure according to any preceding claim, wherein said surface is roughened.

5. A diode structure according to any preceding claim, wherein the diode wafer is a mesa type diode, substantially enclosed by a glass envelope, the other electrode is attached to the face of said diode remote from said mesa, and the three dimensional curved surface is in engagement with said mesa.

6. A diode structure substantially as hereinbefore described and illustrated by the accompanying drawings.

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