

L144380



PATENT SPECIFICATION

DRAWINGS ATTACHED

L144380

Date of Application and filing Complete Specification: 15 Dec., 1966.

No. 56132/66.

Application made in United States of America (No. 518214) on 3 Jan., 1966.

Complete Specification Published: 5 March, 1969.

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Index at acceptance:—C1 M(9A, 9D3C5, 9D3U, 9D4C, 9D4D, 9D5, 9D10, S20).

Int. Cl.:—C 03 b 19/02

COMPLETE SPECIFICATION

Process for Fabricating Hermetic Seals

We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organised according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, 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 glass seals and particularly to the use of such seals in fabrication of packages or enclosures for electrical devices, e.g. semiconductor devices.

Semiconductor packages can be manufactured from a conductive metal alloy known by the trade name "Kovar", glass being disposed between the conductive package and a lead extending through the package to provide electrical insulation between the lead and the package and to hermetically seal the space between the lead and the package. Also, the glass seal frequently provides mechanical support for the lead.

According to the present invention, a process for sealing an electrical lead in a space between surface regions of a support for an electrical device, comprises filling the space with a slurry of glass particles and a carrier liquid, drying the slurry to leave glass particles in the space as a particulate mass separating the lead and the said surface regions, and prior to mounting the electrical device on the support, fusing the particulate glass mass to fill the said space and form a solid glass seal between the lead and the support. Subsequently, the electrical device, e.g. semiconductor device, can be mounted on the support, the lead connected to the device and an enclosure completed around the device. Further leads to the device can be sealed in a similar manner.

The invention is also particularly useful in

the packaging so-called integrated networks having a number of semiconductor components formed in situ on a single semiconductor substrate. The packaging of such networks can be particularly complicated due to the fact that a large number of electrical leads, for example from ten to twenty, may extend from the semiconductor chip through the package for connection to an external circuit. One form of "flat pack" is about 0.250 inch long, 0.125 inch wide and 0.03 inch deep, having 14 leads each of which needs to be electrically isolated from the package. During fabrication of such a package, a rectangular frame is formed integral with the leads to support the leads in proper relative positions by stamping both the frame and the leads from the metal sheet. Then a ring frame, having openings in the side for receiving the leads, and a base plate are positioned on either side of the leads and welded together so that each lead extends through the proper opening in the ring frame into the interior of the package. According to the present invention there is also provided a process for sealing one or more electrical leads to a metallic container for an electrical device, the or each lead extending through a opening in the container. The process comprises placing a slurry of particulate glass and a carrier liquid in the container to enter the or each opening and evaporating the liquid from the slurry to leave a particulate glass mass in the or each opening. Prior to mounting the electrical device in the container, the particulate glass mass is fused to fill the or each opening and form a solid glass seal between and separating the or each lead and the container. Subsequently, the electrical device can be mounted in the container and the or each lead can be connected to the device within the container. The container is then closed to form a hermetically sealed enclosure.

[Price 4s. 6d.]

Suitably, the slurry is composed of glass particles and water and preferably the slurry has a viscosity and surface tension such that the slurry penetrates and occupies the opening in which the lead or leads are located. However, a more viscous form of slurry could be used and pressure applied to force the slurry into the space or openings containing the lead(s) instead of relying on the surface tension of the slurry.

By way of example, the invention will be described in greater detail with reference to the accompanying drawings in which:

FIGURE 1 is a somewhat perspective view showing a portion of a strip of electrical lead frames with base plates and ring frames of containers welded in position prior to application of a glass slurry in accordance with a process embodying the present invention;

FIGURE 2 is a transverse sectional view of one of the assemblies shown in FIGURE 1;

FIGURE 3 is a sectional view similar to FIGURE 2 showing the assembly after the application of a glass slurry;

FIGURE 4 is a sectional view similar to FIGURE 3 showing the assembly after the glass slurry is dried to form a particulate glass mass;

FIGURE 5 is a sectional view similar to FIGURE 4 showing the assembly after the particulate glass mass is fused to form a solid glass seal;

FIGURE 6 is a sectional view similar to FIGURE 5 showing the assembly after the excess glass has been sandblasted away; and

FIGURE 7 is a sectional view similar to FIGURE 6 showing a complete package with an integrated circuit chip encapsulated therein.

Referring now to the drawings, and in particular to FIGURE 1, a lead frame strip 10, which may be stamped from 4 mil thick metal, forms a number of rectangular lead frames indicated generally by the reference numerals 12, 14 and 16, only half of the frames 12 and 16 being shown. Any number of lead frames may be so formed, although typically only eight are formed on a single strip. Each of the lead frames is comprised of a portion of the longitudinally extending strips 18 and 20, which interconnect the lead frames, and transverse strips 21 and 22 extending between the two longitudinal strips. As illustrated, seven leads 24 extend inwardly from the strip 18 and seven leads 26 extend inwardly from the strip 20. The strip also has precisely located holes 28, 29, 30 and 31 for orientation and indexing purposes. The five middle leads 24 extend through openings 40 formed in one side of a ring frame 42 and are bent upwardly and then back toward the center of the ring frame 42 to provide end surfaces 24a. The five middle leads 26 similarly extend through openings 44 in the other

side of ring frame 42 and terminate at end surfaces 26a. The two outer leads 24 extend through openings 46 in opposite ends of the ring frame 42 and terminate at end surfaces 24b, and the two outer leads 26 extend through openings 48 in opposite ends of the ring frame 42 and terminate at end surfaces 26b. The assembly comprised of the lead frame 14, the ring frame 42, and the base plate 52 is assembled by stitch welding the base plate 52 to the ring frame 42 after the ends of the leads are positioned in the openings of the ring frame, and is degassed and oxidized prior to making a glass seal in accordance with a process embodying the present invention.

The metal most often used to form the ring frame strip 10, ring frames 42 and base plates 52 is a metal alloy known by the trade name "Kovar". This alloy is wetted by molten glass and has the same temperature expansion coefficient as certain hard glasses frequently used to make a seal, and therefore is particularly useful in making glass to metal seals. This alloy typically is composed of 54% iron, 28% nickel, 18% cobalt, or 20% nickel, 17% cobalt, 0.2% manganese, and the remainder iron.

The lead frame-ring, frame-base plate assembly illustrated in FIGURE 2 is placed in a suitable support which orients the leads in proper relationship to the ring frame and base plate. Then the assembly is filled with a liquid slurry 60 substantially as illustrated in FIGURE 3. It will be noted that the slurry 60 passes into the openings 40 and 44 and envelops the leads 24 and 26. The slurry 60 is a suspension of finely ground glass particles in water. A particular slurry composition that has been found suitable is ten parts glass to six parts distilled water. No other additive, binder or suspension agent is required. The glass is that sold by Corning Glass Works under the designation Corning glass No. 7052, a borosilicate glass, which has been wet ball milled for ten hours until about 50% of the particles range in size from four to ten microns diameter as determined by a Mine Safety Appliance Company centrifugal type particle size analyzer, with a somewhat even distribution within this range. Some data indicates that if more than about 50% of the particles are greater than ten microns, the final glass product tends to contain bubbles which are undesirable. Also, if the particle sizes are too large, the glass particles tend to settle out like sand and are not carried by the water and distributed as desired. There does not appear to be a minimum limit on the size of the particles. The viscosity of the slurry suitably lies in the range from 11 to 13 centipoises as measured by a Brookfield Viscometer using spindle #10. The surface energy suitably is from 65-75 dynes/cm as measured by a

Fisher surface tensiometer. It is to be understood, however, that the invention, within its broader aspects, is not limited to any particular type of glass, to any particular particle size, or to any particular ratio of liquid and glass. In order to achieve the desired results, however, there must be an adequate volume of glass particles within the liquid to fill the spaces to be sealed after the liquid is evaporated, and the glass particles preferably should be sufficiently small to be carried into the cracks, crevices and openings by the surface tension of the slurry. The viscosity and surface tension of the slurry is preferably chosen so as to penetrate the openings to be sealed, yet remain in the opening once the opening is filled. An important advantage of the process being described is that the individual assemblies can easily be filled with slurry by a machine which automatically indexes the support for a strip of assemblies past a filling station.

Immediately after the assemblies are filled with the slurry 60, the assemblies are transferred to a conveyor which passes through an oven operating at about 70—80° C. to evaporate the water from the slurry. As the water evaporates, the glass particles coagulate into a particulate mass 62 having a cross section substantially as illustrated in FIGURE 4. It will be noted that the particulate glass remains in and fills the openings 40 and 44 around the leads 24 and 26 and also covers over the tips 24a and 26a of the leads and will withstand ordinary handling without crumbling. Next the units are transferred to graphite boats, which support the leads 24 and 26 in proper relationship to the base plate 52 and ring frame 42 and the boat is passed through a fusing furnace operating at about 925° C. A fusing cycle of about 1.5 hours is typical. The glass particles become fused together and form a solid glass seal 64 having a cross section substantially as illustrated in FIGURE 5. It will be noted that the solid glass seal completely fills the spaces between the leads and the ring frame 42 and base plate 52 and also covers the ends 24a and 24b of the leads and the center of the base plate. Because of the greater surface tension of the glass, the glass also tends to coat the roots of the leads 24 and 26 further from the ring frame as indicated at 64a. Even so, the amount of glass 64a is less than the amount of glass produced with a conventional process in which a rectangular glass preform is placed over the ends of the leads in the ring frame and the glass is extruded (during the fusion process) outwardly through the openings 40, 44, 46 and 48 by the weight of a copper plug on the glass between the ends of the leads 24 and 26. Also, the amount of glass over the ends 24a and 26b of the leads is less, although the amount of glass 64b over the center of the base plate 52 is slightly greater.

Next the excess glass 64 is removed using conventional sandblasting techniques to expose the center of the base plate 52 and the ends 24a, 24b, 26a and 26b of the leads, and remove the excess glass 64a from the root of the leads substantially as illustrated in FIGURE 6. The package is then ready for inspection and plating and ultimately installation of the semiconductor chip in the conventional manner. This entails cementing the chip 70 to the exposed inside surface of the base plate 52 by a suitable glass adhesive 72, and then bonding lead wires 74 from so-called expanded contact pads on the chip 70 to the ends of the respective leads inside the ring frame. Then a lid 76 is welded around the top of the ring frame 42 in a conventional manner to complete the hermetically sealed package. When the lead frame is subsequently cut away from the leads 24 and 26, the glass sealing material 64 mechanically holds the leads in place, electrically insulates the leads from the remainder of the package and hermetically seals the package so that the ambient within the package can be controlled.

From the above description it will be noted that the surface tension of the liquid in the slurry is used to advantage to transport the glass particles into the spaces to be sealed. Then as the liquid dries, the surface tension not only holds the particles in the spaces, but tends to transport additional particles into the spaces and firmly pack the particles into a compact particulate mass. However, it is to be understood that within the broader aspects of the invention, the slurry may be thick or more viscous, even to a consistency of paste, in which case the slurry would be forced by pressure into the spaces to be sealed, rather than by the surface tension of the liquid.

Although the process of the present invention has been described in connection with encapsulation of a standard semiconductor network flat pack, it is to be understood that the process is applicable to the fabrication of many other seals, and in particular to other glass-metal seals.

WHAT WE CLAIM IS:—

1. A process for sealing an electrical lead in a space between surface regions of a support for an electrical device, comprising filling the space with a slurry of glass particles and a carrier liquid, drying the slurry to leave glass particles in the space as a particulate mass separating the lead and the said surface regions, and prior to mounting the electrical device on the support, fusing the particulate glass mass to fill the said space and form a solid glass seal between the lead and the support.

2. A process according to Claim 1, including the steps of mounting an electrical device



Fisher surface tensiometer. It is to be understood, however, that the invention, within its broader aspects, is not limited to any particular type of glass, to any particular particle size, or to any particular ratio of liquid and glass. In order to achieve the desired results, however, there must be an adequate volume of glass particles within the liquid to fill the spaces to be sealed after the liquid is evaporated, and the glass particles preferably should be sufficiently small to be carried into the cracks, crevices and openings by the surface tension of the slurry. The viscosity and surface tension of the slurry is preferably chosen so as to penetrate the openings to be sealed, yet remain in the opening once the opening is filled. An important advantage of the process being described is that the individual assemblies can easily be filled with slurry by a machine which automatically indexes the support for a strip of assemblies past a filling station.

Immediately after the assemblies are filled with the slurry 60, the assemblies are transferred to a conveyor which passes through an oven operating at about 70–80° C. to evaporate the water from the slurry. As the water evaporates, the glass particles coagulate into a particulate mass 62 having a cross section substantially as illustrated in FIGURE 4. It will be noted that the particulate glass remains in and fills the openings 40 and 44 around the leads 24 and 26 and also covers over the tips 24a and 26a of the leads and will withstand ordinary handling without crumbling. Next the units are transferred to graphite boats, which support the leads 24 and 26 in proper relationship to the base plate 52 and ring frame 42 and the boat is passed through a fusing furnace operating at about 925° C. A fusing cycle of about 1.5 hours is typical. The glass particles become fused together and form a solid glass seal 64 having a cross section substantially as illustrated in FIGURE 5. It will be noted that the solid glass seal completely fills the spaces between the leads and the ring frame 42 and base plate 52 and also covers the ends 24a and 24b of the leads and the center of the base plate. Because of the greater surface tension of the glass, the glass also tends to coat the roots of the leads 24 and 26 further from the ring frame as indicated at 64a. Even so, the amount of glass 64a is less than the amount of glass produced with a conventional process in which a rectangular glass preform is placed over the ends of the leads in the ring frame and the glass is extruded (during the fusion process) outwardly through the openings 40, 44, 46 and 48 by the weight of a copper plug on the glass between the ends of the leads 24 and 26. Also, the amount of glass over the ends 24a and 26b of the leads is less, although the amount of glass 64b over the center of the base plate 52 is slightly greater.

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WHAT WE CLAIM IS:—

1. A process for sealing an electrical lead in a space between surface regions of a support for an electrical device, comprising filling the space with a slurry of glass particles and a carrier liquid, drying the slurry to leave glass particles in the space as a particulate mass separating the lead and the said surface regions, and prior to mounting the electrical device on the support, fusing the particulate glass mass to fill the said space and form a solid glass seal between the lead and the support.

2. A process according to Claim 1, including the steps of mounting an electrical device

on the support, connecting the lead to the device, and completing an enclosure around the device.

5 3. A process for sealing an electrical lead to a metallic container for an electrical device, the lead extending through an opening in the container, comprising placing a slurry of particulate glass and a carrier liquid in the container to enter the said opening, evaporating the liquid from the slurry to leave a particulate glass mass in the opening, and prior to mounting the electrical device in the container fusing the particulate glass mass to fill the opening and form a solid glass seal between and separating the lead and the container.

10 4. A process according to Claim 3, the container having a plurality of openings through which extend electrical leads, in which the slurry enters each of the openings and the fusing forms a solid glass seal filling the openings and sealing the leads with the container.

15 5. A process according to Claim 3 or Claim 4, in which following the fusion step, glass is removed to expose within the container a surface portion of the or at least one of the leads.

20 6. A process according to any one of Claims 3-5, including the steps of mounting an electrical device in the container and connecting the lead or at least one of the leads to the device and closing the container to form a hermetically sealed enclosure.

25 7. A process according to any one of

the preceding claims, the slurry being composed of glass particles and water.

8. A process according to any one of the preceding claims, the slurry having viscosity and surface tension such that the slurry penetrates into and occupies the said space or opening(s).

9. A process according to Claim 8, the viscosity and surface tension of the slurry being sufficient to retain the glass particles in the space or opening(s) during evaporation of the liquid.

10. A process according to Claim 7, the slurry being composed of about ten parts glass and about six parts water.

11. A process according to any one of the preceding claims, about fifty per cent of the glass particles in the slurry being in the size range 4-10 microns diameter.

12. A process for sealing electrical leads in openings in a wall of a metallic container, substantially as described herein with reference to and as illustrated by Figs. 1-6 of the accompanying drawings.

13. A process according to Claim 12, and including the further steps described herein with reference to and as illustrated by Fig. 7 of the accompanying drawings.

14. The product of a process according to any one of the preceding claims.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.

Published by the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.



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