

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO WELDING TECHNIQUES

(71) We, HEWLETT - PACKARD COMPANY, 1501 Page Mill Road, Palo Alto, California, United States of America, organized and existing under the laws of the State of California, 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 is concerned with improvements in or relating to welding techniques, and is especially concerned with welding techniques suitable for use in the assembly and packaging of micro circuit packages as disclosed in the complete specification of our co-pending U.K. patent application No. 21615/72 (Serial No. 1375667).

As hybrid microcircuits become more prevalent in modern electronic equipment, the packaging of such circuits plays an increasingly important role in their production and sale. Such packaging generally comprises a strong base structure for supporting the substrate or substrates on which the hybrid microcircuitry is formed and for dissipating heat that may be generated by the circuitry in operation, means for securely affixing the substrate to the base structure, electrical feed-through devices for feeding D.C. and A.C. voltages into and out from the package, and a cover or envelope structure hermetically sealing the hybrid microcircuit from the environment and for protecting the circuit structure from physical damage.

The manufacturing cost of hybrid microcircuits per unit device is steadily decreasing as a result of more efficient design and fabrication techniques, and it is necessary that the cost of the circuit packaging decreases in proper proportion to obtain the full benefits of cost savings without sacrifices of the desirable characteristics of such packaging. However, as the different types of hybrid microcircuits increase in number, with varying sizes and forms, the tendency is to utilize individual customized packages with the result that the packaging elements proliferate and package

costs mount. In addition, the tendency has been to adapt packaging concepts heretofore employed in expensive, customized, small lot production, resulting in overall expensive packaging for hybrid microcircuits.

It is an object of the present invention to provide an improved method of welding a cylindrical metallic member in an opening in a second metallic member.

The present invention provides a method of hermetically sealing and affixing a first cylindrically shaped metallic member having a ductile outer surface within a cylindrical opening in a second metallic member, the opening having a ductile surface and also a slightly larger internal diameter than the external diameter of said cylindrical member, the method comprising the steps of simultaneously directing the cylindrical member into said opening and applying a force to the surface of said second member around said opening to force the inner ductile surface of the opening against the outer ductile surface of said cylindrical member, the two surfaces scrubbing against each other, the force of the opening surface against the cylindrical member surface producing a diffusion weld between the surfaces.

Preferably said two members are plated with a ductile metal. Preferably said ductile metal is copper.

Preferably said second metallic member is aluminium with the opening having a ductile inner surface of copper.

Preferably the ductile metal surface of said cylindrical member is copper.

There now follows a detailed description which is to be read with reference to the accompanying drawings of several methods according to the invention described with reference to the construction of a modular microcircuit as disclosed in the aforesaid co-pending U.K. Patent application No. 21615/72 (Serial No. 1375667). It is to be clearly understood that these methods have been selected for description to illustrate the invention by way of example and not by way of limitation.

In the drawings:

Fig. 1 is an exploded perspective view showing a first modular package including members set in openings by carrying out a method according to the present invention;

Fig. 2 is a perspective view partly cut away showing the completed package of Fig. 1;

Fig. 3 is a cross section view of a D.C. feedthrough welded in a microcircuit package by carrying out a method according to the invention;

Fig. 4 is a cross section view of an R.F. feedthrough welded in a microcircuit package by carrying out a method according to the invention;

Fig. 5 is a cross section view of a stud about to be diffusion welded into the base plate of a package in carrying out a method according to the invention;

Fig. 6 is an enlarged perspective view of a part of a microcircuit package;

Fig. 7 is a perspective view of another part of a microcircuit package;

Fig. 8 is a cross section view of a portion of a cover and base plate of a package during diffusion welding thereof;

Fig. 9 is a perspective view partly cut away of a microcircuit package wherein the connections are brought out through a side wall portion of the package.

Figs. 10, 11 and 12 are perspective views of other forms of envelope of a package;

Fig. 13 and 14 are top and side views respectively, of another microcircuit package including members which have been welded together in carrying out a method according to the present invention.

Referring now to Figs. 1 and 2 the microcircuit package illustrated therein comprises a rectangular base plate 11 but which, for different packages, can be square or circular. One suitable plate $\frac{1}{8}$ " thick is made of an aluminium alloy, commercially available as 6061 T4 Aluminium, having holes 12 punched or drilled therein in a selected pattern suitable for accommodating particular microcircuits to be mounted thereon. In this illustration, two rectangular microcircuit substrates 13 and 14 are to be mounted in the package.

To ensure good welds by carrying out a method according to the invention and described below, it is necessary that the plate 11 be clean and of suitable ductility. It is thus desirable that the plate be provided with a suitable coating. For this purpose, the aluminium plate is first plated with zincate followed by immersion nickel plating, with a final electrolytic gold plate. This forms an outer surface which is easily cleaned and degreased and also provides a minimum aluminium oxide layer on the aluminium plate surface to optimize the diffusion weld properties. Only a normal process of degreas-

ing is needed to clean the plate surface prior to diffusion welding.

Studs 15 made from beryllium copper, phosphorus bronze, or stainless steel rod cut to the proper length, for example 50 mil diameter rod cut $\frac{1}{4}$ " long, are provided with a one mill thick copper coating and have seating flanges 16.

D.C. feedthroughs 17 (Fig. 3) each comprise a cylindrical flanged eyelet 18 of cold rolled steel or Kovar (RTM) having an internal glass seal 19 and a pin 20, preferably of Kovar or another suitable alloy, sealed in the axial centre of the glass seal 19 and extending from each end of the eyelet 18 for electrical connection. The eyelet 18 is provided with a few mils thick coating of copper on its outside surfaces.

R.F. feedthroughs 21 (Fig. 4) each comprise a copper coated cylindrical housing 22 having a U-shaped cross-section, the larger internal diameter section of the housing having an internally threaded surface 23 for accommodating the threaded end of the input coupling. A glass seal 24 is sealed in the smaller internal diameter section of the housing 22 and has a gold plated Kovar pin 25 sealed axially therein. A 500 air line 26 is formed between the inner portion of the pin 25 and a small opening in an end wall 27 of the housing 22 to provide a good electrical match into the structure.

The studs 15 and the feedthroughs 17 and 21 are hermetically sealed into the holes 12 in the base plate 11 by diffusion welding by the technique described with reference to Fig. 5. As the stud 15 begins to enter a respective one of the holes 12 the weld fixture 28 applies a force to the surface of the plate surrounding the hole and the surface of the hole begins to tighten on the stud. As the force on the plate surface increases, the plate tightens on the stud at the same time as the stud is forced into the hole, providing a scrubbing action between the zincate, nickel, and gold plated aluminium plate and the copper-plated beryllium copper stud. The scrubbed metals are exposed, and the combined radially directed force and axially directed scrubbing result in a diffusion weld between the stud and plate which meets the U.S. Government mil standard 883 for hermetic sealing.

The combined scrubbing and radial force is also utilized to diffusion weld with R.F. and D.C. feedthroughs into the plate, the diffusion weld being formed between the scrubbed metals of the plate and the feedthroughs since the scrubbing action exposes clean metal. Generally speaking, dissimilar ductile materials such as aluminium and mild steel or aluminium and copper may be joined. Similar materials such as aluminium and aluminium or copper and copper may also be joined.

The end of the weld fixture 28 contacting

the surface of the plate 11 is designed so that, in addition to the inward radially directed flow (by which is meant plastic distortion of the metal of the plate 11) represented by the arrow *a*, is also produces an outward and downward radial flow or plastic distortion of the metal, represented by the arrow *b*. This flow *b* serves to counteract the flow represented by the arrow *c* tending to bend or warp the plate 11. For optimum heat transfer the plate must be flat to maximize surface contact with the carriers.

With the studs and feedthroughs secured by diffusion welding in the plate 11, microcircuit units are then set onto the plate and properly positioned relative to the studs 15 and the feedthroughs 17 and 21. The microcircuit units each include a carrier base 29 on which the microcircuit substrates 13, 14 are fixedly secured, as by soldering, or are held by means of spring clips 30 (Fig. 6) having spring fingers 31. The carriers 29 are flat pieces of copper cut to shape by copper etching or by stamp forming. These carriers serve as heat spreaders for the substrate, the soldered junction between the substrate and the carrier providing good heat transfer.

The carriers 29 are held down by means of the spring clips 30 onto the base plate 11 by nuts threaded down on the studs passing through holes 32 in the carrier, or by Tinnerman Speed-nuts 33, or by self-locking spring clips 34, or by an isolation wall 35 described below followed by a nut or Tinnerman Speed-nut, or equivalent. The spring clips 30 can also serve to engage microcircuit terminals on the substrates, and ground them to the base plate 11. In some instances it may be desirable to mount the substrates 13, 14 directly onto the base plate 11 and omit the carrier 29 as shown in Fig. 2.

The spring clips 30 may be self locking (see Fig. 6) on the studs. Both forms of fasteners 33, 34 are removable so that the carriers 29 and substrates 13, 14 can be removed from the base plate 11 for reworking or replacement.

At times it is desirable that a microcircuit be mounted on the base plate 11 at a higher elevation than another microcircuit. In such cases, the former microcircuit can be mounted on one carrier 29 and this carrier in turn mounted on a second carrier, these three elements being held down on the base plate by nuts, Tinnerman Speed-nuts, or by spring clips. The microcircuit substrate can be soldered to the first carrier or it can be held down thereon by a spring clip.

In certain packages it is desirable that one microcircuit be R.F. isolated from another circuit, and for this purpose an isolation wall 35 (Figs. 1 and 7) of proper configuration is mounted on the base plate 11 by the studs and fasteners together with a cover 36. One preferred form of isolation wall is made from

extruded aluminium, the wall being cut therefrom at the proper height. Where electrical interconnections are to be made between microcircuits on different sides of the isolation wall, a simple R.F. feedthrough 37 comprising a central conductor rod and a dielectric ring carrying the rod and placed in the isolation wall maintains good R.F. isolation and transmission between adjacent sections.

Referring to Fig. 7, the isolation wall 35 is provided with a cut-out 85, rather than a hole, and the feedthrough fits in the cut-out so that the wall 35 can be removed without removing the feedthrough connector. The dielectric is preferably provided by a block 38 having a slot 39 therein, and the connector is in the form of a ribbon 40 which is bonded at both ends of the substrates before the block 38 is slipped over the ribbon and the wall 35 lowered down on the studs 15.

After internal electrical connections have been made between the microcircuits and with the R.F. and D.C. feedthroughs 17, 21 for example by means of gold ribbon conductors, the assembly is ready to receive its cover 41 (Fig. 2). In one preferred embodiment the cover 41 is a thin sheet, as for example 6061 TO aluminium twenty thousands of an inch in thickness, which is formed to the cover shape desired, including a flange edge 42, and is plated in the same manner as described above for the base plate. The cover 41 is cold welded to the base plate 11 around the encircling flange 42 by applying pressure to the flange and plate via a wedge-shaped welding fixture 43 (Fig. 8). The flange metal becomes stretched as it is forced into the plate, both the aluminium base metals of the flange and the base plate becoming bared and diffusing in a diffusion weld which is strong and hermetically tight and accords with the U.S. Government mil standard 883 for hermetic sealing.

No special machining or shaping of the welding surfaces is required as with prior welded assemblies. The flat clean surface of the flange 42 mated with the flat clean surface of the base plate 11 is sufficient when combined with the proper force and metal baring.

With the above described diffusion welding technique it has been found that the cover, although strongly and hermetically sealed to the plate, can be pulled from the plate for access to the microcircuits, and a new cover replaced on the base plate by the same diffusion welding technique. The diffusion weld can be formed at the very same seal position or a slightly enlarged or reduced cover can be sealed along a slightly enlarged or reduced seal periphery.

In Figs. 1 and 2 the feedthroughs are all mounted in the base plate 11. In Fig. 9, the base plate 44 of the package shown therein is formed with an integral side wall portion 45,

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and all of the feedthroughs are mounted in the sidewall 45. The cover 46 is diffusion welded to the side wall 45 to form a hermetic seal for the package.

5 In Fig. 10, the base plate takes the form of a box with four sides and a bottom 51, the stud holes 52 being located in the bottom wall 51, on which the microcircuit assembly is mounted. The feedthroughs are diffusion
10 welded into holes 53 in the side walls. After assembly, a cover can be diffusion welded over the open top of the box.

In Fig. 11, the base plate 54 thereof is deposited in an aluminium or copper can 55 and secured to the bottom thereof. Feed-
15 throughs are diffusion welded into holes 56 in the sides of the can and a cover is diffusion welded over the top of the can to the flange 57.

20 In Fig. 12, the base plate 58 thereof is diffusion welded to one open end of an aluminium or copper frame 59 to form the bottom wall of the package. The feedthroughs are diffusion welded in openings 61 in the side
25 wall. A cover is diffusion welded over the top of the frame.

In Figs. 13 and 14 a rectangular-shaped block 62 of aluminium is shown having an axial bore 63 extending therethrough in the
30 vertical direction, two bores 64 and 65 extending through opposite sides 66 and 67, respectively, of the block 62 and normal to the vertical axis of the axial bore 63, and another bore 83 extending through a third
35 side 68 and normal to the same vertical axis as shown in Figure 13.

A circular, solid base plate 69 having an outer flange portion 70 is diffusion welded into the axis bore in a bottom wall 71 of the
40 block 62, a microcircuit 72 being affixed to an inner end 72 of the base plate 69 for example, by soldering.

A pair of R.F. feedthroughs 74 and 75 are diffusion welded into the two bores 64 and
45 65 respectively in the side walls of the block 62, internal connectors 76, 77 of these feedthroughs being connected to the microcircuit terminals by bonded gold ribbon 82. A D.C.

feedthrough 78 is diffusion welded into the bore 83 in the other side wall 68 of the block 62 and is similarly connected to a microcircuit terminal by a bonded gold ribbon 82.

A circular cover 79 having a flange portion 80 is diffusion welded into the bore in the top wall 81 of the block.

WHAT WE CLAIM IS:—

1. A method of hermetically sealing and affixing a first cylindrically shaped metallic member having a ductile outer surface within a cylindrical opening in a second metallic
60 member, the opening having a ductile surface and also a slightly larger internal diameter than the external diameter of said cylindrical member comprising the steps of simultaneously directing the cylindrical member
65 into said opening and applying force to the surface of said second member around said opening to force the inner ductile surface of the opening against the outer ductile surface of said cylindrical member, the two surfaces
70 scrubbing against each other, the force of the opening surface against the cylindrical member surface producing a diffusion weld between the surfaces.

2. A method according to claim 1 wherein said two members are plated with a ductile metal.

3. A method according to claim 2 wherein said ductile metal is copper.

4. A method according to any one of claims 1 to 3 wherein said second metallic member is aluminium with the opening having a ductile inner surface of copper.

5. A method according to any one of claims 1 to 4 wherein the ductile metal surface of said cylindrical member is copper.

6. A method according to claim 1 substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings.

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