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FILED IN THE
U.S. DISTRICT COURT
EASTERN DISTRICT OF WASHINGTON

MAY 25 2005

JAMES R. LARSEN, CLERK
DEPUTY
SPOKANE, WASHINGTON

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF WASHINGTON
AT SPOKANE

| | |
|---|---|
| Pacific Aerospace & Electronics, Inc., a Washington corporation<br>Plaintiff,<br>v.<br>SRI HERMETICS, INC.,<br>Defendant. | No. CV-05-0155-RHW<br>COMPLAINT |

Plaintiff, Pacific Aerospace & Electronics, Inc. ("PA & E"), for its Complaint states and alleges as follows:

## NATURE OF THE ACTION

1. This is an action for patent infringement under 35 U.S.C. § 271 et seq.

2. This action arises out of activities of Defendant SRI Hermetics ("SRI Hermetics") of selling and offering for sale products that are covered by patents owned by PA & E.

ORIGINAL



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**THE PARTIES**

3. PA & E is a corporation organized and existing under the laws of the state of Washington and having a principal place of business in Wenatchee, Washington.

4. On information and belief, SRI is a corporation organized and existing under the laws of the state of Florida and having a principal place of business in Melbourne, Florida. SRI had an office in this district from which it conducted business in this judicial district and, at that office, employed former PA & E employees to design various items that are the subject of this complaint.

**JURISDICTION AND VENUE**

5. The Court has subject matter jurisdiction over this matter because the complaint alleges a cause of action under the patent laws of the United States, 35 U.S.C. § 1, et seq. The Court has original jurisdiction of such claims pursuant to 28 U.S.C. §§ 1331 and 1338(a).

6. The Court has personal jurisdiction over SRI Hermetics because SRI Hermetics had an office in this district and conducted business here, including the design of products sold and/or offered for sale that are covered by patents owned by PA & E.

7. Venue is appropriate here because SRI has regularly and systematically conducted business in this district, including the design of products



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at issue here, and therefore resides here. *See* 28 U.S.C. §§ 1391(a), (b), and (c) and/or 1400(b).

**PLAINTIFF AND ITS BUSINESS**

8. PA & E is an industry leader in the design, engineering, integration, and assembly of the most advanced hermetic connector and packaging technologies available on the market.

9. PA & E's connectors and packaging technologies are used in a variety of commercial and defense related applications, including in the aerospace industry.

10. PA & E does much of the design, engineering, and fabrication of its products at its facility in Wenatchee, Washington.

11. PA & E's innovative products are protected by a number of United States patents, including United States patent nos. 4,690,480; 5,298,683; 5,986,208; 5,041,019 ("the '019 patent"); 5,109,594; 5,110,307 ("the '307 patent"); and 5,405,272 ("the '272 patent"). These patents are owned by PA & E by virtue of assignments from the inventors to PA & E.



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## DEFENDANT'S ACTIVITIES

12. In 2003, SRI Hermetics established an office in East Wenatchee, Washington, to design and engineer hermetic connectors and packaging technologies.

13. On information and belief, SRI Hermetics hired Mr. Ed Taylor and Mr. Jim Petri, who have experience in the design and manufacture of hermetic connectors and packaging technologies. On information and belief, Taylor and Petri were employed by SRI Hermetics at SRI Hermetics' East Wenatchee office to design and develop hermetic connectors and packaging technologies that compete with those designed, engineered, and manufactured by PA & E. Taylor and Petri are former employees of PA & E.

14. Taylor and Petri have knowledge of both PA & E's products and its patents as well as PA & E's customers for such products by virtue of their former employment by PA & E.

15. SRI Hermetics has offered to sell to an existing customer of PA & E products that are, on information and belief, covered by one or more of PA & E's patents, including the '019 patent, the '307 patent, and the '272 patent. True and correct copies of the '019 patent, the '307 patent, and the '272 patent are attached hereto as Exhibits A, B, and C, respectively.



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**COUNT I – PATENT INFRINGEMENT**

16. PA & E reincorporates by reference paragraphs 1 through 15 above as if fully set forth herein.

17. On information and belief, SRI Hermetics' actions in selling and offering for sale products that are covered by one or more of PA & E's patents amounts to infringement of the '019 patent, the '307 patent; and/or the '272 patent.

18. Before offering infringing products for sale and through its employees who were previously employed by PA & E, SRI Hermetics had knowledge of PA & E's patents. Therefore, SRI Hermetics' infringement was willful.

**PRAYER FOR RELIEF**

WHEREFORE, Plaintiff Pacific Aerospace & Electronics, Inc., prays for judgment against Defendant SRI Hermetics, Inc., as follows:

A. That Defendant and its officers, agents, servants, employees, and attorneys and all other persons in active concert or participation with any of them, be enjoined and restrained during the pendency of this action and permanently thereafter from infringing Plaintiff's patents.

B. That Defendant be ordered to pay Plaintiff such damages as Plaintiff has sustained and adequate to compensate for the patent infringement, including Plaintiff's lost profits, but in no event less than a reasonable royalty, as provided by 35 U.S.C. § 284.



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C. That Damages be increased to three times the amount assessed, as provided by 35 U.S.C. § 284.

D. That Defendant's infringement of PA & E's patents be found to have been willfully committed by Defendant, that the case be found to be exceptional, and that Defendant be ordered to pay Plaintiff the cost of this actions and its reasonable attorneys' fees, and interest, as provided by 35 U.S.C. § 285.

E. That Defendant be ordered to pay Plaintiff prejudgment interest on all sums awarded as allowed by law.

F. That the Court award Plaintiff such other and further relief that this Court may deem just and equitable.

## JURY TRIAL

Plaintiff Pacific Aerospace & Electronics, Inc. hereby demands a trial by jury for all issues so triable.

DATED this 23rd day of May, 2005.

Davis Wright Tremaine LLP

By [signature]

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# EXHIBIT A

# United States Patent [19]

**Sharp et al.**

[11] **Patent Number: 5,041,019**

[45] **Date of Patent: Aug. 20, 1991**



[54] **TRANSITION JOINT FOR MICROWAVE PACKAGE**


[75] Inventors: **William F. Sharp**, Louisville; **Prem R. Hingorany**, Broomfield; **Howard W. Mansell**, Englewood, all of Colo.

[73] Assignee: **Explosive Fabricators, Inc.**, Louisville, Colo.



[21] Appl. No.: **607,563**

[22] Filed: **Nov. 1, 1990**

[51] **Int. Cl.**[5] .......... **H01B 17/26**

[52] **U.S. Cl.** .......... **439/559**; 174/152 GM; 439/935

[58] **Field of Search** .......... 439/559, 566, 935; 174/152 GM; 228/179



[56] **References Cited**

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|---|---|---|---|
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| 4,486,726 | 12/1984 | Schafer et al. | 333/260 |
| 4,487,999 | 12/1984 | Baird et al. | 174/52 |
| 4,642,578 | 2/1987 | Bennett | 331/100 |
| 4,690,480 | 9/1987 | Snow et al. | 439/935 |
| 4,799,036 | 1/1989 | Owens | 333/260 |
| 4,816,791 | 3/1989 | Carnahan et al. | 333/33 |
| 4,906,957 | 3/1990 | Wilson | 333/246 |



*Primary Examiner*—Gary F. Paumen
*Attorney, Agent, or Firm*—Fields, Lewis, Pittenger & Rost



[57] **ABSTRACT**

In accordance with this invention, a hermetically sealed transition joint for use with a microwave package which has a receptacle including a side wall made of a first weldable material with a feed-through opening therein. The transition joint includes a first layer of a first material sized to extend across the feed-through opening and weldable to the side wall to form a hermetic seal. A second layer of a second material is explosively bonded to the first layer and sized to match and be received within the feed-through opening. A connector opening extends through the first and second layers. A pin connector unit made of the second material and having electrical pins extending therethrough is sized to fit within the connector opening and is welded to the second layer to form a hermetic seal. The first layer may be aluminum or aluminum alloy and the second layer can be any one of Kovar, cold rolled steel, stainless steel or iron-nickel alloy. Conveniently, the welding is done by laser welding.


**9 Claims, 1 Drawing Sheet**

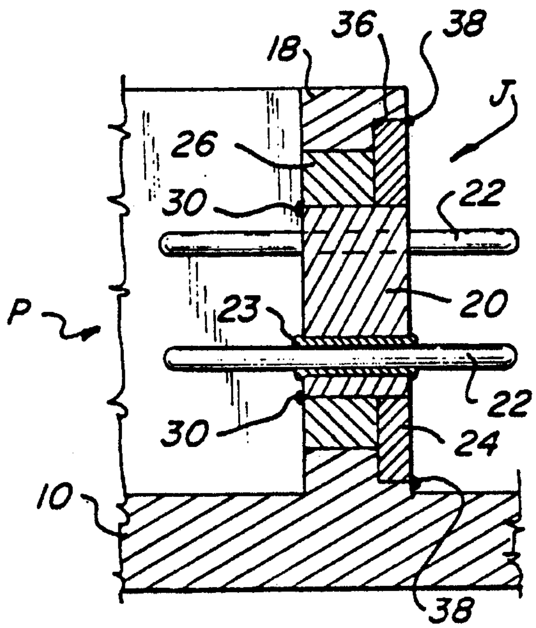


Exhibit A-1

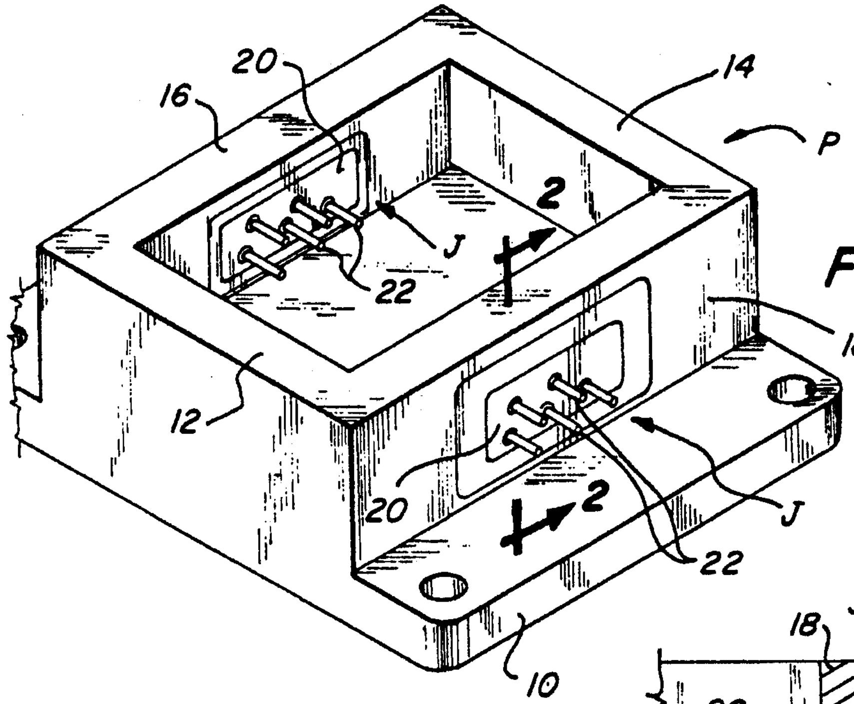


Fig_1

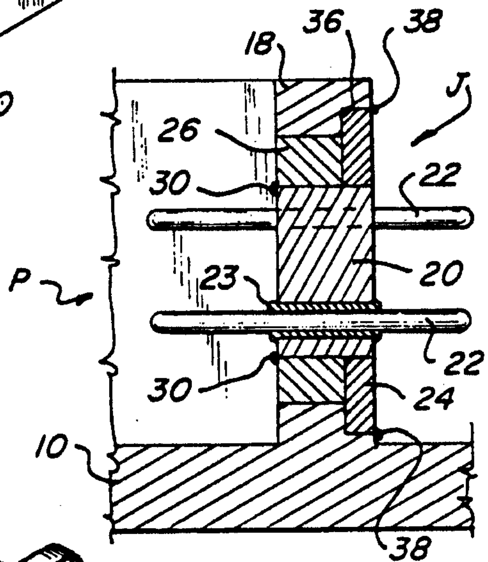


Fig_2

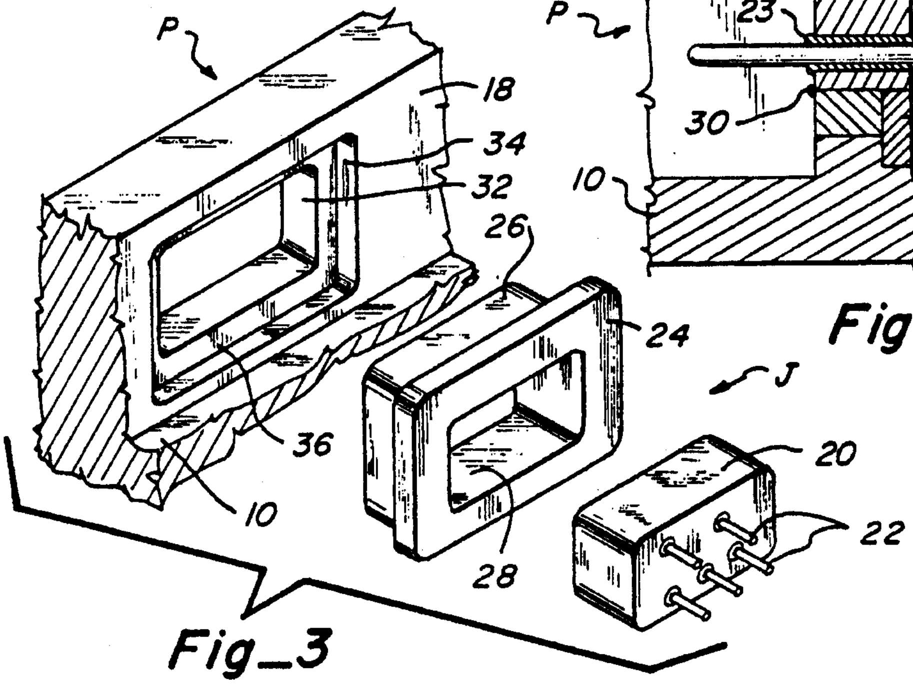


Fig_3

Exhibit A-2

## TRANSITION JOINT FOR MICROWAVE PACKAGE

### TECHNICAL FIELD

This invention relates to the fabrication of a transition joint for microwave packages. In particular, this invention allows the hermetic attachment of standard feed-throughs and power connectors to standard aluminum microwave packages.

### BACKGROUND ART

Microwave electronic packages are frequently produced from aluminum alloys due to low weight and good thermal dissipation. These packages are machined from thick aluminum or an aluminum alloy block. This block is relieved on one side to form a deep cavity within which an electronic circuit is placed. Small holes are formed in the package walls to accept feed-throughs and power connectors, respectively. A cover is placed over the cavity and attached by a suitable method. These packages are required to be hermetic from $10^{-5}$ to $10^{-8}$ helium cc/sec. maximum leak rate.

However, two of the major disadvantages of aluminum are high coefficient of thermal expansion and dewetting properties causing poor solderability. In order to be able to solder the aluminum, these microwave packages are typically electroplated with metals like nickel and/or gold. The feed-throughs and the power connectors which are fabricated from cold rolled steel, stainless steel and iron-nickel alloys are soldered into the holes and the windows along the side walls. There are a variety of solders used for this purpose by the industry.

The electronic signals are allowed to enter and exit the package via pins contained within the feed-throughs and power connectors. The feed-throughs contain a pin of desired metal surrounded by a bead of molten glass which is surrounded by a ring of cold rolled steel, stainless steel and/or iron-nickel alloy. The pin serves as an electrical connection to communicate with the electronic circuit inside the package. The glass provides electronic isolation between the pin and the package.

The reliability of the feed-through and the power connector attachment is typically very poor. Besides the difficulty of a good attachment during manufacture, these joints commonly fail upon thermal cycling. There are two recognized reasons. First, poor nickel and/or gold plating of the packages, feed-throughs and power connectors or excessive leaching of the plated metals during soldering. This results in exposure of dewetting aluminum surface which inhibits soldering. The second reason is mismatched expansion between the aluminum or aluminum alloy of the package and the feed-throughs and power connectors. The coefficient of thermal expansion of aluminum alloys is $22\times10^{6}$ in/deg.C/in. vs. that of cold rolled steel and stainless steel at $12\times10^{-6}$ and iron-nickel alloys at $7\times10^{-6}$. This mismatch in expansion during thermal cycling creates stresses which causes loss of the hermeticity and expensive rework and repeat of testing. In frequent situations upon multiple recurrence, the package becomes useless and is discarded.

In a recent development, some package manufacturers have attempted to develop new glasses that are compatible to aluminum. This, if successful, may allow direct glass sealing of pins into aluminum side walls, allowing most of the foregoing problems to be solved.



Development of these low temperature glasses, however, will impose certain process alterations that may or may not be acceptable.

Patents which are relevant to the present invention are:

Wilson U.S. Pat. No. 4,906,957 which discloses an electrical circuit interconnect system that employs an electrically conductive enclosure and cover which completely encompasses, hermetically seals, and electrically isolates from the outside environment a component mounted on a first surface of an insulating substrate of a microwave circuit. A plurality of conductors mounted on the first surface of the insulating substrate electrically connect the component to the outside electrical circuitry by passing through a corresponding plurality of pass-through bores within the base of the enclosure. Specifically, within each respective pass-through bore, a corresponding glass encased conductor electrically connects each conductor within the enclosure to a conductor outside of the enclosure.

Carnahan et al. U.S. Pat. No. 4,816,791 disclose a transition between stripline transmission lines that includes a coaxial section placed between pads at the ends of the stripline conductors. The coaxial section is formed by a resilient center conductor surrounded by an incomplete circle of pins connected to the ground planes and forming the outer conductor. The connections to the pads enter the ends of the coaxial section at the azimuth of the gap in the circle pins. Good high frequency performance, despite the discontinuity between the pads and coaxial center conductor, is achieved by increasing the characteristic impedance of the coaxial section and that of the stripline near the transition relative to the characteristic impedance of the stripline remote from the transition.

Owens U.S. Pat. No. 4,799,036 discloses a radio frequency coaxial transmission line vacuum feed-through that is based on the use of a half-wavelength annular dielectric pressure barrier disk, or multiple disks, comprising an effective half wavelength structure to eliminate reflections from the barrier surfaces. Gas-tight seals are formed about the outer and inner diameter surfaces of the barrier disk using a sealing technique which generates radial forces sufficient to form seals by forcing the conductor walls against the surfaces of the barrier disks in a manner which does not deform the radii of the inner and outer conductors, thereby preventing enhancement of the electric field at the barrier faces which limits voltage and power handling capabilities of a feed-through.

Bennett U.S. Pat. No. 4,642,578 discloses a radio frequency circuit for ICRF heating that includes a resonant push-pull circuit, a double ridged rectangular waveguide, and a coupling transition which joins the waveguide to the resonant circuit. The coupling transition includes two relatively flat rectangular conductors extending perpendicular to the longitudinal axes of a respective cylindrical conductor to which each flat conductor is attached intermediate the ends thereof. Conductive side covers and end covers are also provided for forming pockets in the waveguide into which the flat conductors extend when the waveguide is attached to a shielding enclosure surrounding the resonant circuit.

Baird et al. U.S. Pat. No. 4,487,999 disclose an all-metal microwave chip carrier with subminiature ceramic feed-throughs, each configured to function as a

Exhibit A-3

coaxial cable having a predetermined impedance. In one embodiment, the feed-throughs are formed by providing ceramic tubing metallized inside and out in which the ends are cut away to provide half-cylindrical bonding pads. In order to permit bonding directly to the feed-through, a flat wire lead is soldered to the channel in the ceramic tube, with the ends of the flat wire extending onto the flat portions of the half-cylindrical portions of the feed-through. In one embodiment, the chip carrier includes a base, ring and stepped lid, all made of Kovar or other suitable material, with the lid being weldable to the ring rather than being brazed or soldered.

Schafer et al. U.S. Pat. No. 4,486,726 disclose one end of a coaxial cable that is telescoped into one end of a microwave component such as an attenuator with the outer jacket of the cable being metallurgically bonded by solder to the metal housing of the component.

## DISCLOSURE OF THE INVENTION

In accordance With this invention, a hermetically sealed transition joint for use with a microwave package which has a receptacle including a side wall made of a first weldable material with a feed-through opening therein. The transition joint includes a first layer of a first material sized to extend across the feed-through opening and weldable to the side wall to form a hermetic seal. A second layer of a second material is explosively bonded to the first layer and sized to match and be received within the feed-through opening. A connector opening extends through the first and second layers. A pin connector unit made of the second material and having electrical pins extending therethrough is sized to fit within the connector opening and is welded to the second layer to form a hermetic seal. The first layer may be aluminum or aluminum alloy and the second layer can be any one of Kovar, cold rolled steel, stainless steel or iron-nickel alloy. Conveniently, the welding is done by laser welding.

More specifically, the feed-through opening has an enlarged counterbore adjacent the outer side and a smaller bore adjacent to the inner side. The second layer has an outer perimeter which exactly matches the inner perimeter of the smaller bore and the first layer has an outer perimeter which exactly matches the inner perimeter of the counterbore.

The apparatus just described can be manufactured by first forming a feed-through opening in the side wall of the receptacle. Next, a layer of the first material is explosively bonded to a layer of the second material to form a transition joint. Next, a passageway is formed through the transition joint which is configured to the shape and size of the pin connector unit. The transition joint is machined to a configuration corresponding to the shape and size of the feed-through opening. A counterbore can be formed in the feed-through opening at a depth equal to the thickness of the first layer and the machining of the transition joint can be done so that the first layer is of a configuration corresponding in size and shape to the counterbore and the second layer is of a configuration corresponding in size and shape to the remainder of the feed-through opening. The pin connector unit is then positioned in the passageway and welded about its perimeter to the second layer to form a hermetic seal. Next the transition joint is positioned in the feed-through opening and the first layer is welded about its periphery to the side wall to form a second hermetic seal.

Additional advantages of this invention will become apparent from the description which follows, taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a microwave package having a transition joint constructed in accordance with this invention;

FIG. **2** is an enlarged, fragmentary, vertical section, taken along line **2**—**2** of FIG. **1**, showing further details of the transition joint; and

FIG. **3** is a fragmentary exploded view of the transition joint.

## BEST MODE FOR CARRYING OUT THE INVENTION

In accordance with this invention, a microwave package P is provided which includes a base **10** a first pair of opposed side walls **12** and **14**, respectively, and a second pair of opposed side walls **16** and **18**, respectively. As illustrated in FIG. **1**, both side walls **16** and **18** are provided with a transition joint J having a pin connection unit **20** positioned therein with electrical contact pins **22** extending therethrough. The microwave package is made out of aluminum or aluminum alloy, such as aluminum 4047 which typically contains more than 3% silicon and usually about 12% silicon. The pin connector unit **20** is made of Kovar or some other material such as cold rolled steel, stainless steel or an iron-nickel alloy.

The transition joint comprises a first layer **24** explosively bonded to a second layer **26**. The first layer **24** will be the same aluminum or aluminum alloy as microwave package P and the second layer **26** will be made of the same material as pin connection unit **20**. These bonded layers form transition joint J.

A passageway **28** is cut through the transition joint and has a size and shape corresponding to that of the outer periphery of pin connection unit **20** for receiving the same therein, as best illustrated in FIG. **2**. Conveniently, the total thickness of layers **24** and **26** is equal to the thickness of pin connection unit **20** so that the facing surfaces of the pin connection unit and the transition joint are flush. After the pin connection unit is inserted into passageway **28**, it is welded to second layer **26** by means of a weldment **30** which extends around the peripheral edge of pin connection unit **20** and forms a hermetic seal at this interface.

A feed-through opening **32** is provided in a side wall, such as side wall **18**, shown in FIG. **3**, and has a counterbore **34** therein providing an abutment face **36**. Conveniently, the counterbore has the same depth as first layer **24** of transition joint J. The first layer of the transition joint is machined so that its outer peripheral edge has a configuration corresponding to the shape and size of the counterbore **34**. Similarly, second layer **26** is machined so that its outer peripheral edge has a configuration of a shape and size to be received within pass-through opening **32**. Thus, when transition joint J is inserted in the opening in side wall **18**, the collar formed by first layer **24** abuts against abutment face **36** and because the depth of counterbore **34** is equal to the thickness of layer **24** the surface of layer **24** is flush with the outer surface of wall **18** and the inner surface of second layer **26** is flush with the inner surface of wall **18**. The first layer **36** is then attached to wall **18** by welding to provide a weldment **38** around the peripheral edge of first layer **24** to provide a second hermetic seal.

Conveniently, the weldments 30 and 38 can be accomplished by means of a laser weld or an electron beam welding technique. Such welds are very reliable resulting in a good hermetic seal.

From the foregoing, the advantages of this invention are readily apparent. This method results in fabrication of a package where the feed-throughs of power connectors have been installed without requiring any electroplating and/or soldering. All the joints are laser sealed which is an accepted reliable method of attachment. Any stresses that develop during the thermal cycling remain concentrated on the explosively created bond. Explosive bonding assures shear strength of the joint greater than the weakest of the parent metal in the transition system. Even in unusual cases the strength of the joint is three to four times greater than that of solders. This assures the resiliency of the joint and package reliability is enhanced. This invention allows production of reliable hermetic microwave packages. It allows use of resilient clad materials with bond characteristics far stronger than current method of electroplating and soldering. It also ensures compliance to military specifications after strenuous testing.

This invention has been described in detail with reference to a particular embodiment thereof, but it will be understood that various other modifications can be effected within the spirit and scope of this invention.

we claim:

1. A hermetically sealed transition joint for use with a microwave package having a receptacle which includes a side wall made of a first weldable material with a feed-through opening therein, said transition joint comprising:

a first layer of said first material sized to extend across the feed-through opening and weldable to the side wall to form a hermetic seal;

a second layer of a second material different from said first material explosively bonded to said first layer and sized to match and be received within the feed-through opening;

means defining a connector opening extending through said first and second layers; and

a pin connector unit made of said second material and having electrical pin connections extending therethrough and sized to fit within said connector opening and being welded to said second layer to form a hermetic seal.

2. A transition joint, as claimed in claim 1, wherein: said first layer is aluminum or aluminum alloy; and said second layer is Kovar.

3. A transition joint, as claimed in claim 1, wherein: said welding is done by laser welding.

4. A transition joint, as claimed in claim 1, wherein the side wall has an outer side and an inner side and the feed-through opening has an enlarged counterbore adjacent the outer side and a smaller bore adjacent the inner side, and wherein:



said second layer has an outer perimeter which exactly matches the inner perimeter of the smaller bore; and

said first layer has an outer perimeter which exactly matches the inner perimeter of said counterbore.

5. In a microwave package having a receptacle made of a first material and having a side wall with a feed-through opening therein, the improvement comprising:

a hermetically sealed transition joint have a first outer layer made of said first material and a second inner layer explosively bonded to said first layer and made of a second material different from said first material, said transition joint being configured to have a peripheral edge to match the shape of said feed-through opening and positioned therein in mating relationship;

a first weldment extending around said peripheral edge of said joint joining said first layer to said side wall in a hermetically sealed relationship;

a central passageway through said first and second layers;

a pin connector unit having a body made of said second material and being configured to have a peripheral edge to match the shape of said passageway and received therein in mating relationship, electrical pin connectors extending through said unit; and

a second weldment extending around said peripheral edge of said unit joining said unit to said second layer in a hermetically sealed relationship.

6. A microwave package, as claimed in claim 5, wherein:

said feed-through opening has a counterbore in the outer portion thereof having a depth equal to the thickness of said first layer and forming an abutment surface;

said first layer being configured to have a peripheral edge to match the shape of said counterbore and to bear against said abutment surface; and

said second layer being configured to have a peripheral edge to match said feed-through opening.

7. A microwave package, as claimed in claim 6, wherein:

the combined thickness of said first and second layers is the same as the thickness of said side wall.

8. A microwave package, as claimed in claim 5, wherein:

said microwave package and said first layer are aluminum or an aluminum alloy; and

said second layer and said pin connector unit are made of any one of Kovar, cold rolled steel, stainless steel or iron-nickel alloy.

9. A microwave package, as claimed in claim 5, wherein:

said microwave package and said first layer have one coefficient of thermal expansion; and

said second layer and said pin connector unit have a second and different coefficient of thermal expansion.

* * * * *

# EXHIBIT B

US005110307A

# United States Patent [19]

**Rapoza**

[11] **Patent Number: 5,110,307**

[45] **Date of Patent: May 5, 1992**

[54] **LASER WELDABLE HERMETIC CONNECTOR**

[75] Inventor: **Edward J. Rapoza**, West Milford, N.J.

[73] Assignee: **Balo Precision Parts Inc.**, Butler, N.J.

[21] Appl. No.: **727,668**

[22] Filed: **Jul. 9, 1991**

[51] **Int. Cl.**[5] .............................................. **H01R 13/74**

[52] **U.S. Cl.** ...................................... **439/566**; 29/843; 174/152 GM

[58] **Field of Search** .................. 439/566; 29/842, 843; 174/50, 61, 151, 152 GM

[56] **References Cited**

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Explosive Fabricators, Inc., Trade Literature "The Most Powerful Name in Metal Fabrication Technology" (Jul., 1989).

Explosive Fabricators, Inc., Trade Literature "EFTEK Explosion-Clad Materials for Power Hybrid and Microwave Packaging" (undated).

*Primary Examiner*—Eugene F. Desmond
*Attorney, Agent, or Firm*—Synnestvedt & Lechner

[57] **ABSTRACT**

Electrical connectors are provided for enabling electrical access through a side wall of a microelectronic, sensor, or fiber optic package housing while maintaining hermeticity. These connectors include a connector body having an aperture therethrough and a coefficient of thermal expansion which is different than that of the housing. The connectors include a connector pin disposed through the aperture of the connector body and hermetically sealed to the connector body with an insulating composition or a ceramic insert bonded to the connector pins. Flange means are also provided for joining the hermetic electrical connector to the microelectronic package housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body with a fusion weld having a heat-affected-zone which does not significantly affect the hermetic seals around the connector pins. The second metallic composition is readily weldable to the microelectronic package housing to provide the final hermetic coupling.

**27 Claims, 2 Drawing Sheets**

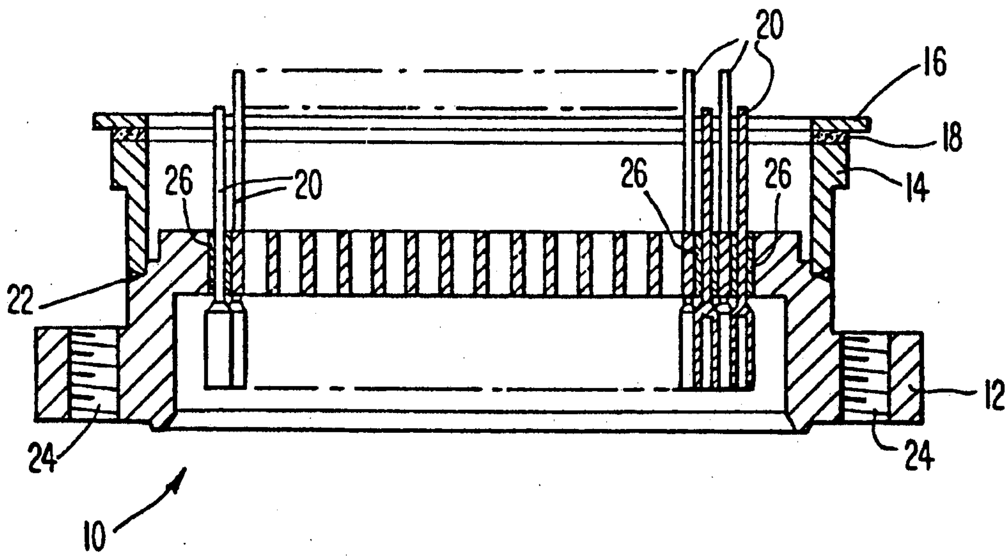


Exhibit B-1

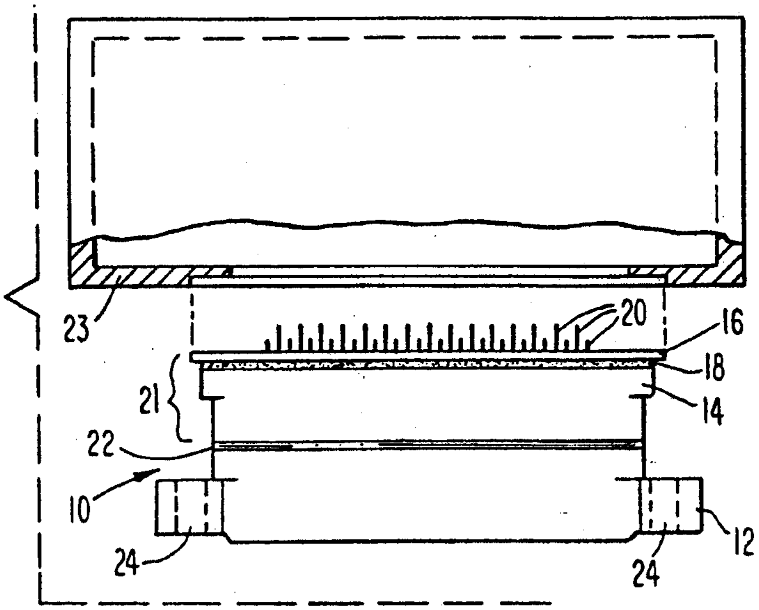


Fig. 1

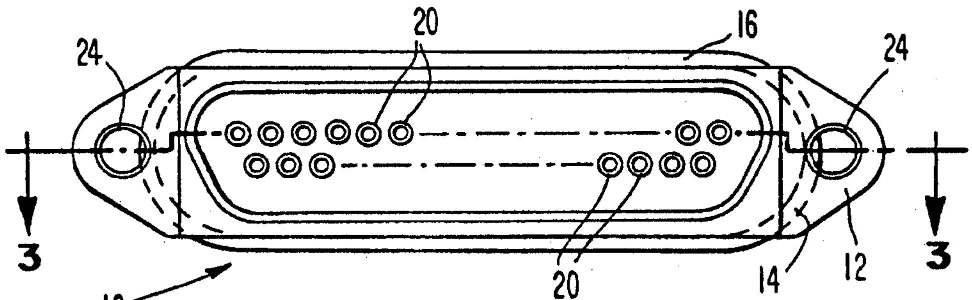


Fig. 2

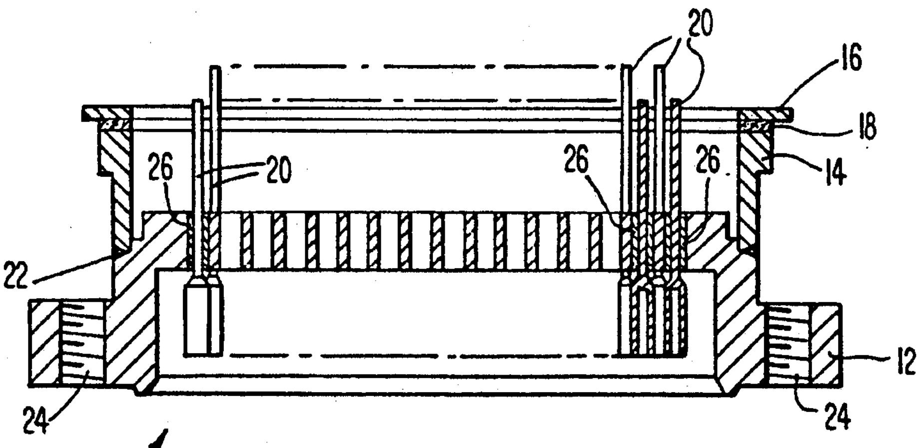


Fig. 3

Exhibit B-2

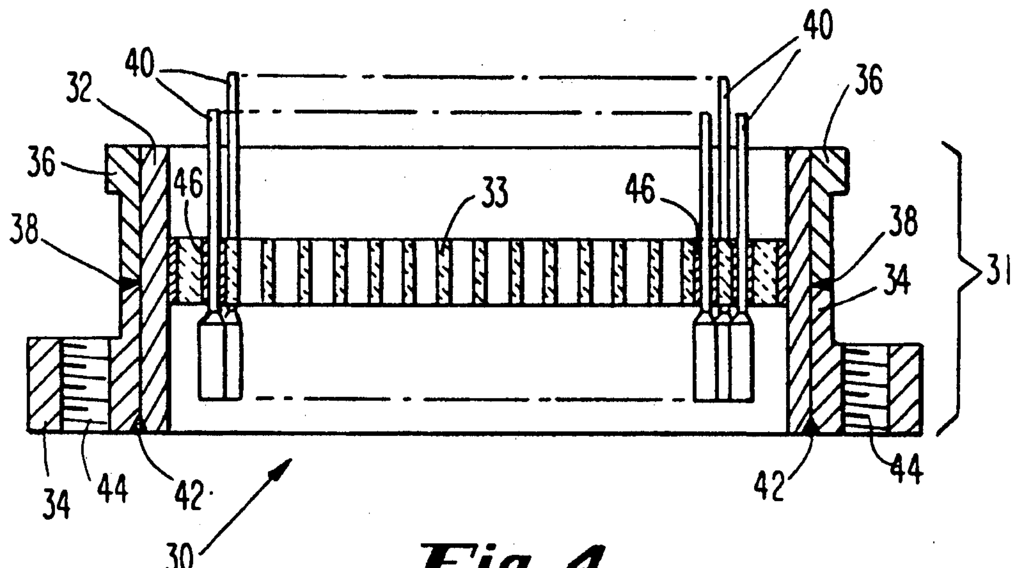


Fig. 4

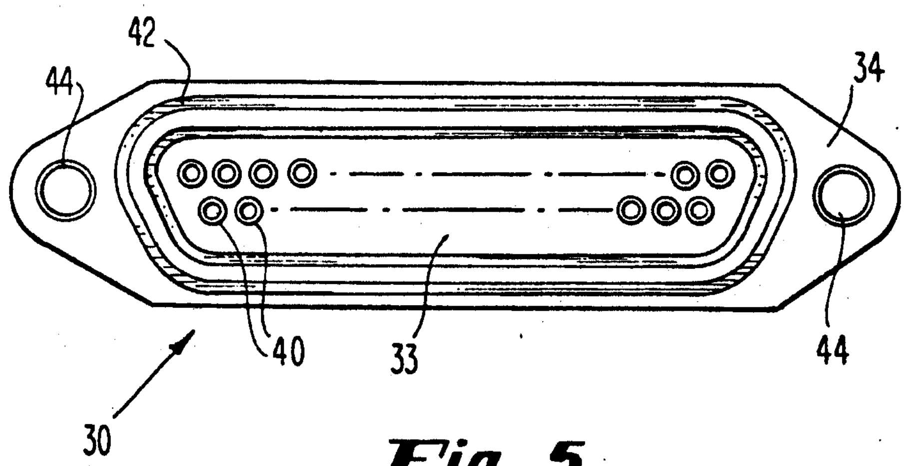


Fig. 5

Exhibit B-3

## LASER WELDABLE HERMETIC CONNECTOR

### FIELD OF THE INVENTION

This invention relates to electrical connectors, and more particularly, to manufacturing methods for maintaining hermeticity and providing metallurgical compatibility between connectors and microelectronic housings.

### BACKGROUND OF THE INVENTION

Microelectronic modules, such as those containing electronic circuit components, fiber optics, or pressure sensing devices, rely on hermetic sealing, i.e., gas-tight seals, to protect these sensitive components from the corrosive effects of the environment. As is often the case, these modules contain a mosaic of materials having various, and often less than compatible, physical properties.

The art has typically relied upon hermetic connectors disposed through a side wall of the housings of such modules to provide input-output electrical access for cables and the like. In the past, such connectors included a connector body made of a low coefficient of thermal expansion, Fe-Ni-Co alloy, such as Kovar®, and one or more connector pins axially disposed through the connector body. These pins are usually hermetically sealed with glass through small pin-receiving holes disposed through the center of the connector body. The glass insulates the pins from the rest of the connector and is relatively compatible with the Kovar® base metal, so as to provide an air-tight hermetic fit around the connector pins during severe temperature cycles, such as those experienced by aircraft during flight.

The module housing, for a number of years, was also made of an iron-based alloy, such as Kovar®, which enabled thermal expansion compatibility with the connector during these wide temperature cycles as well as weldability, such as by fusion welding or brazing, for providing a hermetic seal between the connector body and the housing.

With the advent of cost cutting measures, including weight reduction efforts aimed at conserving fuel in the military and commercial aircraft industries, module housings have recently been made from light weight metals, such as aluminum. Although aluminum is easier to machine, is less expensive, and is lighter in weight than iron-based alloys, it is not very compatible with Kovar®, both in regard to weldability and thermal expansion.

In an effort to accommodate the use of aluminum housings in microelectronic modules, the art has resorted, in certain instances, to plating the connector-receiving window regions of aluminum housings and the matching surface of the Kovar® connectors with nickel, or a similar metal, and then soldering or brazing the nickel-plated surfaces together. Since these metal joining techniques require heating the plated metal surfaces to at least about 200° C. (and as high as 360° C.), and since aluminum and Kovar® have drastically different coefficients of thermal expansion, stress is created in the joint upon cooling the module to room temperature. Such stress can lead to joint failure and a loss of hermeticity when the module component undergoes subsequent manufacturing operations or is placed in service, especially if such service requires exposure to severe temperature cycling, for example, in aerospace applications.



### SUMMARY OF THE INVENTION

Electrical connectors suitable for providing electrical access through a side wall of a microelectronic package or module and methods for preparing such connectors are provided by this invention. The connectors are designed to maintain hermeticity, or gas impermeability, throughout the manufacturing and service life of these components.

In a first embodiment of this connector, the housing of the microelectronic package includes a first coefficient of thermal expansion. The connector has a connector body having an aperture therethrough and a second coefficient of thermal expansion. A connector pin is disposed through the aperture in the connector body and hermetically sealed to the connector body with an insulating composition. In an important aspect of this invention, flange means are provided for joining the hermetic electrical connector to the housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body, preferably by fusion welding thereto, and is metallurgically compatible (i.e., Kovar® to Kovar®, stainless steel to Kovar®, Kovar® to stainless steel, stainless steel to stainless steel, etc.). This fusion weld is produced by progressive spot laser welding or progressive spot resistance welding having a heat-affected-zone ("HAZ") small enough such that it does not significantly affect the hermeticity provided by the insulating composition, i.e., glass or ceramic. The second layer is similarly compatible with the housing package, (i.e., aluminum to aluminum, etc.).

Accordingly, this invention provides sound hermetic joints between Kovar® connectors or iron or steel connectors and aluminum modules (or zinc modules, or titanium modules, etc.) by employing cladded flange members and low HAZ welding procedures. Unreliable soldering or brazing techniques can be avoided altogether, thus minimizing resulting residual stresses to internal sensitive electronic components sensors or optics, etc. Greater reliability of the microelectronic module can be afforded by the carefully orchestrated process steps of this invention, which take into account both weldability and thermal expansion compatibility of the various sealing compositions and base metals of electrical connectors and electronic modules.

In a further embodiment of this invention, a method of manufacturing hermetic electrical connectors is provided. This method includes providing a connector body having an aperture therethrough, disposing a connector pin through the aperture and hermetically sealing this pin to the connector body with an insulating composition. A flange means is further provided by this method for joining the hermetic electrical connector to a microelectronic package housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is weldable to the connector body with a low HAZ welding technique and the second composition is weldable to the microelectronic package housing.

In a further aspect of this invention, an electrical connector is provided for accessing a microelectronic elements within a package housing through a side wall

Exhibit B-4

of the housing. The connector includes a connector body having a cavity therethrough and a coefficient of thermal expansion which differs from the coefficient of thermal expansion of the housing. This connector also includes an insulating body having a pin receiving hole therein. The insulating body is hermetically sealed to the connector body and disposed substantially within its cavity. The connector further includes a pin disposed through the pin receiving hole and hermetically sealed to the insulating body and flange means for joining the hermetic electrical connector to the microelectronic package housing. The flange means, like the ones described above, includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body with a fusion weld having a HAZ which does not significantly affect the hermeticity between the connector pin and the insulating body, and the second composition is bonded to the microelectronic package with a fusion weld having a low HAZ, so as to provide a sound hermetic seal without high temperature brazing or soldering which are known to affect the temperature sensitive components therein.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate preferred embodiments of the invention according to the practical application of the principles thereof, and in which:

FIG. 1: is a side elevation plan view of a preferred electrical connector of this invention;

FIG. 2: is a top plan view of the preferred electrical connector of FIG. 1;

FIG. 3: is a side cross-sectional view, taken through line 3—3 of FIG. 2, illustrating the sealing of the input-output connector pins of this embodiment;

FIG. 4: is a side cross-sectional view of an alternative embodiment electrical connector having a ceramic insulating member; and

FIG. 5: is a top plan view of the alternative embodiment of FIG. 4.

## DETAILED DESCRIPTION OF THE INVENTION

This invention provides electrical connectors suitable for providing input-output access through a side wall of a microelectronic package housing while maintaining hermeticity. This connector utilizes a dual layer flange having layers of relatively incompatible metal compositions which are metallurgically bonded together, preferably by high compression cladding, without the introduction of interface stress or elevated temperatures. The upper portion of the flange of this invention contains a metallic composition which is compatible with the connector body metal. As used herein, the term "compatible" refers to an approximate matching of the metallurgical and fusion welding properties of metallic compositions.

The other portion of the flange of this invention is manufactured with a metallic Composition which is compatible to the module housing. By matching the metallic compositions, fusion welding can be employed to attach the flange to the connector body and in turn to the microelectronic package housing to provide sound, hermetic joints, which are less susceptible to stress during large temperature cycles.

With reference to FIGS. 1—3, there is shown a preferred electrical connector of this invention. This connector 10 preferably includes a connector body 12 having a "male pinned" connector mate which can engage via a coupling flange, which preferably includes bored threaded engagement holes 24. The connector body 12 is preferably made of an iron-based alloy, more preferably a Fe-Ni-Co alloy, such as Kovar® alloy. Alternatively, the connector body 12 can include a material having a thermal expansion similar to borosilicate glass, i.e. about 5.5 ppm/° C.

As illustrated in FIG. 2, a plurality of conducting, connector pins 20, are shown which are disposed through pin-receiving apertures in the middle portion of the connector body 12. These pins 20 are also preferably made of the same metal as the connector body 12, for example, Kovar® alloy, and are hermetically attached through the apertures by an insulating composition. The connector pins 20 are preferably sealed by melting or fusing a glass, such as a borosilicate glass, into the spaces around the pins 20 to produce highly reliable glass seals 26. Alternatively, a single glass preform having pin receiving holes therein can be placed into the connector body interior as a substitute for the metal through-hole section. The pins can then be fused into the glass preform upon heating. Glass sealing or fusion, as it is known in the art, consists of heating a glass mixture to a temperature of at least about 900° C., and ideally about 950° C., to produce, upon cooling, a hermetic bond between the pins 20 and the connector body 12 or a glass preform. This is a very highly reliable seal since Kovar® has a coefficient of thermal expansion similar to that of the glass, which together with the glass, provides a gas-tight intergranular attachment around the connector pins 20 throughout a wide range of temperatures.

The flange means of this invention, generally represented by composite flange 21, comprises an upper flange 14 and lower flange 16 metallurgically bonded together to form joint 18. The upper flange 14 preferably contains a metallic composition which is compatible with the base metal of the connector body 12. Preferably, the coefficients of thermal expansion for alloys of the upper flange 14 and the connector body differ by less than about 5 ppm/° C., and more preferably, differ by less than about 10 % of the coefficient of the connector body alloy. Most importantly these alloys are compatible to allow fusion welding with a narrow HAZ. Ideally, the upper flange 14 includes a substantially similar base metal as connector body 12, for example, Kovar®. The upper flange 14 is preferably hermetically bonded to the connector body 12 with a fusion weld having a HAZ which does not significantly affect the hermeticity provided by the insulating composition, or glass seals 26, which bond the connector pins 20 to the connector body 12. Such low HAZ fusion welding processes include, for example, plasma, electron beam, and laser welding techniques, which are known in the art.

In a preferred method of manufacturing the electrical connectors of this invention, the upper flange 14 is laser welded to the connector body 12, using known laser welding processes and equipment, following the glass sealing operation. This can be accomplished through the application of a small local laser spot which produces a metallurgical fusion weld in a small local area at the joint between the upper flange 14 and the connector body 12.

In an important aspect of this invention, the laser melt heat is restricted to the joint area, which is preferably, is

Exhibit B-5

less than about 1 mm at its widest point, and more preferably less than about 0.33–0.5 mm in width and depth. The weld path of the laser is moved, after the initial starting point, to produce a thin continuous and reliable laser welded joint 22 around the connector body. This process does not produce heating of the metallurgical joint 18 or the glass seals 26. Accordingly, thermal stresses at these critical hermetic sealing areas are thus avoided. Thus, both the laser welded joint 22, the glass to metal seals 26, and the integrity of the composite flange 21 can be hermetic and highly reliable.

The lower flange 16 of the composite flange 21 preferably contains a second metallic composition which is weldable to the microelectronic package housing 23. Typically, the choice of alloy will be compatible with the alloy of the housing 23, preferably, the differences in between the thermal conductivity of the lower flange 16 and the housing 23 are less than 5 ppm/° C., or less than 10% of the coefficient of the housing 23, and most preferably the alloys are substantially similar. Good choices for both the housing 23 and the lower flange 16 include aluminum, for its low weight and good thermal conductivity (coefficient of thermal expansion of about 24 ppm/° C.), brass or copper, for their solderability and good thermal conductivity (coefficient of thermal expansion of about 18 ppm/° C.), titanium, for its high strength to weight ratio (coefficient cf thermal expansion of about 10 ppm/° C.), and stainless steel (preferably, 400 series), for its high strength and good corrosion resistance (coefficient of thermal expansion of about 14 ppm/° C.). In certain situations these alloy selections could also be used for the connector body 12 and pins 20.

In a preferred detailed embodiment of this invention, the microelectronic package housing includes 6061 aluminum, and the lower flange includes 4047 aluminum. The lower flange and microelectronic package housing are preferably fusion welded with a low HAZ welding technique, and most preferably, by laser welding.

The metallurgical bond 18 between the upper and lower flanges 14 and 16, respectively, of this invention, is ideally the result of a cladding technique. One common technique is to metallurgically bond an aluminum plate to a steel or Kovar ® plate with an explosive charge. Such a technique is known as explosive bonding or cladding and is described in U.S. Pat. Nos. 3,233,312; 3,397,444; and 3,493,353, which are hereby incorporated herein by reference. A wide variety of dissimilar metals may be bonded together in this manner without the constraints imposed by other bonding methods which require compatibility between the materials. The resulting laminate exhibits a bonding zone which includes multi-component, inter-atomic mixtures of the metals of the two dissimilar materials. Such explosion cladded materials have been known to exhibit a shear strength of greater than about 75% of the weaker metal in the composite.

In an alternative embodiment of this invention described in FIGS. 4 and 5, an electrical connector 30 is provided having a single insulating body 33, preferably a ceramic or glass preform, disposed in a cavity of the connector body 32 and hermetically bonded thereto. In this embodiment, preferred Kovar ® or 52 Alloy connector pins 40 are disposed through a plurality of pin receiving holes in the insulating body 33. If a ceramic preform is employed, a preferred high temperature braze is used to bond to the metalized surfaces of the ceramic to form hermetic seals 46 between the connector pins 40 and the ceramic, as well as between the ceramic and the connector body 32. If a solid glass preform is used, the connector pins 40 are inserted into the preform holes and then fused with the glass at high temperatures to form hermetic seals 46. As with the embodiment of FIG. 1, the connector body is preferably a low expansion alloy compatible with ceramic and glass, such as Kovar ® alloy. The connector body 32 of this embodiment can conveniently be laser welded to the clad flange 31 with a laser welded joint 42. The clad flange can include an upper flange made of Kovar ® alloy and a lower flange 36 made of aluminum, preferably 4047 aluminum. The upper and lower flanges 34 and 36 respectively, can be explosion cladded to form metallurgical bond 38 as earlier described.

Connector embodiment 30 employs a clad flange 31 which has a slightly different configuration than the composite flange 21. As described in FIG. 4, the upper flange portion 34 of the clad flange 31 includes threaded holes 44 and the connector body 32 is disposed concentrically within the clad flange 31 and laser welded along the lower seam. Nevertheless, the fundamental concepts and principles of this invention are equally applicable to this embodiment.

From the foregoing, it can be realized that this invention provides highly reliable hermetic connectors which provide for compatibility between microelectronic aluminum package housings and Kovar ® alloy connector bodies here-to-fore not achievable. Low HAZ welding techniques are employed to avoid breaking hermetic glass seals around the connector pins. Additionally, explosion clad flange members provide adequate compatibility between housing alloys and connector body alloys for enabling highly reliable, laser welding of these members. Although various embodiments have been illustrated, this was for the purpose cf describing, but not limiting the invention. Various modifications, which will become apparent to one skilled in the art, are within the scope of this invention described in the attached claims.

What is claimed is:

1. An electrical connector suitable for providing electrical access through a sidewall of a microelectronic package housing while maintaining hermeticity, said housing having a first coefficient of thermal expansion, comprising:

a connector body having an aperture therethrough and a second coefficient of thermal expansion,

a connector pin disposed through said aperture and hermetically sealed to said connector body with an insulating composition,

flange means for joining said hermetic electrical connector to said microelectronic package housing, said flange means comprising upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively, said first composition being hermetically bonded to said connector body with a fusion weld having a heat-affected-zone which does not significantly affect the hermeticity provided by said insulating composition and said second composition being weldable to said microelectronic package housing.

2. The connector of claim 1, wherein said second coefficient of thermal expansion is substantially different than said first coefficient of thermal expansion of said housing.

Exhibit B-6

3. The connector of claim 2, wherein said first and second coefficients of thermal expansion differ by more than about 5 ppm/° C. from one another.

4. The connector of claim 2, wherein said connector body cannot be readily fusion welded to said housing.

5. The connector of claim 2, wherein said insulating composition comprises a glass having a coefficient of thermal expansion which is within about 5 ppm/° C. from said second coefficient of thermal expansion.

6. The connector of claim 2, wherein said insulating composition comprises a glass having a coefficient of thermal expansion which is within about 10% of said second coefficient of thermal expansion.

7. The connector of claim 6, wherein said second metallic composition has a coefficient of thermal expansion which is within about 5 ppm/° C. from said first coefficient of thermal expansion of said housing.

8. The connector of claim 6, wherein said second metallic composition has a coefficient of thermal expansion which is within about 10% of said first coefficient of thermal expansion of said housing.

9. The connector of claim 8, wherein said first metallic composition has a coefficient of thermal expansion which is within about 5 ppm/° C. from said second coefficient of thermal expansion of said connector body.

10. The connector of claim 8, wherein said first metallic composition has a coefficient of thermal expansion which is within about 10% of said second coefficient of thermal expansion of said connector body.

11. The connector of claim 1, wherein said first metallic composition and said connector body comprise a first common metal, and said second metallic composition and said housing comprise a second common metal, said first and second common metals having substantially different coefficients of thermal expansion.

12. The connector of claim 1, wherein said upper and lower flanges are cladded to one another.

13. The connector of claim 1. wherein said first metallic composition and said connector body contain alloys having a substantially similar composition, and said second metallic composition and said housing contain alloys having a substantially similar composition, said first metallic composition being not readily fusion weldable to said housing.

14. The connector of claim 13, wherein said first and second flanges are explosion cladded to one another to form said flange means.

15. A method of manufacturing a hermetic electrical connector, comprising:

(a) providing a connector body having an aperture therethrough;
(b) disposing a connector pin through said aperture;
(c) hermetically sealing said connector pin to said connector body with an insulating composition;
(d) providing a flange means for joining said hermetic electrical connector to a microelectronic package housing, said flange means comprising upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively, said first composition being weldable to said connector body and said second composition being weldable to said microelectronic package housing; and
(e) welding said upper flange to said connector body with a low heat affected zone welding technique.

16. The method of claim 15, wherein said hermetic sealing step comprises fusing a glass between said connector pin and said connector body.

17. The method of claim 16, wherein said fusing step is conducted at a temperature of at least about 900° C.

18. The method of claim 15, wherein said providing step (d) comprises providing first and second metallic compositions having a difference in their respective coefficients of thermal expansion of at least about 5 ppm/°C.

19. The method of claim 15, wherein said providing step (d) comprises cladding said upper and lower flanges to one another.

20. The method of claim 19, wherein said cladding step comprises explosion cladding.

21. The method of claim 15, wherein said welding step comprises laser welding.

22. A hermetic electrical connector assembly, comprising:

an aluminum-containing housing having a receiving window therein,

a connector comprising an iron-based alloy connector body, a plurality of connector pins hermetically sealed with an insulating glass to said connector body through a plurality of apertures disposed through said body, an iron-based alloy upper flange member fusion welded to said connector body with a heat-affected zone of less than about 1 mm, an aluminum-containing lower flange member explosion cladded to said upper flange member, said connector hermetically bonded to said housing by at least a fusion weld.

23. An electrical connector suitable for providing electrical access through a sidewall of a microelectronic package housing while maintaining hermeticity, said housing having a first coefficient of thermal expansion, comprising:

a connector body having an cavity therethrough and a second coefficient of thermal expansion,

an insulating body having a pin receiving hole therein, said insulating body hermetically sealed to said connector body and disposed substantially within said cavity,

a connector pin disposed through said pin receiving hole and hermetically sealed to said insulating body,

flange means for joining said hermetic electrical connector to said microelectronic package housing, said flange means comprising upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively, said first composition being hermetically bonded to said connector body with a fusion weld having a heat-affected-zone which does not significantly affect the hermeticity between said connector pin and said insulating body and said second composition being weldable to said microelectronic package housing.

24. The connector of claim 23, wherein said insulating body comprises a ceramic which is hermetically brazed to said connector body and said connector pin.

25. The connector of claim 23, wherein said insulating body comprises a ceramic having a metallic surface thereon and said connector pin and said connector body are hermetically brazed to said metallic surface.

26. The connector of claim 23, wherein said flange means is fusion welded circumferentially around said connector body.

27. The connector of claim 23, wherein said insulating body is a glass.

* * * * *

Exhibit B-7

# EXHIBIT C

US005405272A

# United States Patent [19]

Rapoza

[11] Patent Number: 5,405,272

[45] Date of Patent: Apr. 11, 1995

[54] **LASER WELDABLE HERMETIC CONNECTOR**

[75] Inventor: **Edward J. Rapoza**, West Milford, N.J.

[73] Assignee: **Balo Precision Parts Inc.**, Butler, N.J.

[21] Appl. No.: **878,156**

[22] Filed: **May 4, 1992**

**Related U.S. Application Data**

[63] Continuation of Ser. No. 727,668, Jul. 9, 1991, Pat. No. 5,110,307.

[51] **Int. Cl.**$^{6}$ .................... **H01R 13/74**

[52] **U.S. Cl.** .................... **439/566**; 29/843; 174/152 GM

[58] **Field of Search** .................... 439/566, 559; 29/842, 29/843; 174/50, 61, 151, 152 GM

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*Primary Examiner*—Eugene F. Desmond

*Attorney, Agent, or Firm*—Duane, Morris & Heckscher

[57] **ABSTRACT**

Electrical connectors are provided for enabling electrical access through a side wall of a microelectronic, sensor, or fiber optic package housing while maintaining hermeticity. These connectors include a connector body having an aperture therethrough and a coefficient of thermal expansion which is different than that of the housing. The connectors include a connector pin disposed through the aperture of the connector body and hermetically sealed to the connector body with an insulating composition or a ceramic insert bonded to the connector pins. Flange means are also provided for joining the hermetic electrical connector to the microelectronic package housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body with a fusion weld having a heat-affected-zone which does not significantly affect the hermetic seals around the connector pins. The second metallic composition is readily weldable to the microelectronic package housing to provide the final hermetic coupling.

**14 Claims, 2 Drawing Sheets**

Exhibit C-1

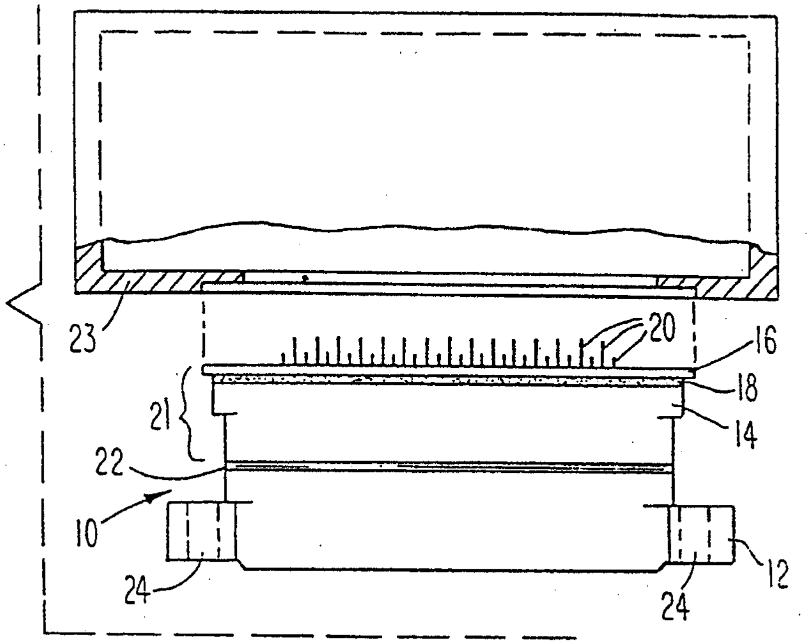


Fig. 1

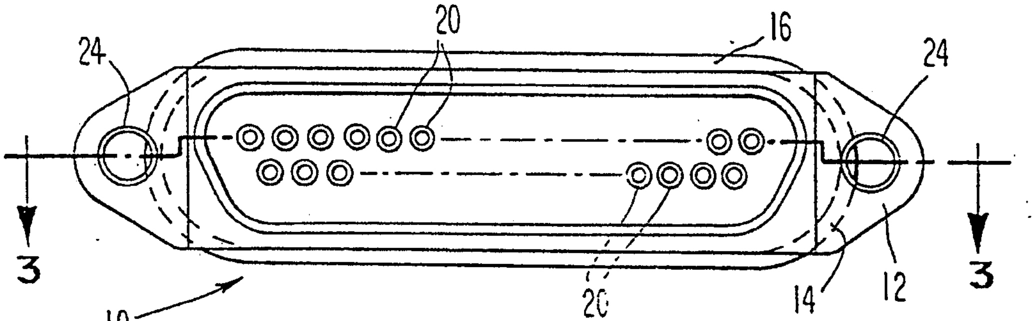


Fig. 2

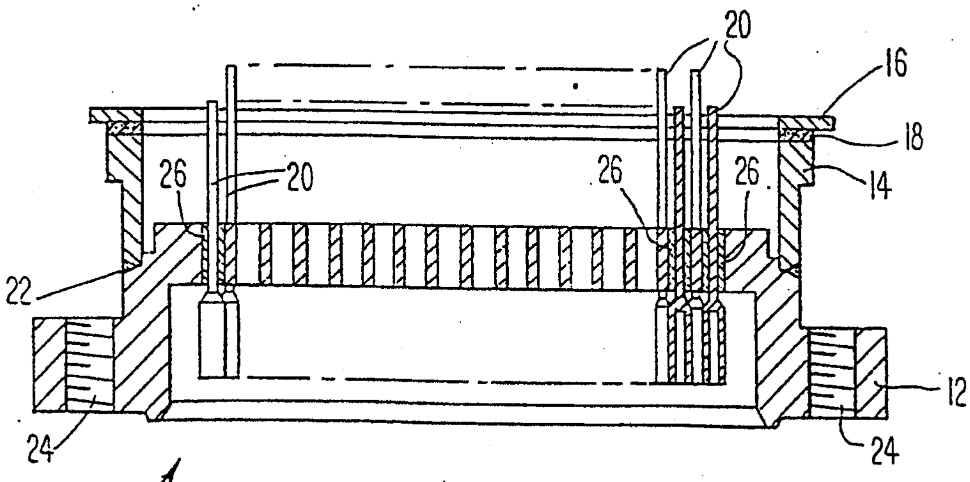


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Fig. 3

Exhibit C-2

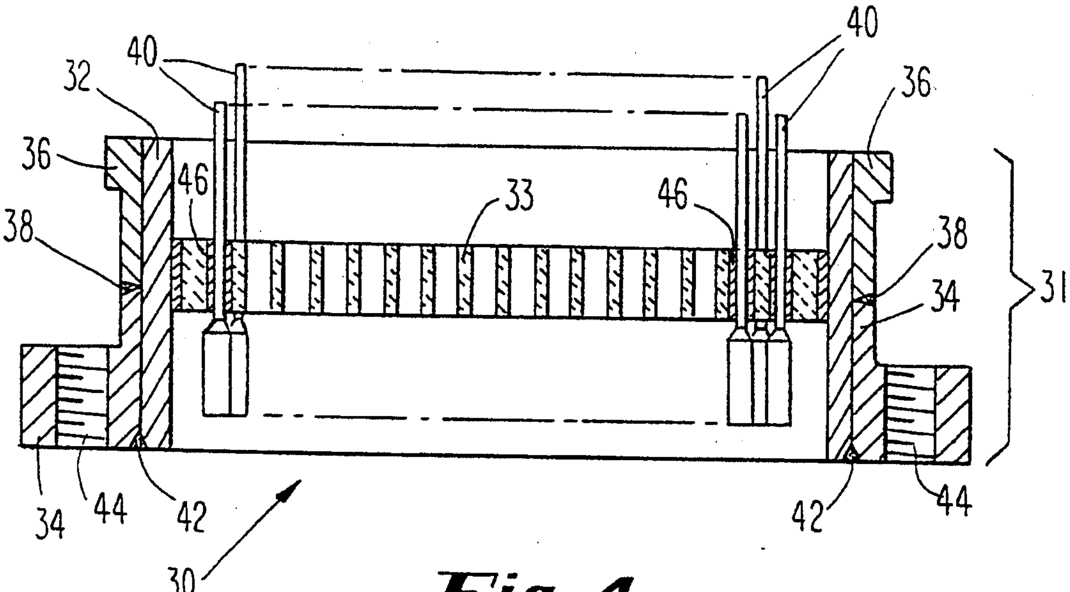


Fig. 4

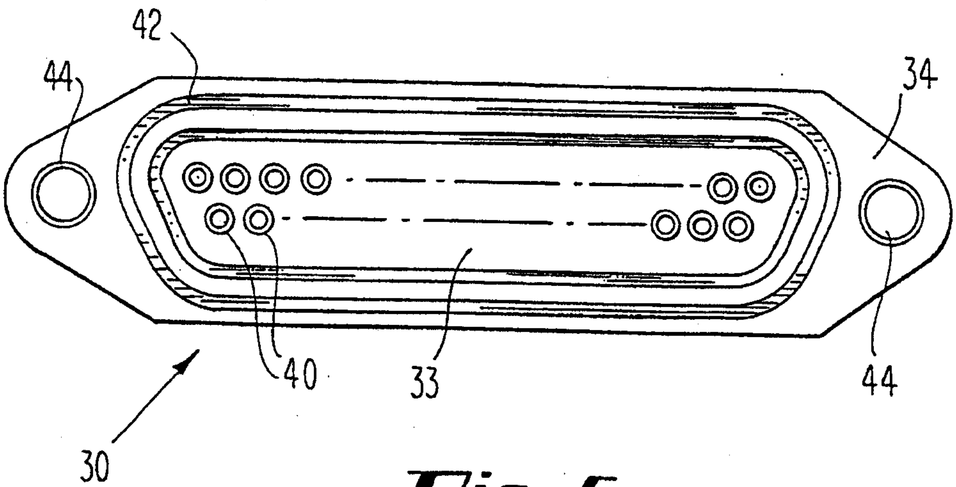


Fig. 5

Exhibit C-3

## LASER WELDABLE HERMETIC CONNECTOR

### CROSS REFERENCE TO RELATED APPLICATION

This application is a Continuation application of U.S. patent application Ser. No. 727,668, filed on Jul. 9, 1991, now U.S. Pat. No. 5,110,307.

### FIELD OF THE INVENTION

This invention relates to electrical connectors, and more particularly, to manufacturing methods for maintaining hermeticity and providing metallurgical compatibility between connectors and microelectronic housings.

### BACKGROUND OF THE INVENTION

Microelectronic modules, such as those containing electronic circuit components, fiber optics, or pressure sensing devices, rely on hermetic sealing, i.e., gas-tight seals, to protect these sensitive components from the corrosive effects of the environment. As is often the case, these modules contain a mosaic of materials having various, and often less than compatible, physical properties.

The art has typically relied upon hermetic connectors disposed through a side wall of the housings of such modules to provide input-output electrical access for cables and the like. In the past, such connectors included a connector body made of a low coefficient of thermal expansion, Fe—Ni—Co alloy, such as Kovar®, and one or more connector pins axially disposed through the connector body. These pins are usually hermetically sealed with glass through small pin-receiving holes disposed through the center of the connector body. The glass insulates the pins from the rest of the connector and is relatively compatible with the Kovar® base metal, so as to provide an air-tight hermetic fit around the connector pins during severe temperature cycles, such as those experienced by aircraft during flight.

The module housing, for a number of years, was also made of an iron-based alloy, such as Kovar®, which enabled thermal expansion compatibility with the connector during these wide temperature cycles as well as weldability, such as by fusion welding or brazing, for providing a hermetic seal between the connector body and the housing.

With the advent of cost cutting measures, including weight reduction efforts aimed at conserving fuel in the military and commercial aircraft industries, module housings have recently been made from light weight metals, such as aluminum. Although aluminum is easier to machine, is less expensive, and is lighter in weight than iron-based alloys, it is not very compatible with Kovar®, both in regard to weldability and thermal expansion.

In an effort to accommodate the use of aluminum housings in microelectronic modules, the art has resorted, in certain instances, to plating the connector-receiving window regions of aluminum housings and the matching surface of the Kovar® connectors with nickel, or a similar metal, and then soldering or brazing the nickel-plated surfaces together. Since these metal joining techniques require heating the plated metal surfaces to at least about 200° C. (and as high as 360° C.), and since aluminum and Kovar® have drastically different coefficients of thermal expansion, stress is created in the joint upon cooling the module to room temperature. Such stress can lead to joint failure and a loss of hermeticity when the module component undergoes subsequent manufacturing operations or is placed in service, especially if such service requires exposure to severe temperature cycling, for example, in aerospace applications.

### SUMMARY OF THE INVENTION

Electrical connectors suitable for providing electrical access through a side wall of a microelectronic package or module and methods for preparing such connectors are provided by this invention. The connectors are designed to maintain hermeticity, or gas impermeability, throughout the manufacturing and service life of these components.

In a first embodiment of this connector, the housing of the microelectronic package includes a first coefficient of thermal expansion. The connector has a connector body having an aperture therethrough and a second coefficient of thermal expansion. A connector pin is disposed through the aperture in the connector body and hermetically sealed to the connector body with an insulating composition. In an important aspect of this invention, flange means are provided for joining the hermetic electrical connector to the housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body, preferably by fusion welding thereto, and is metallurgically compatible (i.e., Kovar® to Kovar®, stainless steel to Kovar®, Kovar® to stainless steel, stainless steel to stainless steel, etc.). This fusion weld is produced by progressive spot laser welding or progressive spot resistance welding having a heat-affected-zone ("HAZ") small enough such that it does not significantly affect the hermeticity provided by the insulating composition, i.e., glass or ceramic. The second layer is similarly compatible with the housing package, (i.e., aluminum to aluminum, etc.).

Accordingly, this invention provides sound hermetic joints between Kovar® connectors or iron or steel connectors and aluminum modules (or zinc modules, or titanium modules, etc.) by employing cladded flange members and low HAZ welding procedures. Unreliable soldering or brazing techniques can be avoided altogether, thus minimizing resulting residual stresses to internal sensitive electronic components sensors or optics, etc. Greater reliability of the microelectronic module can be afforded by the carefully orchestrated process steps of this invention, which take into account both weldability and thermal expansion compatibility of the various sealing compositions and base metals of electrical connectors and electronic modules.

In a further embodiment of this invention, a method of manufacturing hermetic electrical connectors is provided. This method includes providing a connector body having an aperture therethrough, disposing a connector pin through the aperture and hermetically sealing this pin to the connector body with an insulating composition. A flange means is further provided by this method for joining the hermetic electrical connector to a microelectronic package housing. The flange means includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is

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weldable to the connector body with a low HAZ welding technique and the second composition is weldable to the microelectronic package housing.

In a further aspect of this invention, an electrical connector is provided for accessing a microelectronic elements within a package housing through a side wall of the housing. The connector includes a connector body having a cavity therethrough and a coefficient of thermal expansion which differs from the coefficient of thermal expansion of the housing. This connector also includes an insulating body having a pin receiving hole therein. The insulating body is hermetically sealed to the connector body and disposed substantially within its cavity. The connector further includes a pin disposed through the pin receiving hole and hermetically sealed to the insulating body and flange means for joining the hermetic electrical connector to the microelectronic package housing. The flange means, like the ones described above, includes upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions respectively. The first composition is hermetically bonded to the connector body with a fusion weld having a HAZ which does not significantly affect the hermeticity between the connector pin and the insulating body, and the second composition is bonded to the microelectronic package with a fusion weld having a low HAZ, so as to provide a sound hermetic seal without high temperature brazing or soldering which are known to affect the temperature sensitive components therein.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate preferred embodiments of the invention according to the practical application of the principles thereof, and in which:

FIG. 1: is a side elevation plan view of a preferred electrical connector of this invention;

FIG. 2: is a top plan view of the preferred electrical connector of FIG. 1;

FIG. 3: is a side cross-sectional view, taken through line 3—3 of FIG. 2, illustrating the sealing of the input-output connector pins of this embodiment;

FIG. 4: is a side cross-sectional view of an alternative embodiment electrical connector having a ceramic insulating member; and

FIG. 5: is a top plan view of the alternative embodiment of FIG. 4.

## DETAILED DESCRIPTION OF THE INVENTION

This invention provides electrical connectors suitable for providing input-output access through a side wall of a microelectronic package housing while maintaining hermeticity. This connector utilizes a dual layer flange having layers of relatively incompatible metal compositions which are metallurgically bonded together, preferably by high compression cladding, without the introduction of interface stress or elevated temperatures. The upper portion of the flange of this invention contains a metallic composition which is compatible with the connector body metal. As used herein, the term "compatible" refers to an approximate matching of the metallurgical and fusion welding properties of metallic compositions.

The other portion of the flange of this invention is manufactured with a metallic composition which is compatible to the module housing. By matching the metallic compositions, fusion welding can be employed to attach the flange to the connector body and in turn to the microelectronic package housing to provide sound, hermetic joints, which are less susceptible to stress during large temperature cycles.

With reference to FIGS. 1-3, there is shown a preferred electrical connector of this invention. This connector 10 preferably includes a connector body 12 having a "male pinned" connector mate which can engage via a coupling flange, which preferably includes bored threaded engagement holes 24. The connector body 12 is preferably made of an iron-based alloy, more preferably a Fe—Ni—Co alloy, such as Kovar ® alloy. Alternatively, the connector body 12 can include a material having a thermal expansion similar to borosilicate glass, i.e. about 5.5 ppm/°C.

As illustrated in FIG. 2, a plurality of conducting, connector pins 20, are shown which are disposed through pin-receiving apertures in the middle portion of the connector body 12. These pins 20 are also preferably made of the same metal as the connector body 12, for example, Kovar ® alloy, and are hermetically attached through the apertures by an insulating composition. The connector pins 20 are preferably sealed by melting or fusing a glass, such as a borosilicate glass, into the spaces around the pins 20 to produce highly reliable glass seals 26. Alternatively, a single glass preform having pin receiving holes therein can be placed into the connector body interior as a substitute for the metal through-hole section. The pins can then be fused into the glass preform upon heating. Glass sealing or fusion, as it is known in the art, consists of heating a glass mixture to a temperature of at least about 900° C., and ideally about 950° C., to produce, upon cooling, a hermetic bond between the pins 20 and the connector body 12 or a glass preform. This is a very highly reliable seal since Kovar ® has a coefficient of thermal expansion similar to that of the glass, which together with the glass, provides a gas-tight intergranular attachment around the connector pins 20 throughout a wide range of temperatures.

The flange means of this invention, generally represented by composite flange 21, comprises an upper flange 14 and lower flange 16 metallurgically bonded together to form joint 18. The upper flange 14 preferably contains a metallic composition which is compatible with the base metal of the connector body 12. Preferably, the coefficients of thermal expansion for alloys of the upper flange 14 and the connector body differ by less than about 5 ppm/°C., and more preferably, differ by less than about 10% of the coefficient of the connector body alloy. Most importantly these alloys are compatible to allow fusion welding with a narrow HAZ. Ideally, the upper flange 14 includes a substantially similar base metal as connector body 12, for example, Kovar ®. The upper flange 14 is preferably hermetically bonded to the connector body 12 with a fusion weld having a HAZ which does not significantly affect the hermeticity provided by the insulating composition, or glass seals 26, which bond the connector pins 20 to the connector body 12. Such low HAZ fusion welding processes include, for example, plasma, electron beam, and laser welding techniques, which are known in the art.

In a preferred method of manufacturing the electrical connectors of this invention, the upper flange 14 is laser welded to the connector body 12, using known laser welding processes and equipment, following the glass sealing operation. This can be accomplished through

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the application of a small local laser spot which produces a metallurgical fusion weld in a small local area at the joint between the upper flange **14** and the connector body **12**.

In an important aspect of this invention, the laser melt heat is restricted to the joint area, which is preferably, less than about 1 mm at its widest point, and more preferably, is less than about 0.33–0.5 mm in width and depth. The weld path of the laser is moved, after the initial starting point, to produce a thin continuous and reliable laser welded joint **22** around the connector body. This process does not produce heating of the metallurgical joint **18** or the glass seals **26**. Accordingly, thermal stresses at these critical hermetic sealing areas are thus avoided. Thus, both the laser welded joint **22**, the glass to metal seals **26**, and the integrity of the composite flange **21** can be hermetic and highly reliable.

The lower flange **16** of the composite flange **21** preferably contains a second metallic composition which is weldable to the microelectronic package housing **23**. Typically, the choice of alloy will be compatible with the alloy of the housing **23**, preferably, the differences between the thermal conductivity of the lower flange **16** and the housing **23** are less than 5 ppm/°C., or less than 10% of the coefficient of the housing **23**, and most preferably the alloys are substantially similar. Good choices for both the housing **23** and the lower flange **16** include aluminum, for its low weight and good thermal conductivity (coefficient of thermal expansion of about 24 ppm/°C.), brass or copper, for their solderability and good thermal conductivity (coefficient of thermal expansion of about 18 ppm/°C.), titanium, for its high strength to weight ratio (coefficient of thermal expansion of about 10 ppm/°C.), and stainless steel (preferably, 400 series), for its high strength and good corrosion resistance (coefficient of thermal expansion of about 14 ppm/°C.). In certain situations these alloy selections could also be used for the connector body **12** and pins **20**.

In a preferred detailed embodiment of this invention, the microelectronic package housing includes 6061 aluminum, and the lower flange includes 4047 aluminum. The lower flange and microelectronic package housing are preferably fusion welded with a low HAZ welding technique, and most preferably, by laser welding.

The metallurgical bond **18** between the upper and lower flanges **14** and **16**, respectively, of this invention, is ideally the result of a cladding technique. One common technique is to metallurgically bond an aluminum plate to a steel or Kovar® plate with an explosive charge. Such a technique is known as explosive bonding or cladding and is described in U.S. Pat. Nos. 3,233,312; 3,397,444; and 3,493,353, which are hereby incorporated herein by reference. A wide variety of dissimilar metals may be bonded together in this manner without the constraints imposed by other bonding methods which require compatibility between the materials. The resulting laminate exhibits a bonding zone which includes multi-component, inter-atomic mixtures of the metals of the two dissimilar materials. Such explosion cladded materials have been known to exhibit a shear strength of greater than about 75% of the weaker metal in the composite.

In an alternative embodiment of this invention described in FIGS. **4** and **5**, an electrical connector **30** is provided having a single insulating body **33**, preferably a ceramic or glass preform, disposed in a cavity of the connector body **32** and hermetically bonded thereto. In this embodiment, preferred Kovar® or 52 Alloy connector pins **40** are disposed through a plurality of pin receiving holes in the insulating body **33**. If a ceramic preform is employed, a preferred high temperature braze is used to bond to the metalized surfaces of the ceramic to form hermetic seals **46** between the connector pins **40** and the ceramic, as well as between the ceramic and the connector body **32**. If a solid glass preform is used, the connector pins **40** are inserted into the preform holes and then fused with the glass at high temperatures to form hermetic seals **46**. As with the embodiment of FIG. **1**, the connector body is preferably a low expansion alloy compatible with ceramic and glass, such as Kovar® alloy. The connector body **32** of this embodiment can conveniently be laser welded to the clad flange **31** with a laser welded joint **42**. The clad flange can include an upper flange made of Kovar® alloy and a lower flange **36** made of aluminum, preferably 4047 aluminum. The upper and lower flanges **34** and **36** respectively, can be explosion cladded to form metallurgical bond **38** as earlier described.



Connector embodiment **30** employs a clad flange **31** which has a slightly different configuration than the composite flange **21**. As described in FIG. **4**, the upper flange portion **34** of the clad flange **31** includes threaded holes **44** and the connector body **32** is disposed concentrically within the clad flange **31** and laser welded along the lower seam. Nevertheless, the fundamental concepts and principles of this invention are equally applicable to this embodiment.

From the foregoing, it can be realized that this invention provides highly reliable hermetic connectors which provide for compatibility between microelectronic aluminum package housings and Kovar® alloy connector bodies here-to-fore not achievable. Low HAZ welding techniques are employed to avoid breaking hermetic glass seals around the connector pins. Additionally, explosion clad flange members provide adequate compatibility between housing alloys and connector body alloys for enabling highly reliable, laser welding of these members. Although various embodiments have been illustrated, this was for the purpose of describing, but not limiting the invention. Various modifications, which will become apparent to one skilled in the art, are within the scope of this invention described in the attached claims.

What is claimed is:

**1**. An electrical connector, comprising:

a connector body having an aperture therethrough;

a connector pin disposed through said aperture and hermetically sealed to said connector body with an insulating composition; and

flange means comprising upper and lower flanges metallurgically bonded together and comprising first and second metallic compositions having different thermal expansion characteristics, said first composition being hermetically bonded to said connector body with a fusion weld which does not significantly affect the hermeticity provided by said insulating composition.

**2**. The connector of claim **1**, wherein said first and second metallic compositions have coefficients of thermal expansion that differ by more than about 5 ppm/°C. from one another.

**3**. The connector of claim **2**, wherein said insulating composition comprises a glass having a coefficient of thermal expansion which is within about 5 ppm/°C.

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from said coefficient of thermal expansion of said first metallic composition.

4. The connector of claim 2, wherein said insulating composition comprises a glass having a coefficient of thermal expansion which is within about 10% of said coefficient of thermal expansion of said first metallic composition.

5. The connector of claim 1, wherein said first metallic composition and said connector body comprise a common metal.

6. The connector of claim 1, wherein said upper and lower flanges are cladded to one another.

7. The connector of claim 1, wherein said first metallic composition and said connector body contain alloys having a substantially similar composition, and said second and said first metallic compositions are substantially not fusion weldable to one another.

8. The connector of claim 7, wherein said first and second flanges are explosion cladded to one another to form said flange means.

9. A method of manufacturing a hermetic electrical connector, comprising:

(a) providing a metallic connector body having an aperture therethrough;

(b) disposing a conducting connector pin through said aperture;

(c) hermetically sealing said connector pin to said metallic connector body with an insulating glass composition;

(d) providing a flange means on said hermetic electrical connector, said flange means comprising upper and lower flanges cladded together and comprising first and second metallic dissimilar compositions; and

(e) welding said upper flange to said connector body with a low heat affected zone fusion welding technique.

10. The method of claim 9, wherein said hermetic sealing step comprises fusing said glass between said connector pin and said connector body.

11. The method of claim 10, wherein said fusing step is conducted at a temperature of at least about 900° C.

12. The method of claim 9, wherein said providing step (d) comprises providing first and second metallic compositions having a difference in their respective coefficients of thermal expansion of at least about 5 ppm/°C.

13. The method of claim 9, wherein said cladding step comprises explosion cladding.

14. The method of claim 9, wherein said welding step comprises laser welding.

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