BRAZED LOWER VACUUM HOUSING FOR A DEWAR

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A lower vacuum housing (34) of a sensor dewar (26) is fabricated in a single brazing operation from ceramic and metallic components. The components are assembled with ceramic-to-metal interfaces and metal-to-metal interfaces. Brazing is accomplished by active brazing of the ceramic-to-metal interfaces and non-active brazing of the metal-to-metal interfaces. Specific combinations of active braze alloys and non-active braze alloys are provided for various combinations of dewar materials.

References Cited
U.S. PATENT DOCUMENTS
4,645,931 2/1987 Gordon et al. 250/352

FABRICATE AND FURNISH COMPONENTS OF LOWER VACUUM HOUSING

ASSEMBLE COMPONENTS INTO LOWER VACUUM HOUSING ASSEMBLY

PLACE BRAZE ALLOYS BETWEEN COMPONENTS AS ASSEMBLED

HEAT ASSEMBLY TO BRAZE

FIG. 1

FIG. 2

FIG. 3
BACKGROUND OF THE INVENTION

This invention relates to apparatus for maintaining a low-temperature environment, and, more particularly, to an improved construction for a vacuum package dewar.

Many types of electronic devices operate most efficiently at reduced temperatures. For example, infrared sensors using focal plane array, charge-coupled device must be operated at a temperature of 77K or less. Cooling of the sensor elements is accomplished by placing the focal plane array into an evacuated enclosure having an infrared-transmissive window. The sensor within the enclosure, termed a vacuum package or dewar, is cooled to the required reduced temperature by cryogenic gas cooling, Joule-Thomson cooling, thermoelectric cooling, or other operable technique. The vacuum enclosure prevents heat from the surroundings from being conducted to the sensor to warm it at a rate faster than heat can be removed by the cooling apparatus. The present invention relates to the construction of the dewar and the method of its fabrication.

In the conventional practice, the dewar is formed of a two-part housing. An upper vacuum housing includes the infrared-transmissive window, and a lower vacuum housing contains the focal plane array sensor, its support that provides the conductive heat path to the cooling apparatus, and related structure. During assembly of the instrument, the support structure and sensor are installed within the lower vacuum housing, and electrical connections are made to feedthroughs built into the wall of the lower vacuum housing. The sensor is installed in the lower vacuum housing, and the upper vacuum housing is fixed to a flange on the lower vacuum housing. The interior of the device is evacuated and sealed off to complete the fabrication process.

The present invention relates to the manner of construction of the lower vacuum housing, prior to the above-described assembly steps, and to the resulting dewar. The lower vacuum housing is usually prepared by first building a number of subassemblies and joining the subassemblies together. Thus, typically, an outer housing, a coldfinger tube, an adaptor collar, a platform, a ceramic insulator, electrical feedthrough leads, a flange, and a header are fabricated. The coldfinger tube and the adaptor collar are welded or soldered together. A tip-off tube is welded to the flange. The feedthrough leads are brazed to the ceramic insulator. The ceramic insulator is brazed to an opening in the outer housing. The header and flange are welded to the outer housing. The coldfinger tube/adaptor collar is welded to the header. All of these assembly steps require separate joining operations, separate inspections and tests, and the tracking of the various subassemblies through the joining operations.

This approach, while effective in producing an operable lower vacuum housing suitable to receive the focal plane array of the sensor, has some drawbacks. First, the many subassembly and assembly steps are time consuming and costly. Welding procedures in particular require extensive setup and care in positioning the parts, even when automated procedures are used. Second, there may be reliability problems resulting from the many types of joints and procedures utilized. Third, these joining operations and the order in which they are performed dictate the material types which can be used for the various components, which sometimes leads to less than optimal choices for the materials.

SUMMARY OF THE INVENTION

This invention provides an improved fabrication procedure for the lower vacuum housing of a dewar system. The procedure permits the joining of all elements of the lower vacuum housing in a single assembly step. The time required and cost of assembly are thereby greatly reduced as compared with the prior approach. The joining technique is rapidly accomplished and is highly reliable, producing a final lower vacuum housing that is highly reliable. A wider range of materials is available for selection for use in the various components of the lower vacuum housing, due to the flexibility of the joining technique.

In this approach, the components of the lower vacuum housing are first furnished. At least some of the components are ceramic and at least some of the components are metallic. The components are assembled together so that the assembly includes at least one ceramic-to-metal interface and at least one metal-to-metal interface, and the assembled components are joined by a single brazing operation.

Preferably, the joint at the ceramic-to-metal interface is formed by active brazing, and the joint at the metal-to-metal interface is formed by non-active brazing. These techniques are compatible and can be performed concurrently, but require the use of different brazing alloys. Care is taken in selecting the brazing alloys for various material combinations that can be used in the lower vacuum housing. The present approach significantly reduces the time and cost required to fabricate the lower vacuum housing. Instead of the many separate steps of subassembly preparation and final assembly, all of the components of the lower vacuum housing are assembled to the final structure in a single step. The single-step fabrication is accomplished even though there are both ceramic-to-metal and metal-to-metal joints in the structure. The joints are formed by reliable brazing techniques. The incorporation of active and non-active brazing in a single process step also allows many different metallic and nonmetallic materials to be used in constructing the lower vacuum housing.

Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side sectional view of a dewar having a lower vacuum housing, an upper vacuum housing, and a focal plane array sensor therein;

FIG. 2 is a schematic side sectional view of the lower vacuum housing of FIG. 1, with the various components highlighted; and

FIG. 3 is a block flow diagram of the method of preparing the lower vacuum housing shown in FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 depicts an infrared-sensor vacuum package assembly 20. The vacuum package assembly 20 includes a focal...
plane array sensor 22 mounted on a pedestal 24. The pedestal 24 and sensor 22 are fixed within a dewar 26.

The dewar 26 includes two parts that are initially separate and are joined together during final assembly. An upper vacuum housing 28, also termed the window housing, is preferably cylindrically symmetric, although of varying diameters along its length. An infrared-transparent window 30 forms at least a part of one end of the upper vacuum housing 28. An upper flange 32, in this case integral with the body of the upper vacuum housing, is formed at the other end of the upper vacuum housing 28.

A lower vacuum housing 34 is conformably shaped so as to mate with the upper vacuum housing 28. In the preferred embodiment, the lower vacuum housing 34 is cylindrically symmetric and of varying diameters along its length. A bottom end 36 of the lower vacuum housing 34 is closed, with the pedestal 24 mounted to the end 36 such that the sensor 22 is facing the window 30 when the upper vacuum housing 28 is assembled to the lower vacuum housing 34. A lower flange 38 is present at an upper end 40 of the lower vacuum housing 34. The upper flange 32 and the lower flange 38 are dimensioned to permit a vacuum-tight seal between the upper vacuum housing 28 and the lower vacuum housing 34 during final assembly.

During final assembly of the vacuum package assembly 20, the sensor 22 is attached to the upper end of the pedestal 24, and lead wires 42 are attached between the sensor 22 and the upper vacuum housing 28. An electrical feedthrough 44 in the wall of the lower vacuum housing is prepared as a subassembly by brazing the lead 54 to the insulator 56. The insulator 56 is then brazed to the header 52, and the header 52 is welded to the outer tube 53. The header 52 may be made of copper.

In the presently preferred approach, no separate subassemblies are prepared. Instead, the entire lower vacuum housing 34 is prepared in a single step from the individual components. In this approach, the components themselves do not change, but their mode of assembly does change.

FIG. 3 is a block flow diagram of the method for preparing the lower vacuum housing by the approach of the invention. The components are first fabricated and furnished, numeral 90. The components are generally those described previously, and their equivalents. The components may be made of any operable material. In some cases a component may be made of metal, while in other cases a component may be made of ceramic. Certain components may be made of either a metal or a ceramic, depending upon the particular design of the dewar.

The following listing presents some preferred materials of construction of the various components, although the invention is not limited to the use of these materials of construction.

The flange 32 and 88 are facing each other. The edge of the flanges are welded together. The interior of the dewar 26 is evacuated through a tip-off tube 46 in the wall of the lower vacuum housing, and the tip-off tube is sealed. A tip-off tube 46 is required.

The preceding general description of the vacuum package assembly has focused on a preferred design of interest to the present inventors. There is a wide variety of designs for the vacuum package assembly, and the present invention is applicable to all such designs that use a multi-component lower vacuum housing.

FIG. 2 illustrates the components of the lower vacuum housing 34 in greater detail. These components are separately fabricated and then assembled to form the lower vacuum housing 34, prior to adding the sensor 22 and final assembly with the upper vacuum housing 28. The pedestal 24 is prepared as a platform 48 joined to a coldfinger tube 50. The external wall of the lower vacuum housing has a number of components. A header 52 is joined to an outer tube 53. The feedthrough 44, which is joined to an opening in the header 52, is prepared as an electrically conductive lead 54 penetrating through a ceramic insulator 56. The lower flange 38 is typically prepared integral with a cylindric section 58, and the tip-off tube 46 is joined to an opening through the wall of the cylindrical section 58. The pedestal 24 is joined to the bottom end 35 of the outer tube 53 with an adaptor collar 60.

As mentioned before, there can be different designs of the lower vacuum housing 34 with more or fewer components, but in general there are multiple components made of different materials used in the construction of the lower vacuum housing 34. Most of the components are preferably made of metal, but there is at least one ceramic component, the insulator 56, in these designs. It is also not uncommon that the header 52 be made of ceramic.
the coldfinger tube 50 and the adaptor collar 60, between the 
adaptor collar 50 and the outer tube 53, between the outer 
tube 53 and the header 52, between the header 52 and the 
insulator 56, between the insulator 56 and the lead 54, 
between the header 52 and the cylindrical section 58, and 
between the cylindrical section 58 and the tip-off tube 46. 
The nature of each interface depends upon the compositions 
of the components that face each other at the respective 
interfaces, but there will be at least one metal-to-metal and 
one ceramic-to-metal joint. There could be a ceramic-to-
ceramic joint, if the header 52 is made of a ceramic. 

The metal-to-metal, ceramic-to-metal, and ceramic-to-
ceramic (if any) joints corresponding to each interface are 
formed by brazing, all in the same brazing operation and at 
the same time. The metal-to-metal joints are preferably 
formed by non-active brazing, wherein the brazing alloy 
does not substantially chemically react with either compo-
nent. The ceramic-to-metal joint(s) and the ceramic-to-
ceramic joint(s) are preferably formed by active brazing, 
wherein the brazing alloy chemically reacts with one or both 
components to promote wetting of the brazing alloy to the 
component and to attain a metallurgical and chemical bond 
to the component. Reactive metals such as titanium or 
zirconium are typically present in the braze alloys to accom-
plish such reaction. The metal-to-metal joints can also be 
formed by active brazing. Since active brazing materials 
are typically more expensive and difficult to utilize than non-
active braze materials, it is preferred that the metal-to-metal 
joints be formed by non-active brazing.

Non-active brazing has long been used in metal-to-metal 
joints. Active brazing is a more recent development, but is 
now known in the art or brazing. See, for example, H. 
Mizuhara et al., "Joining Ceramic to Metal with Ductile 
Active Filler Metal," Welding Journal, pages 45–51 (Octo-
ber 1986). However, it has not been known to combine 
active brazing with non-active brazing to prepare an entire 
lower vacuum housing made of different materials and 
and having both metal-to-metal joints and ceramic-to-metal 
joints.

After the braze alloys have been placed into the interfaces, 
umeral 94, the assembly is heated to a brazing temperature, 
umeral 96. At that temperature, the various braze materials 
melt and wet the components that face each other across 
each respective interface. After wetting and bonding is 
achieved, which typically requires only 3–15 minutes, the 
assembly is cooled so that the braze alloys solidify, bonding 
the components hermetically together. Typical brazing con-
ditions are a vacuum of less than 10^-5 Torr and a heat-up rate 
lower vacuum housing made of different materials and 
and ceramic-to-ceramic joints is a silver-copper-titanium 
alloy having a composition of 68.8 weight percent silver, 
26.7 weight percent copper, and 4.5 weight percent titanium. 
Such a braze material is available commercially from Wesgo 
Corp. under the trade name "Ticusil".

In a third approach, where 300 or 400 series stainless 
steel is used in the lower vacuum housing, the brazing 
temperature is preferably about 1725° F. The preferred 
active brazing material used for forming the metal-to-
to-metal joints is a gold-copper-nickel alloy having a com-
position of 81.5 weight percent gold, 16.5 weight percent 
copper, and 2.0 weight percent nickel. Such a braze material 
is available commercially from Wesgo Corp. under the 
trade name "Palcusil-10". The preferred non-active brazing 
material used for metal-to-metal joints is a silver-copper-
platinum alloy having a composition of 58 weight percent 
silver, 32 weight percent copper and 10 weight percent 
palladium. Such a braze material is available commercially 
from Wesgo Corp. under the trade name "Cusil-1 ABA".

In a second approach, where the metallic components are 
made of iron-nickel, iron-nickel-cobalt, or copper alloys, 
together with titanium alloys, the brazing temperature is 
preferably about 1625° F. The preferred non-active brazing 
material used for metal-to-metal joints is a silver-copper-
platinum alloy having a composition of 58 weight percent 
silver, 32 weight percent copper and 10 weight percent 
palladium. Such a braze material is available commercially 
from Wesgo Corp. under the trade name "Cusil-1 ABA".

In a second approach, where the metallic components are 
made of iron-nickel, iron-nickel-cobalt, or copper alloys, 
together with titanium alloys, the brazing temperature is 
preferably about 1625° F. The preferred non-active brazing 
material used for metal-to-metal joints is a silver-copper-
platinum alloy having a composition of 58 weight percent 
silver, 32 weight percent copper and 10 weight percent 
palladium. Such a braze material is available commercially 
from Wesgo Corp. under the trade name "Cusil-1 ABA".

In a second approach, where the metallic components are 
made of iron-nickel, iron-nickel-cobalt, or copper alloys, 
together with titanium alloys, the brazing temperature is 
preferably about 1625° F. The preferred non-active brazing 
material used for metal-to-metal joints is a silver-copper-
platinum alloy having a composition of 58 weight percent 
silver, 32 weight percent copper and 10 weight percent 
palladium. Such a braze material is available commercially 
from Wesgo Corp. under the trade name "Cusil-1 ABA".
this text. The single-step fabrication of the lower vacuum housing was thereby determined to be fully effective at producing an acceptable dewar.

The lower vacuum housings prepared by the approach of the Invention are less expensive and time consuming to produce than those prepared by the prior approach. Additionally, the lower vacuum housing have superior expected reliability to those prepared by the prior approach. The brazed joints have been proven to be more robust in thermal cycling and high-vibration environments than identical welded joints. Moreover, the welded joints are possible only for certain material combinations at the joints, and these combinations may not be the most preferred materials of construction for the lower vacuum housing components. As an example, one cannot weld a ceramic platform to a metal coldfinger. Brazing with the present approach allows for optimal materials selection and also for reliable, robust joints between the selected materials.

Although a particular embodiment of the invention has been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited except as by the appended claims.

What is claimed is:

1. A method for preparing a lower vacuum housing of a sensor dewar having an upper vacuum housing and the lower vacuum housing, comprising the steps of:
   furnishing the components of the lower vacuum housing, at least some of the components being ceramic and at least some of the components being metallic;
   assembling the components together so that the assembly includes at least one ceramic-to-metal interface and at least one metal-to-metal interface; and
   joining the assembled components by a single brazing operation.

2. The method of claim 1, wherein the step of joining includes the step of brazing the at least one ceramic-to-metal interface by active brazing to form at least one ceramic-to-metal joint.

3. The method of claim 1, wherein the step of joining includes the step of brazing the at least one metal-to-metal interface by non-active brazing to form at least one metal-to-metal joint.

4. The method of claim 1, wherein the step of furnishing the components includes the step of furnishing at least some metallic components made of metals selected from the group consisting of iron-base alloys, nickel-base alloys, and copper-base alloys, and wherein the step of joining includes the step of brazing the at least one metal-to-metal interface with a braze alloy heated to a temperature of about 1500° F.

5. The method of claim 4, wherein the step of brazing the metal-to-metal interfaces further includes the step of furnishing a braze alloy comprising copper and silver.

6. The method of claim 4, wherein the step of joining includes the step of brazing the at least one ceramic-to-metal interface with an active braze alloy comprising silver, copper, titanium, and tin.

7. The method of claim 1, wherein the step of furnishing the components includes the step of furnishing at least some metallic components made of metals selected from the group consisting of iron-base alloys and titanium-base alloys, and wherein the step of joining includes the step of brazing the at least one metal-to-metal interface with a braze alloy heated to a temperature of about 1620° F.

8. The method of claim 7, wherein the step of brazing the metal-to-metal interfaces further includes the step of furnishing a braze alloy comprising silver, copper, and palladium.

9. The method of claim 7, wherein the step of joining includes the step of brazing the at least one ceramic-to-metal interface with an active braze alloy comprising silver, copper, and titanium.

10. The method of claim 1, wherein the step of furnishing the components includes the step of furnishing at least some metallic components made of stainless steel, and wherein the step of joining includes the step of brazing the at least one metal-to-metal interface with a braze alloy heated to a temperature of about 1725° F.

11. The method of claim 10, wherein the step of brazing the metal to metal interfaces further includes the step of furnishing a braze alloy comprising gold, copper, and nickel.

12. The method of claim 10, wherein the step of joining includes the step of brazing the at least one ceramic-to-metal interface with an active braze alloy comprising silver, copper, titanium, and aluminum.

13. A method for preparing a lower vacuum housing of a sensor dewar having an upper vacuum housing and the lower vacuum housing, comprising the steps of:
   furnishing the components of the lower vacuum housing, at least some of the components being ceramic and at least some of the components being metallic;
   assembling the components together so that the assembly includes at least one ceramic-to-metal interface and at least one metal-to-metal interface; and
   joining the assembled components by a single brazing operation.

14. The method of claim 13, wherein the step of forming at least one ceramic-to-metal joint includes the step of providing an active braze alloy containing titanium.

15. The method of claim 13, wherein the step of forming at least one metal-to-metal joint includes the step of providing a non-active braze alloy containing at least 50 percent by weight of a metal selected from the group consisting of copper, silver, and gold.