ALUMINUM ALLOY VACUUM CHAMBER WITH CONFLAT TYPE SEAL TO AN ALUMINUM ALLOY FLANGE FOR ULTRAHIGH VACUUM

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Abstract: A bakeable (continuous a 150°C) aluminum alloy vacuum chamber (6063-T6) which is structurally the same as traditional conflat types flange (2219-T87) and a pure aluminum gasket (1050) have been constructed. A CrN treatment(5μm) on the knife edge and other surfaces of the flange is performed for hardening (100 gr, Hv ∿1800).

A bakeable aluminum alloy vacuum chamber (6063-T6) and bellows (5052) with an aluminum alloy flange (2219-T87) and metal seal (Helicoflex aluminum O-ring) were developed by author.[1-2] This system can withstand many 150 °C bakeouts without leaking. To demonstrate an all aluminum ultrahigh vacuum system to the conservative vacuum engineer a suitable aluminum conflat flange/gasket combination as shown in Fig. 1 had to be designd and fabricated.

The composition of the aluminum flange and metal seal pose a problem since the surface hardness and the mechanical strength at bakeout temperatures are insufficient in ordinary aluminum alloys. However, a special aluminum alloy 2219-T87 has been found to be have the nesessary mechanical properties. The mechanical properties of 2219-T87 hold up to 200°C. In practice the bakeout temperature is limited to approximately 170°C by the aluminum alloy extruded pipe (6063-T6). A CrN coating by the ion-plating method was carried out on the aluminum alloy surface of the conflat flange. The thickness of the CrN layer was about 5 μm. The surface hardness of the CrN was very high and its micro-Vicker's (100 gr) was about 1800. The CrN treatment on the flange gave nearly perfect protection against bonding between the knife edge of the aluminum alloy flange and the pure aluminum gasket, and other surface scratching. The CrN treatment has no problem for surface outgassing in ultrahigh vacuum. A CrN coated conflat flange looks like a stainless steel conflat flange. The aluminum alloy vacuum chamber and the flange were welded by alternating current (50 Hz) TIG process using an aluminum alloy filler wire (4043). The necessary lathe processing of the CrN coated aluminum flange was performed before welding. Distortion after welding was negligible and remachining was not necessary. Separation between CrN film and the aluminum alloy flange and decrease of the surface hardness of the knife edge could not detected after welding. The pure aluminum gasket (1050) is used for sealing. The dimensions of the aluminum gasket are same as ordinary oxygen free copper gaskets. The sealing characteristics of this system are the same as for the ordinary conflat system. A torque wrench (∿150 kg-cm) is required for tightening the flanges.

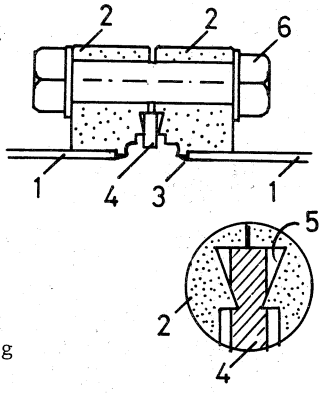

Fig.1 ICF structure conflat type aluminum alloy vacuum flange with metal seal. 1.aluminum alloy pipe (6063-T6), 2. aluminum alloy flange (2219-T87), 3.AC-TIG weld, 4.pure aluminum gasket (1050), 5.CrN treatment, 6.anodized aluminum alloy bolt (2024-T4), nut (6063-T6) and washer (5052).

Vacuum testing was carried out for ICF-70,ICF-114, ICF-152 and ICF-203 as shown in Fig. 2. The following cleaning procedure was adopted: degreasing in

toluen and an ethylalcohol rinse both at room temperature. Leak testing was carried out during repeated cycling from room temperature to 150°C. The leak rate of the flange and metal seal combination was measured with helium leak detector and found to be less than 10^{-11} atm $cm^3 sec^{-1}$. Mass spectrum are shown in Fig. 3.

Such a system can withstand many 150°C bakeouts and repeated opening and closing without leaking. The deformation of the knife edge of the aluminum alloy flange was negligibly small after 10 opening and closing cycles and 150°C 24 hours bakeouts. An aluminum gasket can replace the aluminum Helicoflex O-ring for this conflat system. An aluminum alloy conflat system or the aluminum alloy and the stainless steel conflat mixed system can replace the ordinary stainless steel conflat system. Thus a complete aluminum vacuum system for ultrahigh vacuum operation and is resistent to hard radiation.

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References

1. H.Ishimaru, J. Vac. Sci. Technol., 15(6), Nov./Dec., 1978, 1853.
2. H.Ishimaru at al, IEEE Trans. Nucl. Sci., NS-26, No.3, 1979, 4000.

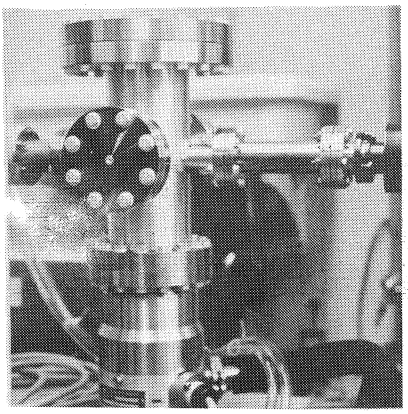

Fig. 2 Test vacuum chamber, 150 ℓ/sec turbomolecular pump and quadrupole mass filter. Outgassing rate after 72 hours without baking is approximately 2×10^{-10} Torrℓ/sec cm^2.

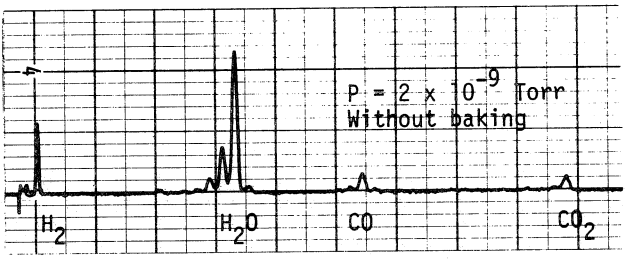

Fig. 3.a Mass spectra at the pressure of 2×10^{-9} Torr without baking.

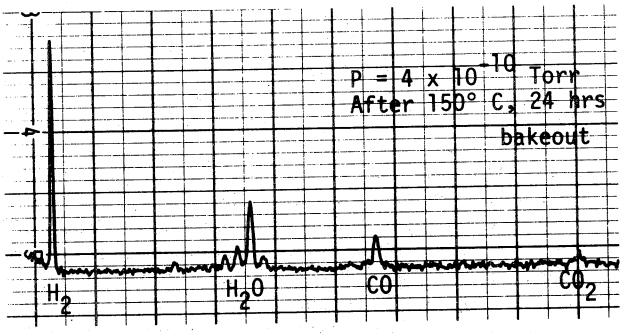

Fig. 3.b Mass spectra at the pressure of 4×10^{-10} Torr after 150°C, 24 hours baking.