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Intense pulsed plasma beams in ceramic/metal brazing

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Obtaining a strong braze joint of ceramic-metal components requires adoption of means that induce wetting either by use of brazes that react chemically with the ceramics or by use of a coating that changes basic chemistry of the ceramics prior to brazing. Metallic coatings are usually fabricated by the PVD, CVD or powder technology. Recently, some novel approaches utilizing ion beam techniques to brazing alumina with metals were presented [2, 3]. In the first case [2] the reactive element (titanium) was implanted directly into alumina to assure its wetting by conventional copper-silver braze. In another case [3] wettability by the copper-silver alloy was achieved by formation of a multi-layer (Al-Ni-Mo) metallization on the alumina surface using ion beam assisted deposition technique. In this letter we report the first results of yet another approach. The key concept relies upon treating ceramic surfaces either by high intensity pulsed plasma beam (HIPPB) to deposit titanium layer about 0.1 μm thick (treatment type 1) or the HIPPB combined with the conventional Arc PVD technique to deposit Ti sublayer and TiN layer (about 2 μm thick) on top of the surface (treatment type 2). In the latter case both HIPPIB and PVD sources operate sequentially in the same working chamber without breaking vacuum.

The HIPPIB treatment was conducted in the mode referred to as Deposition by Pulse Erosion (DPE) [1]. Briefly, in this technique the portion of working gas (nitrogen) is injected into the inter-electrode space. The electrode system consists of two sets of coaxial rod-type Ti electrodes. After an electronically controlled delay a high voltage is applied to the electrodes. Glow discharge produces a pulse of plasma of the working gas. The pulse duration is about 1 μs and its energy density – about 5 J/cm^2. The discharge results also in evaporation of some amount of the electrode material. The DPE process proceeds as follows. At first, the plasma pulse melts the near surface layer of the substrate with the melt duration of a couple of μs and the depth of 0.1–2.0 μm. When the surface becomes re-solidified (after few μs) the metal vapor (Ti) reaches the substrate and forms a layer of a few nm thick. The subsequent pulse melts both the metal layer and the substrate surface. In the presented experiments 2, 5, and 10 pulses were applied. In the Ti-Al_2O_3 system, effective long-range mixing between metal and substrate took place (up to 1 μm) [1].

The experiments were conducted in the full cycle of assembling commercial diode housing shown in Fig. 1. The ceramic element

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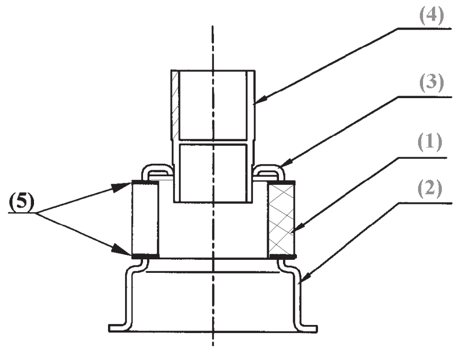

Fig. 1. Layout of housing assembly of the OD06 diode. (1): Al_2O_3 element; (2), (3), and (4): copper elements; (5): brazed joint.

of the housing was an Al_2O_3 cylinder of outer diameter 25 mm, inner one 15 mm, and a height of 15 mm. Both flat surfaces of the cylinder were brazed with the copper element after preparation according to treatment 1 or 2. Since the surfaces were non-wettable by non-reactive Cu-Ag alloy, the reactive braze AgCu19.5Ti3In5 (commercial Deguss symbol CB1) was used. After completing the brazing procedure in the thermal cycle pertinent to the CB1 braze, two parameters of the joints were tested: vacuum tightness and ultimate tensile strength (UTS). All the obtained joints (8 of type 1 and 25 of type 2) passed the routine vacuum seal tests, i.e. the leak rate did not exceed 1.33×10^{-6} mbar l/s. Mean values of UTS amounted to 82.5 and 95.6 MPa for type 1 and 2, respectively. These values are to be compared to the UTS values of 90 MPa obtained in conventional powder process of preparation of alumina surfaces for brazing and 76 MPa for joints obtained with CB1 filler without any preparation of the ceramic surface. The value 76 MPa is too low to pass the production requirements. It is clear therefore that HIPPB may be a competitive method of preparation of alumina surfaces as compared to the conventional multi-step technologies. Further experiments on HIPPB treatment aimed at achieving good wetting of alumina with non-reactive brazes are in progress.

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