A.15: Study on brazing of high purity alumina for fabrication of long ceramic chambers

High purity alumina (Al_2O_3), being a ultra high vacuum (UHV) compatible material with high electrical resistivity, reasonably good tensile & flexural strengths, low specific out gassing rate and high radiation resistance, is a potential candidate material of construction for UHV chambers for rapidly varying magnetic field of the bending and focusing magnets of rapid cycle proton synchrotron machine. Manufacturing of large alumina UHV chambers for proton synchrotron machine requires brazing of multiple standard alumina tube segments, as long alumina tubes are not commercially available. For reliable service of UHV chambers, Al_2O_3-Al_2O_3 brazed joints need to be UHV-compatible, hermetically sealed (permissible helium leak rate 2×10^{-10} mbar.l/s), bakeable upto 423 K with tensile strength higher than 50 MPa.

Vacuum brazing is widely recognized as a suitable joining process for application in UHV systems. Conventional route to produce wettable surface on alumina part, a pre-requisite for obtaining satisfactory brazed joint, is a three-step Mo-Mn metallization process. A simple and cost effective alternative to metallization route is a single-step active brazing process. Active brazing alloys contain small quantity of a highly reactive element like Ti or Zr, which reacts with alumina during brazing to form a thin wettable metallic surface. The present study had been undertaken with an objective to compare the above two brazing routes to obtain helium leak tight, bakeable and reasonably strong brazed joints of high purity alumina suitable for application in UHV.

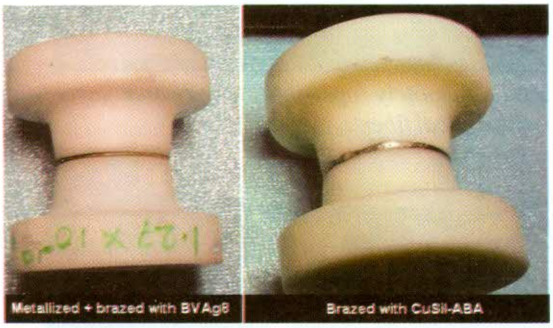

Fig. A.15.1: Vacuum brazed alumina specimens

The study involved vacuum brazing of (i) metallized high purity Al_2O_3 parts (through Mo-Mn route) with BVAg8 braze filler and (ii) high purity Al_2O_3 parts with CuSil-ABA® active brazing alloy. Both the brazing routes yielded leak tight joints (Fig. A.15.1) with helium leak rate less than 2×10^{-10} mbar.lit/sec. Helium leak tightness of the brazed joint remained intact even after undergoing 8 numbers of baking cycles, thereby establishing bakeability of the brazed joints. Both kinds of brazed specimens displayed sound joints across the thickness of the specimens (Fig. A.15.2). Active-brazed specimens exhibited satisfactory tensile and flexural strength values (Table: A.15.1), with fracture occurring close to braze/alumina interface. On the other hand, brazed joints made between metalized alumina parts, displayed relatively lower tensile strength than the targeted value (50 MPa) but satisfactory flexural strength in four-point bend test (Table: A.15.1). In these specimens, metallized layer and its interface with alumina substrate were potential sites for fracture initiation.

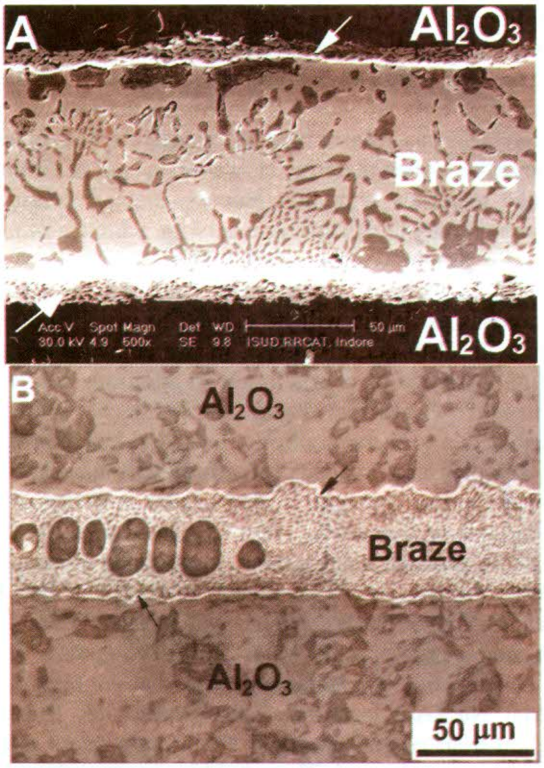

Fig.A.15.2: Cross-sections of vacuum brazed alumina specimens, prepared through (A) metallization and (B) active brazing routes. Arrows mark metalized layer on the surface of alumina parts.

Table: A.15.1: Mechanical strength of brazed joints

Brazing route	Tensile strength	Flexural strength
Metallization	35 MPa	149 MPa
Active brazing	62 MPa	110 MPa

The results of the study demonstrate that active brazing is a simple and economical route to produce UHV-compatible, hermetically sealed, bakeable and strong brazed joint to meet the design requirement for application in rapid cycle proton synchrotron machine.

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