Journal of Medical Implants & Surgery

Losic, J Med Imp Surg 2022, 7:3

Commentary Open Access

Mechanical Properties of Titanium Brazed Joints for Medical Implants

Dusan Losic*

The University of Adelaide, Engineering North Building, Adelaide, SA, Australia

Medical titanium and alumina (Al_2O_3) bio ceramic are widely utilized as biomaterials. A reliable brazed joint of titanium and alumina was successfully obtained using biocompatible Au foil for implantable devices within the present study. The interfacial microstructure and reaction products of titanium/Au/Al_2O_3 joints brazed under different conditions were investigated by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and X-ray diffraction (XRD). In this study, the standard interfacial microstructure of the titanium/Au/Al_2O_3 joint was titanium/Ti_3Au layer/TiAu layer/$TiAu_2$ layer/$TiAu_4$ layer/Au + granular $TiAu_4$ layer/TiOx phase/Al_2O_3 ceramic. With increasing brazing temperature or holding time, the thicknesses of Ti_3Au + TiAu + $TiAu_2$ layers adjacent to the titanium substrate increased gradually. Shear tests indicated that the joint brazed at 1115°C for 3 min exhibited the very best shear strength of 39.2 MPa. Typical fracture analysis displayed that the crack started at the Al_2O_3 ceramic and propagated along the interface of $TiAu_2$ and $TiAu_4$ reaction layers [1].

Titanium and its alloys are intensively investigated and applied for biomedical applications due to their excellent biocompatibilities, mechanical properties, and corrosion resistances. Applications have included dental implants, craniomaxillofacial implants, implants for implant replacement and spinal components, internal fixation plates and screws, and housings for ventricular-assist devices and pacemaker cases. Alumina, a ceramic with outstanding physical, chemical, and mechanical performances, has attracted great interest in industrial applications like biomaterials, aerospace, atomic power, automobiles, and electronics. With excellent advantages in chemical stability, wear resistance, and biocompatibility, alumina has been a preferable orthopedic implant material used in dental and bone replacements as well as coatings for metallic materials. Utilization of metal–ceramic composites for biomedical applications, including implantable pacemakers, retinal implants, and micro stimulators, has dramatically increased in recent years. To extend the sensible utilization of metal–ceramic composite components, biocompatible metal–ceramic joints are desirable for implantable medical devices.

Nevertheless, ceramic–metal joints with sufficient mechanical integrity are difficult to realize due to the massive differences in physical and mechanical properties between ceramics and metals like coefficient of thermal expansion (CTE), chemical composition, and modulus of elasticity (MOE). In the brazing of ceramics to metals, a main problem that must be solved is that the poor wettability of liquid brazing alloy on ceramics. Active brazing may be a promising approach that introduces active elements like Ti, Zr, Ni, or V into brazing alloys, which significantly enhances wettability and spreading of liquid metal on ceramics by metallurgical bonding [2, 3].

Ti may be a typical active element that promotes wetting and adhesion. The interfacial reactions on the metal/alumina interface are investigated using various Ti-containing metal alloys like CuAg-Ti/alumina, AgCu-Ti/alumina, CuSn-Ti/alumina, NiPd-Ti/alumina, SnAgCu-Ti/alumina, and NiTiZr/alumina. Voinovich identified the existence of M6X-type compounds and titanium oxides (TiOx on a metal/Al_2O_3 ceramic interface) whose chemical compositions were believed to be greatly dependent on the activity of Ti. Decrease in the activity of Ti in the system leads to the formation of titanium oxides with higher oxidation on the interface, resulting in a higher final contact angle. Similar conclusions were after studying a NiPd-Ti/alumina system.

It has been widely reported that alumina could be brazed to different metals with Ti-containing filler alloys. The types of titanium oxides that form in an Al_2O_3/Kovar joint using Ag-Pd/Ti filler are found to be suffering from the thickness of the Ti layer, and therefore the joint strengths are influenced by the thicknesses of the reaction layer and residual Ti layer. Investigated the reaction products on the Ti film/Al_2O_3 interface for an Al_2O_3/Kovar joint and suggested that a competitive reaction mechanism existed in the system. At temperatures lower than 1057°C, Ti reacts with Al from the decomposition of Al_2O_3, resulting in the formation of Ti_3Al. As the reaction proceeds, TiO precipitates out from a Ti primary solid solution because the O concentration rises above the solubility in Ti and Ti_3Al. For test temperatures above 1057°C, Ti directly reacts with O from Al_2O_3 to get TiO and Ti_3Al. Simultaneously, the sort of Ti oxide depends on the activity of Ti within the reaction layer, which might be decreased by the interaction between Ti and Ni from Kovar substrate to make Ni3Ti, leading to a shift of reaction product from TiO to Ti_2O_3 or Ti_3O_5 [4]. This is also observed by other investigations.

The other challenge in brazing ceramics to metals is that the thermal stress generated on the metal–ceramic interface resulting from CTE mismatch between them because the joint cools to temperature. The addition of pure gold, which is biocompatible, is desired because it can release thermal stresses by plastic deformation.

In this study, reliable brazing of Al_2O_3 ceramic to medical titanium alloy was achieved using pure gold foil. Detailed investigations on the consequences of brazing temperature and dwelling time on microstructure evolution and mechanical properties were conducted. Mechanical properties were analyzed from micro hardness data for various phases also as shear strength of the joints.

The typical interfacial microstructure of the titanium/Au/Al_2O_3 joint was titanium/Ti_3Au layer/TiAu layer/$TiAu_2$ layer/$TiAu_4$ layer/Au + granular $TiAu_4$ layer/TiOx phase/Al_2O_3 ceramic.

Shear tests indicated that the joint brazed at 1115°C for 3 min exhibited the very best shear strength of 39.2 MPa. Typical fracture analysis displayed that the crack started at the Al_2O_3 ceramic and

***Corresponding author:** Dusan Losic, The University of Adelaide, Engineering North Building, Adelaide, SA, And Australia, Tel no.: 61 249 878 937, E-mail: dusan.losic@adelaide.edu.au

Received: 03-May-2022, Manuscript No. jmis-22-62643; **Editor assigned:** 05-May-2022, PreQC No. jmis-22-62643 (PQ); **Reviewed:** 21-May-2022, QC No. jmis-22-62643; **Revised:** 27-May-2022, Manuscript No. jmis-22-62643 (R); **Published:** 31-May-2022, DOI: 10.4172/jmis.1000133

Citation: Losic D (2022) Mechanical Properties of Titanium Brazed Joints for Medical Implants. J Med Imp Surg 7: 133.

propagated along the interface of $TiAu_2$ and $TiAu_4$ reaction layers [5].

Acknowledgement

None

Conflict of Interest

None

References

1. Geetha M, Singh A, Asokamani R, Gogia A (2009) Ti based biomaterials, the ultimate choice for orthopedic implants-A review. Prog Mater Sci 54: 397-425.
2. Li L-H, Kong Y-M, Kim H-W, Kim Y-W, Kim H-E, et al. (2004) Improved biological performance of Ti implants due to surface modification by micro-arc oxidation. Biomaterials 25: 2867-2875.
3. Symietz C, Lehmann E, Gildenhaar R, Krüger J, Berger G (2010) Femtosecond laser induced fixation of calcium alkali phosphate ceramics on titanium alloy bone implant material. Acta Biomater 6: 3318-3324.
4. Shukla A, Balasubramaniam R, Shukla A (2006) Effect of surface treatment on electrochemical behavior of CP Ti, Ti-6Al-4V and Ti-13Nb-13 Zr alloys in simulated human body fluid. Corros Sci 48: 1696-1720.
5. Ozdemir Z, Ozdemir A, Basim G (2016) Application of chemical mechanical polishing process on titanium based implants. Mater Sci Eng C 68: 383-396.