Abstract

Ceramic matrix composites (CMC) are gaining attention due to their low density and high thermomechanical properties, which make them prominent material in aircraft turbine engines, rocket propulsion components and thermal protection systems. For these applications, high temperature oxidation resistance might be an issue for carbon and silicon carbide based CMC. Oxide fiber /oxide matrix composites (ox/ox CMC), composed of oxide based fibers and matrixes are inherently oxidation resistant, they have high thermomechanical properties, simple fabrication techniques and are generally less expensive than non-oxide CMC. Ox/ox CMC are nowadays potential candidates to replace nickel based super alloys .

However, CMC components have very often complex shapes and it is technologically more convenient and cheaper to fabricate simple shapes and then integrate them together into final components by using robust and reliable joining materials and methods. Of course, the joining materials must withstand the working conditions.

Brazing is a simple and cheap technique for joining ceramics and ceramic matrix composites. Silver based (AgCuSnTi) and zirconium based (ZrNiTiHf) brazing alloys were initially selected to join ox/ox CMC (Nextel^{TM} 610 fiber reinforced YAG-zirconia matrix) and a new brazing system based on Ti, Cu and Al was designed by using metallic interlayer approach.

Glasses and glass-ceramics are well known joining materials used for variety of technical applications. They have good thermo-mechanical properties, intrinsically high oxidation resistance and their properties can be tailored according to the final requirement. They are already used as joining materials, for high temperature components, such as, solid oxide fuel cells.

Nextel^{TM} 610/ YAG-zirconia and Nextel^{TM} 610/alumina-zirconia ox/ox CMC were joined and characterized using novel SiO_2-Al_2O_3-CaO-MgO and SiO_2-Al_2O_3-CaO-MgO-Y_2O_3-ZrO_2 based glass-ceramics. The joining was performed in air without applying any pressure. The coefficient of thermal expansion of each glass-ceramic was tailored and measured by using dilatometry. Their crystallization behaviour was studied by differential thermal analysis and their sintering by hot stage microscopy. Matusita, Sakka and Ozawa equations were used to study the crystallization kinetic behavior of developed glasses.

The joints were analysed by using Field Emission Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy. The phases formed in glass-ceramic joints were identified by X-Ray Diffraction.

To evaluate the mechanical strength of joined samples, Single Lap Off-set shear tests (SLO) and four-point bending tests were performed at room temperature and at 850 °C (850 °C tests at IKTS-Fraunhofer, Dresden, Germany). The bending strength of as-received and thermally treated composites (by the same thermal treatment as for joining) were also performed to evaluate the effect of joining conditions on composites strength.

The thermal stability of the joined samples was also studied by thermal ageing to 850 °C and 930 °C for 100 h and 50 h in air, respectively.

The mechanical and ageing test results showed that the novel glass-ceramics developed within this PhD thesis (SiO_2-Al_2O_3-CaO-MgO and SiO_2-Al_2O_3-CaO-MgO-Y_2O_3-ZrO_2) are promising materials for joining Nextel^{TM} 610/ YAG-zirconia and Nextel^{TM} 610/alumina-zirconia, respectively.