MICROSTRUCTURE, MECHANICAL AND FUNCTIONAL PROPERTIES 
AND CREEP BEHAVIOR OF HOT PRESSED $\text{Al}_2\text{O}_3$/SiC 
MICRO/NANO COMPOSITES

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In comparison to the monolithic alumina ceramics the $\text{Al}_2\text{O}_3$/SiC micro/nano composites are known to exhibit improved mechanical and functional properties and higher creep resistance. In this work the $\text{Al}_2\text{O}_3$/SiC micro/nano composites were fabricated by hot pressing for 1h at 1740 °C and 30 MPa in the atmosphere of Ar. Various aspects of the hot pressed composites, including starting materials, microstructure, mechanical properties (hardness, fracture toughness, flexural strength), functional properties (thermal and electrical conductivity) and creep behavior were studied. Two different SiC powders (with the mean size of the SiC particles 200 nm (denoted as micro), and 50 nm (denoted as nano)) were used as the raw materials, together with the high purity $\text{Al}_2\text{O}_3$ powder with mean particle size of 150 nm. Different compositions (the addition of SiC in the range of 3 – 20 vol.%) were prepared and the properties of the composites were compared to the monolithic $\text{Al}_2\text{O}_3$ reference. The X-ray powder diffraction, before and after sintering, detected $\alpha$-$\text{Al}_2\text{O}_3$ and $\beta$-$\text{SiC}$ as the only crystalline phases presented. This is an important observation, because the persistence of the SiC phase in the final composite is prerequisite for the improvement of the mechanical and functional properties, and higher creep resistance of the $\text{Al}_2\text{O}_3$/SiC micro/nano composite. Significant attention was paid to investigation of the influence of the size of SiC nanoparticles (micro vs. nano) on the properties of composites prepared under identical conditions and containing equivalent volume fractions of the SiC particles. The flexural strength increased with increasing volume fraction of silicon carbide particles. The maximum flexural strength (655 ± 90 MPa) was achieved for the composite containing 20 vol.% of micro SiC, which is more than twice as high as in the $\text{Al}_2\text{O}_3$ reference. Vickers hardness improved moderately, but the fracture toughness was lower when compared to the monolithic $\text{Al}_2\text{O}_3$. The observed improvement of mechanical properties (hardness, fracture strength) was mainly attributed to refinement of the alumina matrix, grain boundary reinforcement, and the related change of fracture mode from intergranular in the alumina reference to transgranular in the composites. The scanning electron microscopy observations confirmed that the fracture mode changed from intergranular in the alumina
reference, to transgranular in the composites. The creep behavior at temperatures up to 1350 °C, and mechanical load of 200 MPa of the composites was also studied, and compared to the monolithic Al₂O₃ reference. The studied parameters include volume fraction, size, distribution of SiC particles, and the presence/absence of silica as the result of surface oxidation of SiC. To elucidate the influence of silica, which is always present in the form of oxide layer at the surface of SiC particles, on creep resistance, the composites were also prepared from the SiC powder washed in HF in order to remove SiO₂. The Al₂O₃/SiC nanocomposites with 5 vol.% of SiO₂-free SiC, and with deliberate addition of 0.5; 1 and 5 wt.% of SiO₂ were also prepared. Tetraethylortosilicate was used as the source of SiO₂. However, the expected positive effect of SiO₂ removal on creep resistance of the composites was not confirmed. In the Al₂O₃/SiC nanocomposites the creep rate was influenced by the volume fraction of SiC particles and the size of alumina matrix grains. The creep resistance of Al₂O₃/SiC composites was significantly higher when compared to the creep resistance of the monolithic Al₂O₃. Particularly, the Al₂O₃/SiC nanocomposite with 10 vol.% of micro-SiC exhibited excellent creep resistance. The material was able to withstand the stress of 200 MPa at 1350 °C and 1400 °C for 150 h, while the monolithic Al₂O₃ reference failed already after 0.8 h at 75 MPa and 1350 °C. Long loading time before mechanical failure suggests diffusion controlled creep behavior. The improvement of the creep resistance was attributed to pinning effect of the SiC particles at grain boundaries, which inhibited grain boundary sliding, and reduced the creep strain rate. Thermal and electrical conductivity were also modified in the composites, and increased with increasing volume fraction of silicon carbide.

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