論 文 内 容 の 要 旨

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Aim of the present dissertation is to develop the self-healing function of ceramic-based composites for high-temperature applications such as gas turbine engines or jet engines. Engineering ceramics have many excellent properties that are suitable for high-temperatures applications. Unfortunately, applications of ceramics must face huge challenges on their brittle property due to the covalent and ionic bonds. Over the last few decades, many studies have been conducted to fabricate ceramic-based composites incorporated with non-oxide phases for toughening the ceramics. The recent interests on ceramic-based composites are the self-healing functions induced by the oxidation of non-oxide phases at high temperatures. Oxidation of the non-oxide phases develops oxidation products which fill up surface cracks. This effect causes the reduction of stress concentrations at crack tips and consequently involves in strength recovery. The mechanism of self-healing function is attributed to the volume expansion and/or the diffusion of cations caused by oxidation of non-oxide phases within the matrices. From this inspiration, self-healing functions of Ni/Al_2O_3, Ni/(ZrO_2+Al_2O_3) and Ni/mullite nanocomposites are investigated and discussed in this present dissertation. Investigation of self-healing function for each nanocomposite is conducted and discussed via mechanical properties, surface crack-disappearance by thermal oxidation, self-healing-induced strength recovery and oxidation resistance. High-temperature bending tests are applied to estimate the self-healing performance of Ni/Al_2O_3 and Ni(ZrO_2+Al_2O_3) nanocomposites at high temperatures. Influences of Al_2O_3 grain size on self-healing effectiveness as well as oxidation resistance of Ni/Al_2O_3 nanocomposites are discussed from the view point of the oxidation kinetics. Influences of ZrO_2 on self-healing performance of Ni/(ZrO_2+Al_2O_3) nanocomposites are also discussed. Based on the investigations of self-healing function for alumina-based and mullite-based composites, the roles of matrices on self-healing performance are discussed.

Ni/Al_2O_3 nanocomposites exhibit a great self-healing performance at high temperatures caused by the oxidation of Ni particles. Ni/Al_2O_3 nanocomposites could be suitable for the components in hot sections of gas turbine engines. However, high-temperature strength of Ni/Al_2O_3 nanocomposites must be improved. Dispersion of ZrO_2 is one of the solutions for high-temperature strength of Ni/Al_2O_3 nanocomposites. ZrO_2 dispersion does not influence significantly on self-healing performance of Ni/Al_2O_3 nanocomposites. Nevertheless, ZrO_2 accelerates the oxidation rate of the composites. Ni/mullite nanocomposites possess the best self-healing performance among the investigated composites. With a great oxidation resistance and excellent self-healing performance, Ni/mullite nanocomposites are potential for high-temperature applications. For further applications, mechanical properties of Ni/mullite must be improved.