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나노크기 구리입자가 분산된 알루미나 나노복합재료의 제조와 기계적 성질
(Fabrication and Mechanical Properties of Nano-Sized Cu Particulate Dispersed Alumina Nanocomposites)

Synergy Ceramics Lab., FCRA — 오 승 탁 (Sung-Tag Oh)*
National Industrial Research Institute of Nagoya — M. Sando
ISIR, Osaka University — T. Sekino and K. Niihara

1. Introduction

Nanocomposite materials in the form of nano-sized second-phase particles dispersed in a ceramic matrix have been shown to display uniquely enhanced mechanical properties and high possibility for application to functional materials. In spite of this potential, the incorporated second phases have been restricted to that having at least higher melting point than conventional hot-pressing temperature of ceramic matrix. So for a wide application to multicomponent-multiphase system with functional properties, an elaborate approach to microstructure control, especially in the systems appearing the liquid phase of dispersoids during consolidation, is required. In this investigation Al_2O_3 matrix Cu composite was chosen as an experiment system. An optimum route to fabricate the Al_2O_3/Cu nanocomposites with sound microstructure and desired properties is suggested and its relationship is analyzed.

2. Experimental Procedures

Starting mixtures were prepared from the following powders; α- Al_2O_3 (0.2 μm, Sumitomo Chem. Co.) and either 5 vol.% Cu metal powder (1 μm) or CuO powder (1-2 μm) corresponding to 5 vol.% Cu, produced by High Purity Chemetals Lab., Japan. The mixtures were ball-milled in ethanol for 24 h using a polyethylene pot with high purity Al_2O_3 balls. They were reduced by H_2 gas and consecutively hot-pressed at 1400°C to 1600°C for 1h in Ar atmosphere under pressure of 30 MPa. The microstructure was observed by SEM and TEM. Fracture strength and toughness were measured by the 3-point bending test and by the indentation fracture method, respectively.

3. Results and Discussion

Al_2O_3/5 vol.% Cu nanocomposite fabricated by reduction and sintering method using Al_2O_3 and CuO powder mixture showed relative density levels of 99.3 % with marked refinement of the matrix grain size and homogeneous distribution of Cu with average size of 150 nm (Figure). The enhanced fracture toughness and maximum strengthening of 819 MPa, which is much higher than that of Al_2O_3 as 536 MPa, are achieved. The toughness increase is explained by the crack bridging and compressive thermal residual stress. The strengthening is mainly attributed to the toughness improvement and the refinement of matrix grains by the nano-sized Cu dispersion at the grain boundaries.

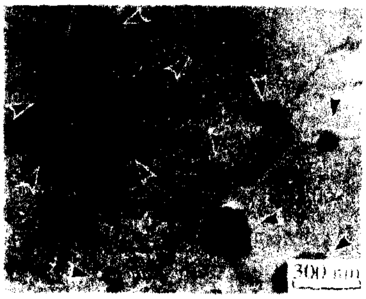

Figure TEM micrograph for Al_2O_3/5% Cu nanocomposite (at 1450°C)

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