

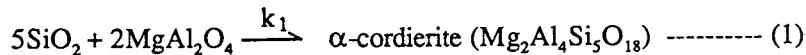
Phase-Formation and Densification Characteristics of Cordierite-ZrO₂ Composites Prepared by a Mixed Sol-Gel Route

(혼합Sol-Gel Route에 의해 제조한 Cordierite-ZrO₂복합체의 상 생성 및 치밀화 특성)

포항공과대학 재료공학과 정밀 세라믹스 공정과학 연구실
장현명, 임병철(현재 삼성 코닝 연구소)

Based on the electrokinetic properties of aqueous silica, boehmite, and ZrO₂ dispersions, cordierite-ZrO₂ composites were fabricated by a mixed colloidal processing route (or nanometer-scale sol mixing route). The average particle sizes of boehmite and ZrO₂ used in this study are 70 and 40 nm, respectively. The incorporation of ZrO₂ in a cordierite matrix suppressed the transformation of tetragonal ZrO₂ to monoclinic phase after a cooling to room temperature.

The formation of detrimental zircon phase in a cordierite matrix was practically avoided by employing a faster heating rate and sintering above a certain critical temperature (~ 1250 °C). To explain this observation, we have considered two relevant reactions involving silica as a reactant based on the phase-formation characteristics of the mixed gel specimens. These are :



where k_1 and k_2 are overall rate constants (including chemical reaction and diffusion) of the above solid-state transformations (1) and (2), respectively. The fact that the amount of zircon phase formed increases significantly when the composite specimen is soaked (below sintering temperature) suggests that the transformations (1) and (2)

compete with each other, but the rate of zircon formation is greater than that of α -cordierite formation below a certain critical temperature. Further analysis of the kinetic data indicated that the transformations (1) and (2) are diffusion-controlled processes rather than interfacial-reaction-controlled processes.

The densification of composite specimens occurred rapidly above 1000 °C and essentially completed before amorphous silica crystallized to quartz. Thus, it can be concluded that the dominant sintering mechanism of the cordierite-ZrO₂ powder compacts fabricated by the mixed colloidal route is a viscous-flow sintering of amorphous silica component when viscosity of the matrix sufficiently reduces to a certain critical value around 1050 °C.

The sintered composite was characterized by a dense and homogeneous microstructure and by a uniform spatial distribution of submicron-sized (0.2 ~ 0.3 μm) tetragonal ZrO₂ particles throughout the matrix. The ZrO₂ particles remained well-dispersed with little agglomeration between them. K_{1C} increased from 2.4 MPa.m^{1/2} for the pure cordierite specimen to 4.3 MPa.m^{1/2} for the ground and annealed composite containing 40 wt% ZrO₂. The enhanced toughening in the presence of ZrO₂ was partly attributed to martensitic t \rightarrow m transformation of the dispersed tetragonal ZrO₂ particles. This conclusion was deduced from the change in the relative phase distribution of ZrO₂ polymorphs before and after the grinding. Besides, crack-deflection mechanism contributed somewhat to the increase in toughening.