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Cobalt incorporation in mullite

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ABSTRACT

Mullite samples doped with cobalt were derived from diphasic gels with constant atomic ratio (Al + Co)/Si = 3:1, where 0, 1, 2, and 3 at% of aluminum was replaced by cobalt. X-ray powder diffraction showed that the samples contained mullite phase and some amount of α-Al_2O_3 (for pure and doped samples) and $CoAl_2O_4$ (for doped samples). Cobalt doping caused an increase in unit-cell parameters of the mullite phase. Transmission electron microscopy and energy dispersive X-ray spectroscopy were used for sample microanalysis and determination of the chemical composition of the Co-doped mullite phase. The Rietveld method was performed for quantitative phase analysis of the samples and for structure refinement of the mullite phase in the samples. It was found that a small amount of Co^{2+}, 0.36 wt%, substituted for Al^{3+} in the AlO_6 octahedra of the mullite structure. Simultaneously, the same amount of tetrahedral Al^{3+} ions was likely substituted by Si^{4+} in the $(Al,Si)O_4$ tetrahedra for the purpose of charge compensation. The remaining cobalt reacted with alumina forming $CoAl_2O_4$, and dissolved in the glassy phase. The proposed formula for Co-doped mullite is $Co_yAl_{4+2x-2y}Si_{2-2x+y}O_{10-x}$.

Keywords: Co-doped mullite, ceramics, X-ray diffraction, Rietveld method, energy dispersive X-ray spectroscopy