Microstructure development and piezoelectric properties of highly textured CuO-doped KNN by templated grain growth

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Source: JOURNAL OF MATERIALS RESEARCH Volume: 25 Issue: 4 Pages: 687-694 Published: APR 2010

Abstract: This paper demonstrates the production of < 001 >-oriented CuO-doped $(K_{0.476}Na_{0.524})NbO_3$ (KNN) piezoelectric ceramics with a polymorphic phase transition (PPT) temperature greater than 180 ºC by templated grain growth (TGG) using high aspect ratio $NaNbO_3$ template particles. A novel (to the KNN system) two-step sintering and annealing process combined with CuO doping is demonstrated to improve density and maximize texture quality (F_{001} = 99% and rocking curve FWHM = 6.9 degrees) in textured KNN ceramics. The best electromechanical properties (k(p) approximate to 0.58, k_{31} ~ 0.33, d_{33} ~ 146 pC/N, T_{o-t} ~ 183 ºC, T_c ~ 415 ºC, ε_r = 202, and tan delta = 0.016) are achieved in 1 mol% CuO-doped KNN with F_{001} = 99% and a relative density of 96.3%. The values of d_{33}, k_p, and k_{31} are 70-90% higher than randomly oriented ceramics and are obtained without a significant reduction in the PPT temperature, resulting in stable piezoelectric performance over a wide temperature range (-50 to 180 ºC). These results show that high-quality textured KNN can be obtained by TGG and that a reactive matrix is unnecessary.