Synthese

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Modellierung

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Synthesis and sintering of lead-free piezoelectric sodium potassium niobate

Piezoelectric materials based on complex lead perovskites such as $Pb(Zr,Ti)O_3$ (PZT) or $Pb(Mg_{0.33}Nb_{0.67})O_3$ –$PbTiO_3$ (PMN-PT) solid solutions have been widely used due to their excellent piezoelectric properties. As a consequence of a stronger environmental consciousness and also more stringent regulations in the last years intensive research has been focused on lead-free piezoelectric materials. The ceramics based on alkaline niobates or niobate tantalates comprise the group of lead-free piezoelectrics which could in some applications replace lead-based materials. The problems related to alkaline niobate based ceramics include solid state synthesis and sintering, control of chemical and phase composition and microstructure.

In the contribution we present the results of our work on the solid state synthesis and sintering of the $K_{0.5}Na_{0.5}NbO_3$. This solid solution has been selected as a model material for more complex, e.g. Li-, Ta-, (and Sb-) modified, compositions with enhanced piezoelectric properties.

Diffusion couples, thermal analysis, chemical and phase composition studies have been implemented to get insight into the solid-state synthesis pathway. The synthesis of alkali niobates occurs via coupled diffusion of alkali and oxygen ions into the niobia. The first reaction products are not perovskites but polyniobate phases with different alkali/niobium ratios and crystal structures for individual alkalines. Different diffusion rates of sodium and potassium ions may lead to local inhomogeneities in the solid solution. Possible approaches to overcome problems in processing are discussed.

Solid state sintering of $K_{0.5}Na_{0.5}NbO_3$ powder compacts occurs in a narrow temperature range close to the solidus line at 1140°C and most often results in a bimodal microstructure. Two approaches to control the microstructure of $K_{0.5}Na_{0.5}NbO_3$ are discussed. The grain growth of $K_{0.5}Na_{0.5}NbO_3$ could be hindered by the addition of a small amount of ZrO_2 inclusions, which on one hand occupy grain junctions, but also enrich the grain boundary regions relative to grain interiors, and therefore decrease via both mechanisms the matrix grain-boundary mobility. Sodium potassium germanate with the melting point at about 720°C has been introduced as a liquid-phase sintering aid. The alkali-germanate-modified ceramics could be sintered to high density (95.6 % TD) at as low as 1000°C, which is more than 100°C lower than usually required for solid state sintering, and still keep piezoelectric properties comparable to the best values obtained for $K_{0.5}Na_{0.5}NbO_3$ ceramics sintered in solid state.

Die Vortrag findet um **16:15** im Gebäude der Materialwissenschaften, Lichtwiese, Petersenstr. 23, **Raum 77** statt