The kinetics of the cubic-to-tetragonal transformation in $Bi_{3-y}Nb_{1+y}O_{7+y}$ dielectrics

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Interesting dielectric properties in the Bi_2O_3–Nb_2O_5 system were observed for the tetragonal $Bi_{3-y}Nb_{1+y}O_{7+y}$ ($-0.2 < y < 0.04$) solid solutions. Within this range the dielectric constant is constant at approximately 90, the temperature coefficient of resonant frequency is 110 ppm/K and the dielectric losses continuously decrease with the increasing Nb_2O_5 concentration. These dielectric characteristics, together with suitable sintering behaviour and chemical compatibility with silver, suggest the applicability of $Bi_{3-y}Nb_{1+y}O_{7+y}$ for technology. To avoid an irreproducibility of tetragonal phase formation and to understand the conditions for its synthesis, we decided to study the kinetics of the cubic-to-tetragonal transformation. From the analysis of the XRD pattern, the temperature stability of the tetragonal phase was determined. The temperature stability was found to increase with increasing Nb_2O_5 concentration. The stability of the tetragonal phase with the composition 21 mol% Nb_2O_5 is up to 800°C, whereas the composition with 26 mol% Nb_2O_5 is stable up to 930 °C. When the solid solutions are synthesized the cubic phase is formed first, even under conditions where the tetragonal phase is thermodynamically stable. If the correct temperatures and times of annealing are used the cubic-tetragonal transformation occurs.

The kinetics of this transformation was estimated from XRD patterns as a function of the annealing times and temperatures. We have observed the occurrence of a temperature-dependent induction time, which is characteristic of homogeneous nucleation. The next step of the transformation is the thermally activated growth of the crystal, which we additionally observed in-situ in the transmission electron microscope. With this study we managed to determine the conditions of a heat treatment that enables controlled and optimised synthesis and processing of tetragonal $Bi_{3-y}Nb_{1+y}O_{7+y}$ dielectrics.