Dielectric properties of lead-free ceramics with perovskite structure

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Abstract

The aim of the work was searching for new lead-free high permittivity materials of perovskite structure. Four compounds with compositions analogous to relaxor ferroelectrics - $Bi_{1/2}Cu_{1/2}(Fe_{2/3}W_{1/3})O_3$ (BCFW), $Bi_{1/2}Cu_{1/2}(Fe_{1/2}Ta_{1/2})O_3$ (BCFT), $Bi_{1/2}Cu_{1/2}(Zn_{1/3}Nb_{2/3})O_3$ (BCZN), and $Bi_{1/2}Cu_{1/2}(Mg_{1/3}Nb_{2/3})O_3$ (BCMN), in which lead was substituted by bismuth and copper, were synthesized. Phase composition of the synthesized powders was detected by X-ray diffraction analysis. The ceramic pellets were sintered at temperatures 870 - 1050°C. Capacitance and dissipation factor of the specimens were measured in the temperature range from –55 to 400°C at frequencies 10 Hz – 1 MHz. Resistivity of the ceramics was investigated as a function of temperature in the range 20 - 500°C. Microstructure and chemical composition of the samples were studied using scanning electron microscopy and X-ray microanalysis. As a result of the sintering of all synthesized materials dense ceramics were obtained. BCFW, BCFT and BCZN specimens showed a broad maximum in dielectric permittivity versus temperature plots and a distinct dependence of dielectric properties on frequency. The maximum relative permittivity of these materials was very high (30000 - 40000 at 1 kHz). Maxwell-Wagner polarization is supposed to be responsible for these values. The dielectric permittivity for BCMN ceramics was found to be much lower (1000 at 1 kHz). Some maxima in dissipation factor versus temperature plots were also observed, shifting towards higher temperatures with increasing frequency. Relaxation times corresponding to the peak frequencies obeyed well Arrhenius law.