Relaxor-like dielectric properties and history dependent effects in a new lead-free (K,Na)NbO_3-$SrTiO_3$ ceramic system

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The dynamic processes in a newly synthesized, environmental friendly (K,Na)NbO_3-$SrTiO_3$ lead-free ceramics have been studied by measurements of the temperature and frequency-dependent linear (ε_1) and third-order nonlinear (ε_3) dielectric constants. Typical relaxor-like properties have been observed: broad dispersive dielectric maximum, rapidly increasing polydispersivity of the relaxation spectrum on cooling, Vogel-Fulcher temperature dependence of the characteristic relaxation frequency, and paraelectric-to-glass crossover in the temperature dependence of the dielectric nonlinearity $a_3 = \varepsilon_3 / \varepsilon_0^3 \varepsilon_1^4$.

Disorder enforced to the ferroelectric (K,Na)NbO_3 system by the admixture of $SrTiO_3$ therefore results in the formation of nanosized polar clusters rather than in macrodomain state. The absence of long-range order has been confirmed by polarization vs. electric field measurements – a slim hysteresis loop, typical for relaxors, has been detected. Furthermore, the influence of the composition on dielectric properties suggests that, on higher $SrTiO_3$ content, increasing disorder results in decreasing of the average polar clusters' relaxation time.

In addition, (K,Na)NbO_3-$SrTiO_3$ ceramics seems to be very promising for various applications – not only are relatively large values of the linear dielectric constant almost independent of the frequency in the range of 100 Hz-1 MHz, but the history dependent effects, such as aging of the dielectric constant and fatigue of the polarization switching, are in this lead-free system much weaker than in some widely used lead-based relaxor ceramics.