Electrocaloric effect in barium titanate based ceramics and single crystals

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Last years the electrocaloric effect (ECE), that is an adiabatic change of temperature of a dielectric material under an applied (removed) electric field, has attracted a significant attention opening possibilities for developing compact solid-state environmentally-friendly cooling devices [1]. Of particular interest are materials showing large ECE close to room temperature. Among them are solid solutions based on BaTiO3. In these environmentally friendly compounds substitution in either A- or B-site of perovskite lattice allows to tune the ferroelectric-paraelectric phase transition, where the maximal ECE occurs. In spite of intensive studies, there is still a lack of direct measurements of the ECE.

We performed direct measurements of the ECE in BaTiO3 single crystals [1], Ba(Ti1-xSnx)O3 (BTSn) [2], and Ba(Ti1-xZrx)O3 (BTZr) ceramics using both a modified differential scanning calorimeter and a specially built quasi-adiabatic calorimeter. In the single crystals we investigated anisotropy of the ECE. We showed that the value of the ECE depends on the direction of the applied electric field. Moreover, for the orthorhombic-tetragonal phase transition the electric field applied along [001]c direction results in the inverse ECE [1].

For the BTSn and BTZr ceramics substitution of Ti by Sn or Zr results in a merger of different ferroelectric phases of parent BaTiO3 at x ~ 0.10. The corresponding compositions show the largest ECE. On further reducing of the Ti content a cross-over to relaxor behavior occurs. On the one hand, it is accompanied by decreasing of the maximal ECE value. On the other hand, the peak of the ECE broadens and a large ECE is observed in a broad temperature range. Results of the direct measurements are compared with the indirect estimation of the ECE from temperature dependences of polarization. The discrepancy between the results of the two methods is discussed.

References

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