(Pb, La) (Zr, Ti) O_3 セラミックスの正と負の電気熱量効果

Positive and Negative Electrocaloric Effects in (Pb,La)(Zr,Ti)O_3 Ceramics

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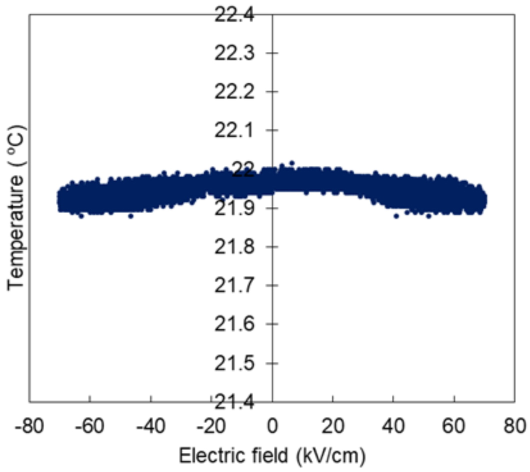
Electrocaloric effect (ECE) has recently been attracting attention due to the possible application alternative to the vapor-cycle cooling refrigeration. Usually, external field application orders the electric dipoles and reduces corresponding entropy. Subsequent depolarization randomizes the dipoles and causes an increase of entropy, leading to cool the materials adiabatically. However, recently, unusual "negative" electrocaloric effects have been reported. In this case, the materials cool under electric field and they warm by the field removal. Anti-ferroelectric materials are expected to exhibit negative ECE under low field and large normal (positive) ECE accompanying electric field induced phase transition under high filed.

In this work, (Pb,La)(Zr,Ti)O_3 (PLZT) ceramics were fabricated by solid state reaction. The dielectric, electromechanical and electrocaloric properties are evaluated. The electrocaloric properties of PLZT(4/90/10), (8/80/20) and (8/70/30) ceramics were investigated by indirect estimation and direct measurement of temperature–electric field (T–E) hysteresis loops. PLZT(4/90/10) ceramics exhibited double hysteresis peculiar to antiferroelectrics in P-E loop. Temperature drop of -0.07K due to application of electric field of 70kV/cm are observed directly by measurement of T-E loop. This is due to negative electrocaloric effect. PLZT(8/80/20) and (8/70/30) ceramics exhibited slim P–E loops slim with constriction due to the double hysteresis and the typical ferroelectric loops, respectively. The temperature change induced by a bipolar switching field of 40 kV/cm in the PLZT(8/80/20) and PLZT(8/70/30) ceramics were both positive values of 0.22 K. Looking carefully at this loop, it can be seen that the temperature decreases from zero to the coercive field as the electric field is applied. The negative electric calorific effect below this coercive field is also studied including the stability of operation.



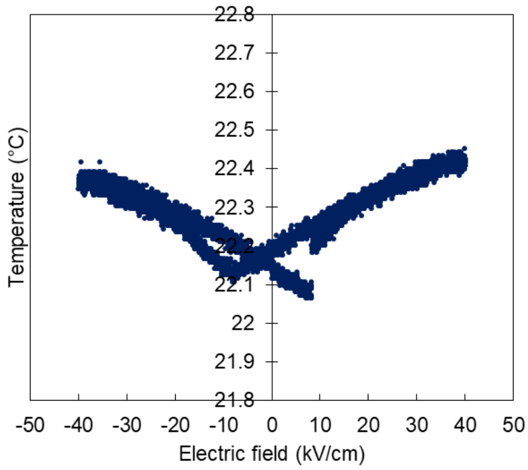


Fig. 1. T-E loops of (Pb,La)(Zr,Ti)O_3 (4/90/10) and (8/70/30) ceramics.