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反強誘電体 $PbZrO_3$ 薄膜の電気熱量効果

Electrocaloric Effects in Anti-Ferroelectric $PbZrO_3$ Thin Films

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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. This effects are expected to enhance the cooling efficiency in combination with normal (positive) ECE.

In this work, antiferroelectric $PbZrO_3$ (PZ) films were fabricated on $Pt/Ti/SiO_2/Si$ substrate by chemical solution deposition. Preparation method and basic electrical and electromechanical properties of PZ films including filed-induced strain were reported.[1)] Since the evaluation of the energy storage and ECE applications have not been done, here, I will report on these issues.

Temperature dependences of polarization hysteresis loops of $PbZrO_3$ thin films fabricated chemical solution deposition were evaluated for applications of energy storage capacitor and the cooling refrigeration using electrocaloric effects. The maximum polarization did not change to 175ºC and decreased at 205ºC. With increasing of temperature, the stored energy decreased in keeping pace with the monotonous decrease of switching electric fields of double hysteresis lops. Temperature dependence of the polarization, P(T), under different electric field draw convex curves on the top. P(T) curves with positive slope are observed at temperatures below 145ºC under electric field less than 300kV/cm. The adiabatic temperature change ΔT of -4.4ºC at 25ºC is estimated under ΔE = 160kV/cm.

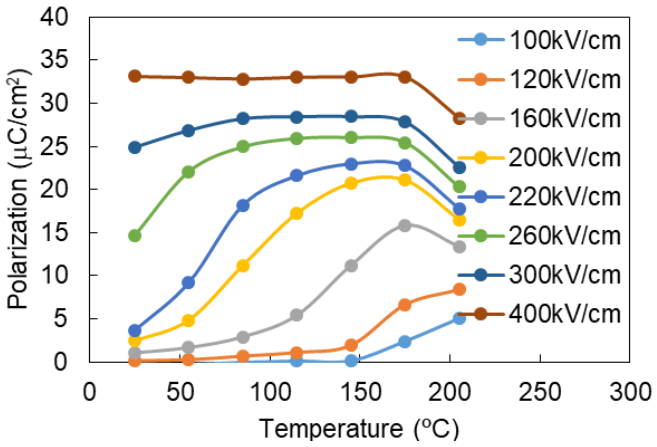

Fig. 1. Temperature dependence of the polarization, P(T) under different electric field.

References

[1] H. Maiwa, Jpn J. Appl. Phys., **40**, 5507 (2001).