Electrocaloric Effect of Perovskite High Entropy Oxide Films

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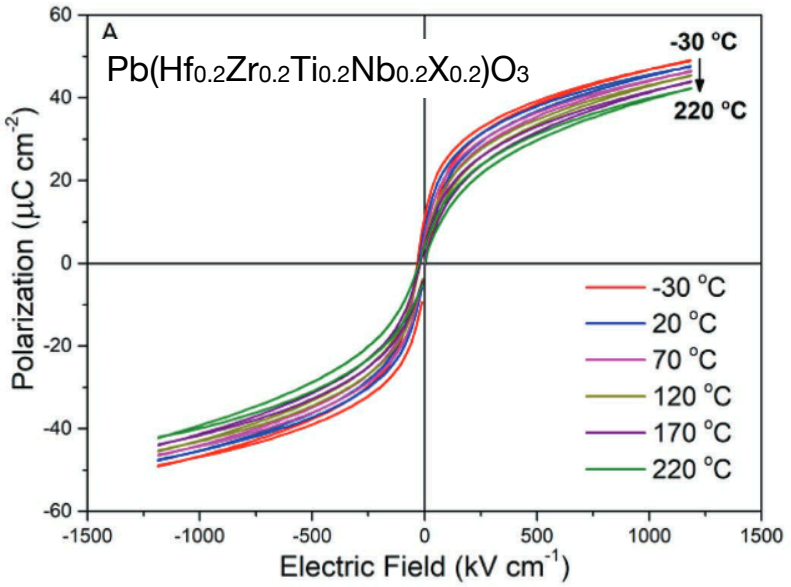
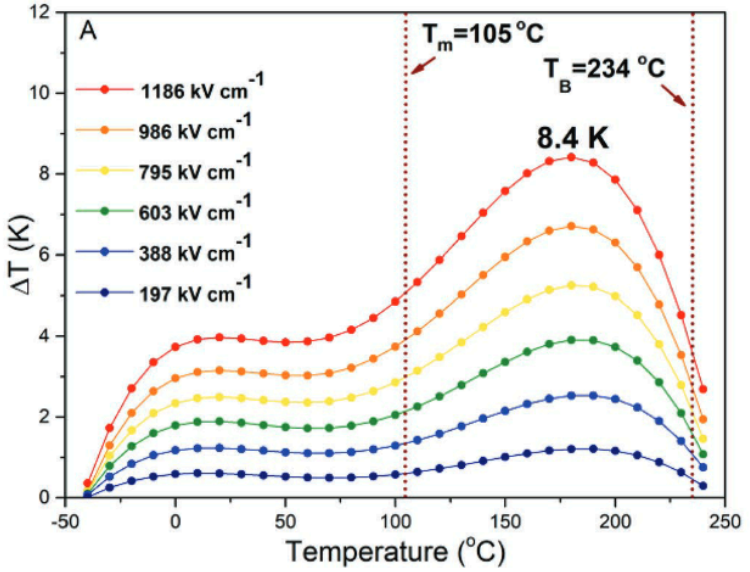
$Pb(Hf_{0.2}Zr_{0.2}Ti_{0.2}Nb_{0.2}X_{0.2})O_3$, a high-entropy perovskite, undergoes an entropy-driven phase transformation when X=Mn while X=Al always contains minor second phases in bulk ceramics. Thin films with X=Al show a narrow ferroelectric hysteresis loop and relaxor-like characteristics, i.e. a high dielectric permittivity of ~2000 and low dielectric loss. These are the characteristics needed for device applications.



Narrow hysteresis loop indicating relaxor behavior.



Electrocaloric temperature change of for a range of applied electric fields $\Delta E = E_2 - E_1$ with E_2 =1186 kV cm^{-1}.

Indirect measurements (based on Maxwell relations) yield a electrocaloric temperature change of 8.4 K at 180°C under an applied electric field of 1186 kV cm^{-1}. The temperature changes in this initial example of a high-entropy electrocaloric oxide are already comparable to those of other oxide-based materials. The huge design space available for optimization of high-entropy formulations now offers opportunities to exceed known electrocalorics in terms of both size of response and operating temperature range.