Correlation Between Cation Order-Disorder and the Electrocaloric Effect in the MLCCs Of Complex Perovskite Ferroelectrics

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The physical properties (dielectric, ferroelectric, piezoelectric, etc.) of complex perovskite ferroelectrics depend on the degree of order/disorder and the scale of the ordered domains. In this study, the electrocaloric (EC) properties of three representative complex perovskite ferroelectrics, $Pb(Mg_{1/3}Nb_{2/3})_3$–$8PbTiO_3$ (PMN-8PT), 1mol% Sm-doped $Pb(Mg_{1/3}Nb_{2/3})O_3$–$8PbTiO_3$ (1S-PMN-8PT) and $Pb(Sc_{1/2}Ta_{1/2})O_3$ (PST) are evaluated. Multi-layer ceramic capacitors (MLCCs) with identical structural configurations were fabricated for these three compounds, and their EC properties were characterized by direct measurement using a thermocouple. The EC temperature change ΔT of PMN-8PT, 1S-PMN-8PT and PST MLCCs under 20 V μm^{-1} at room temperature were found to be 1.42 K, 1.54 K, and 3.10 K, respectively. X-ray diffraction and high-resolution transmission electron microscopy data suggests that the high EC performance of PST is related to the ordering of B-site cations (Sc^{3+} and Ta^{5+}) with the ordering parameter S = 0.82 and a long coherence length of ~100 nm, such that the sample transitioned from a relaxor ferroelectric to a normal ferroelectric. These results provide pathway towards design of high performance EC materials required for solid state refrigeration and air-conditioning technologies.