$NaNbO_3$ Based Lead-free Antiferroelectric Ceramics

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Antiferroelectric (AFE) materials demonstrate dc bias dependency and higher recoverable energy when compared with ferroelectric materials. $NaNbO_3$ majorly presents its AFE P phase at room temperature[1], but it doesn't show the characteristic double P-E loops due to the field-induced metastable ferroelectric Q phase. Through considering crystal chemistry regarding both Goldschmidt tolerance factor and polarizability, Na and Nb were simultaneously substituted with other elements to lower the tolerance factor of the materials.

In this work, we used $CaZrO_3$ (2%-5%)[2] , $SrZrO_3$ (4%-6%)[3], and $CaHfO_3$ (3%-4%)[4] to modify $NaNbO_3$. It was found that through lowering tolerance factor, AFE P phase in $NaNbO_3$ was successfully stabilized. The structural composition was examined by using X-ray diffraction, where there showed enhanced signature AFE superlattice diffractions in these doped $NaNbO_3$ ceramics. Domain analysis was performed by using transmission electron microscopy, which revealed the sole existence of AFE domains in these modified $NaNbO_3$ ceramics. The signature double hysteresis polarization loops were, then, induced and observed in $CaZrO_3$ and $SrZrO_3$ modified $NaNbO_3$ at 120°C, and $CaHfO_3$ modified materials at room temperature. It noted that the critical nonpolar-to-polar switching field increased with the doping amount. The present results pointed out a general strategy to explore broad lead-free antiferroelectric material family.

Reference

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