CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Saranesh Prembabu

Project Number

35581

Project Title

Coupled Electric and Magnetic Properties in Artificially-Layered Perovskite Thin Films

Abstract

Objectives/Goals

Ferroelectric materials have wide-ranging electronic applications due to their uniquely switchable electrical polarization states. This work studied the effect of compositional variation of the PbTiO(3)/SrRuO(3) superlattice on electrical and magnetic ordering. Specifically, the experiment sought to understand how to modulate ferroelectricity, symmetry breaking, and magnetoelectricity as functions of PbTiO(3) volume fraction and of SrRuO(3) layer thickness.

Methods/Materials

Samples with various compositions grown through off-axis magnetron sputtering were compared with each other and with previously-studied samples through X-ray diffraction and measurements of capacitance, current and polarization at room temperature as well as low-temperature magnetocapacitance in a superconducting solenoid chamber.

Results

Tetragonality increased with volume fraction and SrRuO#(3) layer thickness. PbTiO#(3)-rich n/2 samples showed asymmetric capacitance-voltage hysteresis. The PbTiO#(3)-poor n/2 sample lacked hysteresis, as did the corresponding n/1 sample, but, contrary to expectations, preserved inversion symmetry. Magnetocapacitance was observed on the order of a few percent.

Conclusions/Discussion

It was concluded that the ferroelectric phase transition and self-poling due to symmetry-breaking is highly dependent on stoichiometric ratio, independent of layer thickness. However, the increased SrRuO(#3) layer thickness contributed to significantly higher dielectric screening. Magnetoelectric coupling is suggested and likely a result of interface spin-polarization, and further work remains to fully confirm and understand it. This superlattice and similar structures thus appear promising for various novel electronic applications, particularly those exploiting spin states for highly efficient spintronic memory storage.

Summary Statement

I analyzed how novel and useful properties pertaining to electric and magnetic ordering can arise from the interactions between ferroelectric and metallic layers in an artificial nanocrystal.

Help Received

Used equipment at Stony Brook University under supervision of Dr. Matthew Dawber; Participant in Simons Summer Research Program at Stony Brook University