Artificial ferroelectric superlattices - tailoring ferroelectric properties on the nanoscale

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The fabrication of artificial superlattices from extremely thin layers of ferroelectric materials presents exciting possibilities for the development of materials with novel electronic properties. A combination of strain and electrostatic interactions between layers determine the properties of the overall superlattice which can be varied considerably from those of the parent materials. The enormous parameter space of controllable parameters includes the choice of material for the layers, relative thickness of the constituent layers and the overall strain state of the sample by choice of substrate. This degree of control opens prospects for the precise tailoring of key material properties such as switchable polarization, piezoelectric coefficient, dielectric constant and coercive field. We can combine this with our well developed techniques for manipulating ferroelectric domains on the nanoscale using atomic force microscopy to give us an unprecedented level of control of ferroelectricity on the nanoscale. Thus, in addition to the long term goal of advanced material synthesis, at present these systems represent a fascinating adventure playground for the exploration of the fundamental physics of ferroelectricity.

Our efforts to date have focused on the combination $PbTiO_3$/$SrTiO_3$ and in this system we have found that, surprisingly, 1 unit cell thick layers of lead titanate sandwiched between 3 unit cell thick layers of strontium titanate have a strong ferroelectric polarization and a ferroelectric transition temperature about 300 degrees higher than bulk lead titanate.

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