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Ferroelectricity in Ultrathin Perovskite Films[1]

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The ferroelectric phase transition in ultrathin perovskite films is exquisitely sensitive to strain and to compensation of depolarizing fields arising from divergences in polarization at interfaces. However, in most experiments there is significant uncertainty in the degree of compensation by internal or external space charge (even for electroded thin films), or by the formation of domain structures that minimize depolarization energy. This in turn affects interpretation of size effects in thin films, as depolarization contributions are film thickness dependent. Here we will describe our work utilizing in-situ synchrotron x-ray scattering to study the phase transition and equilibrium 180° domain structure in fully coherent, epitaxial $PbTiO_3$ thin films deposited onto $SrTiO_3$ and $SrRuO_3/SrTiO_3$ substrates by metalorganic chemical vapor deposition. We will show that we can control the degree of top interface compensation by controlling the gas environment in our deposition and analysis system, and monitor this via details of the 180° stripe domain pattern that forms for $PbTiO_3$ on insulating $SrTiO_3$. Furthermore, we will demonstrate that compensation can be accomplished at the ferroelectric film surface by adsorption of molecular or ionic species, in contrast to electronic mechanisms that occur in the presence of a conducting electrode. Exploitation of this for novel devices or templating techniques may be possible, both through chemical control of polarity and through polarization control of ionic adsorption.

[1]This work was performed in collaboration with the ANL MSD In-Situ Studies Team and the A. Rappe group (U. Penn).