IN-SITU SYNCHROTRON STUDIES OF CHEMICAL VAPOR DEPOSITION

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We have constructed a metal-organic chemical vapor deposition (MOCVD) system on BESSRC-CAT beamline 12-ID-D of the Advanced Photon Source, for real-time studies of epitaxial thin film growth. The precisely controlled environmental conditions available in this system also allow *in situ* investigation of surface reconstructions, phase transitions, and stress relaxation following growth. Grazing incidence x-ray scattering is used to characterize growth modes and resulting film structures in the near-atmospheric-pressure, high-temperature, reactive MOCVD environment. This talk will include examples from our recent studies of $PbTiO_3$, the prototype of an important class of perovskite ferroelectric materials. Epitaxial single-crystal $PbTiO_3$ films are deposited on $SrTiO_3$ using tetraethyl lead, titanium isopropoxide, and O_2 as precursors. We find that the growth mode is layer-by-layer at 650-750°C for most conditions studied [1]. A surface reconstruction is observed, consisting of oxygen cages rotated to form an antiferrodistortive structure [2]. The films are coherently strained, resulting in a significant increase in the Curie temperature, T_c. We observe that 180° stripe domains form in the ferroelectric phase below T_c, indicating that electric fields arising from the polarization distribution are important. We also observe a strong dependence of T_c on film thickness. Ferroelectricity is observed in films as thin as a few unit cells. These results shed light on a fascinating competition between polarization, strain, electric field, and surface effects in these materials. This work is supported by the U. S. Department of Energy, Office of Science, under Contract W-31-109-Eng-38, and by the State of Illinois, under HECA.

[1] M.V. Ramana Murty *et al., Appl. Phys. Lett.* **80**, 1809 (2002).
[2] A. Munkholm *et al., Phys. Rev. Lett.* **88**, 016101 (2002).