Reflectivity From Doped SrTiO3 Thin Films

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Introduction: We have been studying the layer-by-layer growth of SrTiO3 with a wide range of electron carriers from insulating to 10^21 cm-3 doping levels. SrTiO3 is an important material because it is well lattice matched with many perovskite materials, and it is commercially available with atomically flat TiO2 surfaces. We have achieved Hall mobilities in SrTiO3 thin films as high as 40,000 cm2/Vs at 4 K (far above previous reports in bulk or thin film). The doping mechanisms include oxygen deficiencies induced during growth, Nb on the Ti site, and La doping on the Sr site. We find that with Nb/La doping, there is a local oxygen defect structure formed that complicates controlled carrier doping at low doping levels. Since La forms a solid solution with Sr (unlike Nb, which is limited to ~5% solubility), and is chemically stable, highly doped films can be grown with atomic precision. Measurement of the in-plane/out-of-plane lattice parameters allows a comparison with bulk values to extract the relative contributions of intentional chemical doping and oxygen deficiency induced during growth.

Methods and Materials: The experiment was performed at bending magnet X16B beamline together with a singly bent triangle Ge(111) monochromator. A high resolution 4-circle diffractometer with a high resolution Si(220) analyzer crystal.

Results: A series of these films have been measured, and we show typical results from one sample below in Figure 1. In order to correctly determine the mobility one needs to know the thickness of film in addition to the sheet resistance. As can be seen from Figure 1, we can determine the strain and film thickness from the periodicity and maximum of the fringes in the vicinity of the (002). The film shown clearly has smooth interfaces, which is another useful parameter that can be extracted. Finally from data not shown, one can prove that the films are coherent with the substrate, i.e. the in-plane lattice constant of the substrate is equal to that of the film.