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Phonon Anomalies in Strained $SrMnO_3$ Films Studied by THz and Infrared Ellipsometry

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I will present the case for investigating the optical response of thin, strained and ultrathin films with spectroscopic ellipsometry in the far-infrared and THz range. Spectroscopic ellipsometry is usually associated with film thickness measurements with commercially available tools operating around visible part of electromagnetic spectrum. At the University of Fribourg, we have built ellipsometers based on Fourier-transformed infrared (FTIR) and Time Domain Terahertz (TD-THz) spectroscopies. I will briefly introduce the techniques and discuss specifics of ellipsometry on ultrathin films - ultrathin in the sense of film thickness being much smaller than the wavelength. $SrMnO_3$ in bulk is a cubic perovskite with antiferromagnetic ordering under T_N =230-260 K. Under epitaxial strain it is possible to stabilize polar order caused by off-center displacement of the central magnetic Mn^{4+} ion. Such multiferroic state is expected to show large magnetoelectric coupling. The strong interaction between the spin ordering and lattice phonons has been demonstrated on bulk $Sr_{1-x}Ba_xMnO_3$ (x = 0-0.3). Our study was motivated by the possibility to see changes of the phonon spectra upon entering the ferroelectric state. We prepared a series of 30 nm thick $SrMnO_3$ films by pulsed laser deposition (PLD) with varying epitaxial strain driven by lattice mismatch of $SrMnO_3$ with respect to substrate. The substrates were chosen accordingly: $LaAlO_3$ causing small compressive strain (-0.3%), tetragonal $SrLaGaO_4$ (001) with moderate 1.1% tensile strain and cubic LSAT with tensile strain of 1.8% that should be sufficient for the ferroelectric instability. In the temperature dependent (10-400 K), THz-FIR ellipsometric spectra we observe the three characteristic phonons of cubic perovskite, with dominant low-energy mode that shows softening with increasing strain and anomaly at temperature of the antiferromagnetic transition.