Shubnikov-de Haas Oscillations in $LaAlO_3/SrTiO_3$ Heterointerfaces to Determine a Possible 2D to 3D Conductivity Crossover

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Introduction

Recently, superconductivity[1] and room temperature control of a metal-insulator transition[2] have been observed in the $LaAlO_3/SrTiO_3$ (LAO/STO) interface. However, all the mechanisms that contribute towards interfacial conductivity are not well understood. One of the major mechanisms is atomic reconstruction, which occurs at a critical thickness of just under 4 unit cells of LAO on STO in order to prevent a divergent voltage from forming in the heterostructure and allows electrons to move along the interface.[3]

One question that arises is how the growth conditions change the conductivity at the interface. The stoichiometry determined during PLD growth had been shown to have a direct effect on the conductivity of LAO/STO.[4] Noting the connection between stoichiometry and conductivity, the next question is whether a stochiometry-dependent cross-over between two- and three-dimensional transport can be determined.

Experiment

Each LAO/STO sample was grown using PLD and with different growth conditions. Two sets of experiments were performed at NHMFL – one using SCM-1 and SCM-2. For each set of experiments, a Lakeshore 370 was used to measure the sheet resistance and the mobility as per the van der Pauw method. In general, measurements were taken at base temperature of the system. The goal was to determine if Shubnikov-de Haas oscillations (SDHO) appeared as a function of angle, which would be definitive evidence of 2D behavior.

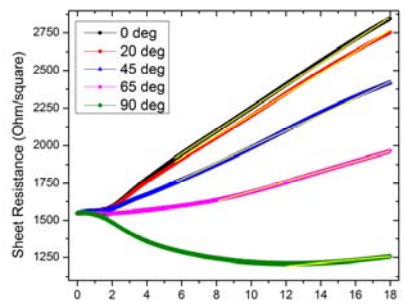

Figure 1. Magnetoresistance measurements show hints of quantum oscillations. Measurements were taken at 20 mK. Other samples show similar behavior. The yellow lines are a linear fit to the high field curves and reveal a hint of SDH oscillatory behavior.

Results and Discussion

We did not observe superconductivity in any of the samples measured in SCM-1 and -2. We found mobilities between 2000 – 3000 $cm^2 V^{-1} s^{-1}$. The angular dependence of the magnetoresistance measurements (Fig. 1) are qualitatively consistent with similar measurements from the Triscone group.[5] At high fields, there seems to be a low frequency and low amplitude oscillation.

Despite some hints of oscillations at high fields, SDHO were not obvious in the data. The likely cause of this is the small mobilities of the samples. It is possible that the Van der Pauw method contributed to a large overestimation of the mobilities. Future plans include measuring the conductivity at even higher fields and with a patterned Hall bar.

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