Quantum Oscillations in Low Carrier Concentration $SrTiO_3$ FETs

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Introduction

Quantum size effect of electrons at oxide interfaces may provide novel functionalities for future electronic and spintronic devices, but direct experimental data showing such quantum states are limited. A key issue is how an electric field due to the breaking of inversion symmetry at the interface reconstructs the bulk *d*-electron bands into two-dimensional (2D) subbands. A further question is the influence on the details of the realized state from the interface-electric-field-induced coupling between the spin and the angular momentum of the electrons, and how an applied electric field might be use to tune this effect and other device parameters. The oxide field-effect transistor (FET) studied here is unique compared to other artificial structures comprising oxides, in that a strict quantum-mechanical two-dimensionality may be reached; i.e., only a few (and possibly single) quantum wells are populated due to the extraordinarily low carrier density achieved in our high-quality FETs, which facilitates unambiguous determination of the 2D electron gas state realized in an oxide.

Experimental

Our high mobility FETs are fabricated using a high quality STO substrate with metallic electrical contacts deposited using thermal evaporation, and a parylene insulator between the substrate and gold electric field gating top gate. We performed magnetotransport measurements to obtain R_{xx} and R_{xy} up to 18T in SCM1 (down to 20mK) and in the 35T DC resistive magnets (down to 300mK) at NHMFL Tallahassee.

Results and Discussion

We observed quantum oscillations over a wide range of temperatures and fields consistent with possibly two distinct frequencies or more, depending on the gate bias. In Fig. 1 we show the derivative of R_{xx} vs B data taken in SCM1 at 20mK which clearly shows two distinct frequencies, and in the inset, the FFT of the raw data in shows that in fact there are possibly three distinct oscillations, however our current interpretation from further analysis suggests that there is a splitting of one of the frequencies.

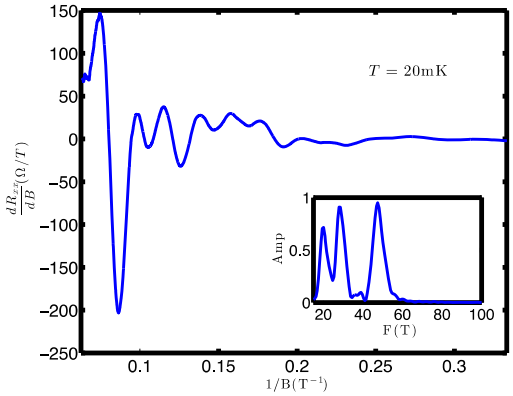

Fig.1 Derivative of magnetic field dependent R_{xx} obtained in SCM1 at 20mK, inset shows FFT of raw data.

Conclusions

In order to clarify our recent findings we have applied for time in the dilution fridge up to 35T at the DC field facility. Combining higher field with the lower temperatures should provide sufficient information to pin down the subband responsible for these new features in the data, and how it evolves with gate electric field (carrier concentration)

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