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Termination of Two-Dimensional Metallic Conduction near the Metal-Insulator Transition in Si/SiGe Quantum Wells

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Introduction

The physical properties of two-dimensional (2D) electrons have been a subject of interest for a long time. Yet after many years of research, the ground states of a 2D electron system (2DES) in the presence of disorder and electron-electron interaction, a realistic situation in experiments, remain an open question. Recent observations of a downturn in conductivity at low temperatures in a Si/SiGe quantum well [1], Si-MOSFETs [2,3], and 2D holes in GaAs [4-6] seem to suggest that disorder plays an important role in the so-called 2D metal-insulator transition (MIT) and at $T \rightarrow 0$ 2DES may eventually become insulating. In this experiment, we focus on the downturn behavior as a function of spin polarization, which is varied by an in-plane magnetic field.

Experimental

The 2DES is capacitively induced in an insulated-gate field-effect transistor (IGFET) device on an undoped Si/SiGe heterostructure, grown in an ultrahigh-vacuum chemical-vapor-deposition (UHVCVD) system. Ohmic contacts were formed by alloying AuSb into the heterostructure. The electron density n is tuned by biasing the front gate, which consists of a stack ofAl_2O_3, Cr, and Au. Low-temperature transport experiments were performed using standard low-frequency lock-in techniques.

Results and Discussion

The results of σ_{xx} as a function of temperature are shown at B = 0T and the in-plane magnetic field of 4T where the 2DES has become polarized. In both cases, there is clearly a downturn in conductivity and the downturn temperature increases with increasing in-plane magnetic field. These results suggest that in addition to disorder the spin polarization of 2DES also plays an important role in 2D MIT.

Conclusions

The experiment provides the first observation that the downturn temperature in 2D conductivity in Si/SiGe quantum wells depends on the spin polarization.

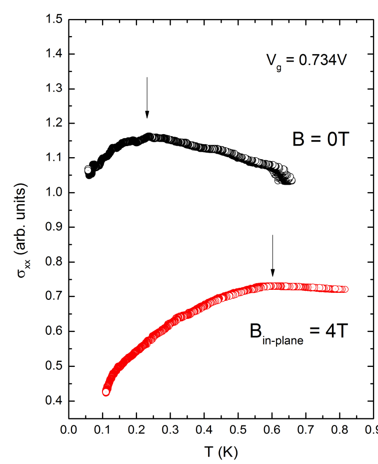

Fig. 1 σ_{xx} as a function of temperature at the gate voltage of V_g=0.734V. The arrows mark the downturn temperature at B = 0 T (~0.24K) and at $B_{in-plane}$ = 4T

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