Systematic Investigation of the Metal-Insulator Transition at Ultralow Temperatures in *p*-type GaAs HIGFET Structures

D.R. Luhman (Princeton University), D.C. Tsui (Princeton University), L. Yin (UF & NHMFL), J.S. Xia (UF & NHMFL), L.N. Pfeiffer (Bell Labs) and K.W. West (Bell Labs)

Introduction

It has been predicted that the ground state of a two-dimensional electronic system should be insulating [1]. The discovery of an apparent metal-to-insulator transition (MIT) in two-dimensional systems [2] has triggered an intensive theoretical and experimental effort [3] to determine the underlying physics of this transition. The experimental signature of the MIT is a crossover in the temperature dependence of the resistivity from metallic-like behavior to insulating-like behavior with a changing experimental parameter, most often the carrier density. Experimental studies are, of course, limited to finite temperatures. This leaves open the possibility that the apparent metallic-like behavior observed in experiments may not be the true ground state of the system and that as the zero-temperature limit is approached, the state will become an insulator

Experimental

Recently, Huang *et al.* [4] have experimentally examined this problem in the regime of very high quality samples and very low temperature. Their sample consists of a *p*-type undoped GaAs HIGFET structure for which the density can be tuned to very low values due to the high quality of the structure. Using the High B/T facilities of the NHMFL, they were able to measure down to temperatures of 0.5 mK. Huang *et al*. find that as they cool their sample below 30 mK, at a density that appeared to show metallic behavior for T>30 mK, the resistivity begins to increase. At a lower density no such upturn was observed. This observation potentially indicates that the observed metallic state is not a true metallic state, however the physical origin of the upturn in resistivity at low temperatures is still not clear. To provide further insight into this observation, we have initiated systematic measurements of the resistivity of several HIGFET samples down to T=0.5 mK for a wide range of densities.

Results

Currently we are in the midst of a series of transport experiments using a collection of samples from newly grown HIGFET wafers. The samples hitherto investigated have all shown unusually weak temperature-dependence in the resistivity at low temperatures. The origin of this weak temperature-dependence has not yet been determined, and current work is underway to elucidate these observations.

Conclusions

We are in the progress of investigating the apparent metal-insulator-transition in GaAs HIGFET samples at very low temperatures. Anomalous transport is observed in the low temperature regime and is currently being investigated.

References

[1] E. Abrahams *et al.*, Phys. Rev. Lett. 42, 673 (1979).
[2] S.V. Kravchenko *et al.*, Phys. Rev B 51, 7038 (1995).
[3] S.V. Kravchenko and M.P. Sarachik, Rep. Prog. Phys. 67, 1 (2004).
[4] J. Huang *et al.*, Phys. Rev. Lett. 98, 226801 (2007).