HIGH FIELD DC MAGNETOTRANSPORT IN *P*-TYPE SI/SIGE HETEROSTRUCTURES

I.L. Drichko, I.Yu. Smirnov (Ioffe PTI); A.V. Suslov (NHMFL); M. Mironov (Musashi Institute of Technology); O.A. Mironov (NANOTEC); T.E. Whall (Warwick University); Yu.M. Galperin (Ioffe PTI and Oslo University); V.M. Vinokur (Argonne)

Introduction

Transport mechanism in the low-density 2D electron gas at strong magnetic fields and low temperatures has been a subject of intense discussions [1]. Several types of dielectric behaviors at very low temperatures were observed and various explanations of the results, in particular, the Anderson localization of carriers, the formation of the Wigner crystal, or quantized Hall insulator, were proposed. In this communication we report on high field measurements of the magnetoresistance and Hall resistance in *p*-type Si/SiGe heterostructures exhibiting the quantum Hall effect. The measurements were directed to help deduce mechanisms of conductivity and localization of the charge carriers (holes) in these heterostructures in *the extreme quantum limit*.

Experimental and Results

We measured the longitudinal (ρ_{xx}) and Hall (ρ_{xy}) resistivities, as well as *I-V*-characteristics in the Hall bar samples of *p*-type Si/Si_xGe_{1-x} heterostructures with the mobility of 10^4 cm^2/Vs and hole densities $p=8.2\times10^{10}$ cm^{-2} (sample 1, x=0.95) and 1.6×10^{11} cm^{-2} (sample 2, x=0.87), at temperatures down to 0.3 K in magnetic fields of up to 18T corresponding to the ultra-quantum limit realized at B>3.4T (sample 1) and B>6.8T (sample 2). The samples exhibit the integer quantum Hall effect at relatively low magnetic fields, yet the fractional quantum Hall effect is absent in the ultra-quantum limit. In the low density system ρ_{xx} and ρ_{xy}, show continuous growth with the field, which is a character of the Anderson localization or Wigner crystallization, while in the high density sample ρ_{xx} increases with B, but ρ_{xy} doesn't change until 12T – behavior that is typical of the quantized Hall insulator. Temperature dependence of the transverse DC conductance shows the activation-like behavior typical for an insulating state. *I-V* curves in all samples are nonlinear in high magnetic fields, with a threshold value depending on B and T. In the lowest density sample the threshold current is a function of the current sweep rate as well. The log-log current-voltage curves at T=0.3 K for the current ramping rate 5 nA/min are shown in Fig. 1. Moreover, it demonstrates a clear hysteresis in strong magnetic fields, see inset measured at T=0.3 K at the ramping rate 0.1 nA/min. Demonstrated in Fig. 2 is the log-log plot of the *I-V* curve for B=18 T, T=0.3 K and the slowest available current ramping rate (0.02 nA/min). It can be represented as $I\sim\exp(-A/V^{\mu})$ with μ=0.3-0.4, see inset.

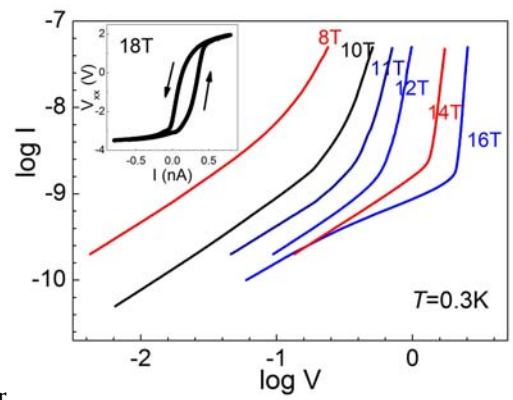

FIG. 1. *I-V* characteristics at different magnetic fields, T=0.3 K. Inset: *I-V* curve at T=0.3K, B=18T, at slow (0.1 nA/min) decreasing-increasing current.

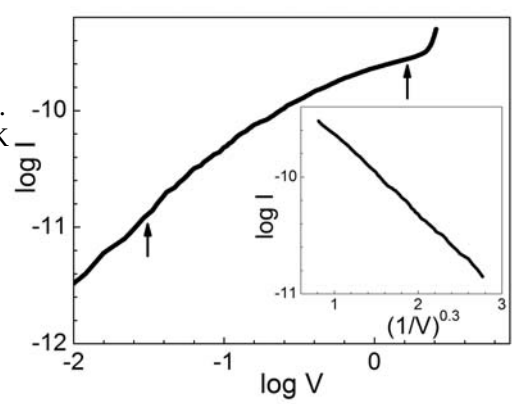

FIG. 2. log I vs log V at current sweep rate 0.02nA/min; B=18T, T=0.3 K.

Discussion and Conclusions

The most unusual experimental facts – (i) the threshold-like shape of the *I-V* curve and its hysteresis, (ii) the law $I\sim\exp(-A/V^{\mu})$ typical for a creep in a crystal [2] – support the idea that in the low-density sample the hole transport at T < 0.8K and B >14T is probably due to formation of a Wigner crystal. This conclusion agrees with the results of Ref. [3].

References

[1] Dolgopolov, V.T., *et al*., Phys. Rev. B **46**, 13303 (1992).
[2] Blatter, G., *et al*., Rev. Mod. Phys. **66**, 1125 (1994).
[3] Pudalov, V.M., *et al*., in Phys. of Quantum Sol. of Electrons, 124 (1994), Int. Press.