High Field Magnetotransport in Mn Implanted Ge

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The giant and colossal magnetoresistivity (GMR/CMR) remains one of the hot topics in the condensed matter physics during the last two decades because of the great variety of potential and already realized applications (magnetic recording, magnetic field sensors, etc) and due to many fundamental problems which arise in the course of the study of various aspects of this multifaceted phenomenon. There are three main classes of systems, in which the electrical resistivity changes by the order of magnitude or even more in an external magnetic field: (i) Multilayered systems containing ferromagnetic layers separated by non-magnetic metallic layers (ii) Granular nanocomposites containing magnetic granules; (iii) Transition metal and rare-earth oxides, in which the electron transport is sensible to external magnetic field in the vicinity of structural, metal-insulator and magnetic field induced transitions as well as charge and orbital ordering phenomena. The mechanisms of the field enhancement or suppression of the magnetic scattering in these three systems are different, and one may anticipate that other mechanisms of (GMR/CMR) may act in other types of materials with nanoscale inhomogeneity.

This work is devoted to magnetotransport in germanium heavily doped by Mn. Magnetoresistance and Hall effect were measured in two samples with Mn concentration of 3% and 6% in fields up to 33 T and temperatures down to 4.2 K at the National High Magnetic Field Laboratory. Selection of magnetoresistance and Hall resistance at several temperatures is presented in Fig.1a and b.

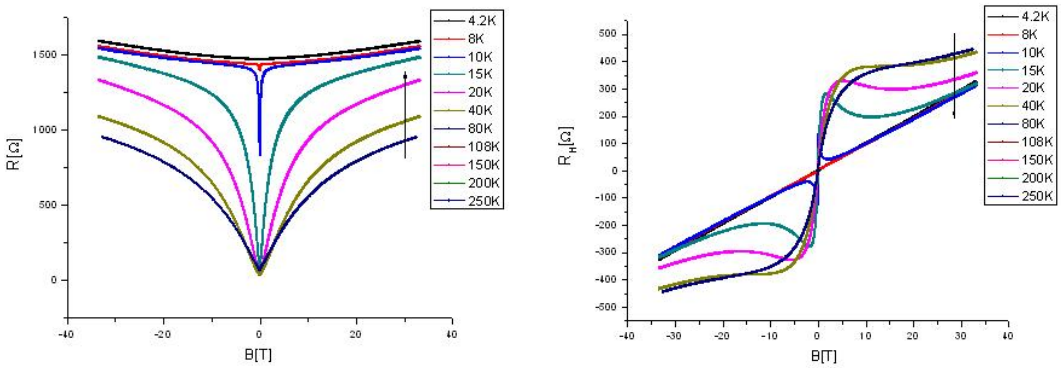

Fig. 1. Magnetoresistance (a) and Hall effect (b) of MnGe sample with 3% Mn at different temperatures. Arrows indicate the reduction of temperature.

Magnetoresistance depends strongly on temperature. It is relatively small at 4.2 K, but grows to thousands of percents around 30 K with the further reduction at higher temperatures. Magnetic field driven metal-insulator transition takes place at fields of about 10 T with metallic state at lower fields and insulator-like state at high fields. Magnetoresistance rise is very sharp below 20 K were the zero field metal-insulator transition takes place as a function of temperature.

Hall effect data is not less puzzling. Both the ordinary and the Extraordinary Hall effects (EHE) contribute to the shape and magnitude of the Hall resistance. The EHE component is usually generated by spin orbit scattering by magnetic impurities and ferromagnetic clusters embedded in a conducting matrix. The remarkable feature shown in the figure is suppression of the EHE by magnetic field, resulting in a non-monotonous field dependence. To the best of our knowledge this is the first observation of such phenomenon.

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