Colossal Negative Magnetoresistance in a Two-Dimensional Electron Gas

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Introduction

Strong negative magnetoresistance (MR) effects have been predicted long time ago [1]. Here, we report on a colossal negative MR focusing on the effects of temperature, in-plane magnetic field, and dc current [2].

Experimental

Our sample is a 200 μm-wide Hall bar, fabricated from GaAs/AlGaAs quantum well with the density 3×10^{11} cm^{-2} and the mobility 1.3×10^{6} cm^2/Vs. Some measurements were performed in SCM-2 using a rotator probe.

Results and Discussion

The hallmark of the effect is a sharp drop of resistivity ρ with increasing magnetic field B; at low T and $B = B^* \approx 1$ kG, the resistivity ρ (B^*) is an order of magnitude smaller than its value at $B = 0$. Comparison with theory revealed that the MR is stronger than any theoretical prediction [1], is not parabolic in B, and is strongly temperature-dependent. The tilt-field measurements revealed that the MR is insensitive to in-plane magnetic field. With increasing T, the MR becomes weaker but remains significant up to $T = 30$ K, see Fig.1(a), in contrast to recent study [3] where MR disappeared above 2.5 K. The most striking feature of the T-dependence is that ρ (B^*) is linear in T over the entire T range and that the slope of this dependence is well described by $d\rho(0)/dT$ in the high T limit, see Fig.1(b). Furthermore, measurements at different currents I revealed, surprisingly, that the dependence of ρ (B^*) on I is also linear, suggesting linear scaling between T and I. By setting $\rho(I) = \rho(T)$, we have obtained the effective temperature T_I which grows linearly with I, see Fig.1(c).

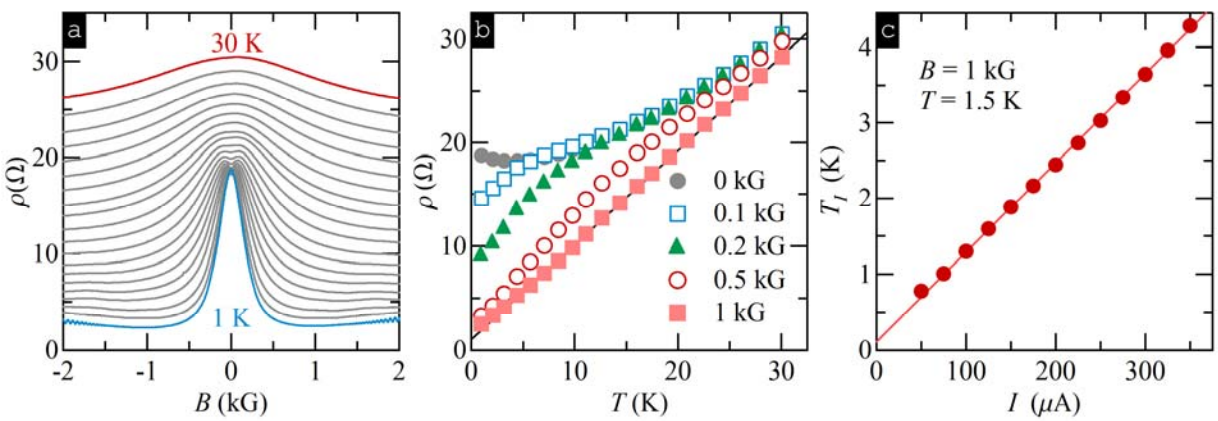

Fig. 1: (a) ρ (B) at T from 1 K to 30 K. (b) ρ (T) at different B, see legend. (c) Effective temperature T_I obtained from $\rho(T) = \rho(I)$ versus I at $B = 1$ kG and T = 1.5 K. Solid line is drawn at $T_I = T_0 + \beta I$, where $T_0 \approx 0.1$ K and $\beta \approx 12$ K/mA.

Conclusions

We have observed a colossal negative MR which is characterized by a minimum at $B \approx 1$ kG. The resistance at this minimum depends linearly on both temperature and current, suggesting linear scaling between T and I.

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