Thermally and optically excited multi-channel transport at the interface of $LaAlO_3/SrTiO_3$ heterostructures

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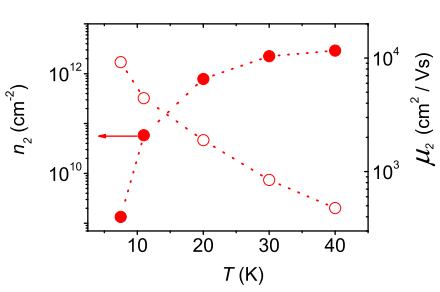
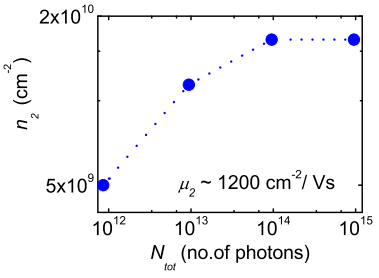
We have performed magnetotransport experiments on a $LaAlO_3/SrTiO_3$ interface [1] with a 10 nm $LaAlO_3$ film, in magnetic fields up to 30 T. The temperature was varied in the range $T = 4.2$ K to 150 K and additionally the sample was illuminated with UV radiation at a fixed $T = 4.2$ K.

Our experimental results show that the low-temperature regime (T$\leq$ 4.2 K) is dominated by one type of charge carriers, $n_1 \simeq 10^{14}$ cm^{-2}, with a lower carrier mobility, $\mu_1 \simeq 5$ cm^2/Vs, yielding a linear Hall resistance. Increasing T above 4.2 K or illuminating with UV light with an energy higher than the $SrTiO_3$ band-gap (3.65 eV) at a fixed $T = 4.2$ K, leads to a significant decrease of the resistance, a strong positive magnetoresistance appears and the Hall resistance becomes distinctly non-linear. We explain our observations by thermal or optical excitation of an additional high-mobility electron channel situated 6 meV above the low-mobility channel.

Our magnetotransport data can be quantitatively explained within a simple two-carrier model, where thermal activation (Fig. a) or UV illumination (Fig. b) creates a low-concentration (n_2) and high-mobility (μ_2) electron channel [2], in addition to an existing low-mobility one at 4.2 K. The carrier concentration and the mobility values of this second-electronic channel are extracted from a two-band model fits of the magnetoresistance and the non-linear Hall resistance.



(a) Concentration (left axis, filled circles) and mobility (right axis, open circles) of thermally activated high-mobility electron channel as a function of temperature.



(b) Concentration (filled circles) of the photo-excited carriers as a function of illumination intensity expressed in terms of the photon number, N_{tot}, at 4.2 K.

[1] A. Ohtomo and H. Y. Hwang, Nature **427**, 423 (2004).
[2] V. K. Guduru *et al.*, Appl. Phys. Lett. **102**, 051604 (2013).