Spin splitting and effective masses in p-type GaAs two dimensional hole gases

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We present magnetotransport measurements of two-dimensional hole gases (2DHG) embedded in carbon doped p-type GaAs/AlGaAs hetorostructures grown on [100] oriented substrates. A pronounced beating pattern in the Shubnikov-de Haas (SdH) oscillations (see Fig. 1(a)) proves the presence of strong spin-orbit interaction in the 2DHG. With the use of a global top gate we can tune the hole density from 0.8×10^{15} m^{-2} to 3.0×10^{15} m^{-2} and observe a corresponding change in the spin-orbit interaction induced spin-splitting.

It is possible to distinguish various peaks in the Fourier spectrum of the data (see Fig. 1(b)). Two of them are identified as originating from spin-split subbands at frequencies $f_1 = n_1 \times h/e$ and $f_2 = n_2 \times h/e$. Other prominent peaks are also observed at frequencies $f_1 + f_2$ and $f_2 - f_1$, as reported by others [1, 5]. Here we associate them with magneto intersubband (MIS) [3] oscillations resuling from spin-split subbands. In contrast to the case where two size-quantized subbands are occupied, spin-split subbands have significantly different effective masses. The resulting MIS oscillations have a peculiar temperature dependence.

We further estimated the effective masses of heavy-light holes (HLH) and heavy-heavy holes (HHH) by measuring the temperature dependence of the SdH oscillations similarly to Ref. [1]. In previous work [1, 2] a linear dependence of the effective mass on the perpendicular magnetic field was observed. The high quality of the 2DHG in our samples allows us two resolve SdH oscillations at lower magnetic field. In the limit of low magnetic field our results suggest that the effective masses are independent of the field and a deviation occurs only outside the validity range of the model in use. While the LHH mass is independent of Fermi energy, the HHH mass has a strong Fermi energy dependence, suggesting a SOI-induced non parabolicity of the valence band [4].

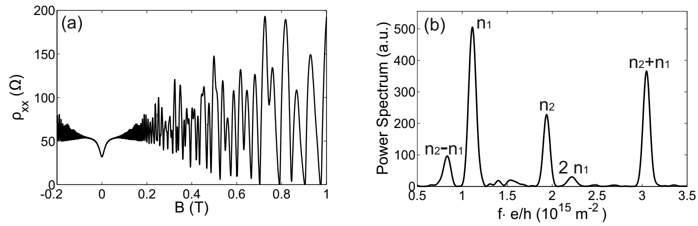

Figure 1: a) Longitudinal resistivity measured in a Hall bar geometry at a density of $n = 3.0 \times 10^{15}$ m^{-2}. b) Power spectrum of the data in a) plotted as a function of $1/B$.

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