Dresselhaus Spin-Orbit Interaction in Square *p*-AlGaAs/GaAs/AlGaAs Quantum Well Studied by Surface Acoustic Waves

A. V. Suslov[1], I. L. Drichko[2], I. Yu. Smirnov[2], K. W. Baldwin[3], L. N. Pfeiffer[3], and K. W. West[3]

[1]*National High Magnetic Field Laboratory, Tallahassee, Florida 32310, USA*
[2]*Ioffe Institute, Russian Academy of Sciences, St. Petersburg 194012,*
[3]*Princeton University, Princeton, New Jersey 08544, USA*

suslov@magnet.fsu.edu

We studied ac conductivity in a 17 nm wide *p*-GaAs/AlGaAs quantum well with hole concentration $\sim 1.2\times10^{11}$ cm^{-2} and mobility $\sim 1.8\times10^{6}$ cm^2/Vs (at 300 mK). The GaAs single quantum well was positioned between 100-nm undoped spacer layers of AlGaAs and was symmetrically δ-doped on both sides with carbon. We utilized the surface acoustic waves (SAWs) technique. A SAW propagated along the surface of a piezoelectric lithium niobate ($LiNbO_3$) delay line, and the two-dimensional hole system (2DHS) under investigation was pinned down on that surface of the $LiNbO_3$ crystal by means of springs. The AC electric field accompanying the SAW penetrated into the two-dimensional channel. The interaction of the SAW electric field with holes in the quantum well resulted in a change of the SAW attenuation and velocity. Measurements of these SAW parameters were performed in magnetic fields up to 18 T at SAW frequencies ranging from 30 MHz to 300 MHz, in the temperature interval from 20 mK to 300 mK. At the base temperature of 20 mK the magnetic field dependencies were measured at various SAW intensities. Integer and fractional quantum Hall effects observed in high B > 2 T magnetic fields prove excellent quality of the structure under study.

The ac conductivity of 2DHS $\sigma_{ac}=\sigma_1 - i\sigma_2$ was calculated from simultaneously measured SAW attenuation and velocity. In this work we focused on the study of the conductivity quantum oscillations observed in low B < 2 T magnetic fields. Due to the very small value of the imaginary part $\sigma_2 \ll \sigma_1$ in this magnetic field range, we analyzed only the real part of the conductivity. In the magnetic fields B < 2 T, oscillations of conductivity σ_1 undergo beating, which is specific to the existence of two spin-split subbands induced by spin-orbit interaction. The Fourier spectrum obtained by fast Fourier transform revealed a split component with maxima at 2.4 T and 2.6 T. Thus, the densities of the lower and higher populated subbands are $p^- \cong 5.8\times10^{10}$ cm^{-2} and $p^+ \cong 6.3\times10^{10}$ cm^{-2}, respectively, in agreement with the total hole concentration. Further analysis allowed the calculation of the effective masses and quantum scattering times for carriers in each subband, as well as the value of the spin-orbit interaction $\Delta_{SO} = (0.16 \pm 0.04)$ meV. The quantum well profile, together with the small magnitude of the spin-orbit interaction, allowed us to conclude that the spin-orbit splitting is governed by the Dresselhaus mechanism.