Scattering mechanisms of highest-mobility InAs/$Al_xGa_{1-x}Sb$ quantum wells

T. Tschirky [1,*], **S. Mueller** [1], **Ch. A. Lehner** [1], **S. Fält** [1], **T. Ihn** [1], **K. Ensslin** [1] **and W. Wegscheider** [1]

[1] *Laboratory for Solid State Physics, ETH Zürich, 8093 Zürich, Switzerland*

Heterostructures containing InAs are commonly studied due to their potential applications in high-speed, low power-electronics, such as in heterostructure field effect transistors (HFETs) and THz imaging and sensing. The large band offset between InAs and the AlSb barriers results in excellent carrier confinement and enhanced radiation tolerance. Its narrow band gap and strong spin-orbit coupling makes the system ideal for spintronic devices research. In recent years research on InAs quantum wells has gained significance due to their similarity to InAs/GaSb composite quantum wells for topological insulators [1] and due to new prospects for realizing a topological superconducting phase supporting Majorana fermions when combined with *s*-wave superconductors [2,3,4].

The carrier mobility of InAs quantum wells [5,6,7,8] has for a long time been confined to regions below 1 x 10^6 cm^2/Vs, whereas GaAs/AlGaAs heterostructures can reach mobility values above 3 x 10^7 cm^2/Vs [15,16,17,18] despite their higher effective mass. This implies that there is ample room for improving the growth techniques and structure designs of InAs quantum wells.

The recent availability of high quality, almost lattice-matched GaSb substrates has led to a considerable increase of growth quality and the subsequent carrier mobilities [7]. In this work, we show that by further optimizing structural design parameters, the mobility can be drastically increased. The highest electron mobilities were achieved with $Al_{0.33}Ga_{0.67}Sb$ buffers and lower barriers and a quantum well width of 24 nm. These quasi-single-interface InAs/AlSb quantum well devices reached a gate-tuned mobility of 2.4 x 10^6 cm^2/Vs at a density of 1 x 10^{12} cm^{-2} at 1.3 K.

In Hall bar devices boundary scattering is found to strongly influence the mobility determination in this mobility regime. Using

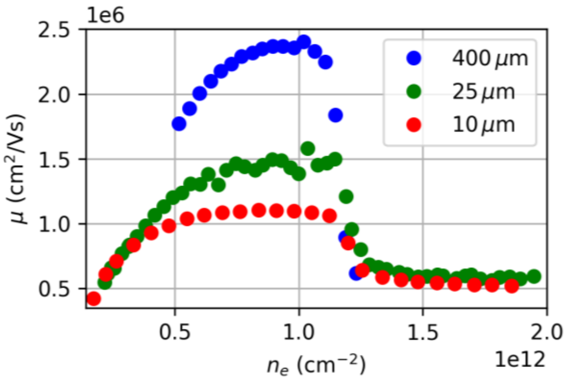

Fig. 1: Measured electron mobilities at 1.3 K of an InAs QW with varying Hall bar widths.

temperature and density dependent magnetotransport measurements, ionized background impurity scattering at low electron densities, device boundary scattering at intermediate electron densities, and intersubband scattering at high electron densities were identified as the most dominant scattering processes. Ringlike structures appearing in the Landau fan at high electron densities are explained using a single-particle model of crossing Landau levels.

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*Contact: tschthom@phys.ethz.ch