Magnetoresistance studies in GaAs/AlGaAs single quantum wells with different impurity densities

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GaAs/AlGaAs heterostructures with GaAs single quantum wells have been grown using the molecular beam epitaxy (MBE) technique. The two dimensional electron gas (2DEG) in the quantum well is provided by Si δ-doping in AlAs/GaAs barriers on both side of the quantum well. The Si-doping is separated from the quantum well by 70 nm thick spacers. All grown samples have the same layer sequence but with different impurity densities in the quantum wells. For each sample, the quantum well has been intentionally doped with a different Si doping density. The quantum well of the reference sample has been left undoped, exhibiting only the unintentional background doping of the growth chamber.

Transport measurements have been performed on the samples for temperatures ranging from 0.4 K to 30 K. For the reference sample, we found a high electron mobility of 2×10^{6} cm^{2} V^{-1} s^{-1}. Upon doping, the electron mobility decreases to 5×10^{4} cm^{2} V^{-1} s^{-1} and 1×10^{4} cm^{2} V^{-1} s^{-1} for samples with additional doping of 5×10^{15} cm^{-3} and 4×10^{16} cm^{-3}, respectively. The electron mobilities show quite different temperature dependences.

All samples exhibit negative magnetoresistances at low magnetic fields and low temperatures. For increasing doping density weak localization [1,2] dominates more and more the magnetoresistance. In addition a parabolic magnetoresistance is observed where the curvature of this negative parabolic part of the magnetoresistance decreases with increasing doping density. This parabolic magnetoresistance is attributed to electron-electron interactions [3]. With increasing temperatures, the peak of the weak localization for the doped samples decreases continuously until it disappears. At the same time, the curvature of the negative parabolic magnetoresistance which has been decreasing with increasing temperature becomes positive. This behavior is in contrast to the temperature dependence of the magnetoresistance for the reference sample. In contrary to the doped samples, the curvature of the negative parabolic magnetoresistance decreases with increasing temperature, but it stays negative.

The differences in the magnetoresistance curves are analyzed in detail in order to study the direct influence of the impurity density on the magnetotransport in 2DEG systems.

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