Tunable Charge Detectors for Semiconductor Quantum Circuits

Clemens Rössler, Tobias Krähenmann, Stephan Baer, Thomas Ihn, Klaus Ensslin, Christian Reichl, and Werner Wegscheider

Solid State Physics Laboratory, ETH Zurich, 8093 Zurich, Switzerland

Nanostructures defined in high-mobility two-dimensional electron systems offer a unique way of controlling the microscopic details of the investigated device. Quantum point contacts play a key role in these investigations, since they are not only a research topic themselves, but turn out to serve as convenient and powerful detectors for their electrostatic environment. We investigate how the sensitivity of charge detectors can be further improved by reducing screening, increasing the capacitive coupling between charge and detector and by tuning the quantum point contacts' confinement potential into the shape of a localized state [1]. An example is depicted in figure 1. If the detector channel (shaded region in figure 1a)) is defined far away from a small gap in-between the bottom gates, typical quantized conductance is observed (figure 1b)). Pushing the detector channel closer to the gapped region (figure 1c)) gives rise to additional resonances due to the formation of a localized state (figure 1d)). Finally, we demonstrate how such a localized state can be employed for fast and well-resolved charge detection of a large quantum dot in the quantum Hall regime.

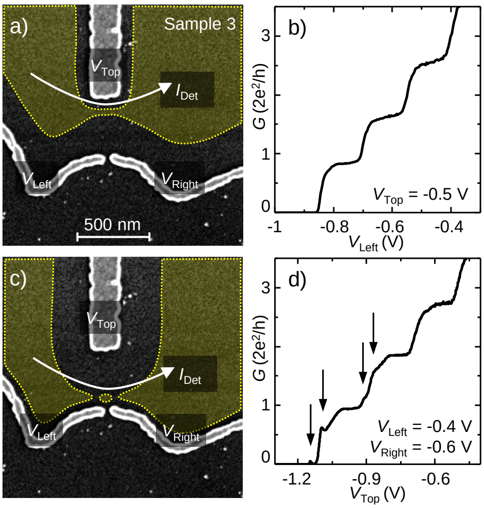

Figure 1: a) Scanning electron micrograph. Applying more negative voltages to the bottom gates shifts the conducting channel (shaded area) upwards. b) Linear conductance of the channel, plotted as a function of V_{Left} while $V_{\mathrm{Right}} = V_{\mathrm{Left}} - 0.2\,\mathrm{V}$. The expected conductance quantization is observed. c) Applying more negative voltage to the top gate shifts the channel downwards, enabling a localization to form at the gap between the left and right gate. d) Linear conductance as a function of V_{Top}. Multiple charging events of a localized state are observed (arrows).

[1] Clemens Rössler et al., arXiv:1209.4447.