# Quantitative Scanning Capacitance Microscopy on Buried InAs Quantum Dots

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InAs self assembled quantum dots embedded in GaAs $n-i$–Schottky diodes were imaged by quantitative scanning capacitance microscopy. As these measurements are extremely sensitive to light, a modified AFM feedback procedure was developed, where the AFM laser can be turned off up to several seconds while the AFM feedback loop keeps running.

The InAs quantum dot samples we used for our capacitance studies were initially designed for photocurrent spectroscopy, and had the following layer structure: on a highly doped *n*-doped back contact, a 40 nm i-GaAs layer was grown. On top, 1.55 ML of InAs were deposited at 500 °C followed by 80 nm of *i*-GaAs, a 40 nm thick AlGaAs blocking barrier (Al concentration 30%), and a 10 nm GaAs capping layer. The nominal dot density was in the order of 500 $\mu m^{-2}$.

In the low frequency (f = 1 kHz) capacitance images, InAs dots are clearly visible. The dot size in the capacitance images is larger compared to what was expected for the geometrical size, which we attribute to the fact that the dots are located 130 nm below the sample surface. A contrast rich capacitance landscape is also revealed in between the dots, which we attribute to local thickness variations of the InAs wetting layer. We also find that the image contrast depends on sample bias. A systematical measurement yielded best contrast at a sample bias of –0.6 V, which approximately corresponds to flatband conditions.

In addition to the images, capacitance spectra were recorded at on-dot and off-dot positions, which exhibit a clearly different behavior. At off-dot positions, the capacitance increases monotonically in forward bias direction, as it is expected for the capacitance of a Schottky contact on semiconductors. On contrast to that, one clear minimum and a step-like feature is observed in the capacitance spectra at on-dot positions. Attributing these features to a sequential filling of the dot states, the level spacing can be determined. For our sample, we obtain an energy spacing of 46 meV between the lowest levels, which is in reasonably good agreement with previous results of optical measurements.