Tunable Charge Detectors for Semiconductor Quantum Circuits

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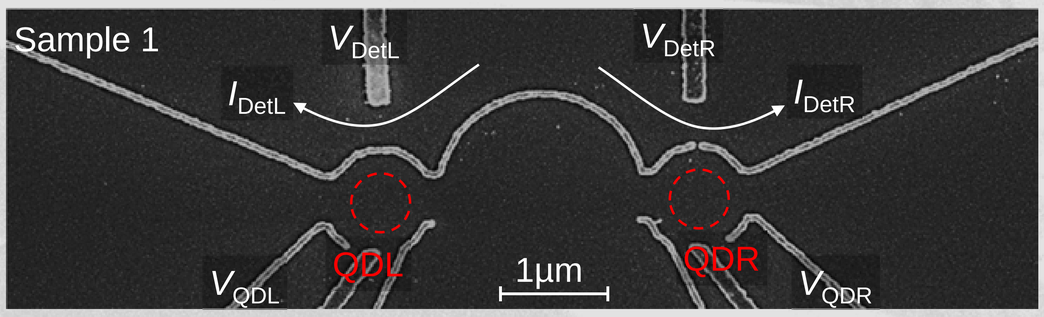
Motivation

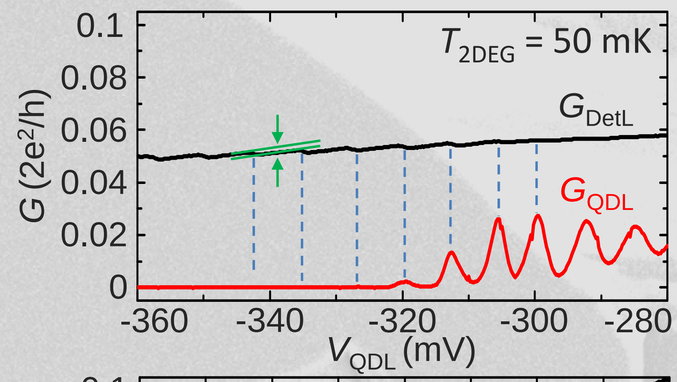
- Goal: real-time measurement of a quantum state
- Requires sensitive charge detection of quantum dot (QD)via adjacent quantum point contact (QPC)
- Investigate different methods of increased sensitivity:
  1. Reduce screening
  2. Increase capacitance between QD and QPC
  3. Tuning of QPC's confinement potential into localized state

1. Reduced Screening

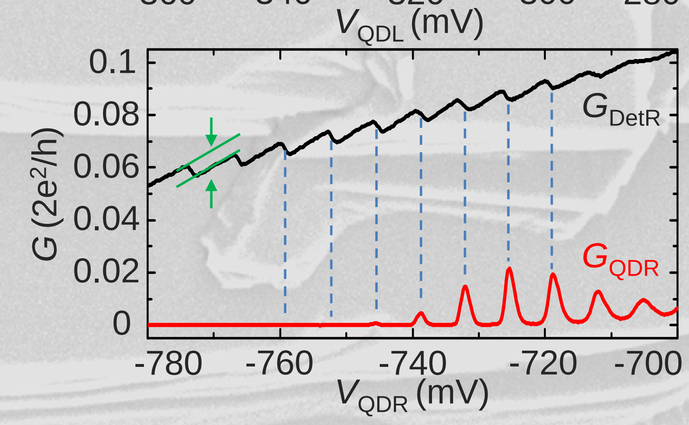


Left QD:
$\Delta G_{DetL} \approx 0.0015 \times 2e^2/h$

$V_{QDL\text{-}SD}$ = 100 µV
$V_{DetL\text{-}SD}$ = 100 µV

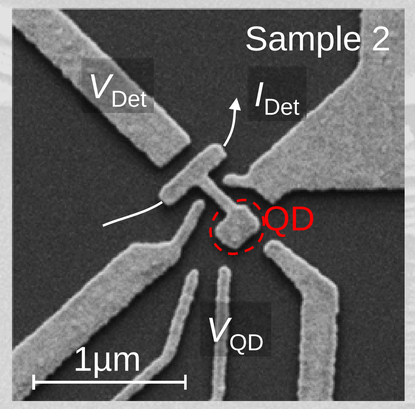


Right QD:
$\Delta G_{DetL} \approx 0.007 \times 2e^2/h$

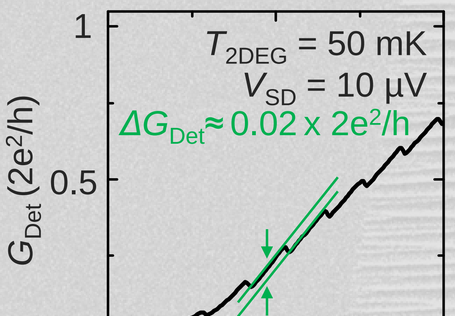


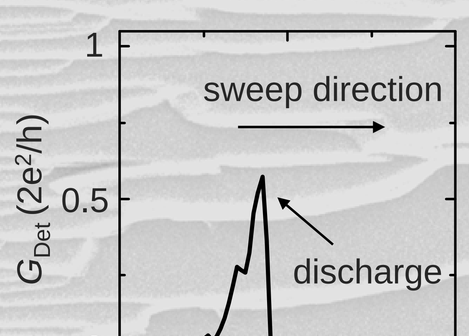
- Small gap between gates of right QD
- Increases readout fidelity from $\Delta G_{Det} \approx 0.0015 \times 2e^2/h$ to $\Delta G_{Det} \approx 0.007 \times 2e^2/h$
  ⇨ due to reduced screening?

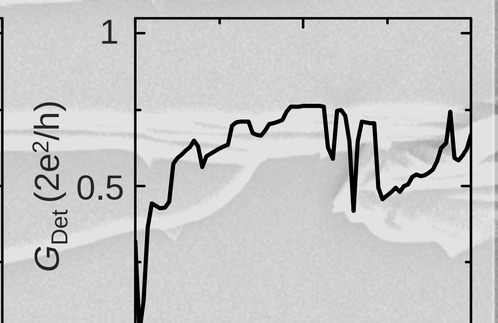
2. Floating Gate



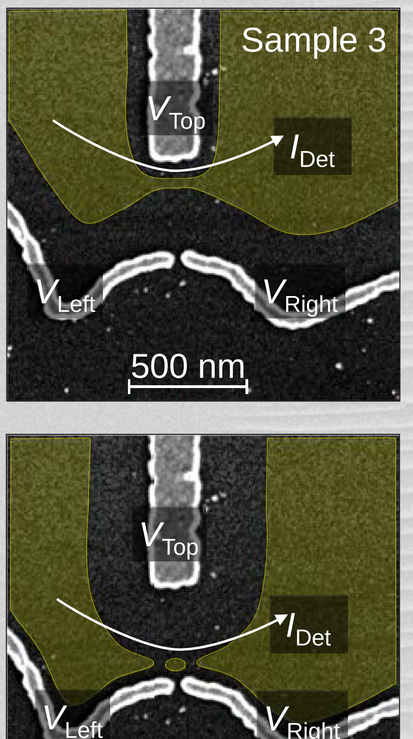
- Floating top gate increases capacitive coupling between QD and detector
- Enhanced readout fidelity of $\Delta G_{Det} \approx 0.02 \times 2e^2/h$
- However: not sufficiently stable over time

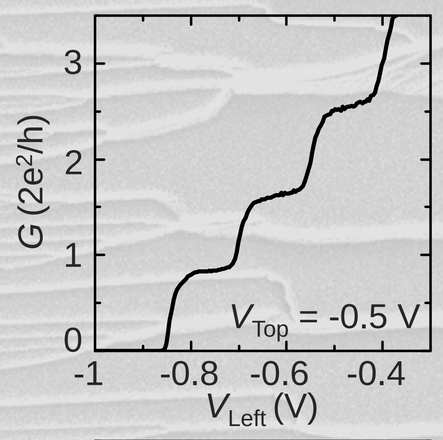


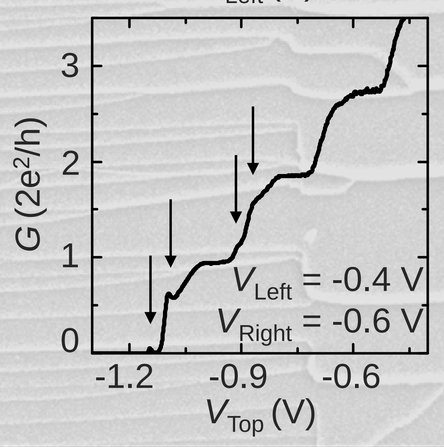


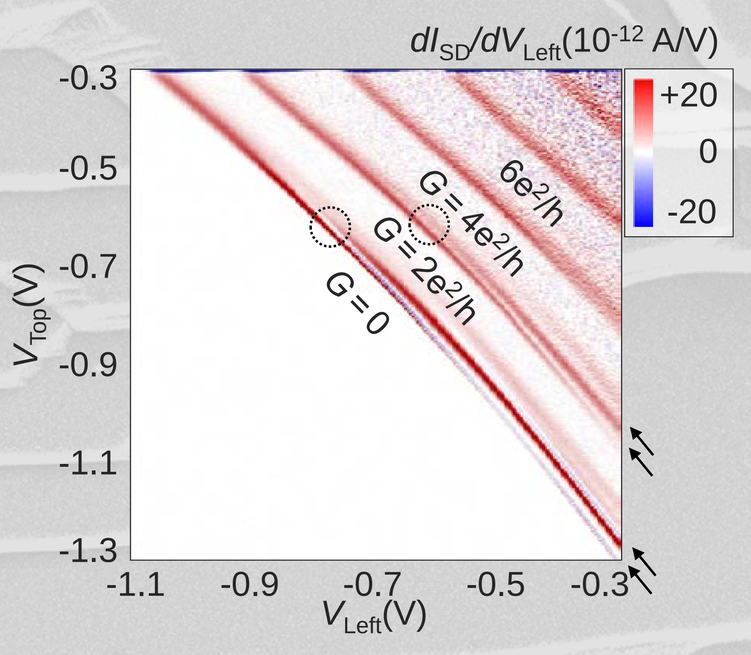


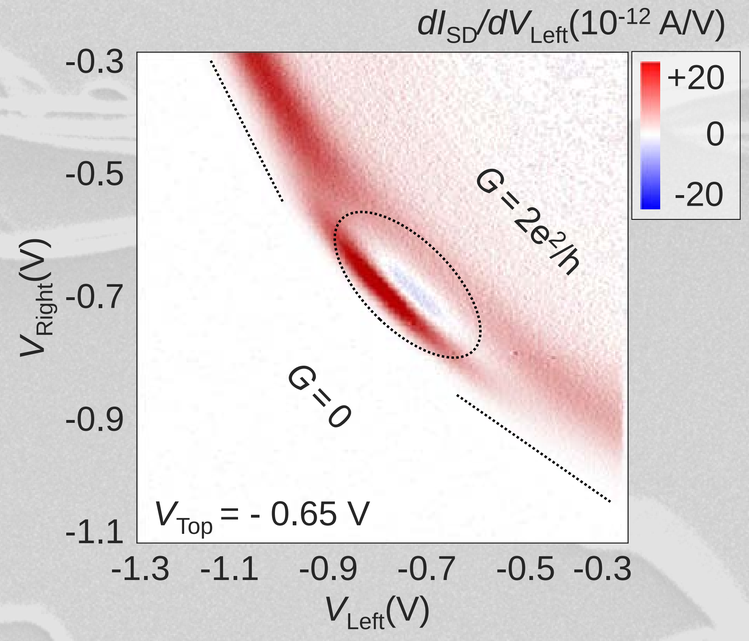
3. Tune Detector Into Localized State





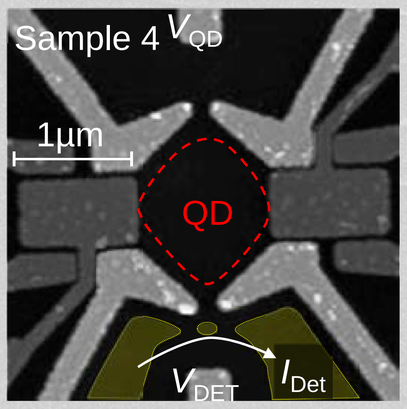


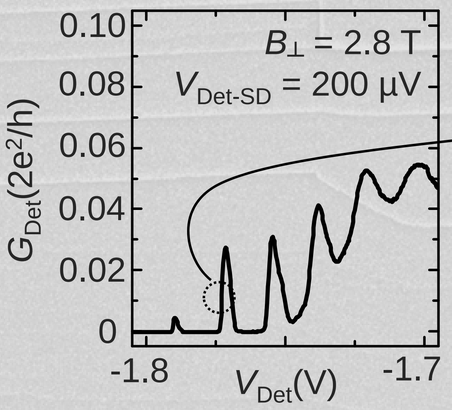


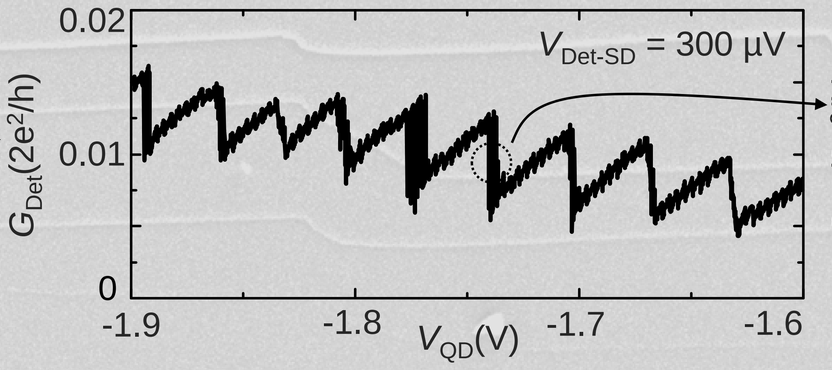


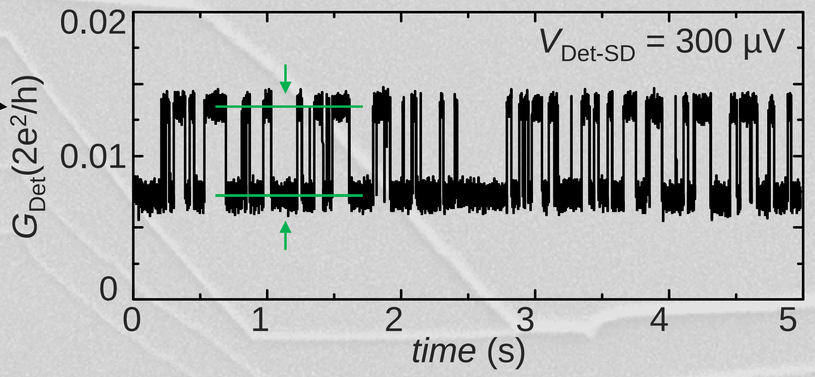
- Large negative voltage applied to barrier gates ⇨ detector shifted upwards ⇨ QPC
- Less negative voltage applied to barrier gates ⇨ detector shifted downwards ⇨ localized state
  Localized state should provide more sensitive charge readout capabilities

QD in Quantum Hall Regime









- Effective charge detection of a large QD: $\Delta G_{Det} \approx 0.006 \times 2e^2/h$
- Future studies: detection of fractional charge?