GERMANIUM QUANTUM WELLS AS A NOVEL PLATFORM FOR SPIN QUBITS

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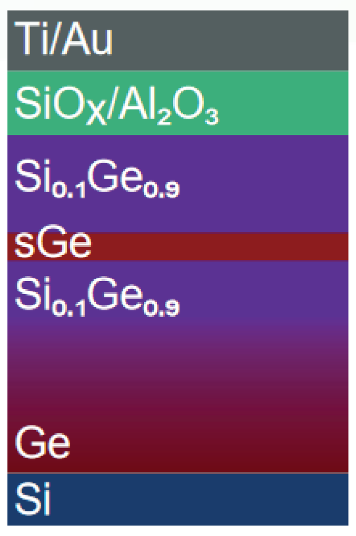
WHY GERMANIUM?

Novel Spin Qubits in Strained Si/Ge

- Heavy hole spin qubit
- All electrical control due to SOI[1]
- Electrical Rabi frequency of more that 100 MHz[2]
- Fermi level pinning near valence band: Easy ohmic contact
- Light effective mass: relaxed lithography requirements



Typical quantum well material stack[4]

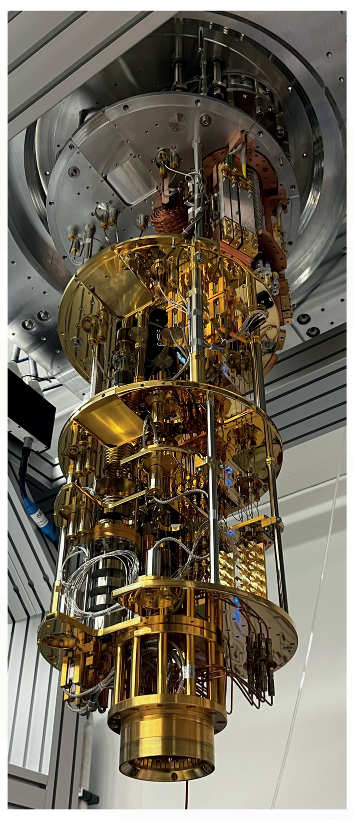
CRYOGENIC SETUPS

Two Dilution Refrigerators (T_{base} < 10 mK)

- Self-built DC filters, MW electronics being assembled
- 9-1-1 vector magnet, fast sample exchange capability
- First QW devices measured

Adiabatic Demagnetization Refrigerator (T_{base} < 44mK)

- Custom magnetic shielding developed
- Set up for superconducting device and cryogenic amplifier optimization



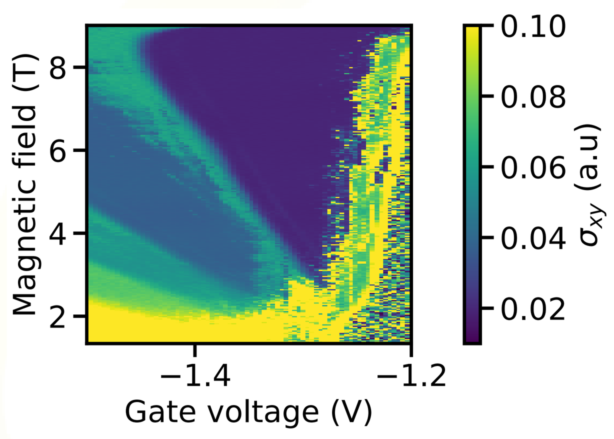
Fabrication:
Helmholtz Nanofacility,
FZ Jülich

Measurement:
DPP Building,
Melaten Campus,
Aachen

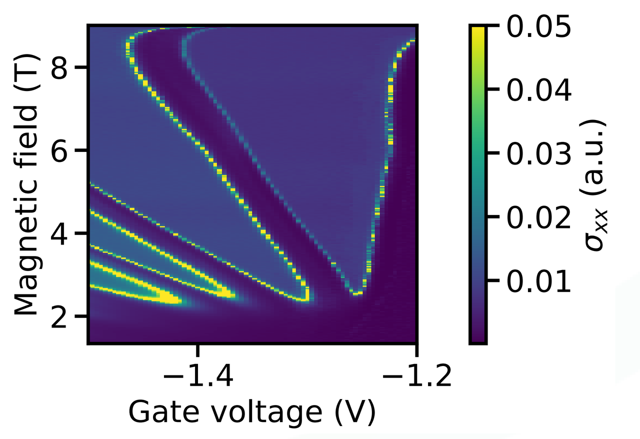
QUANTUM WELL DEVELOPMENT

- Tune SOI and g-factor through quantum well paramaters: thickness, Ge content, etc.
- Use Hall bar magnetotransport for standarized wafer characterization
- g-tensor mapping using 9-1-1 vector magnet (upcoming)

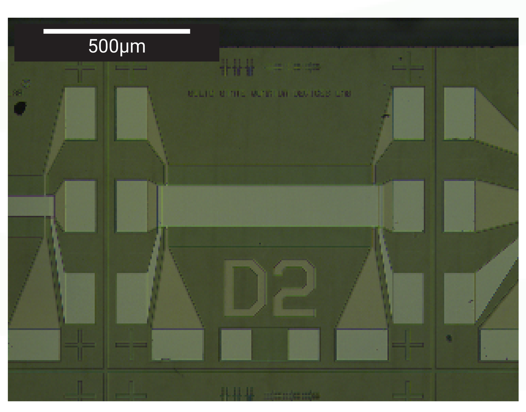
- Material by Leibniz Institute for High Performance Microelectronics (IHP)
- Hall carrier concentration $3x10^{-11}cm^{-2}$
- Landau fan visible but unstable turn on voltage requires further optimization



Transverse quantum hall conductance plateaues



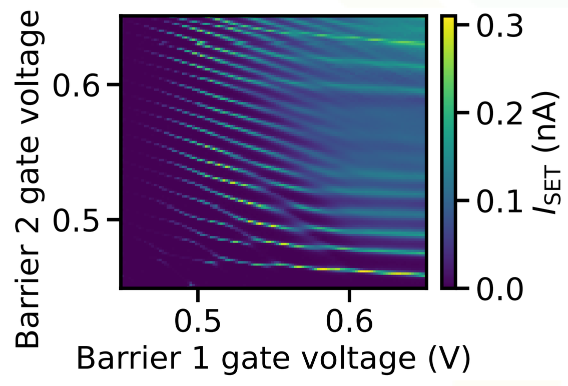
Longitudinal SdH conductance peaks



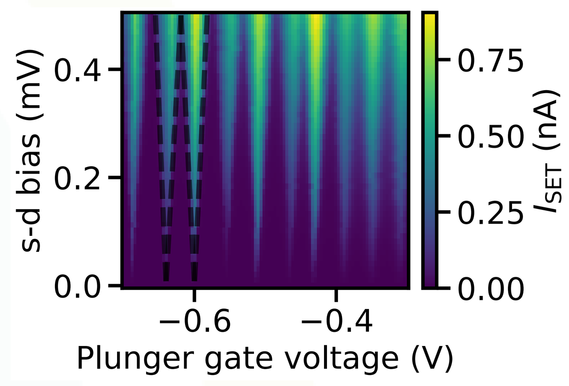
Typical hallbar

SPIN QUBITS - CURRENT STATE

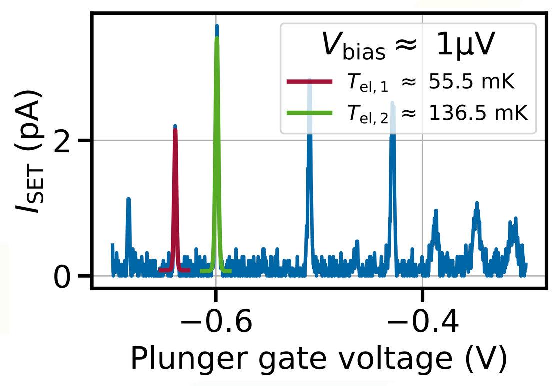
- Si/SiGe quantum dot samples from PGI-11 Bluhm group[3] used to estimate electron temperature
- Estimated T_{el} of 55mK from thermal broadening of Coulomb peaks
- First generation spin qubit devices fabricated



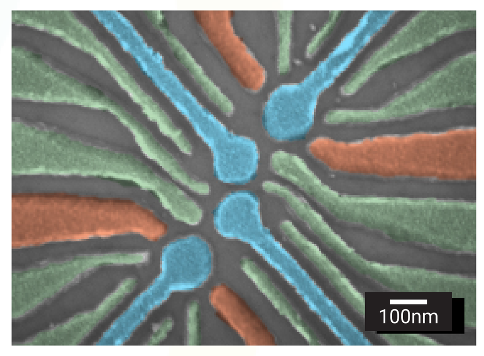
SET measurement at 100 µV bias



Coulomb diamond measurement



SET current trace (blue) at 1 µV bias with fits (red, green) to extract electron temperature

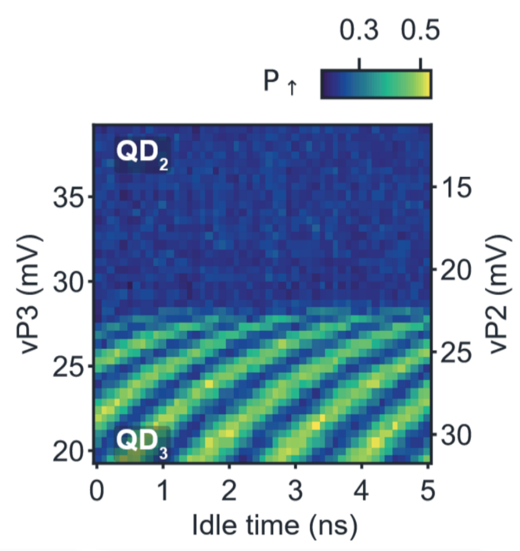


Single layer double QD device

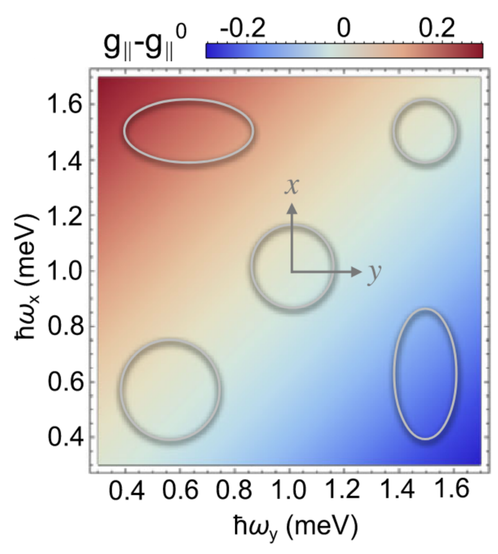
SPIN QUBITS - OUTLOOK

Spin-Orbit-Interaction in Ge offers novel approaches to Spin Qubits

- The g-tensor dependent on QD shape: changing driving speeds[4] and individual adressability possible
- Inter-dot variability of quantization axis[5]: novel qubit driving through tunneling between dots
- Nuclear spin (9/2) of natural ^{73}Ge interesting for Qudit experiments



Oscillations induced by tunneling between two quantum dots with different quantization axis, QuTech Delft group[5]



Change of in-plane g-factor due to change of dot shape, ISTA group[6]

PEOPLE AND REFERENCES

Dr Vincent Mourik (Project lead)

Niels Focke (Spin Qubits)

Spandan Anupam (Super-Semi Devices)

Lino Visser (Spin Qubits)

Sebastian Kock (Nuclear Spins)

Ashish Panigrahi (Spin Qubits)

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