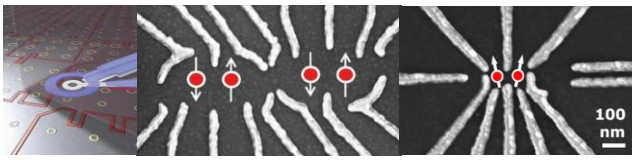


Quantum Technology Group

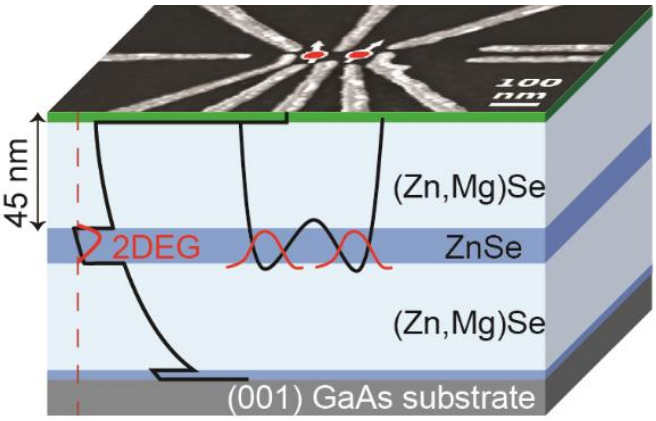
RWTH AACHEN UNIVERSITY

Towards electron spin quantum bits in ZnSe

Master's project starting SS 2019

Scientific background

(Zn,Mg)Se is a II/VI semiconductor system that exhibits decisive advantages as a host material for electron spin qubits. (I) It can be used to grow high qualitative quantum wells confining a 2D electron gas (2DEG). (II) It can be made nuclear spin free by isotopical purification. Thus, the electron spin coupling to an uncontrolled bath of nuclear spins is not an issue. (III) It is also a direct semiconductor without valley degeneracy in the conduction band. Thus uncontrolled valley excitation is absent and spin-to-photon conversion is possible in the future, in order to transport qubit information across a large distance.

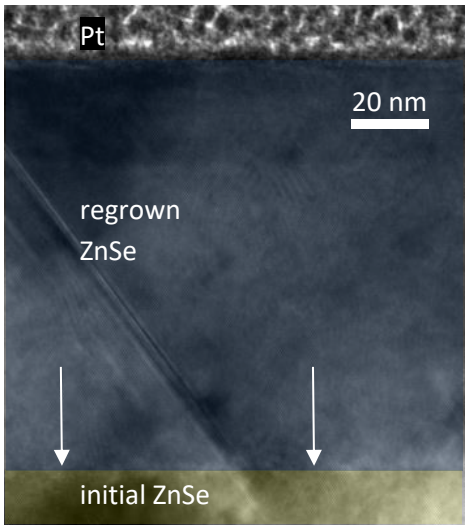


Research goal Despite its ideal properties, not much is known about electrical contacts from outside to the 2DEG operating at 10 mK. These are a prerequisite for electrical manipulation and detection of qubits. Ohmic contacts to the 2DEG are expected for a novel regrowth technique using epitaxially doped ZnSe. As a first step we characterize the regrown contacts and later 2DEG at low temperatures down to 1 K by measuring the (quantum) Hall effect. Manipulation of carrier concentration in gated devices is required to control the 2DEG mobility. High 2DEG mobility is required for the next step, formation of electrically defined quantum dots in ZnSe material systems.

Your task You will fabricate and characterize Hall bars with special focus on sample crystallinity. In low temperature experiments you will study electron transport mechanisms on Hall bar devices.

- Material properties of (Zn,Mg)Se
- Clean room fabrication
- Nanoscale sample analysis
- Cryogenic temperature physics
- Low-noise electrical measurement techniques

Furthermore, you will attend group seminars and journal clubs to learn about new developments in quantum computing.



Top: Layer structure of the (Zn,Mg)Se sample forming a ZnSe quantum well filled by a 2D sheet of electrons.

Bottom: Regrowth contact on Cl doped ZnSe, atomically resolved by transmission electron microscopy. Crystal imperfections such as lattice dislocations lead to contrast variations. The arrows points at the interface lying on a horizontal plane.

Cooperation partners: Helmholtz Nano Facility in Jülich, Dr. Alex Pawlis (PGI-9)

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