Master Thesis Topic

Acoustic Control of Spin Qudits

Background and Motivation

Defects are not always bad! Optically active defect centers in solids can play an important role in quantum technology. For example, they can act as single-photon sources and spin memories. Of particular interest are optically addressable spin centers, i.e. defect centers whose electronic spin states can be selectively initialized and read out with light. In such systems, spin dynamics are typically probed via optically detected magnetic resonances (ODMR), i.e. changes in light intensity caused by changes in the spin state.

Among the various materials for implementing such a technology, SiC is attracting increasing attention. SiC is a wide bandgap semiconductor compatible with CMOS technology that also contains highly coherent and optically active spin centers. One such center is the negatively charged silicon vacancy (V_{Si}), with a total spin of S=3/2 (qudit). The dynamic strain fields of surface acoustic waves (SAWs) have proven to be particularly powerful to control the spin of the V_{Si} center in 4H-SiC, since SAWs can interact with quantum systems located on their propagation path. Thanks to this interaction, it is possible to control the spin dynamics using sound.

Objective

The goal of this project is to control the spin dynamics of V_{Si} centers in the 6H-SiC polytype using SAWs. Specifically, we aim at the acoustic spin manipulation of the V3 center, which is promising for the implementation of robust spin–photon entanglement schemes. The key objectives are:

1. Fabrication and characterization of SAW resonators on 6H-SiC substrates.
2. Measurement of SAW-driven ODMR for the V3 centers.

Methodology

The project will involve a combination of clean-room, RF characterization and photoluminescence spectroscopy techniques. The key tasks include:

1. **Sample fabrication:** Sputtering of piezoelectric films such as ZnO or AlN, and patterning of interdigital transducers (IDTs) for the excitation and detection of SAWs.
2. **Characterization of SAW resonators:** Measurement of the reflection and transmission coefficients of the IDTs and spatial mapping of the SAW beams by interferometric and/or AFM techniques.
3. **SAW-driven spin manipulation:** optical characterization of the spin centers and measurement of SAW-driven ODMR under transverse magnetic fields.

Expected Outcomes

The expected main results of the project are

- Demonstration of efficient SAW resonators on 6H-SiC substrates.
- Demonstration of acoustic spin control in V3 centers.
- Detailed analysis of the spin-phonon coupling for the ground and excited states of the V3 center.

Skills and Requirements

- Background in solid state physics, materials science, or related fields.
- Experience or interest in clean-room technology and optical spectroscopy techniques.
- High motivation, excellent interpersonal and project management skills.

Opportunities and Benefits

- Modern labs with a wide range of experimental techniques.
- Supportive environment with experts for various scientific sub-fields.
- International and culturally diverse community.
- Location in the heart of Berlin with excellent public transport connections.
- Subsidized travel ticket.

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For further details or clarification, please feel free to contact us. Lab tours are also available for interested applicants.