Universität
Basel

Departement
Physik

The National Center of Competence in Research (NCCR) SPIN was founded in 2020 at the University of Basel in order to support research, education and technology transfer in various disciplines, such as quantum physics, materials science, engineering and computer science. Its main objective is to develop reliable, fast, compact, scalable spin qubits in silicon. In the Nanolino Lab we perform various atomic scale experiments, namely controlled self-assembly of materials with atomic precision and we study the unique materials' properties by means of various scanning probe and spectroscopic techniques.
In a project titled ***Scanning Probe Microscopy for the Characterization of ultra-clean nanowires*** funded by the NCCR SPIN we will characterize the Si-Ge Nanowires (Si-Ge NW) and Fin FET transistors by pendulum Atomic Force Microscopy (pAFM). Our main objective is to measure energy dissipation and charge noise in Si-Ge NW quantum dots.

For these research activities we are looking for a:

PhD student position in scanning probe microscopy

Short description of the project:

Quantum qubits can be realized in a spin state of a single charge confined in a semiconductor quantum dot [1]. Silicon seems particularly promising material due to its matured fabrication process in classical electronics. As a result of tunable spin-orbit coupling and suppressed hyperfine interaction insulating the quantum devices from environmental noise [2], it is possible to push the silicon technology towards quantum circuits. Understanding nanoscale energy dissipation is nowadays among few priorities particularly in solid state systems and the presence of energy dissipation has a great impact on qubit lifetime. It is therefore critical to know, how and where energy leaks.

In pendulum atomic force microscopy (pAFM) [3] experiment the oscillating tip would probe the charge and spin state transition in Si-Ge NW. The ultra sensitive mechanical oscillators suspended in pendulum geometry (pAFM) detect the charge of the quantum dot due to change of cantilever dynamics.The local potential μ is controlled by the AFM tip voltage and tip-sample separation. The external perturbation caused by an oscillating tip might push a finite quantum system, or a collection of them towards a transition or a level crossing with subsequent relaxation of the system. A level crossing implies a dissipation channel for the external agent provoking the change. For AFM this leads to distance and bias-voltage-dependent dissipation rise of the tip oscillation energy and the modification of the interaction force. The method can quantify the capacitive forces between quantum dot and oscillating cantilever gate as well as amount of dissipated power in the quantum device. Despite high quality of Si/Ge, Si/SiO2, metal-semiconductor interfaces, a minute charge noise might still be present in those structures. Measurements of 1/f – noise in quantum devices will help to reduce the charge noise and further improve the quality of the structures. The topography of the quantum devices will be reliably measured down to the atomic scale.

The AFM tip position on the sample is controlled with nanometer accuracy and the enhanced sensitivity allows to distinguish between electronic, phononic or van der Waals types of dissipation. Measurements can be performed in a wide range of temperatures from liquid helium, liquid nitrogen up to room temperature and in magnetic fields spanning from B=0T to B=7T. The design of the sample holder with implemented external electrodes allows to apply bias voltage to the measured quantum devices.

[1] - Loss D and Di Vincenzo D. P, Phys. Rev. A 57, 120 (1998)

[2] - Andreas V. Kuhlmann, Veeresh Deshpande, Leon C. Camenzind, Dominik M. Zumbühl, *and* Andreas Fuhrer, Applied Physics Letters 113, 122107 (2018)

[3] - Kisiel M, Gnecco E, Gysin U, Marot L, Rast S, Meyer E. Suppression of electronic friction on Nb films in the superconducting state. Nat Mater.10(2), 119-122 (2011)

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The candidate may be responsible for:

Installation of quantum device in the microscope under cryogenic conditions. Creation and measurement of a hole quantum dot with pendulum AFM as a charge sensor. Implementation of the additional wiring in pendulum AFM microscope.

Your profile:

We seek for a highly motivated person with master degree in areas as such Physics, Nanoscience or related. Ideally you have an experience in ultra high vacuum and scanning probe techniques and knowledge of nanofabrication, cryogenics or electronics is an advantage.

Application procedure
The application should be written in English and it should contain:

- CV
- Reference
- Personal letter where you introduce yourself and describe your previous research experience

Further Information / Contact:

dr. Marcin Kisiel, tel: +41 (0)61 207 3725, marcin.kisiel@unibas.ch
Prof. dr. Ernst Meyer, tel: +41 (0)61 207 3724, ernst.meyer@unibas.ch
https://nanolino.unibas.ch