NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

M2 Internship in Si spin qubits, academic year 2021/2022

Large scale parametric characterization and test of quantum devices at cryogenic temperatures

Context: A natural way to address the scalability of quantum devices is to design and realise arrays of individual quantum objects with nearest-neighbor interaction. In large-scale semiconductor quantum processors, a quantum bit is encoded in the spin of an isolated electron, trapped in an array of quantum dots (QDs) [1]. Over the years, we have studied devices with an increasing number of QDs, in designs that allow for the coherent control of individual spin. **However, there is a pre-requisite for a precise control of spin qubits: a deep knowledge of the quantum dots used to confine the electrons in arrays [2]. Therefore, demonstrating the extensive and scalable characterization and calibration of QD systems is crucial for the development of our quantum processor.** Last year CEA-Leti has acquired a unique automatised measurement tool for 300-mm wafers at cryogenic temperature, which gives us a new way to develop intelligent and efficient characterization techniques (Figure 1).

Objectives and means available: The systematic characterization of the QD control parameters scales with the number of control knobs and QDs. The dense exploration of the parameter space to determine the array's charge state limits the experimental throughput of relevant data points. During his/her internship, the student will develop QD characterization algorithms, like adaptive meshing or feature recognition using signal and image processing algorithms to optimise the parameter space exploration. Consequently, within this project, the student will develop feedback loop in the computer software fast real-time processing to optimise the characterization speed and allow for statistical analyses. Parallel to this, the student will work on the development, based on existing works, of optimized experimental characterization protocols. Indeed, the characterization of quantum devices at large scale will build up a statistical knowledge of the structures that can enhance the measurement protocols. As such, they will be embedded in the automated characterization workflow for arrays of quantum dots and will progressively enrich the physical modelling and understanding of the QD arrays.

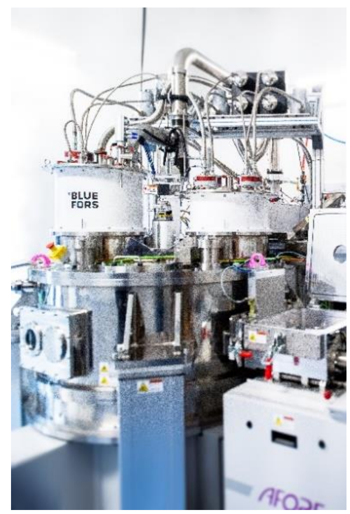

Figure 1: Photograph of the cryogenic 300mm-wafer prober

Interactions and collaborations: This work is part of a large collaborative effort to develop and push the technology of spin qubit in silicon and investigate its potential scalability. Therefore, the candidate will work in close collaboration with the LETI's characterization and integration team designing the quantum devices, with the CEA-IRIG where the quantum devices are characterized at mK temperatures and used as qubit platforms.

Skills and training: We are looking for a motivated student, with an interest for experimental physics. This internship requires skills in semiconductor physics. A strong interest in algorithm programming and quantum physics is required. A knowledge of nano-fabrication techniques, low-temperature physics and/or spintronics will be appreciated but is not mandatory.

[1] Vinet, M. et al. Towards scalable silicon quantum computing, IEDM (2018).

[2] Mortemousque, P.-A. *et al.* Coherent control of individual electron spins in a two-dimensional quantum dot array. *Nat. Nanotechnol.* (2020) doi:10.1038/s41565-020-00816-w

Possible extension as a PhD: Yes. **Starting date / Duration**: Flexible

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