INSTITUT NEEL Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Fast and efficient one- and two-qubit gates in slicon based quantum processors

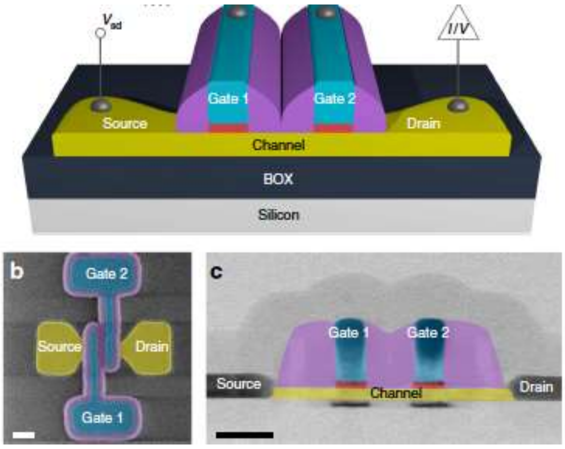

Figure: Views of a basic sample envisioned to realize a two-dot structure to perform basic quantum operations. (from Maurand et al. Nature Communication 2016)

Context : In quantum nanoelectronics, a major goal is to use quantum mechanics in order to build efficient nanoprocessors. This requires the ability to control electronic phenomena in a nanostructure at the single electron level. In this context, the electron's spin has been identified as an appropriate degree of freedom for efficient storage and manipulation of quantum information. The defined building block of this quantum computer strategy is the spin of a single electron trapped in a quantum dot. The implementation of the system as a quantum nanoprocessor resembles the classical circuit boards contained in a classical computer. In dot systems, all the basic operations of a quantum nanoprocessor have been demonstrated for GaAs spin qubits. Intense experimental effort is nowadays invested in silicon where coherence properties are the best observed so far for electron spin qubits and which offers compatibility with CMOS technology used in microelectronics.

Objectives and means available: The goal of the project is to design and measure silicon architectures to perform basic quantum operations. More precisely, we will start with two electron spin qubits coupled together in a device. We will investigate how to measure the spin state of such system and how to implement two-Qubit logic gates. All the samples will be fabricated at CEA-LETI with a state of the art Si facility to enable maximum output and reproducibility. To perform full control, we will add micromagnet close to the dot system to enable efficient one- and two-qubit gates. To control and manipulate the electron spin coherently, the applicant will benefit from the long-standing expertise of the Neel-group in AlGaAs based electron spin qubits (computer control, low temperature cryogenics, low-noise electronics, Radiofrequency electronics).

Interactions and collaborations: This work is part of a large collaborative effort between the CEA-INAC, CEA-LETI and CNRS-Institut Néel to develop and push the technology of spin qubit in silicon and investigate its potential scalability. Collaboration with ATOS (the group lead by Cyril Allouche) will guide the design of the elementary spin qubit brick with respect to the constraints of large scale architecture.

Skills and training: The experimental project relies on the knowledge accumulated in the field of few-electron quantum dots and its new implementation in Si devices. All along this project, the candidate will acquire important skills in the field of condensed matter physics: nanofabrication, cryogenics at mK, low-noise electronics, computer control…

Foreseen start for the beginning of the internship: From January to April 2020

Possibility of continuation as a PhD on the same subject with funding already secured.

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