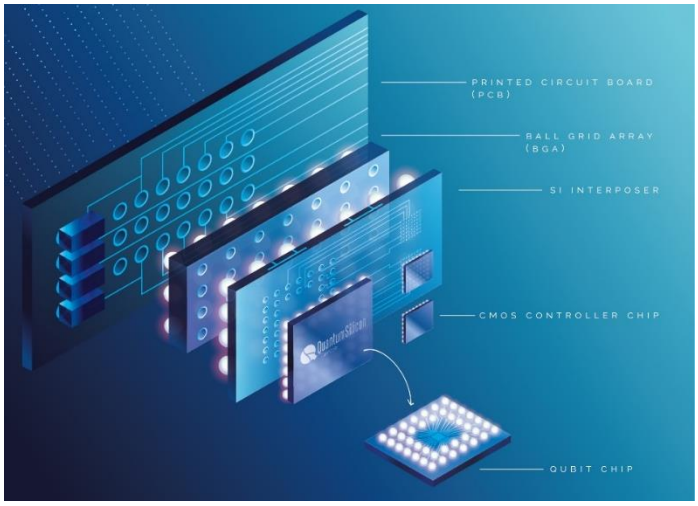
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Measure of a semiconducting qubit chip with embedded control and readout circuits.

General scope:
Quantum computing is a field of growing interest, especially in Grenoble with an exceptional concentration of both research and industrial groups active in this field. The global aim is to develop a new kind of nano-processor, based on quantum properties. Its building brick is a two-level quantum system (the qubit), in our case the spin of an electron trapped in a quantum dot. In this context, the Grenoble Quantum Silicon Group is actively trying to leverage the decades of development of the Silicon industry in Grenoble to realize a network of inter-connected semiconductor spin qubits.

Research topic and facilities available:
The aim of this project is to demonstrate the complete control of a quantum chip via a cryo-electronic circuit operating at low temperature. For this, a demonstrator composed of a silicon interposer, a GaAs quantum circuit, a multiplexed control chip and a trans-impedance amplifier are co-integrated and placed in a cryogenic test environment. Following the recent demonstrations of quantum dot arrays [1] and long-range coupling protocols [2], the GaAs quantum circuit represent a good testbed for the future Si qubits. The control electronics is the third iteration of a cryo-electronic circuit [3] designed to enhance the scalability and performances of the electrostatic control and readout techniques.



Representation of the integrated quantum chip

The candidate will benefit from the extensive knowledge of the Néel group on the control of GaAs nanostructures, and from the resources offered by the technical poles (electronics, cryogenics). The Leti group will support the project with their important effort on the modeling of the control circuits' behavior at low temperatures.

[1] *Coherent control of individual electron spins in a 2D quantum dot array*
P-A Mortemousque et al, Nature Nanotechnology 2020.
[2] *Distant spin entanglement via fast and coherent electron shuttling*
B. Jadot et al, Nature Nanotechnology 2021.
[3] *A 110mK 295µW 28nm FDSOI CMOS Quantum Integrated Circuit with a 2.8GHz Excitation and nA Current Sensing of an On-Chip Double Quantum Dot*, L. Le Guevel et al, ISSCC 2020.

Possible collaboration and networking:
This topic is co-directed by the CEA-Leti and the CNRS-Néel Institute via the "Grenoble Quantum Silicon" group. The circuit is conceived and fabricated by the CEA-Leti, and measured at the Néel Institute, under the supervision of a post-doctorate researcher with a shared affiliation between the two entities. The candidate will have strong interactions with other actors of the QSG project and benefit from their developments.

Required skills: We are looking for a motivated student, with an interest for experimental physics. This internship requires skills in electronics, programming, and a basic understanding of quantum physics. A knowledge of nano-fabrication techniques, cryogenics or electronic circuit design will be appreciated but is not mandatory.

Possible extension as a PhD: Yes, with funding already secured.
Starting date / Duration: Flexible
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