NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

Graphene based superconducting quantum bit

General Scope:
The future of nanoelectronics will be quantum. The downscaling in electronics has now reached a point where the size of the devices (less than 10 nm) means that their quantum behavior must be taken into account. While this might be seen by some industries as a major problem this also gives a real opportunity to imagine and build devices with new quantum functionalities.
A key building block for future quantum electronics systems is the quantum bit (Qubit). Such system has two possible states (0 and 1) that follow the laws of quantum mechanics. One example is that one might build any superposition of 0 and 1. This will have implications for building future quantum computers.
Research topic and facilities available:
In this work we will build a new type of device to implement a Qubit that would have strong advantages over other competing systems. We will use the know-how that has been developed in the superconducting Qubit community over the past 20 years and integrate in the core of the system a semiconducting material to bring novel electrical functionality to the device, in the form of a voltage-tunable energy. We will use graphene, a two-dimensional zero-band-gap semiconductor, because of the potential scalability of such approach. Such device is expected to behave as a quantum two-level system with an energy structure that can be tuned with an electric field (gate) thanks to graphene (see figure).
A one atom-thick sheet of graphene will thus have to be integrated into a superconducting Qubit design using nanofabrication techniques available at the Institute. Such sample will then be measured at very low temperature (20mK) in a dilution refrigerator using radiofrequency (1-10 GHz) techniques. After the demonstration of the electrical tunability, more advanced measurements will be carried out in the following PhD project: lifetime, coherence, coherent manipulation...

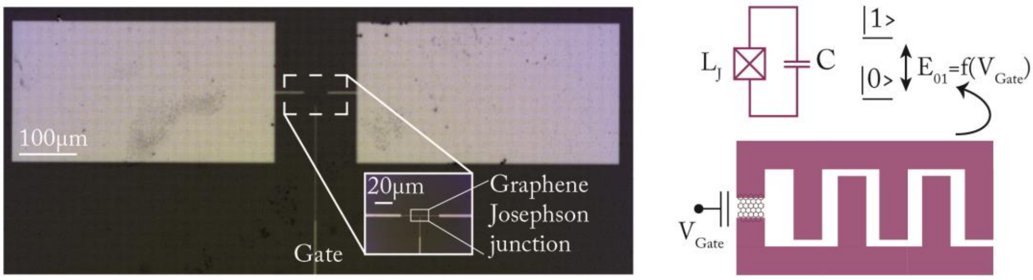

Figure 1: Optical image of the first generation of graphene based superconducting qubit. The graphene link (Josephson junction), 200nm long, is not visible at this scale. On the right, the equivalent electrical circuit shows that this device will behave as an electrically tunable quantum two-level system.

Possible collaboration and networking:
The student will be part of the Hybrid team, which has a multidisciplinary expertise (growth, nanofabrication, electronic transport, spectroscopy...). The team has also several external collaborations worldwide (France, Switzerland, Germany, Canada).
Possible extension as a PhD: Yes (already funded)
Required skills:
The internship (and the PhD thesis) will require a solid background in solid state/condensed matter physics. The work will be mainly experimental. The candidate is expected to be strongly motivated to learn the associated techniques (nanofabrication in clean room, radiofrequency electronics, cryogenics...) and engage in a hands-on experimental work.
Starting date: March 2021 (Flexible)
Contact:

Name: Julien Renard Institut Néel - CNRS
Phone: 0456387176 e-mail: julien.renard@neel.cnrs.fr http://perso.neel.cnrs.fr/julien.renard/

More information: http://neel.cnrs.fr