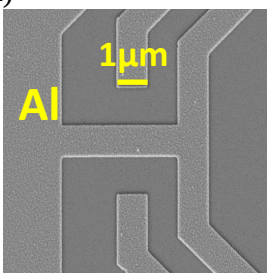
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Single electron transistor microscopy of two dimensional electron systems

General Scope:
A number of phenomena in condensed matter physics lead to an inhomogeneous distribution of a physical quantity, e.g., the flux distribution in superconductors or the electron density of states of a semiconductor. A direct visualisation of these inhomogeneous states is often the only way to reveal their existence. In a bulk measurement without spatial resolution these effects may stay hidden. Scanning probe microscopy allows the visualization of a physical quantity by scanning the surface of interest with a small detector or probe. The images represent high resolution maps of the specific property. Today these techniques are a key tool in nanoscience and nanotechnology.

a)



b)

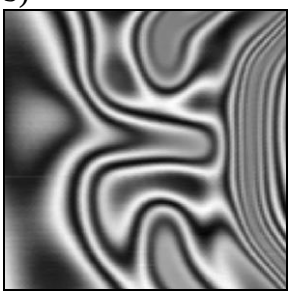


Fig. 1 a) Test sample with Al electrostatic gates b) Scanning single electron transistor image of the test sample.

Research topic and facilities available:
In this project, we will use a scanning single electron transistor microscope at low temperatures (<300 mK) and high magnetic fields (0-18T). This microscope has been recently developed at Néel Institute and is now fully operational. The probe, a single electron transistor, allows very sensitive electric charge detection. With such a scanning probe microscope most of the two-dimensional electron systems can be studied. Some prominent systems are edge channels in the quantum Hall regime, surface states of three dimensional topological insulators or inhomogeneous electronic states close to a metal-insulator phase transition.
In this project, the electronic states of graphene based structures will be imaged. These structures are currently intensively studied all over the world but so far mostly by transport measurements. With an external magnetic field or an electrostatic gate, these samples exhibit a variety of phase transitions, between the insulating and the conducting state. We expect to image directly localized and delocalized electronic states in these graphene heterostructures with nanoscale spatial resolution. Transport measurements can be done simultaneously in situ which allows a careful characterisation of the sample close to a phase transition.

Possible extension as a PhD: YES

Required skills:
We are looking for a motivated student with a solid background in quantum and condensed matter physics who is attracted by experimental physics. This project involves the work with scanning probe techniques in a cryogenic environment (dilution refrigerator) and high magnetic fields. The candidate will also learn to fabricate new single electron transistor probes in the Néel Institute clean rooms and to elaborate the graphene samples for the project.

Starting date: 2020

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