NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Electron beam induced current study of p-n junction electrical properties

General scope:

The electrical properties of semiconducting materials can be engineered by adding dopant atoms to the lattice, that donate or accept an electron from conduction or band valence, respectively. In this way the density of mobile charges can be tuned over several orders of magnitude. It is very well known that a transition from one type of dopant to the other kind will generate a so-called p-n junction, giving rise to rectifying current voltage characteristics and potentially light emission, for example in light emitting diodes. However, challenges remain to control and measure the electrically active doping levels in semiconducting materials with nm precision, especially in wide bandgap materials with high dopant activation energies. At nm scale the build in electric field at the pn junction gives rise to an electron beam induced current, allowing to study the junction properties.

Research topic and available facilities:

The aim of this internship is to contribute to the study of p-n junction semiconducting materials regarding their electrical properties, in particular studied at nm length scales. The student will integrate a multi-institute, multi-disciplinary research group.

His/her role will be to fabricate electrical contacts to p-n junction nanowires of GaN or AlN, potentially first thinned down by FIB. The p-n junctions will be electrically contacted on membrane chips compatible with transmission electron microscopy (TEM) measurements, and the student will be in charge of their preliminary electrical characterization by current-voltage measurements. The junction will then be studied by electron beam induced current (EBIC) both in scanning electron microscopy (SEM) as well as TEM. The aim is to compare SEM and TEM to carry out EBIC experiments and compare junction qualities between them, to improve our understanding of doping, which will aid device fabrication, for instance for NW solar cells or light emitting diodes.

The student's work will involve:

- Nanowire contacting in a cleanroom environment. It implies training in nanowire dispersion, mapping using scanning electron microscopy, making drawings of the contact lines, assisting electron beam lithography and finally preforming lift-off.
- Current-voltage measurements.
- The electron beam lithography step for nanowire contacting and microscopy experiments will be performed by the supervisor, but the student will participate in the experiments.
- The student will be involved in the data analysis of EBIC results.

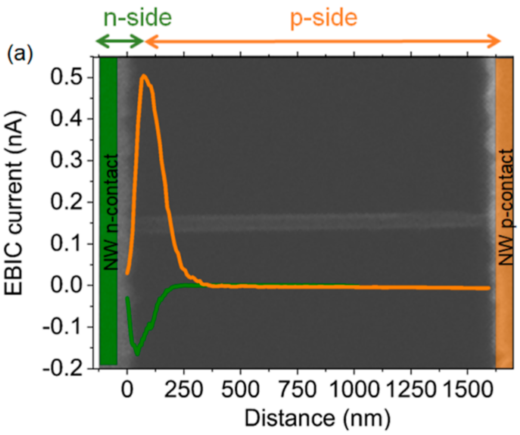

Figure 1a) EBIC scan along a single GaN NW overlaid on an SEM. The orange and green EBIC line scans correspond to the current collection from the n-side and the p-side of the NW, respectively.

Possible collaboration and networking: The internship will be in collaboration with Gwenolé Jacopin (NEEL, SC2G).

Possible extension as a PhD: Not granted in advance, but we support applications for a PhD grant.

Required skills: Interest in solid-state physics, electrical and optical properties of semiconductors and advanced characterization techniques like transmission electron microscopy.

Starting date: Jan/Feb 2023 or earlier.

Contact: den Hertog Martien & Gwenolé Jacopin

Institut Néel - CNRS : tel: 0476881045 mail: martien.den-hertog@neel.cnrs.fr & gwenole.jacopin@neel.cnrs.fr

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