NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Nanowire betavoltaics

General Scope: The internship will part of a collaborative research project that aim at developing advanced betavoltaic (BV) energy sources, addressing the growing demand for long-lasting, autonomous power generation in challenging environments. The principle of these BV generators is rather simple: they convert the kinetic energy of β-particles (electrons or positrons) into electrical energy in a semiconductor, similar to the photovoltaic effect. The energy output of these devices persists for a period of time on the order of the radioisotope source's half-life, making BV sources durable and insensitive to environmental conditions. Thus, BV source is offering a promising alternative to traditional batteries due to its higher energy density and extended lifespan.

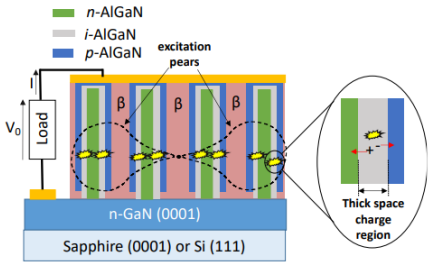

Figure 1 - BV generator proposed within the framework of the master internship

The project aims to overcome the limitations of current commercial BV devices by exploring innovative semiconductor structures. While existing solutions use planar designs with limited efficiency, this research proposes using core-shell nanowire p-i-n junctions, particularly with (Al)GaN semiconductors. This novel approach seeks to optimize the conversion of β-radiation to electron-hole pairs by decoupling particle absorption and charge carrier collection directions.

Research topic and facilities available: In this context, the aim of this internship is twofold:

(1) Firstly, the student will be in charge of making such betavoltaic cells from core-shell nanowires epitaxied by our partner at CEA-IRIG. To reach this objective, the intern will have access to all the necessary clean-room equipment (resin deposition, lithography, metal deposition, etc.).

(2) Once the device has been realized, the intern will be in charge for characterising the device. Firstly, he/she will carry out standard electrical characterisation (I(V), C(V), etc.). Finally, in order to quantify the efficiency of the BV cell, the student will carry out electron beam induced current (EBIC) measurements in which the beta emitter will be simulated by the electron gun of a scanning electron microscope.

Possible collaboration and networking: This work will involve strong collaborations with researchers from CEA (Bruno Daudin & Christophe Durand) as it is part of a collaborative research project.

Possible extension as a PhD: It will be possible to pursue as a PhD on the same subject with funding already secured (ANR Funding). The thesis will be shared between CEA-IRIG and Institut Néel. The student would be in charge of growing the core-shell nanowires at the CEA and would produce and characterise the BV cells at the Néel Institute. He will also have the opportunity to collaborate with other laboratories: LTM in Grenoble, CRHEA in Nice and McMaster University in Canada.

Required skills: The candidate should have a master 2 in Nanosciences or equivalent, with a marked interest in experimental physics, material growth and characterization

Starting date: The internship could start from January to April 2025

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