Master internship project

Heat transport in III-V semiconductor nanowires by means of a Scanning Thermal Microscopy

Location: Centre d'Energétique et de Thermique de Lyon (CETHIL), UMR 5008 CNRS - INSA de Lyon, France
Duration: 6 months
Supervisors: Séverine GOMES (CETHIL), CNRS Director (severine.gomes@insa-lyon.fr) and Nicolas CHAUVIN (INL), CNRS Researcher (nicolas.chauvin@insa-lyon.fr)

Keywords: nanoscale heat transport, III-V semiconductors, nanowire, thermoelectricity, atomic force microscopy (AFM), scanning thermal microscopy (SThM),

Research project

Context and goal. Thanks to their unique morphology, structural and physical properties, III-V semiconductor superlattice nanowires have potential promising applications in different key challenging industrial areas including thermoelectricity. Their lower heat transfer ability (thermal conductivity) compared to the bulk has proven practical for increasing their thermoelectric figure of merit ZT.

$$ZT = \sigma.S^2.T / k = \sigma.S^2.T/(k_e + k_L) \qquad \text{(Eq. 1)},$$

with σ, the electrical conductivity, S, the Seebeck coefficient, T, the absolute temperature, and k_e and k_L, the electronic and lattice thermal conductivity respectively.

Various strategies have already been used to reduce the heat transport in superlattice nanowires (SL NWs) but the additional nanostructuration is often associated to an additional electron scattering, i.e. a decrease of NWs electrical conductivity (σ) (Eq. 1). This σ decrease is undesirable for devices. Consequently, the need for more energy carrier-specific mechanisms in NWs persists.

This Master internship is part of a long-term project that aims to provide a first evaluation of the impact of the internal electrical polarization (IEP) field in a III-V SL NW on its thermoelectric properties. **Among the NW thermoelectric properties, the research in the Master internship will focus on the NW thermal conductivity.**

Master internship Program. The work plan includes the following six main steps.

1. Understanding the project goals through bibliography research and learning to use the scanning thermal microscope [1] (SThM), which will be used to measure the NWs thermal conductivity.
2. Performing SThM measurements of SL NWs produced by INL. Adapting the 3D numerical modelling used at CETHIL to reproduce the SThM measurement to the geometry of the investigated samples.
3. Identifying the NWs thermal conductance and conductivity combining the new model and experimental data.
4. Comparing the results obtained with those elsewhere published. This step comprises also bibliography research.
5. Writing of the report.

References:

[1] Gomès et al. (2015). *Scanning thermal microscopy: A review*. physica status solidi (a), 212(3), 477-494.