Master internship project

Heat transport in a 2D hexagonal boron nitride (2D-hBN) material

by means of a unique dual Scanning Electron and Thermal Microscopy (SEM-SThM) equipment

Location: Centre d'Energétique et de Thermique de Lyon (CETHIL), UMR 5008 CNRS - INSA de Lyon, France

Duration: 6 months

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Research project

Context and goal. This project aims at continuing the laboratory - demonstration of the capabilities of a dual Scanning Electron and Thermal Microscopy instrument (SEM-SThM [1-2]) developed by the Centre d'Energétique et de Thermique de Lyon and the Institut Lumière et Matière in Lyon. The instrument was initially set for analyzing microscopic processes and understanding the nanoscale mechanisms of energy dissipation in nanostructures in unique and highly controlled experimental conditions. It was recently shown allowing the characterization of a suspended silicon (Si) nanowire (NW) with a diameter of 100 nm (Fig. 1). Reproducible experimental data were obtained, enabling quantitative estimations of not only the NW thermal conductivity but also its moment of inertia at the same time [2].

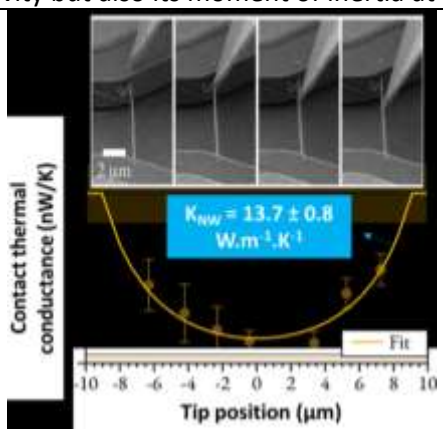

Fig. 1: *Scanning electron microscopy images :Scanning thermal microscopy probe scanning a Si 100 nm in diameter nanowire (up) ; measured thermal conductance profile (down).* [2]

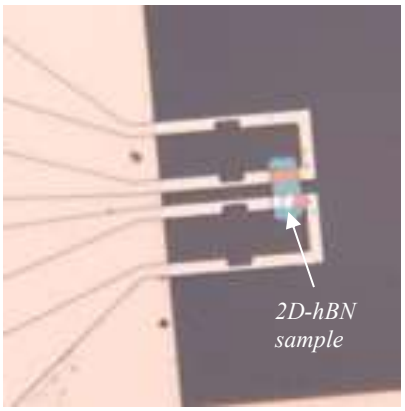

Fig.2: *Suspended 2D-hBN sample to be tested.*

In the Master internship project, the characterization of the instrument will be continued on other suspended nanostructures to which a thermal gradient can be applied to identify the current limitations of the instrument and specify ways for its improvement. The thermal and mechanical properties of nanostructures technically identified measurable and of high scientific impact will also be estimated and compared with measurement or simulation results elsewhere obtained.

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 dual SEM-SThM instrument.
2. Performing experiments and measurements with the SEM-SThM instrument of already-existing samples. These samples were manufactured by the Centre de Nanosciences et de Nanotechnologies (Julien Chaste, C2N, Palaiseau) and consist in 2D hexagonal boron nitride (2D-hBN) samples with different thicknesses. As shown in Fig. 1, these hBN nanostructures are grown directly on silicon microheaters, which can be used to generate a thermal gradient in the nanomaterial. Heat transport but also mechanical properties of 2D-

hBN samples will be analyzed as a function of the force between the probe and the sample and for different thermal gradients through the sample.

3. Adapting the modelling used in the aforementioned nanowire study to the geometry of the investigated samples.
4. Identifying the thermal and mechanical properties of 2D-hBN samples using the new model and experimental data.
5. Comparing in terms of heat transport properties the results obtained with those of C2N. This step comprises also bibliography research.
6. Report writing.

References:

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

[2] Sojo Gordillo et al., *Local heat dissipation and elasticity of suspended silicon nanowires revealed by dual scanning electron and thermal microscopies*. submitted on August, 3rd, 2023, under review by Small.