INSTITUT NEEL Grenoble

Proposition de stage Master 2 - Année universitaire 2024-2025

Beyond Fourier heat transport in 2D materials

General context :

Thermal transport is a major challenge with important fundamental and technological implications for thermal management of electronic nano-components or the conception of new thermoelectric devices. Graphene and other 2D materials exhibit outstanding thermal properties. The project here aims at designing asymmetric 2D heat conductors in order to favour a heat conduction direction and therefore perform heat rectification. Raman spectroscopy has been widely used as a non-contact thermal probe at the micrometer scale to access the thermal conductivity of graphene (1,2,3). Recently, an insightful approach was developed by Reparaz *et al.* (4) and at NEEL for graphene (5), that uses two lasers, one as a heater and one as a non-invasive thermal probe, giving access to spatial mapping of temperature within graphene (4). Furthermore, NEEL has a renowned expertise in thermal bridge measurements of heat conduction thanks to the development of unique thermal platforms at the microscale (6).

Description of the project and facilities:

Within this global objective, the Master 2 internship aims to find out more about how defects and substrate interactions can change thermal properties of 2D materials. The work will be dedicated to the fabrication and thermal characterization in ambient conditions of graphene channels which are asymmetric 1/ due to intentional defect gradient creation (made by lithography and amorphization); or 2/ due to semi-suspension on a substrate (variation of the out-of-plane thermal contact). The student will be in charge of the sample fabrication and their characterization by Raman opto-thermal spectroscopy. She/He will address the challenge of implement graphene onto the thermal bridge platform to realize the first microscale heat transport in this unique configuration and demonstrate innovative heat management. This work is preliminar to a following PhD work on this subject.

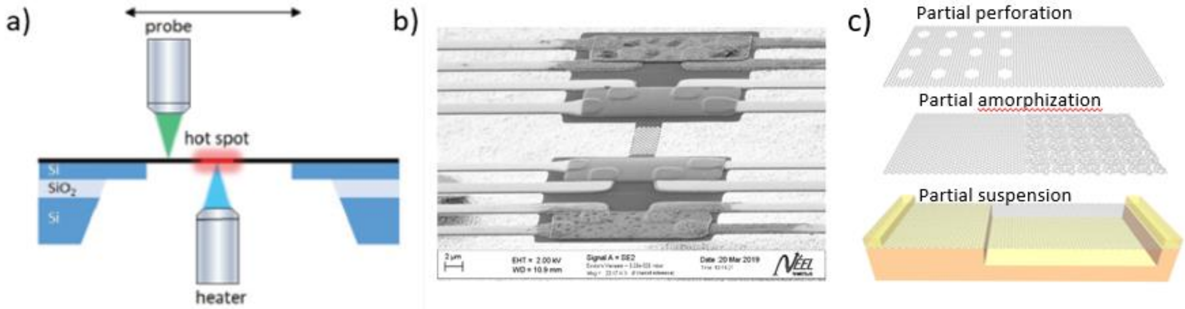

Figure 1: a) Schematics of the two-laser optothermal Raman experiment; b) SEM image of the thermal bridge suspended platforms; c) different sample configurations to be tested.

References :

1) A.A. Balandin, S. Ghosh, W. Bao, I. Calizo, D. Tewelde-brhan, F. Miao, and C.N. Lau, Nano Lett. 8, 902-907 (2008).
2) W. Cai, A.L. Moore, Y. Zhu, X. Li, S. Chen, L. Shi, and R.S. Ruoff , Nano Lett. 10, 1645-1651 (2010).
3) C. Faugeras, B. Faugeras, M. Orlita, M. Potemski, R.R. Nair, and A.K. Geim, ACS Nano 4, 1889-1892 (2010).
4) J.S. Reparaz, et al., Rev. Sci. Instr. 85, 034901 (2014).
5) P. Singh, …, L. Marty, J. Chaste, M. Lazzeri and N. Bendiab, Submitted to PRB.
6) A. Tavakoli, K. Lulla, T. Crozes, E. Collin, and O. Bourgeois, Nat. Commun. ***9****, 4287 (2018)*

Interactions and collaborations :

The student will work in close collaboration between the Quan2m and the TPS teams at Néel Institute. Theoretical support will be provided by collaborators from IMPMC and INSA Lyon.

Required skills :

A M2 in Condensed Matter or Nanosciences is required with motivation for clean room fabrication too.

Start date : February/March 2025

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More information on : Quan2m and TPS teams websites