Stage de Master de physique / Physics Master Internship

Proposition de stage/ Internship proposal

Date de la proposition :23/10/2023

Responsable du stage / *internship supervisor*:			
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Nom du Laboratoire / *laboratory name*: Institut des NanoSciences de Paris (INSP)			
Code d'identification : UMR7588		Organisme : Sorbonne Université, CNRS	
Site Internet / *web site*: https://w3.insp.upmc.fr			
Adresse / *address:* 4 place Jussieu, 75005 Paris, France			
Lieu du stage / *internship place*: Paris			

Titre du stage / *internship title*: **Study the energy landscape of a 2D-based device in operando using spatially resolved X-ray photoemission spectroscopy**

Résumé / *summary*

Nowadays, the family of two-dimensional (2D) materials expands vastly beyond graphene, including semiconductive materials as transition metal dichalcogenides (TMDs) of the MX_2 type (M = Mo, W; X = S, Se, Te). Due to their relatively small band gap (1.2-2.2 eV) and the atomically flat surface, free of dangling bonds in this material, we can easily obtain an ambipolar transistor operation under an electric field by generating a p-n junction. This a quite important property of TMDs making them promising candidates for a variety of opto-electronic devices. However, different from a conventional p-n junction, in the field induce one, donors or acceptors are absent. Since their densities determine many fundamental parameters of conventional p-n junction, such as the built-in potential and the depletion region length, these parameters are basically unknown from field induced p-n junction.

This internship project aims to go a step further in the understanding of TMD p-n junction by probing directly the electronic structure of this device in *operando* (i.e., during device operation) using spatially resolved X-ray photoemission spectroscopy at the synchrotron facility (spatial resolution below the µm - ANTARES beamline -SOLEIL synchrotron)[1–3]. The device that will be studied is a dual gate transistor (Figure 1 (a)) where the two gates are used to create a planar p-n junction in the TMD nanoflake by generating an electrostatic doping.

During the internship the candidate will be in charge of TMDs flake exfoliation and transfer (using a 2D transfer system) with micrometer precision across the device channel (Figure 1(b)), device characterization at the laboratory with AFM, PL, Raman, and electrical measurements before to perform *operando* spatial resolved X-ray photoemission measurement at the synchrotron facility.

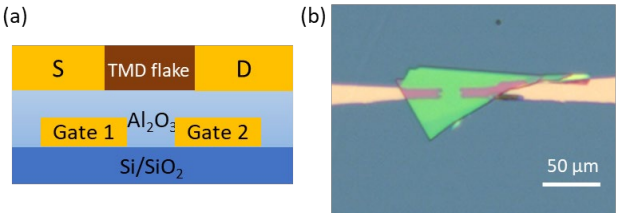

Figure 1: (a) Schematic of the dual gate device which active channel is made of a TMD flake. (b) microscopy image of the dual gate device zooming on the active region where the TMD flake is located. The TMD flake is precisely positioned on top of the electrodes using a 2D transfer system at the INSP laboratory.

REFERENCES :

1 Cavallo, M. et al. Nanoscale 15, 9440–9448 (2023)
2 Cavallo, M. et al. Nano Lett. 23, 1363–1370 (2023)
3 Cavallo, M. et al. Adv. Funct. Mater. 2300846 (2023)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : YES**

Si oui, financement de thèse envisagé/ *financial support for the PhD*: **ANR project (Emap) already secured**