Internship offer 2024/2025:

Unveil thermoelectric properties of 2D α-In_2Se_3

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Recently bidimensional (2D) van der Waals (vdW) III−VI semiconductors have drawn intense attention due to their unique electronic properties[1]. Among these materials, In_2Se_3 in its most studied α phase, shows a great potential for a wide variety of applications in electronics, photonics and even thermoelectricity, due to its good mobility, excellent photoresponsivity, exotic ferroelectricity, and unique band structure[2-4]. In_2Se_3 possess an in- and out-of-plane ferroelectricity, which remains robust down to the monolayer limit. Moreover, very recently, 2H α-In_2Se_3 single crystals have also shown the occurrence of a 2D electron gas (2DEG) at their surface[5], with high electron density (~10^{13} elec/cm^2) even at room temperature.

First-principles calculations based on the density functional theory and Boltzmann transport theory show that monolayered α-In_2Se_3 is also a great candidate for high-performance thermoelectric materials with the power factor PF and the figure of merit ZT as high as 0.02W/mK2 and 2.18 at room temperature[4].

In this context, the main goal of the internship is to go a step forward in the investigation of the correlation between thermoelectric and ferroelectric properties of α-In_2Se_3 thin layer[6]. The student will fabricate α-In_2Se_3 based transistors in a 4 contacts configuration with a local gate for electric and thermoelectric investigation. The activity will cover sample fabrication in clean room (dry transfer of the 2D material, e-beam lithography, etching, metal deposition, AFM/Raman analysis …) and electrical measurements in a multi-probe station as a function of the temperature. The team has a strong expertise in the investigation of charge and spin transport in 2D materials and in clean room micro and nano fabrication techniques. This expertise will be exploited in the project.

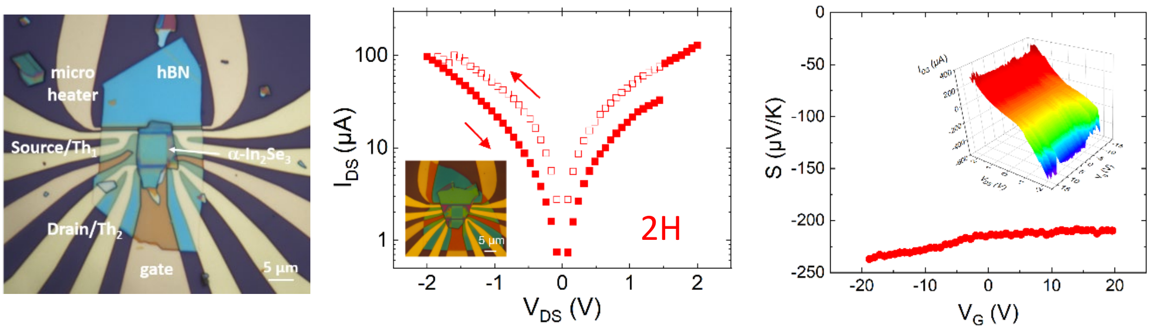

Fig: a) 2H α-In_2Se_3 based device for standard DC electric and thermoelectric measurements. b) IV characteristics of the 2H α-In_2Se_3 based device at zero gate voltage showing ferroelectric switching controlled by the source -drain voltage, V_{DS}. c) Measured Seebeck coefficient, S, as a function of the gate voltage, V_g. Inset: 3D plot of the IV characteristics of the 2H α-In_2Se_3 based device by varying the gate voltage and the source/drain voltage in the range.

1. J. Li et al, *ACS Nano* **15** 18683 (2021)
2. Z. Yu et al. *Nano Lett.* **17**, 5508 (2017)
3. P. Hou et al., *ACS Appl. Electron. Mater.* **2**, 140 (2020)
4. T. Nian et al., *Appl. Phys. Lett.* **118**, 033103 (2021)
5. G. Kramer et al., *ACS Nano 17, 19, 18924 (2023)*
6. M. Rahimi et al., *Appl. Phys. Lett. 124, 253503 (2024)*

Methods and techniques: micro-fabrication in clean room, transport measurements

Possibility to go on with a PhD ? YES
Envisaged fellowship ? participation to the EDPIF competition and/or PhD funding in submitted project