Post Doctoral position available (starting oct. - dec. 2021)

Hybrid Nano-Perovskite/TMDC 2D Photodetectors

Location: CEA Interdisciplinary Research Institute of Grenoble & CNRS Néel Institute of Grenoble

CEA-IRIG/SyMMES, STEP group
https://www.symmes.fr/en/Pages/STEP/Presentation.aspx
CNRS-Néel/Hybrid Team
https://neel.cnrs.fr/en/equipes-poles-et-services/systemes-hybrides-de-basse-dimensionnalite-hybrid

Duration: 2 years

Funded by the National Agency for Research
Matra2D project

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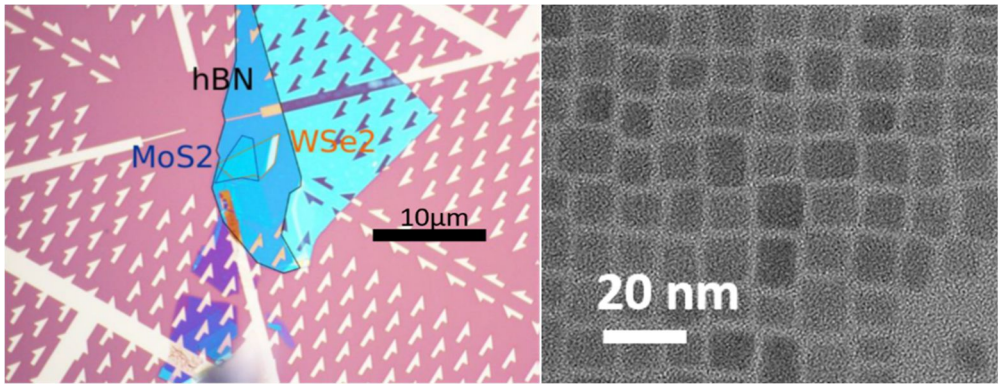
Matra2D project: Mastering the Charge Transfers and Trapping Dynamics in Hybrid Nano-Perovskite/TMDC 2D Photodetectors

Hybrid interfaces between metal halide perovskites and two dimensional (2D) transition metal dichalcogenides (TMDC) hold great promises for the development of smart photodetector devices, as they combine two classes of model materials displaying exceptional opto-electronic properties. The low dimensionality of electric field-tunable TMDCs and the broadband detection brought by the perovskite nanocrystals (NanoX) provide an ideal platform for smart detectors. However, achieving balanced photo-detection performances, i.e. fast photo-switching and high gains, remains a challenge and the time-response of most perovskite-NanoX/TMDC photodetectors remains limited to the ms range. To achieve better performances, it is mandatory to reach an optimal balance between the effective photocarrier lifetime and the carrier transit time between the electrodes of the device. In the Matra2D project, our goal is to implement a rational approach for understanding and mastering all the processes that will ultimately determine the performances of hybrid photodetectors, realized by sensitizing TMDCs with perovskites NanoX and nanoplatelets (NanoP). One major objective is to substantially improve the photo-response time of hybrid photodetectors while keeping a high photoresponsivity. Our approach encompasses the synthesis and processing of high

quality TMDC films, the synthesis of perovskite NanoX/NanoP along with a suitable ligand engineering, the systematic use of complementary advanced photophysical characterization methods, and the fabrication of field-effect photo-transistor devices with an improved dielectric interface. The experimental characterizations will cover a large range of complementary techniques: photoluminescence (PL), cathodoluminescence, Raman spectroscopy, Atomic Force Microscopy (AFM) and Kelvin Probe Force Microscopy (KPFM). One highlight of MaTra2D will be to systematically use advanced potentiometric and electrostatic modes derived from the AFM to probe the nature of the built-in electric fields at the perovskite/TMDC interfaces, the photo-induced charge transfer mechanisms, and the trap-release dynamics and carrier dynamics in the active device channel by time-resolved surface photovoltage imaging. Thanks to this near field approach without equivalent in the literature, we will be able to predict if a given perovskite/TMDC interface has the potential to achieve fast photoswitching, prior to characterizing the performances of the full operating device by macroscopic photo-transport measurements.



Left: TMDC-based device realized by deterministic stacking of 2D materials at Institute Néel. Specific metal marks have been added for localization by nc-AFM under UHV at SyMMES. **Right:** $CsPbBr_3$ nanocrystals (SEM image) synthesized and processed by SyMMES's chemists.

Context & resources available for the project

Matra2D is a 42 months collaborative project funded by the National Agency for research, and which involves 3 partners, two of which in Grenoble (IRIG-SyMMES/STEP, Institut Néel/Hybrid Team) and one in Saclay (CEA-IRAMIS/NIMBE, team of Dr. V. Derycke). This 3-lab consortium is composed of physicists and chemists with skills/expertises covering all aspects of the project: TMDC growth and processing, device fabrication and photo-transport measurements, photo-physical characterizations, semi-conductor nanocrystals synthesis and chemical functionalization, and advanced state of the art near-field characterizations.

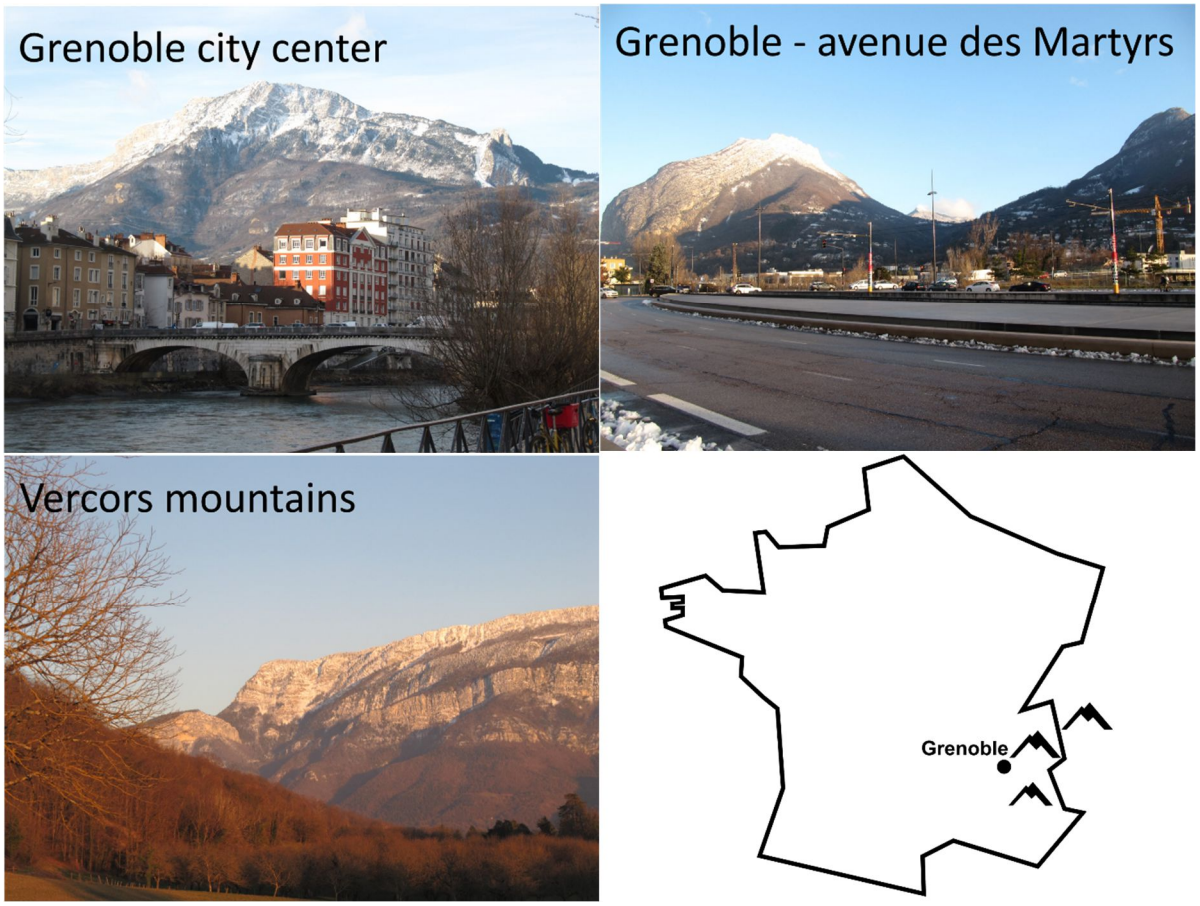
The post-doctoral fellow will share her/his time between Institut Néel and IRIG-SyMMES. Both institutes are located in Grenoble a stone throw away from each other. She/he will have full access to a huge range of complementary facilities pooled for this project, including clean room facilities (device fabrication), setups for opto-electronic & photo-transport characterizations, deterministic micro-transfer setup (2D TMDC processing), PL and Raman spectroscopy, SEM, facilities for solution-processing (spin coating, dip-coating), self-service AFM in ambient conditions, and nc-AFM/KPFM under UHV.

STEP group (Synthesis, Structure and Properties of Functional Materials) is an interdisciplinary team within *SyMMES* comprising chemists, physico-chemists, and physicists, whose joint research covers fundamental and device-oriented approaches of molecular and hybrid

functional materials developed for opto-electronic applications, energy conversion and storage, and sensors. B. Grévin coordinates the Matra2D project. He is an internationally recognized expert in the applications of noncontact-AFM & Kelvin Probe Force Microscopy for local investigations of photoactive materials and devices. Two other STEP permanent researchers taking part in Matra2D are D. Aldakov and P. Reiss, they have a very strong expertise in the synthesis, functionalization and applications of semiconductor nanocrystals.

Néel Institute is one of the largest academic laboratories for condensed matter physics in France. *The Hybrid Team* has been for several years at the forefront in the field of advanced structures based on 2D materials and has expertise in nanofabrication, Raman spectroscopy, photoluminescence and electrical transport measurements that will be suited for the project. Laetitia Marty is the local coordinator for Matra2D project. She will supervise the sample fabrication and phototransport measurements. Two other permanent researchers involved in Matra2D are Julien Renard and Nedjma Bendiab (photoluminescence, Raman spectroscopy).

Grenoble, capital of the Alps and pole of scientific excellence



Grenoble lies at the foot of the French Alps. It offers a very attractive living environment, and has grown to be one of Europe's most important research, technology and innovation centers. In addition to being an international and scientific metropole, Grenoble is a very nice base for lots of sports and outdoor activities (https://www.grenoble-tourisme.com/en/). Grenoble is also the winner of the European Commission's European Green Capital Award 2022 (https://ec.europa.eu/environment/news/grenoble-gabrovo-and-lappeenranta-win-prestigious-european-green-city-awards-2020-10-09_en). Both SyMMES and Institut Néel are located in Grenoble, avenue des Martyrs.

Candidate profile / applications

The post-doctoral researcher will be in charge of TMDC device fabrication & characterization. She/he will spend half of her/his time within Institut Néel, to process the TMDC layers by mechanical exfoliation/stacking and fabricate FETs devices. She/he will also participate to the processing (sample deposition) of perovskite nanocrystals by SyMMES. She/he will carry out photo-physical characterizations at NEEL, and may participate to the nc-AFM/KPFM experiments within SyMMES.

The applicant should hold a PhD degree in Physics, Nanotechnology, Materials Science, Engineering or other science-related discipline. She/he shall have experience with 2D materials processing, micro/nano fabrication of 2D devices, and electrical transport measurements/characterizations. A former experience in complementary characterization techniques (photoluminescence, Raman spectroscopy) may also be a plus. Background knowledge of AFM/KPFM techniques may also be appreciated, but is not mandatory.

Applications including a cover letter (explain why you are interested in this project), Diploma (PhD), a publication list and a curriculum vitae, should be sent to benjamin.grevin@cea.fr and laetitia.marty@neel.cnrs.fr. Recommendations (with contact details) will also be appreciated.