MSc topic on “Deep-level charge-carrier traps in 2D-material-based devices: From fabrication to spectroscopy"

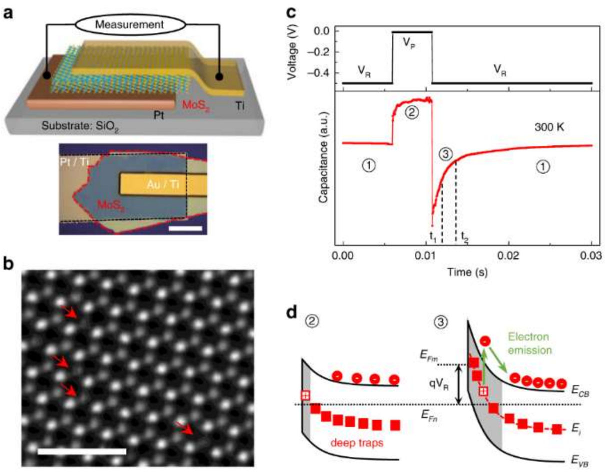
Defects in semiconductors play a crucial role in device engineering for determining the suitability of a specific material in terms of performance and reliability. Atomically thin 2D materials are an exciting and continuously expanding platform for realizing future artificial systems with unique properties that do not exist in the 3D-based counterparts [1]. Our goal is to shed light on the main trap characteristics on novel 2D-layered materials, that could hinder the performance of future 2D-material-based (opto)electronics, such as 2D-based solar cells and FETs.

This project aims at systematically study the nature of deep-defects in exfoliated-, CVD- and MBE-grown 2D materials and their effects on the (opto)electronic properties of 2D-based devices. The work will focus on transition metal dichalcogenides (TMDs) and post-transition metal chalcogenides (PTMCs) such as MoS_2, $MoSe_2$ and GaSe, InSe, respectively.

The project will mostly involve work in a clean-room, where you will learn all the details concerning semiconductor nanofabrication, and in an optical lab, in which the electrical characterization of the devices will be performed. The main techniques that you will learn to master are standard and optical-Deep-level-transient-spectroscopy (DLTS), thermal admittance spectroscopy (TAS), capacitance-voltage profiling, and thermally-stimulated-current-spectroscopy (TSC), which will be employed to determine the properties (capture cross section, activation Energy, etc.) of electrically active defects and their concentration. Additionally, you will correlate the results with measurements obtained via typical characterization techniques in solid-state-matter, such as atomic-force-microscopy (AFM), photoluminescence spectroscopy (PL), Raman spectroscopy and differential reflectivity.

We are seeking highly motivated, hardworking students with an inclination for technical and optical lab work. Some experience with optical spectroscopy, electronics of semiconductors, 2D materials, cleanroom fabrication, scripting (Python) will be beneficial but not essential.

If you are interested to become part of our research team, please send your CV, transcript of your records and Bachelor thesis to Dr. Eugenio Zallo (eugenio.zallo@wsi.tum.de), Michele Bissolo (Michele.Bissolo@wsi.tum.de) and Prof. Jonathan J. Finley (finley@wsi.tum.de).



(a) Schematic and optical image MoS2 device for DLTS. (**b**) STEM image of Sulfur-vacancies in a monolayer MoS2 flake. (**c**) Capacitance transient (bottom) in response to a pulsed change in bias voltage (top). (**d**) Band bending of the Schottky junction (MoS2/Pt), illustrating the electron trapping and emission process. Figure from [2].

[1] A. K. Geim and I. V. Grigorieva “Van der Waals heterostructures”, Nature 499, 419–425 (2013).
[2] P. Ci et al. “Chemical trends of deep levels in van der Waals semiconductors”, Nat. Commun. 11, 5373 (2020).