The main idea of this project is to understand the physical phenomena at hybrid semiconductor interfaces in terms of their use in novel semiconductor devices. This idea is inspired by the famous sentence: “The interface is the device” proclaimed by Herbert Kroemer, Nobel Prize winner in Physics in 2000. The hybrid interface in this case is the interface of a van der Waals (vdW) crystal (MoS_2, $MoSe_2$, $MoTe_2$, WS_2, WSe_2, ...) and a covalent crystal i.e., group IV (Si and Ge) or group III-V (GaN, GaAs, InAs and others) semiconductor.

From the moment of mechanical exfoliation of vdW crystals to single layers (also an important discovery awarded by Nobel Prize in Physics in 2010 for Andre Geim and Konstantin Novoselov with the justification: "for groundbreaking experiments regarding the two-dimensional material graphene"), Kroemer’s idea becomes more important because it is possible to produce very good quality hybrid interfaces from materials with very different electronic band structures and very different electrical and optical properties. While research on single-layer vdW crystals has been quite intensive in recent years and has been widely reported, research on the properties of hybrid vdW/covalent semiconductor interfaces has not been widely reported.

In this project we do not want to focus on the crystals forming the interfaces but on the interfaces themselves, because they have not been carefully studied so far and are of crucial importance for semiconductor devices. We expect that properties of such hybrid interfaces can be significantly tuned because of their new features, i.e. electronic states at the interface, which can be engineered by selecting appropriate materials at the interface, preparing the surface of the group IV (or III-V) semiconductor before depositing the vdW layer - we mean the reconstruction of the surface for this semiconductor, controlling the method of depositing the vdW layer (i.e., temperature, environment, etc.) or the angle of rotation of the vdW layer relative to the surface of the group IV (or III-V) semiconductor, which will produce different Moiré patterns.

To understand the physical phenomena at the hybrid vdW/covalent semiconductor interface, we will use advanced electro-optical methods such as: electromodulation spectroscopy, which enables the study of the Fermi level position at semiconductor interfaces, time resolved microwave photoconductivity, which enables the study of carrier dynamics including trap states at interfaces, and deep level transient spectroscopy, which studies deep defects in semiconductors and trap states at interfaces. We are confident that the results of this research will have a significant impact on the development of novel semiconductor devices containing hybrid vdW/semiconductor interfaces.