

Novel van der Waals heterostructures for next-generation nano and optoelectronics.

Two-dimensional materials are atomically thick layers and promising candidates for basic building blocks of new generation nanoelectronics. The best-known example of 2D material is graphene: first to be discovered, Nobel prize-winning, an atomically thin sheet of carbon atoms. Today we know several hundreds of different kinds of 2D materials with various electrical, optical, and thermal properties. This variability combined with their often unusual properties is the key to their applications. This project will focus on how various 2D layers interact with each other by stacking them into artificial, not found in nature towers called van der Waals heterostructures. The project's goal is confirmation of the hypothesis that we can build new devices with specific, needed properties by choosing the right layers, modifying, and stacking them. This approach, when material properties are designed for a particular application, is called material on demand.

This project will specifically look into two areas of building electronic devices: electrical contacts, which are the link for the signal between our 3D world and 2D device, and passivation, which deals with protecting the device from the environment. These are essential and unresolved problems that we need to deal with before using 2D materials in the electronic industry. With contacts, we will study how to minimize contact resistance and the nature of electronic transport between metallic contact and 2D layer. We will use various experimental techniques to understand and find the best solution for contacting devices made from 2D materials and van der Waals heterostructures. With passivation, we will study how its presence influences the device performance, find the differences between currently used and new materials for this purpose, and use this knowledge to further improve our device.

Expected final results include the building of well-optimized specific devices like field-effect transistors or photodetector. During the project, knowledge about the interaction between layers will be gained and used to design crucial components of electronic devices like contacts and passivation. This project will confirm the hypothesis that with proper design, combination, and modification of 2D layers, one can build highly efficient electronic devices which can be used in the future electronic application.