Rapid development of two-dimensional materials research allowed today access to tens of 2D layers with different electronic, optical and thermal properties. Moreover one can stack available layers to create van der Waals heterostructures – new, artificial structures that do not occur naturally in nature. The main advantage of such structures is potential to create material with tailored properties for chosen application. This approach is often referred to as material on demand. One of the main challenges of current production technology is to answer the question how each layer contributes to final heterostructures. In one-atom thick materials whole surface is by definition an interface, which implicates that the closest surrounding can have deep impact on characteristic parameter of material. Well known example is thermal conductivity of graphene. Its values can be even one order of magnitude smaller in supported graphene than suspended, and in stacked bilayer graphene strongly depends on interlayer twist angle.

In this project we plan to investigate phonon properties of van der Waals heterostructures, which can have direct influence on carriers scattering and thermal properties of created materials. Research of phonon properties of heterostructures has a purely scientific character but also is necessary for proper heat management and energy dissipation in new devices based on two-dimensional materials. We will focus on Transition Metal Dichalcogenides (MX_2, M = Mo,W, X = S,Se), which heterostructures have large potential in optoelectronic and electronic applications. Combining these materials with graphene as electrode and boron nitride as passivation layer, allows us for holistic study of interfaces in future devices build only with 2D layers.

As the main outcome of the project we expect to get well characterized phonon properties of heterostructures made from transition metal dichalcogenides. We expect that study of phonons in function of structural arrangement will allow for more reliable design of heterostructures, especially in cases of quality of interface and thermal properties. It will be first step in future production of phonon optimized devices.