Graphene, since its rediscovery in 2004, has ignited worldwide research of 2D materials due to its fascinating properties, mainly electronic but also mechanical and optical. Currently, tens of 2D materials have been isolated and studied, leading to discoveries of new physical phenomena which can be used in the future to fabricate completely new types of devices with unprecedented performance. Among the new materials, transition metal dichalcogenides (TMDCs, for example MoS_2 or WS_2) are intensively studied due to the presence of bandgap. Besides single materials, also stacks consisting of different atomically thin layers, called heterostructures, can be fabricated. The range of their possible applications is extremely wide, for instance TMDCs/graphene heterostacks can be used as photodetectors and transistors or as catalysts for hydrogen production.

There are two main methods to fabricate 2D heterostructures – mechanical exfoliation, the so-called Scotch tape method, and chemical vapour deposition (CVD). While the first produces high-quality layers, they are small, and the process is not scalable and repeatable. Therefore, for the industrial-scale production a different method of fabrication is necessary, that is CVD. This method allows growing 2D materials and their heterostructures in a controllable manner at a large scale, hence it is more favourable for the industry.

Still, the research of CVD growth of 2D heterostructures is in its infancy. The initial reports presenting the growth of heterostacks are either incomplete or show layers with inferior quality, and more research is necessary in order to improve the quality of the obtained layers. Also, a detailed study of the influence of the growth parameters, especially the type of substrate, on the synthesized materials has not been published yet. Additionally, the growth of more complex heterostructures is still to be presented.

In this project, we aim to investigate the impact of growth parameters on the properties of the as-grown TMDCs. The growth will be conducted in a modified CVD tube reactor, while the as-grown layers will be characterized by various methods, including scanning probe microscopy, electron microscopy or Raman spectroscopy. During the project, the most important and the most studied variable will be the growth substrate. We propose to grow the heterostructures on top on graphene (also obtained by CVD) and compare them with layers synthesized on other substrates, like SiO_2. This is also the main research hypothesis of the project, which can be stated as follows:

Graphene is a superior growth platform for 2D heterostructures.

Not only we plan to grow simple heterostructures, that is MoS_2 or WS_2 on top of graphene, but also we aim to explore the growth of alloyed ($Mo_xW_{1-x}S_2$) and vertically stacked (MoS_2/WS_2/graphene or WS_2/MoS_2/graphene) heterostructures, what has not yet been reported. As the main outcomes of the project, we want to achieve the growth of these types of materials and we plan to propose a simplified growth model for TMDCs which includes the impact of the growth substrate. The know-how gained during this project can be transferred to other research fields as well as to industry.