Boron nitride (BN) is, due to its unique physical properties, such as high chemical stability, excellent thermal conductivity and a wide bandgap (~ 6 eV), a very promising candidate for a broad range of applications. It is very promising to use boron nitride in combination with other nitrides (AlN, GaN) for detectors and light sources in the deep ultraviolet (DUV) range. Recently, there have been single reports showing the achievement of significantly better electrical properties of p-type BN, compared to p-type AlN, indicating the great potential of this material to solve the important problem of optoelectronic devices in the DUV range - good electrical and optical quality of the p-type layer.

The growing interest in BN after 2010, and in particular in its hexagonal layered structure (h-BN) analogous to graphite, is related, among others, to the development of hybrid structures (so-called van der Waals heterostructures) obtained on the basis of single atomic layers, using materials with entirely different properties, in which particular layers act as a conductor (e.g. graphene), a semiconductor (e.g. WSe_2) and an insulating barrier. For this last role, h-BN is an ideal candidate because of its crystalline structure, compatible with other employed materials, a smooth surface and a wide bandgap. The use of h-BN as a substrate for graphene increased the electron mobility in graphene by more than an order of magnitude compared to the "classic" structures deposited on amorphous SiO_2. The more complex van der Waals structures, sometimes called NanoLego, open up wide possibilities for flexible electronics, ultra-fast transistors, or sources of single photon emitters used in quantum cryptography. Currently, bulk h-BN growth technology allows obtaining small (in the order of single millimeters) high-quality crystals. They enabled the presentation of many interesting physical phenomena and the production of promising test devices in which flakes exfoliated from such crystals were used.

There is no doubt that practical application of BN depends on mastering the epitaxial growth technology of high quality, large surface layers on commercially available substrates (e.g. sapphire). Epitaxial layers obtained with the use of MOVPE (Metalorganic Vapor Phase Epitaxy) are still of lower quality than bulk crystals, but they give great hope for improving the quality on a macroscopic scale. The epitaxy of BN is still at an early stage of development and faces a number of problems. Recent results obtained at the Faculty of Physics of the University of Warsaw with the use of MOVPE, allowed to obtain epitaxial BN layers with parameters similar to the best reported in literature. However, they indicate that the BN growth process is extremely complex, still insufficiently described in the literature, and requires a detailed analysis, which is crucial for the understanding of basic structural and electronic properties of h-BN required for novel van der Waals structures based on epitaxial wafer-scale BN technology. The aim of this project is to understand the growth and basic physical properties of the epitaxial layers of BN grown by MOVPE and adjust their properties for the requirements of novel van der Waals structures based on layered BN. The project includes investigation of the nucleation and ordering BN layers using MOVPE which is crucial for the exfoliation process and effectiveness of encapsulation of the 2D materials. It is proposed to study the doping of the BN layers which is crucial for use of epitaxial BN as an IR-VIS-UV transparent conductive electrode. We would like to investigate the exfoliation of epitaxial BN layers and their transfer to desired substrates as well as to van der Waals structures. We plan to test epitaxial layers BN grown by MOVPE as substrates for growth of other 2D materials using MBE technology available at the Faculty of Physics of the University of Warsaw, which in our opinion is the most innovative part of the project. The important part of the project is optimization of BN layers and BN structures growth conditions in terms of potential applications including van der Waals structures as well as deep UV optoelectronic devices. Advanced characterization including, among others, X-ray diffraction, scanning and transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy, optical spectroscopy (transmission and reflection measurements, Raman effect, luminescence, cathodoluminescence), EPR will provide a basis for a phenomenological description of individual growth phases and their impact on the properties of layered BN. This knowledge is crucial from the point of view of understanding of basic structural, optical and electrical properties of epitaxial h-BN as well as potential applications of this material in van der Waals heterostructures.