

The aim of this project is to investigate the band structure, distribution of electric fields and optical properties of wide-bandgap semiconductors from group III-nitrides (III-N) such as GaN, AlN, BN and their alloys. Such materials are very attractive candidates for the construction of high electron mobility transistor (HEMT), and UV-radiation sources such as light emitting diodes or lasers. Due to the very high mobility of carriers, high breakdown voltage and high band gap energy, transistors based on III-N materials show many advantages over transistors based on silicon or other III-V group semiconductors technology. The main advantages include higher cut-off frequency, higher operating voltage and high impedance. This makes these transistors ideal for use as high-power switches and amplifiers. Furthermore, the wurtzite crystal structure of group-III nitrides is highly piezoelectric, offering device design possibilities not accessible with common GaAs and InP based semiconductors. HEMTs based on GaN are characterized by at least one order of magnitude higher power density and efficiency than similar devices based on Si and GaAs. Thanks to this it is possible to 10 times reduce the size of electronic components at the same power output. Moreover high chemical and thermal resistance of GaN and AlN crystals makes the transistors of this type very promising from the point of view of high temperatures or operation under high radiation, where the transistors based on other materials could be damaged.

Because of the large value of the energy gap materials such as GaN (~ 3.4eV) and AlN (~ 6eV), they are also interesting candidates for the creation of semiconductor light sources in the UV range. Deep ultraviolet light has attracted considerable attention due to its wide range of applications, such as disinfection, sensing, water purification, bio-medical. Currently there are available sources of this type of radiation, but they are generally very large and inefficient. In contrast, the light sources based on semiconductors are very small (the active part of the LED can have dimensions well below 1mm), have high efficiency and can be easily charged. This causes that in many cases semiconductor light sources are the most desirable light sources. Unfortunately, in the case of the UV (especially deep UV) semiconductor light sources are still at the laboratory stage.

To improve the operation of these instruments it is necessary to know the basic parameters describing the GaN material, AlN or BN and their heterostructures. Research carried out in the framework of this project will allow to determine these parameters leading to a better understanding of the operation of devices based on these materials, and can contribute to their improvement in the future.