As-induced VLS-MBE growth of dodecagonal GaN microrods

GaN-based materials are of great interest from many years now due to their unique properties and wide range of possible applications. They can be used in optoelectronic devices like light-emitting diodes and laser diodes and in high-speed, high-power electronic e.g. high power transistors and high-electron-mobility transistors. Particularly interesting is their possible application in new optoelectronic devices operating in the deep ultraviolet range. The development of new, efficient deep UV emitters is crucial for versatile applications, like water and air purification, surface sterilization and medical diagnostics. Currently available on the market are only conventional mercury vapor lamps, which suffer from low efficiencies and a lack of tunability. Moreover, they are toxic for environment.

Unfortunately, there are many technological issues associated with creating efficient UV devices based on group-III nitrides. The efficiency of III-nitride devices is still limited mostly by the large defect density. To overcome this problem, devices based on vertical nano- and microstructures like nanowires and microrods have been proposed. Vertical structures offer new possibility in designing future devices. However, not many efficient and reproducible methods of growing nanowires and microrods have been developed, especially by molecular beam epitaxy (MBE). For optoelectronic applications an accurate control over height, diameter and density of microrods must be provided and developed. By ensuring ultra-high vacuum conditions and very precise growth control MBE is a technique of choice for growing nano- and microstructures.

Within the project "As-induced VLS-MBE growth of dodecagonal GaN microrods" a new growth method will be developed and optimized. First promising results have already showed that arsenic can act as an antisurfactant under specific growth conditions. Antisurfactant properties of arsenic are characterized by its possibility to change growth mode from two-dimensional to three-dimensional under excess of Ga inducing VLS-like growth. Moreover, arsenic is not incorporated into the bulk during growth. That property of arsenic enables the growth of 12-walled GaN microrods, which have not been observed before by any other growth method. The example of a microrod grown by this method is presented in Figure 1. SEM image shows a whole microrod with Ga droplet on top, which is an indicator of VLS-like growth mechanism. This growth method of vertical nano- and microstructures provides new opportunities to develop novel kind of optoelectronic devices.

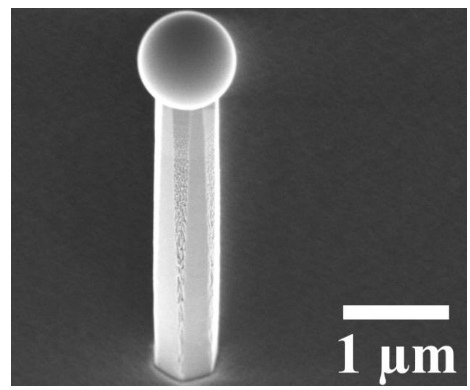

Figure 1. SEM image of an individual microrod with clearly visible rough and smooth surfaces and gallium droplet on top.

A major motivation for this study is to understand, how the control over the growth of microrods can be assured and why arsenic induces the growth of dodecagonal microrods, which have not been obtained by any other method. The project will result in understanding of the basic physics involved in a process of growing 12-walled GaN microrods. Fully optimized, described in details new efficient growth method will be presented. This may be a starting point for further development of novel optoelectronic devices for wide range of possible applications. The dodecagonal shape of microrods may bring many novel properties, useful in optoelectronics.