One of the most successful technological advancements of recent years is the development and commercialization of white light sources basing on blue light emitting diodes (LEDs) made of nitrides of group III metals (In, Ga, Al). A substantial reduction in energy consumption over incandescent bulbs and increased longevity over both incandescent and fluorescent bulbs enabled the great success of white LEDs. The impact of this innovation was so great that in 2014 a Nobel prize was awarded to three scientists who contributed most to the creation of nitride-based light emitters: Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura. Currently there is an undergoing research effort aiming to fabricate nitride-based light emitters in the UV spectrum that would replace the conventional UV light sources like mercury lamps. Despite the commercialization of UV LEDs based on nitride technology there are still many obstacles reducing the efficiency of devices.

The currently produced III-nitride LEDs face many technological problems that hamper their efficiency. In the semiconductor technology world the common way to obtain high quality devices is to use a basis (called a substrate) made of the same material that will be produced on top of it. This is true for the most wide spread semiconductor technology based on silicon, the technology that bring us 99% of electronics that surrounds us. Due to technological difficulties and high cost this approach cannot be used for the III-nitride based electronics. Instead, other substrates are used. The downside is that the produced devices lack in quality, their internal structure is disordered. This leads to a lowering of the device efficiency. In this project a novel approach to III-nitride material preparation will be applied to mitigate the problems resulting from using of non-perfectly matching substrates. Instead of preparing the material in a planar way (that is, making it of continuous layers stacked on top of each other) microscopic columns will be prepared in a process called molecular beam epitaxy. Addition of arsenic to the process affects the material growth process in such a way that the planar mode changes to the columnar mode. The internal structure of the columns prepared in this way is not affected by a choice of a foreign substrate.

Another advantage of the columnar growth of LEDs is their natural ability to increase the amount of light that escapes from such devices. In commonly prepared planar structures most of the emission is trapped inside of the device. This is a result of a phenomenon called a total internal reflection that is caused by a significant difference in refractive indices of the III-nitride material and external medium. Without sophisticated treatments of the planar devices, that only increase the complexness of their creation and, of course, their cost, their efficiency would be very low with only a small fraction of the emission escaping from the device. LEDs prepared basing on micro columns will act as wave guides (much like an optical fiber) allowing a much greater amount of light to escape without he need for additional treatments.

The goal of this project is to take advantage of the unique properties of columnar structures in preparation of LEDs emitting in the UV spectrum. The success of this project brings closer the perspective of efficient UV emitters that will be able to replace the mercury lamps so widespread even today.