Seizing the advantages of Nitrogen-polar GaN for III-nitride light emitters

Gallium Nitride (GaN), the “semiconductor of the XXI century”, and its related family of alloys have truly unique features that distinguish them from other compounds. A key example is their wide bandgap tunability enabling light emitting diodes (LEDs) and laser diodes that emit light across the spectral range from deep ultraviolet (UV) to infrared. Nitride LEDs are so widely demanded that the invention of the blue Nitride LED by Isamu Akasaki, Hiroshi Amano and Shuji Nakamura earned the 2014 Nobel Prize in Physics. Wide application of nitrides in everyday life, especially in light emitting diodes (LEDs), can give an impression that “everything” is already known about nitride emitters. However, in fact the situation is different. Despite unquestionable success of nitride lasers, none of the structures were ever obtained on N-face GaN substrates. Furthermore, achievement of a laser diode (LD) is often regarded as an irrefutable evidence of high optical quality of obtained material and maturity of the growth method. In this project we will explore completely new areas of nitrides growth on N-face GaN to present such a device for the first time.

Institute of High Pressure Physics Polish Academy of Sciences possesses experience in various epitaxial processing techniques of gallium nitride. This project will be conducted in plasma-assisted molecular beam epitaxy (PAMBE) laboratory. Our laboratory has long traditions in nitride LD epitaxy and achieved the first PAMBE-grown LD in the world in 2004. Over the next years we made a significant progress by improving lasing parameters, expanding accessible wavelengths spanning from UV into green (Fig 1.) and performing epitaxy on semi-polar GaN substrates what proves versatile capabilities of our technique.

Aim of the project is to understand and exploit advantages of the growth of III-nitrides on N-face, i.e. (000-1), surface by PAMBE. We will investigate the origin of low luminescence efficiency of N-face nitride emitters. Using recently defined new growth window, we will limit amount of incorporated point defects and present improved optical quality of N-polar structures. Combining improved active region with p-n junction, we will obtain light emitters profiting from advantages offered by N-polar GaN devices.

N-polar grown laser diode will be presented, proving the high optical quality of nitride heterostructure obtain in this project. This achievement could be a “new opening” for also other devices obtained on nitrogen-polar GaN.

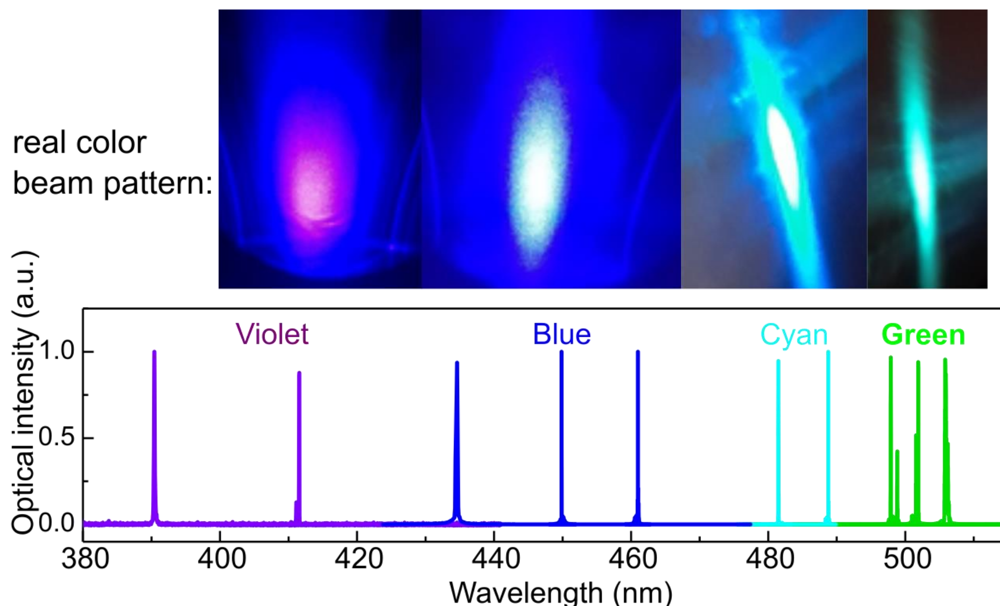

Fig 1. Exemplary lasing spectra obtained for laser diodes grown by plasma-assisted molecular beam epitaxy at the Institute of High Pressure Physics Polish Academy of Sciences on Ga-polar and semi-polar GaN substrates. Real color beam pattern for corresponding device is presented above each spectra.