The project objectives and motivation. Aim of the project is to develop a technology for the fabrication of new generation of superluminescent diodes (SLD) with a wide spectrum of light (above 25 nm) operating in the visible light range (400-440 nm).

Nitride semiconductor based light emitters are widely used in our daily life. The most widespread and known are light emitting diodes (LED) and laser diodes (LD) operating in the visible range. This family of emitters also includes the lesser known superluminescent diodes (SLD), combining the spatial coherence of the emitted light typical for LDs with the low time coherence (wide emission spectrum) typical for LEDs.

The structure of SLD is very similar to that of a LD, but the concept of SLD focuses on the suppression of light oscillations along the waveguide which is crucial for SLDs. In SLD, part of the light that is generated in the process of spontaneous emission can become trapped in the waveguide and can be amplified by stimulated emission (so-called enhanced spontaneous emission).

There is a need in medicine and industry for light sources with a broad spectrum of light emission. In medicine, there is a growing demand for imaging systems, such as optical coherence tomography (OCT) for imaging of the cardiovascular system and the lungs, which is the most important medical applications of SLDs. Another important application of SLD technology is fiber optic gyroscope (FOG) used in the navigation and stabilization of autonomous vehicles (cars, airplanes, jets and others). This technology can also be used as line of sight stabilization and earth rotation detection systems. Therefore, advanced automotive technologies require SLD gyroscopes that ensure high performance and low operating costs.

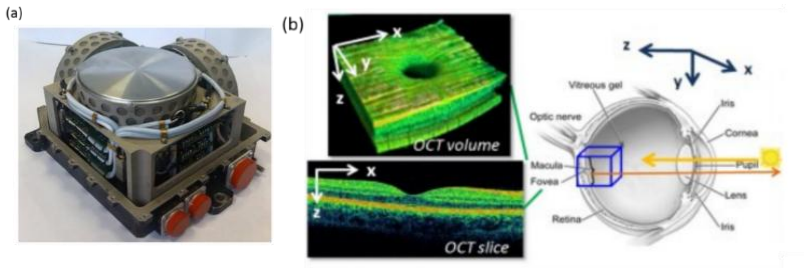

Figure 1. Examples of applications of SLDs with a wide emission spectrum: (a) 3-axis optical fiber gyroscope, FOG [https://www.findlight.net], (b) optical coherence tomography, OCT, of the eye [http://www.baysteyecare.com/optical-coherence-tomography-oct/].

In SLDs, the main problem is to obtain a sufficiently wide emission spectrum. Several methods have been proposed to broaden the nitride SLDs spectrum. Unfortunately, they do not bring the expected results - spectrum widening results in a significant decrease in optical power.

In order to solve these problems, we propose the use of an innovative structure of SLD active area consisting of: (*i*) a set of $In_xGa_{1-x}N/GaN$ quantum wells (QWs) – SLD type I (Fig.2a) and (*ii*) a set of $In_xGa_{1-x}N/GaN$ superlattices (SLs) - SLD type II (Fig.2b); with various geometries and with extremely narrow QWs of 0.5–2 nm, variable indium content $x \leq 0.25$ and with a quantum barriers (QBs) width of 0.75–6 nm.

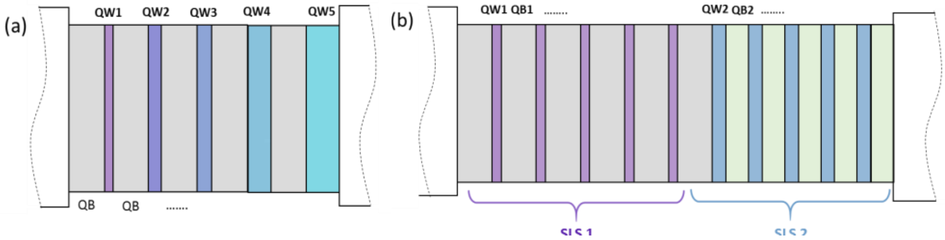

Figure 2. An example of an active area of investigated samples: (a) structure consisting QWs with different QW widths, (b) double structure based on SLs with different QW and QB widths.

The superlattices that we plan to use as the active area of SLDs consist of a small number of atomic layers in QWs and the QBs separating them. The wave functions QWs and QBs interact with each other, thanks to which it is possible to modify their optical properties. The main advantage of SLs is the possibility of tuning the emission wavelength by changing the thickness of QWs and/or QBs. By selecting the widths of QWs and/or QBs, is it possible to obtain simultaneous emission at several wavelengths, which will ultimately translate into a wider spectrum of light. In addition, the tunneling effects of carriers between quantum wells through a thin barrier will allow for a more uniform filling of the bands than in the case of "standard" quantum wells.

Impact of the project on the development of the field. There are not many studies on the use of nitrides in SLDs and this field is still very underdeveloped. On the other hand, the use of nitride materials allows to obtain emissions in a very wide spectrum (from UV to red) offering new possibilities of applications, previously unavailable for other material systems. The innovative approach proposed in the project, consisting in the use of modified structures of the active area, aims to meet the conditions required in SLD applications. Obtaining wide emission spectrum will result in showing "proof of concept" regarding in particular the applicability of SLs in the new generation of SLDs. This knowledge will constitute a new and significant contribution to the state of the art in the field of light emitters.