Title: Nitride superlattice lasers: design strategies for ultra-high external quantum efficiency

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Institute: Institute of High Pressure Physics PAS

Unit: Optoelectronic Devices Laboratory NL-15

WWW of the unit: https://www.unipress.waw.pl/en/labs/optoelectronic-devices-laboratory

Background:
The project concerns the development of a new nitride laser diode design in which the conventional multiple-quantum-well active region is replaced with an InGaN/GaN short-period superlattice. This approach is expected to enable more uniform electron and hole injection, reduce the Quantum-Confined Stark Effect, lower internal strain, and improve the thermal stability of layers with increased indium content. Different superlattice variants will be designed by varying layer thickness, the number of periods, and indium composition. The structures will first be modelled numerically using nextnano and then selected variants will be grown by MOCVD on sapphire and GaN substrates. Their structural quality will be examined using TEM, HRXRD, SEM, and cathodoluminescence, while electro-optical performance will be assessed from L-I-V characteristics, emission wavelength, threshold current, differential efficiency, and thermal stability. The project aims to develop an optimized laser diode emitting at wavelengths up to 488 nm, with high thermal stability and external quantum efficiency exceeding 50%. The results may establish a new design route for efficient laser diodes used in optoelectronics, medicine, telecommunications, and sensing technologies.

Aim of the project:
The aim of the project is to develop and experimentally verify a nitride laser diode with an InGaN/GaN short-period superlattice as its active region. The study will determine how layer thickness, number of periods, and indium content affect carrier transport, optical gain, strain, the QCSE, and thermal stability. The expected outcome is emission at wavelengths up to 488 nm, injection efficiency above 70%, and external quantum efficiency above 50%.

Requirements:
- Master’s degree in physics or materials engineering,
- English level B2.