Description for the general public

The project aims to research on a new type of semiconductor lasers, polariton lasers, which fundamentally differ from conventional lasers regarding the mechanism of coherent light generation.

Polariton lasers operate in the so-called strong coupling between the active material and the light field confined in the optical resonator. In this case, the ultra-fast energy exchange between excitons, which are the excitation of electrons in the active semiconductor material, and photons, quantum particles of light, leads to the mutualisation of their properties, thus creating a new type of particle called the excitonic polariton or just a polariton. These particles are sharing properties between light (negligible mass) and matter (they are subject to strong interactions). The group of polaritons can condense to a state called Bose-Einstein condensate, which is often referred to as the fifth state of matter. All polaritons accumulated in a condensate have the same properties, i.e. they are in a fixed phase with each other. This property, called coherence or cohesion, is transferred to emitted photons as a result of condensate loss, and the structure itself becomes a generator of coherent and monochromatic light having similar properties as for conventional lasers. The advantage of polariton lasers is their energy efficiency because they consume much less energy to generate light than the currently available conventional lasers. The disadvantage of polariton lasers is the need to cool down the device to low temperatures, at least two hundred degrees below the freezing point of water, for their efficient operation. This disadvantage inhibits the development of polariton laser technology for the practical application.

The goal of the project is to achieve close to room temperature operation of polariton lasers based on semiconductor alloys made of arsenic and gallium (GaAs). The research will be based on the new architecture of the laser structure, additionally using aluminium (Al) in the GaAs alloy in the active area of the device. Besides, a new approach to the optical generation of polaritonic condensate will be used. It assumes the spatial separation of the condensate from the excitation. These treatments are aimed at increasing the resistance of the polaritonic laser to the adverse effects of elevated temperatures.

An additional aspect of the research in the project is the use of specific physical phenomena in the polaritonic condensate to emit light packs instead of a continuous generation of radiation. In the event of success, it would be the first implementation of a pulsed polariton laser.

The project implementation can become an essential step towards the practical use of lasers based on the polariton effect in modern optoelectronic technologies.