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The main scientific goal of the proposed research project is to investigate the process of ultrashort pulses generation in passively mode-locked solid-state lasers with nanomaterials (e.g. graphene, topological insulators and black phosphorus) based saturable absorbers (SA). The aim of the study is to demonstrate that such kind of SAs can operate in very broad spectral range and can be considered as a new class of SA for practical applications. In order to prove such a broadband operation ultrashort pulses generation will be investigated in two main spectral ranges: 1020 – 1080 nm and 1900 – 2100 nm. In order to achieve the main goal the intensive study on nonlinear optical properties of recently discovered nanomaterials like: graphene, topological insulators and black phosphorus will be carried out. Because the saturable absorbers for mode-locked solid-state lasers should have a low non-saturable loses and low modulation depth it is extremely important to investigate influence of nanomaterials layer thickness and manufacturing technology on their nonlinear optical properties. Hence a large emphasis will be placed on development and optimization of SAs operating in transmission and reflection regime.
The effective project realization requires the cooperation of scientists with complementary competencies in such areas as modern materials science, modern techniques of characterization of materials, nonlinear optics and laser technology. To fabricate nanomaterials based structures the following technique will be used: CVD epitaxy, magnetron sputtering, chemical and mechanical exfoliation. The parameters of the structures will be characterized using atomic force microscopy (AFM) and scanning electron microscopy (SEM), Raman spectroscopy, and the Z-scan setup (measurement of optical parameter).
The ultrafast lasers using nanomaterials based saturable absorber are currently intensively investigated by many research groups from around the world. This is mainly because of the many practical applications of ultrafast lasers (e.g. precise metrology, medicine, laser micromachining, optocommunication). The operating spectral range of the commercially available passively mode-locked lasers are mostly by the saturable absorbers bandwidth. Currently obtained results indicate high application potential of the nanomaterials based saturable absorbers. It is expected that the ultrafast lasers with such saturable absorbers can operate in the spectral range up to 5 μm.