The project aims to fabricate a gas sensor based on combined low-dimensional materials (including two-dimensional (2D) graphene, metal-oxide nanostructures, and metallic nanostructures) that will operate under the enhancement of ultraviolet (UV) or visible light. The hybrid structure with metallic gold nanostructures will exhibit localized surface plasmon resonance to improve the sensitivity and selectivity of the prototype sensor. The phenomenon is induced by light, and its properties strongly depend on the surrounding atmosphere, which can be used in detection. Gas-sensing layers will be fabricated using a simple solution method, consisting of mixing dispersions of graphene flakes and titanium dioxide (TiO_2) nanostructures, then deposition of the mixture on the selected substrate and modification with the gold (Au) nanoparticles to form a plasmonic platform. Such a hybrid structure will combine graphene's high sensitivity to changes in the ambient conditions, photocatalytic properties of TiO_2, and plasmonic properties of Au nanostructures. Combining metallic and semiconducting materials will enable modulation of the sensor's performance with light. This relatively simple technique of fabrication of layers consisting of nanoscale structures is a method with a low environmental impact; moreover, such a sensor will require low energy to operate. At the same time, with such a simple fabrication technique and suitably developed measurement methodology, gas sensors working as effective probes can be created with the potential for being used in practical applications from different fields.

The undertaken scientific subject is directly connected with today's need for novel sensing systems of enhanced sensitivity, selectivity, fast operation, and low cost with uncomplicated production methods. Environmental monitoring by detecting toxic and hazardous gases for both the environment and humans is one of the applications that demand efficient detection systems. Health monitoring is another potential application of sensors that requires very low detection limits, when some of the gases in a patient's exhaled breath inform about specific diseases. Thus, studies of novel materials (and their combinations) and effective methodology are crucial for developing efficient sensing devices for practical applications. The proposed investigation will also broaden the current knowledge of gas detection systems based on combined low-dimensional materials enhanced by light and using a plasmonic effect.

The project includes three main tasks: fabrication of hybrid structures, structural and electrical investigation of the prototype sensor, and critical assessment of possibilities of using a graphene-based sensing platform for real-environment detection. In our project, we propose using light modulation and plasmonic effect induction to increase the sensitivity and selectivity of gas-sensitive layers since these parameters are essential properties of effective sensors. Additionally, the sensor's selectivity can be enhanced by methodology based on resistance measurements and studies of the fluctuations of this resistance. We plan to implement low-frequency noise ($1/f$ noise) measurements that constitute an additional tool to identify characteristic processes connected to gas molecules' adsorption on the sensing surface. Then, the gas-sensing layers work as a highly precise probe for any changes in the environment and molecular processes occurring at the sensor's surface. This way, we propose to improve sensor parameters by the fabrication method and modification of the main active layer, light modulation, and measurement methodology.

We expect to increase the sensitivity of the hybrid sensor by its surface irradiation and increase the selectivity of the sensing device by observing changes in resistance fluctuations due to induced plasmon resonance in Au. The activation of localized surface plasmon resonance can enhance the surface activity of the sensing layer by orders of magnitude. The project's main task is to confirm that the simple method of fabrication of gas sensors based on low-dimensional structures can be used for effective light-assisted gas sensing with an induced plasmonic effect.