Why methane detection? Sensing and analysis of methane levels in exhaled air is highly relevant for health condition monitoring and could be used in industry for the leak detection. While ambient methane levels are predicted to be at the level of ~ 1900 particles per billion, it was shown that the normal concentration of methane in exhaled air is only ~ 3000–8000 particles per billion with higher concentrations indicating possibility gut bacteria, colonic fermentation and intestinal problems. Currently, the methane sensing instruments are using mostly the mid-wavelength spectral range. In our approach, we propose to explore the longwave infrared range due to the fact that distinct and highly useful absorption peaks are observed for wavelengths near ~ 8 μm. Importantly, the methane absorption peaks are not interfering with absorption spectra of other common compounds observed in longwave range such as H_2O, CO_2. In addition, the two main detrimental scattering effects of Rayleigh and Mie are significantly reduced. It is expected that the development of $A^{III}B^{V}$ bulk ($InAs_{1-x}Sb_x$) and $A^{III}B^{V}$ type-II superlattices longwave heterostructures technology will enable realization of detectors with high frequency response at operating temperatures above 300 K. Theoretical analysis shows, that the inherent material parameters of type-II superlattices detectors might be considerably improved by introducing appropriate design changes in the photosensitive elements. That possibility is offered by structures with unipolar barriers. The main goal of the proposed project is research on fundamental photoelectrical effects related to the response time, designing, numerical modeling, growth by molecular beam epitaxy $A^{III}B^{V}$ bulk $InAs_{1-x}Sb_x$ at the very first stage and after type-II superlattices InAs/GaSb and $InAs/InAs_{1-x}Sb_x$ barrier infrared detectors with short time operating at $T \geq 300$ K. Moreover, proposed project is also focused on research on determination of the structure and development of the technology of barrier $A^{III}B^{V}$ detectors operating at room temperatures (or higher), in longwave exhibiting high frequency response without impeding detectivity. Those detectors are planned to be used in the methane longwave sensing system set-up. The proposed subject of research will be of *great importance* in development of both, the theory and technology of new type of IR detectors exhibiting high frequency response without influencing detectivity and possible implementation to the LWIR CH_4 sensing systems what underlines the innovative character of the project.

High frequency response and detectivity of the high operating temperature longwave infrared detectors stays in contradiction, meaning that one optimized parameter lowers the other and inversely. On the other hand, we believe that barrier structures give an opportunity to design and fabricate the HOT longwave infrared detectors with detectivity $\geq 10^9$ cmHz$^{1/2}$/W ($T = 300$ K). In addition, detectivity could be artificially increased by implementation of the immersion lens to the detector structure, e.g. GaAs substrate.

By taking all of the above into consideration, the proposed project will include:

1) input performance (for methane sensing) to launch the detector's designing procedure;
2) advanced numerical analysis of the charge carrier transport and response time in the $A^{III}B^{V}$ bulk and type-II superllatice barrier detectors;
3) growth of $A^{III}B^{V}$ type-II superllatice barrier structures on GaAs substrates by the molecular beam epitaxy technique and material characterization;
4) fabrication (*processing*, GaAs immersion lens formation) of $A^{III}B^{V}$ type-II superllatice detectors;
5) detector characterization: frequency response, detectivity, responsivity;
6) detector testing for spectroscopy applications - methane sensing.