The current state of the art and development of the “Ga-free” InAs/InAsSb type-II superlattices (T2SLs, superlattice - SL) technology enables to design and fabricate infrared (IR) detectors operating without extra cryogenic cooling, meeting the high operating temperature (HOT) and size weight and power (SWaP) conditions. The T2SLs InAs/InAsSb based photoconductors were demonstrated to reach the higher detectivity (D^*) than HgCdTe at 210/230 K and longwave (LWIR) and very longwave infrared radiation (VLWIR). There is a trend being observed that many IR applications require $T \geq 300$ K (e.g. FSO system - *fibreless communication*) and this subject presents one of the main research challenges in terms of the IR detectors optimized for the LWIR (10 μm) spectral range.

It was proven that the performance of the IR detectors based on the “Ga-free” T2SLs InAs/InAsSb active layers might be considerably improved by introducing appropriate design changes in the photosensitive elements. This was reached by structures with both multi-stage non-current-matched, (equal- *EA*) and current-matched, (matched-absorbers - *MA*) based on T2SLs InAs/GaSb active layers. The “Ga-free” T2SLs InAs/InAsSb exhibits higher carrier lifetimes related to the lack of Ga within the structure in comparison to the T2SLs InAs/GaSb what influences the device performance. The multi-stage architectures increase quantum efficiency (*QE*) and limit shot noise resulting in improved device performance at HOT conditions in comparison to the conventional photodiodes. Except implementation of the T2SLs InAs/InAsSb active layers the further improvement in D^* could be reached by exploitation of the photelectric gain effect (*G*) in non-current-matched *EA* multi-stage IR detectors what theoretically allows to increase D^* by ~40 %.

The main goal of the proposed project is to research on the fundamental photoelectric gain effect in *EA* T2SLs InAs/InAsSb LWIR HOT interband quantum cascade photodetectors (IB QCPs) to improve device’s performance - D^* and reach short response time (τ_s). The project will encompass designing, numerical simulation to include photoelectric gain effect, growth by molecular beam epitaxy (MBE) on GaAs substrates, characterization and fabrication of IB QCPs based on T2SLs InAs/InAsSb active layers operating at $T \geq 300$ K.

The main goal of proposed project is to maintain or strengthen of the Polish specialty in global scale (what we have been doing for nearly 25 years with mercury cadmium telluride, HgCdTe) in terms of designing and fabrication of HOT LWIR detectors ($T \geq 300$ K). This goal could be met only by introduction and implementation of the new material with higher parameters in comparison to the HgCdTe being the most explored compound in IR detectors’ technology. The proposed project fully uses internal research potential and what is most important it offers further step ahead in terms of development of the new type of multi-stage detectors. The successful realization of the proposed project will have a significant influence on the level of the knowledge in proposed subject. Our main effort will be to increase operating temperature and increasing the detectivity and time response at the same time by exploitation of the photelectric gain. It requires high technology and numerical modeling capability of the effects related to detection of IR. Advanced simulation of the multi-stage detectors should lead to optimal architectures and should reduce the cost of fabrication. This allows to increase the range of potential applications in particular where cooling is difficult to realize. The proposed subject of research will be of great importance in development of both, the theory (to include photelectric gain) and technology of new type of IR detectors exhibiting high frequency response without influencing detectivity. The progress in this project will enable a better understanding of the charge carriers transport with photoelectric gain effect influence on detectivity and time response. Also, it will significantly contribute to a development of the optimal design and technology of LWIR cascade IR detectors ($T \geq 300$ K).