The main focus of the project is to research and examine the possibility of reaching the photocurrent gain > 50 with the excess noise < 2 in materials and avalanche photodiodes (APDs) operating at longwave infrared radiation (LWIR) range (with cut-off wavelengths $\lambda_c$ ~ 8 μm) with either 4- ($T$ > 190 K) or 2- stage thermoelectrical (TE) cooling. Mentioned research would encompass an approach to determine the LWIR APDs' structure and technology development of the device (III-V layer growth on GaAs substrates and *processing*). Within the project it is planned to determine whether it is possible to reach the gain > 50 of the photocurrent under high operating temperature (HOT) conditions, and what factors have a decisive influence on the avalanche effect in analyzed III-V bulk and type-II superlattices (T2SLs) InAs/GaSb and InAs/InAsSb - materials and APDs. It must be underlined that higher performance in terms of gain and excess noise in LWIR III-V APDs operating without cryogenic cooling may be reached by improving the detector's architecture to include absorber and multiplications regions and improvement of growth and *processing* procedures.

Why III-V for LWIR APDs? III-V family should be considered as an industry materials for the fabrication of IR detectors for critical and strategic applications covering the important IR ranges. Asymmetry between the effective mass of electrons in the conduction band and heavy holes results in an unequal ionization coefficient for electron and hole. In addition, both have a highly favorable electron to hole impact ionization ratio. High avalanche gain can be reached with low noise as the multiplication process is initiated by a single carrier. Currently, the highest performance of the LWIR HOT APDs has been reached at 77 K. Having the experience in the HOT MWIR and LWIR detectors we believe that the numerical simulation will allow to design an optimal LWIR III-V APDs operating without $LN_2$ cooling. In the next stage the technological parameters allowing to fabricate device structures will be determined. The III-V heterostructures will be grown by the MBE on GaAs substrates. Next, the grown heterostructures will be characterized by classical methods used in IR detectors technology. The structure, optical, and photoelectrical properties will be assessed. The results of this work will be employed to improve the detector's architecture (geometry, active area, multiplication region and contact layers doping optimization) and technological parameters crucial for their fabrication.

APDs are useful for the detection of low power optical signals in the space based imaging applications. APDs with high bandwidth (BW) and internal gain are suited for the detection of attenuated optical signals in the long range applications offering a combination of high speed, high sensitivity and high quantum efficiency. APDs are an attractive choice for many IR applications such as night vision, LIDAR/ LADAR, and free - space optical communications (FSO) where LWIR range is much more favorable than mid- or short wavelengths (MWIR, SWIR). In addition, the two main detrimental scattering effects of Rayleigh and Mie are significantly reduced within LWIR in comparison to the MWIR. Although many applications, where APDs could be potentially implemented there is one fundamental limitation - APDs require $LN_2$ cooling (77 K). In order to meet SWAP (*size weight and power*) conditions there is a high demand to increase operating temperature to the level of either 4- or 2- stage TE cooling. That could be reached by the material where multiplication process is initiated and limited by one type of carriers. That could be potentially reached by III-V family.

Tasks to be undertaken in this project are new and original compared to the previously implemented. That have significant benefits, for example enabling reduction of the device's SWAP requirements and what is most important, reduction of cost of production (lack of the $LN_2$ cooling). In addition, research on extending of the IR technology into the field applications where $LN_2$ cooling is impossible or very difficult to be deployed are extremely important.