Printed electronics can effectively replace traditional technologies being applied in the production of semiconductor-based electronic and opto-electronic devices, such as photodiodes used for light detection, and organic light emitting diodes. The fabrication of thin organic layers applied in this type of devices is based on two main techniques: vacuum deposition technique and a non-scalable, laboratory technique: spin-coating. Therefore, efforts have been made for several years to adapt printing techniques, such as inkjet printing and screen printing, to the production of semiconductor electronic components. The main problem in achievement of fully printed multilayer optoelectronic devices is printing the electrode by the means of commonly used inks based on silver or expensive gold nanoparticles, on the surface of semiconductor thin layer. Due to the strong hydrophobic nature of the organic active layers, this type of electrode is actually non-printable with silver ink mainly composed of polar solvents. Therefore, it is necessary to apply an interlayer between the electrode and semiconductor's active layer, of a made of a material whose one of the molecule fragment will have a strong affinity to the inorganic electrode, characterized by both strong affinity to the inorganic electrode and organic active layer of the device. The second reason to implement the interlayer is the fact that the work-function of the unmodified silver electrode does not allow an effective injection of charge carriers into the active layer.

The first goal of the project is to develop methods for modification of silver electrode work function using a series of perylene diimide (PDI) derivatives, which, properly designed, can be used to alter not only the silver electrode work function, but also other commonly used electrodes such as indium tin oxide (ITO). This modification can occur through the introduction of an ultra-thin layer (<10 nm) of PDI-based material between the electrode and the active layer.

Regardingthe synthesis of new materials, the project is based on the three concepts: (1) the synthesis of perylene diimide derivatives equipped with polar functional groups, serving as an anchor for the electrode surface and efficiently modifying its work function, (2) the use of the new perylene diimides as dispersants of graphene flakes in order to produce a composite that efficiently modifies electrode work function, (3) the development and obtainment of perylene diimide PDI-based systems forming well-organized 3D structures.

The second goal of the project is to understand the mechanism of action of the implemented interlayers by applying comprehensive physical and electrical studies, including measurements of their work function, relationship between ability to modify the work function of the electrodes and their chemical structure, and testing the interlayers in metal-semiconductor systems. Studies on the efficiency of electrode work function modification will be tested in photodiodes and light-emitting diodes, which architecture will be designed with taking into account the parameters of the developed electrode-interlayer systems (work-function ability to inject or block charge carriers). Interlayers used in fabricated optoelectronic devices will be prepared by the means of inkjet printing technique from appropriately developed ink, using a laboratory printer. The analysis of the obtained results will be supported by a properly selected simulation model (the drift-diffusion method), which will help in the identification of physical phenomena occurring at the electrode-interlayer-semiconductor interface, and to improve the operating parameters of the produced optoelectronic devices.

The proposed project will be carried out by consortium of 3 partners: Lodz University of Technology, Adam Mickiewicz University and University of Lodz.