There has been an exponential increase in the popularity of 3D printing technology in the last few years, also in everyday life. The area of new applications for various types of electrochemical microsensors is also growing rapidly. Some of the solutions have a chance to change the face of our civilization, allowing for ultra-sensitive molecular recognition in chemistry, medicine or biology. Their increasing general availability creates new diagnostic possibilities of civilization diseases. The constant increase in the availability of the 3D printing technology of plastics (FDM) means that the sensors produced by this method have a high potential for popularization on a large scale, e.g. in daily diagnostic tests.

The Project will develop new carbon hybrid materials, based on diamond-reinforced polylactide (PLA), with specially designed properties, dedicated to FDM printing. Various diamond powders will be used, including boron-doped diamond (BDD), one of the most effective electrode materials. One of the main objectives of the project is to investigate and thoroughly understand the interactions between composite components and those that affect the mechanical parameters and electrochemical characteristics of printed elements. As a result, the implementation of the project will allow the development of a technology for the production of a new class of PLA-diamond composite polymer materials, having a number of positive features, i.e. high electroactivity, high material strength and shape stability, biocompatibility and dedicated to the production of sensors and transducers with complex shapes. Taking into account the fact that the vast majority of electrodes used for electrochemical sensors are disposable and must be disposed of after their use, the three-dimensional structures proposed in the project will be non-toxic and biodegradable.

The authors plan to identify environmental factors affecting the decomposition of the PLA-based composite. As a result, the developed PLA-diamond composites can be used in accordance with the concept of intelligent, responsive 4D materials, changing their shape and/or properties under the influence of factors such as temperature, pH or electrode polarization. The electroactivity of 4D intelligent materials will be predictably modified when exposed to certain external conditions. The possibility of a controlled release of specific chemical compounds from the volume of the composite matrix will also be investigated.

The development of multi-material printing, with the use of 2 or more extruders, allows for unprecedented freedom to create new, free-standing structures, such as e.g. electrochemical cells with electrodes made of conductive PLA-diamond material, built around the structure of an insulating polymer (matrix without fillers). Based on the spatial resolution available for the FDM printing technology, the project will investigate the processes of joining various polymers, adhesion, electrochemical properties and the degree of their modification in the joint area. This knowledge will help the authors to create microelectrode arrays and flow targets, enabling the detection of anti-inflammatory drugs (paracetamol, ibuprofen), neurotransmitters (serotonin, dopamine) and antibiotics, which will allow the development of environmentally friendly diagnostic procedures.