Description for the general public

The main goal of the proposed project is to study how parameters such as perfusion, nanofibers, stem cells and biochemical factors influence regeneration of heart cells under disease (hypoxia) state. This goal will be achieved through the integration of a few parameters simultaneously: (1) *Lab-on-a-chip* system (2) biomaterials (nanofibrous mats) used to parallel cardiac cell culture (3) mimicking of heart disease, and (4) stem cells culture and differentiation towards heart cells.

According to the statistical analysis, cardiovascular diseases (CVDs) are the most common cause of death around the world. CVDs damage cardiomyocytes (CMs), as a result these cells lose their ability to renew. One of CVDs is ischemic heart disease (IHD), which results from chronic insufficient supply of cardiac cells with oxygen and nutrients. Chronic hypoxia leads to myocardial necrosis and irreversible cell damages, which results in heart failure. The use of a particular treatment method is determined of type and state of disease. Various drugs, medical and surgical procedures, artificial hearts and mechanical devices supporting left ventricular function are used to treat heart diseases. Heart transplants is also applied, however their usage is limited by a number of donors. Recently, regenerative medicine based on stem cells (SCs) seems to have an important role in cardiology. Stem cells, thanks to the usage various factors, e.g. biochemical, physical (electrical, structural, surface) or mechanical (strain, shear stress), have the ability to differentiate into other types of the cells, including heart cells. However, it should be noted that heart regeneration research is at an early stage. Therefore, many important issues still need to be resolved.

Therefore, we proposed to study hypoxia on cardiac cells and their regeneration based on stem cells in a new developed *Lab-on-a-chip* system. For this purpose, a new *Lab-on-a-chip* system will be developed and integrated with additional biomaterials (a new fabricated nanofibrous mats), which will influence parallel cell orientation, cardiac cell maturation and stem cells differentiation towards heart cells. The geometry of the microsystem will be optimized and designed in such a way that both mono- and cocultures of cardiac and stem cells will be performed simultaneously. Thanks to the above mentioned features, *Lab-on-a-chip* system, which we will used in our research, is designed in such a way that nature microenvironment of heart tissue is mimicked. Thanks to that, the obtained results will be more reliable than macroscale studies and it could help to optimize heart regeneration in clinical application in the future. Thanks to the use developed hypoxia model in the microsystem, it will be possible to answer how the parallel orientation of the cardiac cells (thanks to the usage of nanofibers), perfusion conditions (correspond to blood flow in the vascular system), stem cells and biochemical factors influences heart cell regeneration and SC differentiation towards cardiac cells. Study of hypoxia of cardiac cells and their regeneration using stem cells in a developed *Lab -on-a-chip* system will give a new knowledge of heart disease mechanisms as well as parameters useful for cardiac cell regeneration. The developed *Lab-on-a-chip* system could be used in future as a tool for optimization parameters of heart cell regeneration in personalized medicine.