Type 1 diabetes is a devastating chronic disease rapidly becoming a 21st century epidemic. It is characterized by the body's inability to produce insulin, a hormone responsible for regulation of the glucose level in blood. The disease affects up to 40 million people worldwide and leads to nearly 5 million deaths each year. It is also estimated that about 80 000 children develop the disease yearly. Despite overall progress in treatment, the cause of type 1 diabetes is not known and it is not preventable under current knowledge.

One of the most promising methods of treatment, still experimental, is the transplantation of the so-called islets of Langerhans, tiny organs (less than 0.5 mm in size) located in pancreas and responsible for the production of insulin. Unfortunately, currently applied transplantation procedures are harmful to the islets which in turn requires multiple donors and makes the treatment ineffective.

In response to the increasing demand on the pancreatic islets, tissue-engineers aim at creation of artificial islets de novo, that is from individual pancreatic endocrine cells (cells regulating levels of hormones in pancreas), be it stem cells or derived from animal tissue. In the project, we will explore one of the particularly appealing strategies relying on micro-encapsulation to generate implantable insulin-producing islet-like micro-organs. We will encapsulate the insulin-producing cells inside so-called 'microbeads', tiny particles made of hydrogel, a soft and bio-friendly material resembling gelatin, additionally enriched with proteins and nutrients for enhanced survival of the cells. It is well known that pancreatic cells prefer to be suspended in a soft but elastic matrix, an environment possibly resembling the native pancreatic tissue. In the project we will formulate hydrogel microbeads optimally supporting cell growth, aggregation and maturation to achieve fully functional artificial islets.

The main novelty of the project consists of using microfluidics, i.e., the technique of manipulating nanoliter volumes of fluids in channels of width of a human hair, to form cell-laden droplets and then to transform them into micro-tissues. Two-, or more, liquid streams, each containing a different type of cells suspended in hydrogel solution, merge and get reproducibly discretized into micro-droplets which subsequently solidify via a mild chemical reaction resulting in cell-laden micro-particles. The proposed strategy is scalable: while previous approaches to micro-tissues relied on aggregation of cells inside plastic wells, thus limiting the number of generated islets, microfluidics put no constraint on the number of generated droplets: in fact, current state-of-the-art microfluidic devices are technically capable of turning of even one liter of cell suspension into droplets within a day; that translates into generation of hundreds of millions of artificial islets daily using just a single device.

The project joins the increasing worldwide efforts towards the development of new strategies of treatment of type 1 diabetes. It is noteworthy that islet transplantation is likely to be soon approved for clinical application by Federal Drug Administration in the USA (currently in phase 3 clinical trial), for which we believe that the proposed project is very timely. Finally, the new formulation strategies developed in the project will also have a general impact on microfluidics, tissue engineering and organ-on-chip technologies.