POPULAR SUMMARY

High-throughput screening is a method of trial-and-error testing of drugs or drug combinations, which in pharmaceutical industry typically involves thousands or even millions of trials. Nowadays, in industrial setting, operations on liquid samples—such as pipetting—are typically performed by fully automated robots. Such robots—operating at the industrial scale—are extremely large- and expensive devices. However, drug testing becomes increasingly important even in hospital setting, at the 'scale' of a single patient. In particular, in cancer treatment, the combination and administration of drugs, often expensive and/or toxic, optimally should be custom-tailored to a given patient to reduce cost and minimize harmful side-effects. Such procedure could be realized via on-site testing of drugs on cells from biopsy. Microfluidics offers a solution for high-throughput testing of drugs using very small volumes of a sample, such as few grams of a tissue from biopsy. The sample, injected onto microfluidic chip gets dispersed into thousands of nanoliter droplets, each of diameter well below the width of a human hair (and so, hardly visible), and merges with a droplet containing a drug sample—typically a mixture of drugs at various concentrations. The response of the cells to a combination of drugs, different in each droplet, is subsequently measured with the aim of identifying the most efficient drug combination. One of the bottlenecks of this emerging technology, yet at the development stage, is so-called 'barcoding' of individual droplets, that is unique labeling allowing to identify the observed effect on cancer cells in a given droplet with the initially prepared drug combination.

Recently, several alternative approaches have been proposed towards high-throughput barcoding of microfluidic droplets. Some of them involved addition of coloring dyes at various concentrations allowing to distinguish droplets by measuring dye intensity. However, those methods suffer from rather low 'resolution' allowing to uniquely identify only up to around a hundred droplets, whereas thousands or tens of thousands need to be identified. In the project, we will develop a droplet-barcoding technique based printing of droplets at a substrate. For most efficient identification of individual droplets, we will further exploit an intriguing phenomena—which we recently discovered—of spontaneous formation of ordered patterns along the printed lines of droplets. Such patterns emerge due to random droplet rearrangements occurring under specific printing conditions. As a result, each droplet is labeled by unique neighboring sequence of rearrangements, inscribed in the printed structure. In the project we will develop basic understanding of the phenomena of droplet rearrangements during printing and study the capacity of the generated patterns to uniquely label individual droplets, in particular in sequences spanning thousands of droplets. We will also perform proof-of-concept experiments involving encapsulation of living cancer cells inside the printed droplets for screening of their response to a varying drug concentration.

The technology developed in the project will provide a non-invasive (dye free) and cost-effective alternative to existing methods of droplet barcoding, potentially transformative for the fields such as drug development, personalized medicine or point-of-care diagnostics.