ABSTRACT

Wang, Jun. Ph.D., Purdue University, December 2009. Microfluidic Devices for Cellular Analysis and Processing. Major Professor: Chang Lu.

The emergence of microfluidic techniques provide an unprecedented opportunity for peering into molecular mechanism and cell-cell interaction based on single cells. Those microfluidic platforms integrated with optic and electronic components have simply demonstrated their potential applications in drug discovery, clinical diagnostics and disease treatment, etc. However, most of them find great difficulties of further development due to fundamental limitation in the design where single cell resolution often has tradeoff with high throughput and post-processing step. Microfluidic flow-through analysis can be the key to overcome that limitation. In this research, I combine electric field with flow-through analysis to process cells and obtain important cellular information with high throughput ($\geq 200\,\mathrm{cells/s}$) at the single cell resolution. This combined technique, namely flow-through electroporation, has been used to fuse cells and deliver gene into cells, in which Dean vortices are implemented to enhance gene delivery and transfection. I also find that intracellular molecules can be released to surrounding buffer selectively under appropriate electric field, depending on physiological state and location of that molecule inside the cell. The platform integrating flow-through electroporation and microfluidic flow cytometry, namely electroporative

flow cytometry, has been demonstrated to be able to detect kinase and other signaling protein translocation. To avoid cell damage after analysis, total internal reflection fluorescence flow cytometry has also been developed to detect signaling protein translocation and study signal transduction. These novel tools not only give new insight and perspective to fundamental biological processes, but also have great potential for fast and costless point-of-care diagnostics with high automation.