Microfluidic systems for single-cell biophysical characterization

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The cell is the fundamental unit of life. Understanding cell function in health and disease is critical to diagnosis and treatment. Modern approaches towards personalized and precision medicine highlight the potential of single-cell analysis and manipulation for the development of novel therapeutic solutions. This raises the need to develop suitable, advanced technological tools.

Microfluidic impedance cytometry is a label-free, high-throughput technique that uses electric fields to stratify the heterogeneity of cellular systems, based on their biophysical properties, such as cell size, shape, and deformability. Emerging applications range from fundamental life-science and drug-assessment research to point-of-care diagnostics and precision medicine. Novel chip designs and data analytic strategies are laying the foundation for multiparametric cell characterization and subpopulation distinction, which are essential to understand biological function and follow disease progression.

We present recent approaches to elucidate cellular and subcellular features from impedance cytometry data, covering the related subjects of device design and data analytics (i.e., signal processing, dielectric modelling, population clustering). We give special emphasis to the exciting recent developments of the technique and provide our perspective on future challenges and directions. Its synergistic application with microfluidic separation, sensor science and machine learning can form an essential toolkit for label-free quantification and isolation of subpopulations to stratify heterogeneous biosystems.