

Single-Cell Impedance Cytometry: Recent Progress and Challenges Ahead

Federica Caselli

University of Rome Tor Vergata, via del Politecnico 1, 00133 Roma, Italy
caselli@ing.uniroma2.it

Abstract:

Microfluidic impedance cytometry (MIC) is a label-free technique that characterizes individual flowing cells based on their interaction with a multifrequency electric field [1]. It has been successfully applied across a range of domains, including life-science research, diagnostics, and environmental monitoring. In this talk, I will outline emerging trends that are expected to further expand the capabilities and adoption of MIC, together with the key challenges associated with these developments.

The presentation will focus on:

(i) The evolution from MIC to microfluidic impedance spectroscopy [2], in which thousands of single-cell spectra can be acquired within minutes and fitted to physically grounded models, enabling the extraction of cell dielectric parameters.

(ii) The integration of MIC with other microfluidic tools to create multifunctional single-cell analysis platforms [3]. MIC relies on a simple setup, making it naturally compatible with other microfluidic technologies.

(iii) The synergy with Artificial Intelligence (AI) [4–6]. As microfluidic systems gain functionality, they require a “brain” capable of interpreting signals from the sensing units and making task-level decisions. AI-based approaches are highly promising, as they enable real-time perception and decision-making in complex operational scenarios.

Keywords:

single-cell analysis, microfluidics, impedance cytometry, multifunctional platforms, artificial intelligence.

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