Impedance characterization of particles one by one using a nanosensor electronic platform

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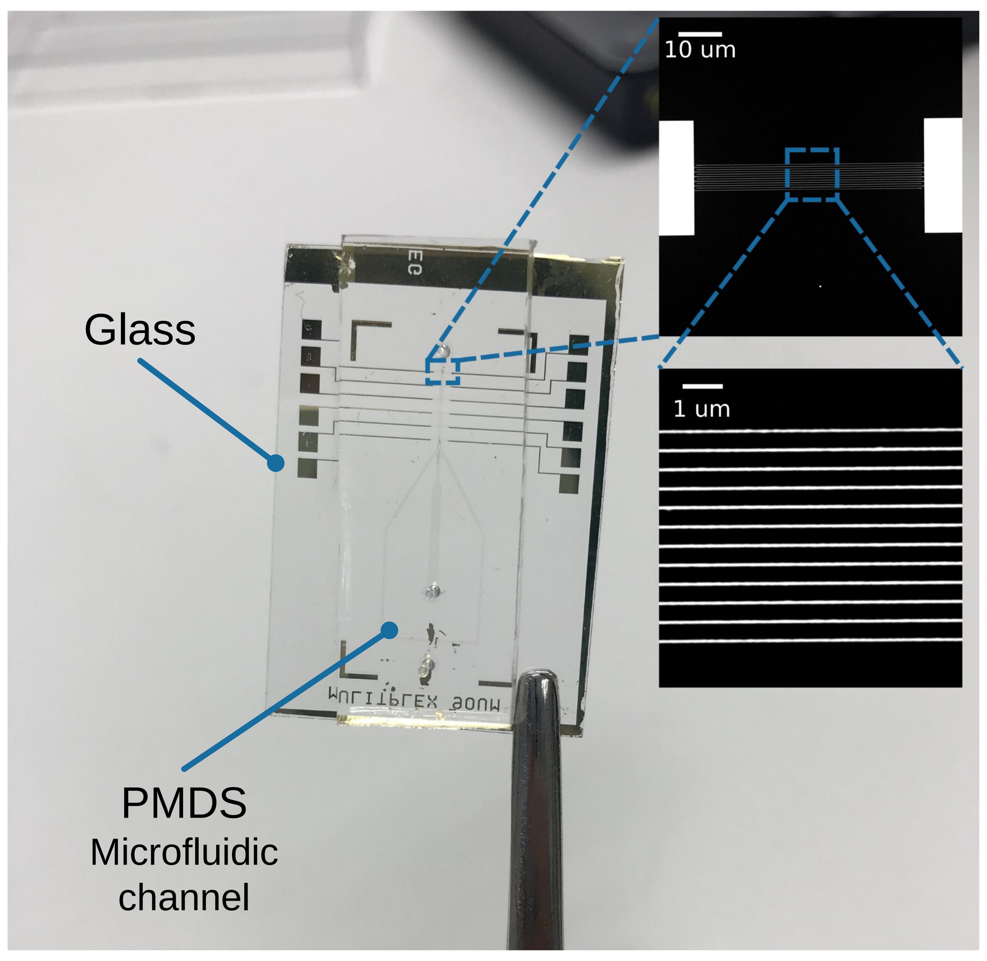
Introduction

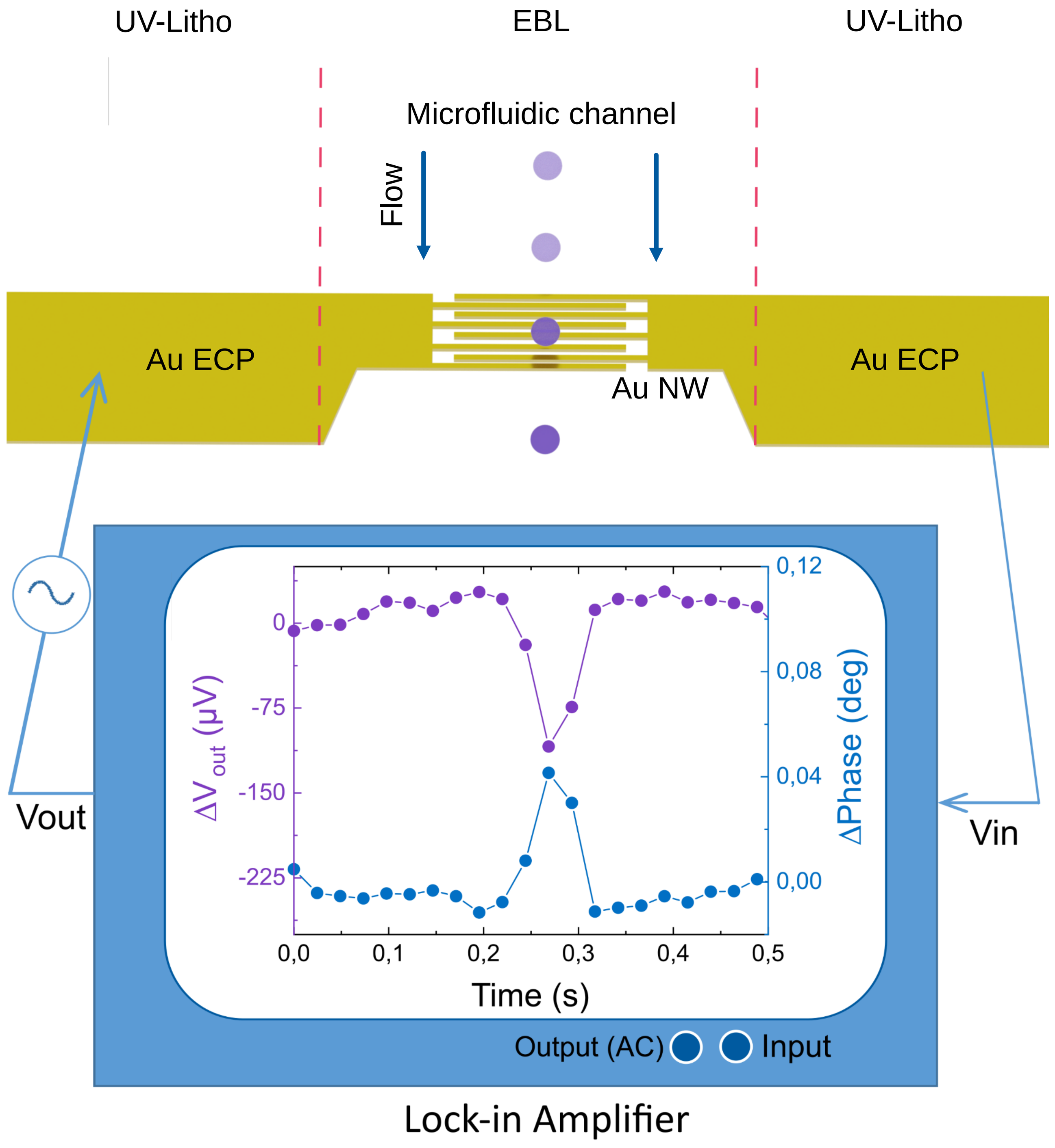
- The on-chip integration of nanostructures for biosensing is becoming a promising approach for label-free measurements [1].
- Impedance cytometry allows the electric characterization of colloids in a highly miniaturized way.
- By measuring the electrical properties of particles in suspension, the dielectric characteristics of particles can be determined [2].

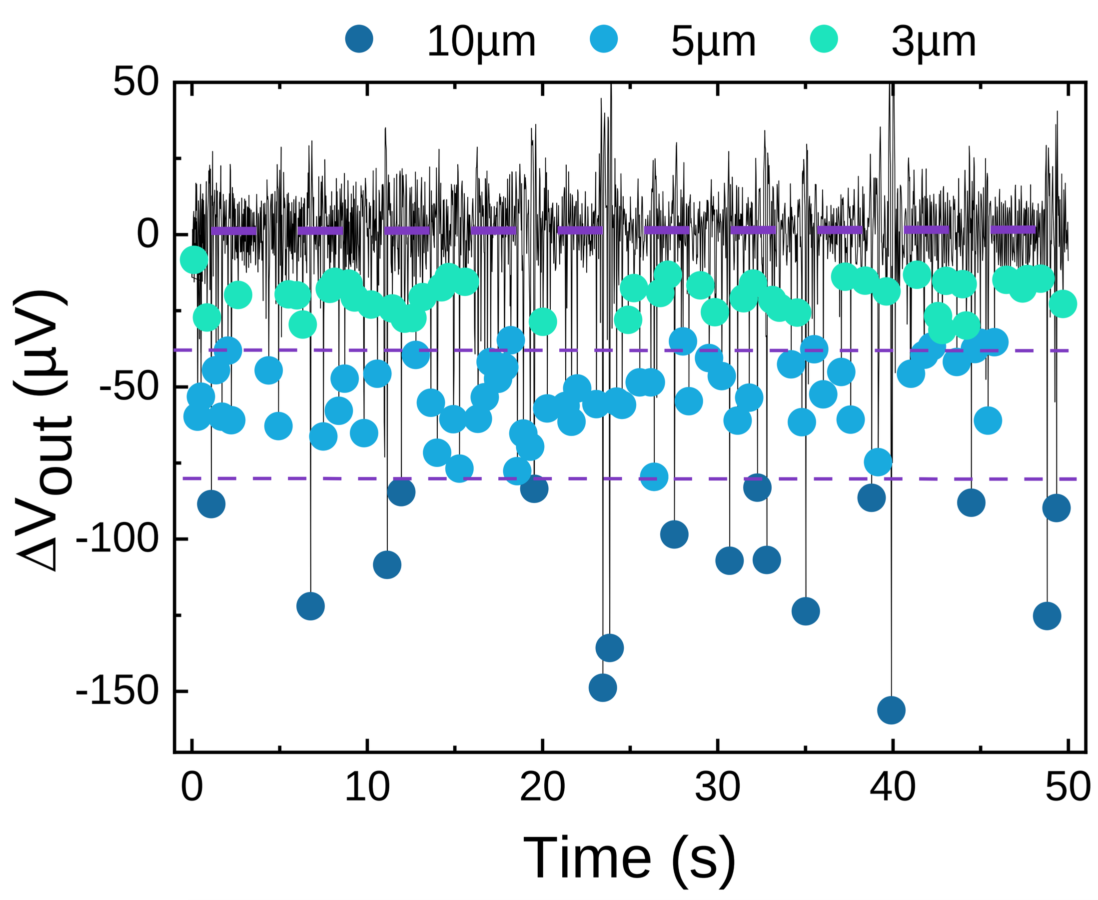
Results

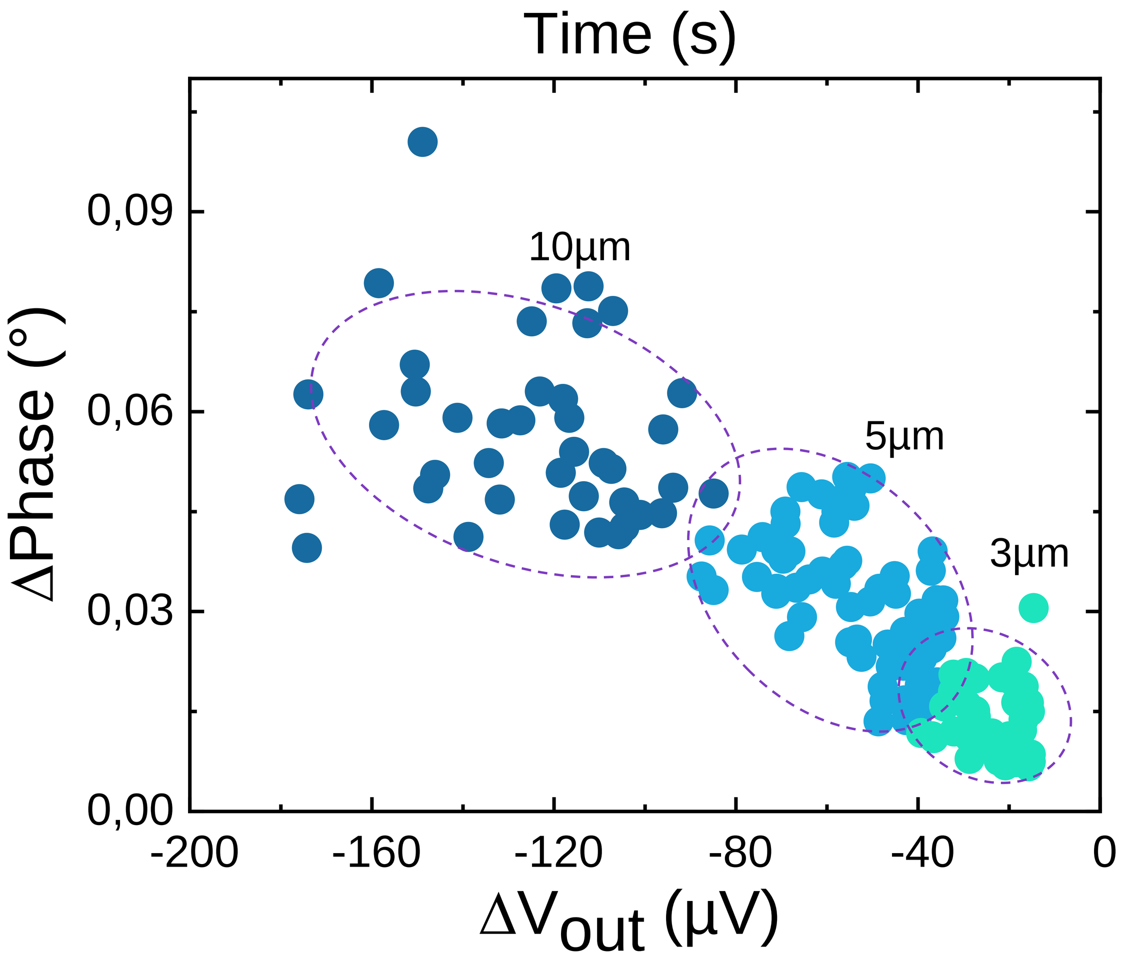
Impedimetric chip

- Interdigitated gold nanowires of 100 nm in width and 50 µm in length were fabricated by EBL.
- An AC signal (500 mV) is applied between the sensing elements at a fixed frequency (100 kHz) using a lock-in amplifier.
- The changes in amplitude and phase of the applied signal are measured with the lock-in amplifier.
- Real-time monitoring of silica particles (sizes: 3 µm, 5 µm, and 10 µm) flowing over the sensing area was achieved.









Methods

Fabrication of the impedimetric chip:

- The interdigitated gold nanowires (NW) were fabricated by electron beam lithography (EBL).
- The external contact pads (ECP) that allow the connection with the measuring device (lock-in amplifier) were fabricated by standard UV-lithography.
- The microfluidic channel (200 µm width, 15 µm height) that allows the flow of particles over the sensing area was fabricated by soft-lithography using SU-8 structures to make the PDMS replica containing the channel.

Single-particle detection events

- When a particle reaches the sensing area, there is a voltage drop of the signal and, at the same time, a phase shift can be observed.
- As soon as the particle leaves the sensing area, the signal stabilizes back to the baseline value.

Detection of particles of different sizes

- A complex mixture containing particles of different sizes (sizes: 3 µm, 5 µm, and 10 µm) was tested with the impedimetric platform. The signal change induced by a particle passing over the sensing area is size-dependent. Particles of 3 µm, 5 µm, and 10 µm show a mean ΔV_{out} of -19 µV, -52 µV and -108 µV, and a mean ΔPhase of 0.015°, 0.03° and 0.06°, respectively.
- This leads to a size-discrimination of the analytes based on the detection signal.

Scatter plot representation

- Each detection event is plotted according to its change in amplitude and phase.
- Bigger particles (10 µm in diameter) produced higher signal change compared to smaller particles (5 µm and 3 µm), however they show the higher signal dispersion.
- This representation allows to identify clusters and data patterns.

Conclusions and Outlook

- It was possible to fabricate a platform for detection of single-particle events.
- A complex mixture containing particles of different sizes was measured and it was possible to discriminate them based on the detection signal.
- The scatter plot representation allows for a clear identification of cluster formation and data pattern analysis.
- This platform could be a powerful tool for the detection of different cell subpopulations in a highly miniaturized way [3].

Acknowledgments

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References

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