Electronic Supplementary Material (ESI) for Lab on a Chip.

Electronic Supplementary Information (ESI)

Microfluidic impedance cytometry with N-shaped electrodes for lateral position measurement of single cells/particles

Dahou Yang and Ye Ai*

Pillar of Engineering Product Development, Singapore University of Technology and Design, Singapore 487372

*Corresponding author: Ye Ai (aiye@sutd.edu.sg).

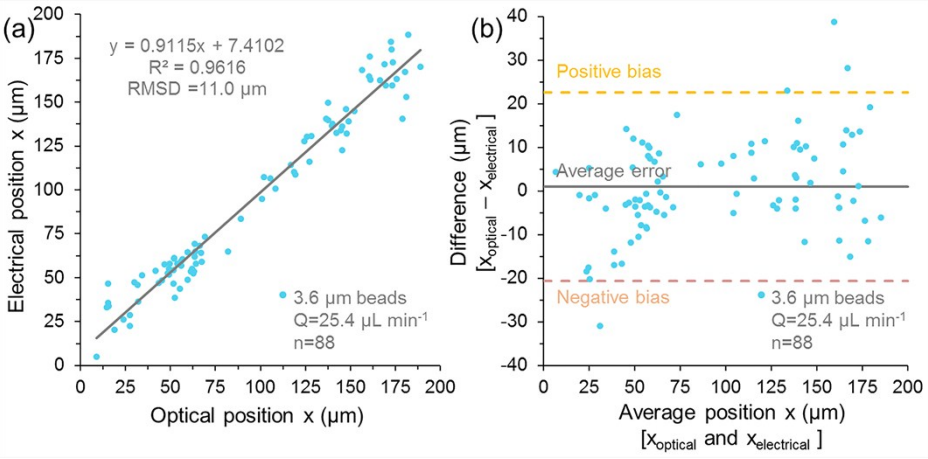


Fig. S1. Quantitative comparisons of the lateral position of 3.6 µm beads between our results and those obtained by the optical method at the flow rate of 25.4 µl min^{-1}. (a) Electrical position x versus optical position x, showing the good linear correlation of coefficient of determination: R^2> 0.96. Root-mean-square deviation (RMSD) = 11.0 µm (i.e., 5.5% of the channel width). (d) Bland-Altman analysis comparing the lateral position x obtained by the electrical method and optical method. Most values are well placed between the 95% limits of agreement, which are represented as two dotted lines in the figure.

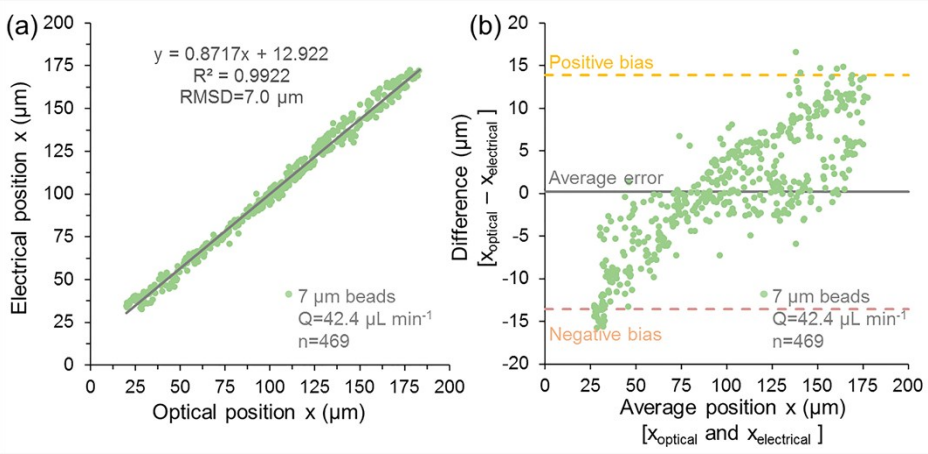
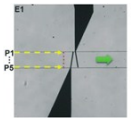
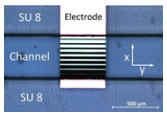
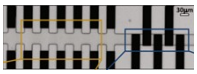
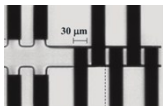
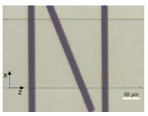


Fig. S2. Quantitative comparisons of the lateral position of 7 µm beads between our results and those obtained by the optical method at the flow rate of 42.4 µl min^{-1}. (a) Electrical position x versus optical position x, showing the good linear correlation of coefficient of determination: R^2> 0.99. Root-mean-square deviation (RMSD) = 7.0 µm (i.e., 3.5% of the channel width). (d) Bland-Altman analysis comparing the lateral position x obtained by the electrical method and optical method. Most values are well placed between the 95% limits of agreement, which are represented as two dotted lines in the figure.

Table S1. Impedance-based Techniques for the Measurement of Particle Lateral Position

	Wang et al. *Lab Chip* 2017 [Ref. 14]	**Solsona et al. *Lab Chip* 2019 [Ref. 24]**	**Reale et al. *Microfluid. Nanofluid.* 2018 [Ref. 25]**	**Reale et al. *Lab Chip* 2019 [Ref. 26]**	**Proposed**
					
Test samples	6 and 11 μm diameter beads	83 μm diameter beads	6 and 11 μm diameter beads	6 and 7 μm diameter beads Human and chicken red blood cells(RBCs)	3.6, 5, 7 and 10 μm diameter beads Human red blood cells(RBCs)
Minimum particle size tested	6 μm diameter beads	83 μm diameter	6 μm diameter	6 μm diameter	3.6 μm diameter
Channel dimensions (width × height)	188 μm × 17 μm	477 μm × 219 μm	40 μm × 21.5 μm	50 μm × 21.5 μm	200 μm × 20 μm
Measuring width (channel width)	188 μm	477 μm	40 μm	50 μm	200 μm
Working mechanism	width (i.e., transit time) and height of peaks through non-parallel electrodes	peak magnitude through a gradient in the electric field	linear estimate utilizing the ratio of transit time by five pairs of electrodes	a linear mapping used to transform the peak unbalance information to the electrical position estimates	a simple analytic expression derived from the geometry of N-shaped electrodes and resulting differential signal profile
Resolution in lateral position detection (normalized as the percentage of the channel width**)**	20% (11 μm beads, 2ul/min)	12.5% (83 μm beads, relatively low flow rate)	5.6% (6 μm beads, 10ul/min)	4.8 % (Chicken RBCs, 20ul/min) 3.8 % (7 μm beads, 20ul/min) 6.2 % (Human RBCs, 20ul/min)	3.5 % (7 μm beads, 42.4ul/min) 5.7% (Human RBCs, 42.4ul /min) 5.5% (3.6 μm beads, 25.4ul/min)
Presented data number	N.A.	<100	>2000	>2000	>2000
Throughput	Up to 400 cells/s	0.3 cells/s	50-375 cells/s	125-460 cells/s	Up to 800 cells/s
Demonstrated applications	distinguishing five lateral beads position induced by sheath flow	tracking the beads and measuring the system conductivity	monitoring the inertial focusing of beads	monitoring the sheath flows-induced beads/RBCs focusing	monitoring the sheath flows-induced beads focusing

This Table and figures except our work's are adapted from Refs. 14，24 and 26 with permission from The Royal Society of Chemistry.