

Machine Learning Classification of Microplastics by Integrating Optical and Dielectrophoresis Features

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Dielectrophoresis (DEP) and forward light scattering are integrated within a microfluidic system to classify and characterize polystyrene microspheres (PSS), which can be used to mimic microplastics and biological particles. Microplastics are one of the contributors to water supply pollution and have been known to enter the human food chain. A dual-modality approach combines differential velocity DEP with a lens-less imaging system to analyze both the optical and dielectric properties of microparticles (E. Kovacs, B. Arzhang, E. Salimi, M. Butler, G.E. Bridges, D.J. Thomson, "Light-Emitting Diode Array with Optical Linear Detector Enables High-Throughput Differential Single-Cell Dielectrophoretic Analysis," *Sensors*, vol. 24, 8071, 2024). The system, Fig. 1 (a), utilizes LED light sources to illuminate particles flowing in a microfluidic channel, while a linear CMOS array sensor captures a set of optical intensity patterns. The microfluidic channel has coplanar gold electrodes on the bottom to generate a non-uniform electric field for DEP manipulation. Particles moving through the channel experience a velocity change due to the applied DEP force. The timing of the four optical intensity patterns contains information correlated with velocity changes. Analyzing these velocity changes allows for inferring each particle's dielectric properties. Individual intensity patterns, as shown in Fig. 1 (b), arise from the interference of incident and scattered light provide data on particle size and refractive index (S. Saltsberger, I. Steinberg, and I. Gannot, "Multilayer Mie Scattering Model for Investigation of Intracellular Structural Changes in the Nucleolus and Cytoplasm," *International Journal of Optics*, vol. 2012, 2012, 947607). Different particle sizes or material compositions produce a unique interference pattern signature. A machine learning SVM model is trained using signatures from PSS samples with known sizes. This model then uses the measured interference pattern features to predict the particle sizes in a mixture of 10 μm and 15 μm diameter PSS. Classification results are shown in Fig. 1(c). Integrating DEP and optical features significantly enhances particle classification accuracy compared to using only one of the modalities.

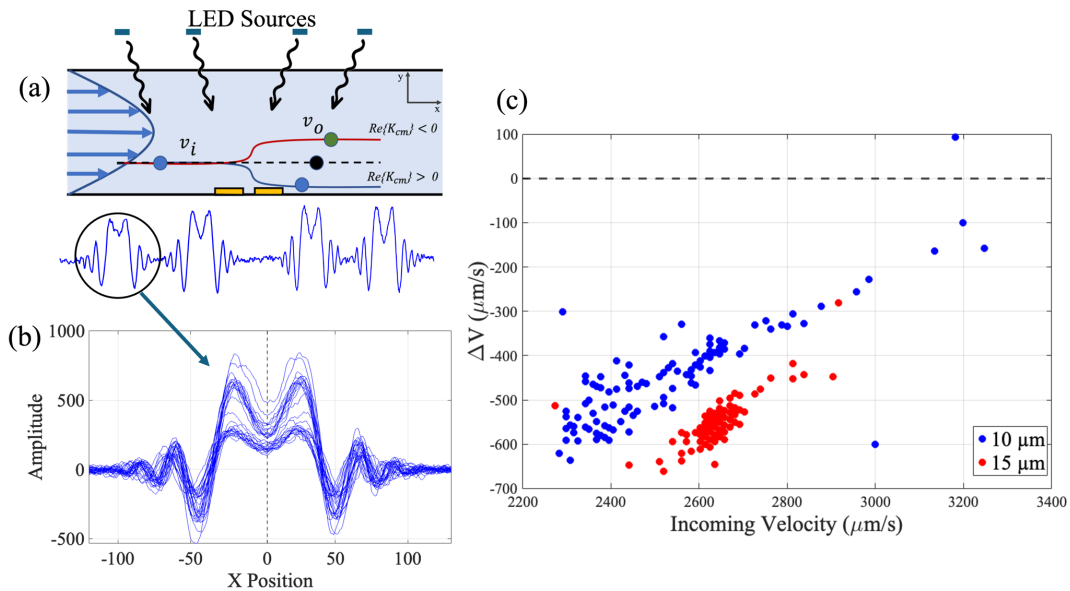


Figure 1. (a) A schematic of a lens-less imaging system showing particles in flow illuminated by four LED sources. (b) Detected interference patterns for 10 μm and 15 μm PSS. (c) Plot of differential velocity versus incoming velocity for a mixture of 10 μm and 15 μm PSS, with size classified by machine learning.