Particle analysis is an effective tool for analytical chemistry in which it is important to size and count micrometer-sized particles such as emulsions, colloids, and biological cells in large heterogeneous populations [1]. However, conventional particle analyzers based on sieving, sedimentation, Coulter counting, and dynamic light scattering fail to perform accurate statistical characterization of particles with high throughput and little chemical specificity.

Here we present a high-throughput optofluidic particle profiler that provides both morphological and chemical information of individual particles and hence can statistically characterize a heterogeneous population of particles with high accuracy and high precision. The key element of the system is optical time-stretch imaging — a method for ultrafast imaging with a single-pixel photodetector by spectrally encoding and decoding the spatial profile of the imaging target with dispersive properties of light in both spatial and temporal domains [2-4].

As shown in Fig. 1, by equipping the time-stretch optical microscope on top of an inertial-focusing microfluidic device [6], continuous high-speed imaging of flowing particles at a frame rate far beyond conventional imagers can be achieved. With an 800-nm femtosecond pulse laser as an optical source, we demonstrated a sub-micrometer spatial resolution of 780 nm within a 1D field of view of 90 μm (orthogonal to the flow direction) at a fast 1D frame rate of 75 Mfps and a high throughput of 20,000 particles/s. In addition to its ability to provide morphological information, the system is also capable of acquiring chemical characteristics of the target particles by integrating with a simultaneous multi-color fluorescence detector [6].

Our optofluidic microparticle analyzer is capable of conducting quantitative analysis for different kinds of particles in terms of shape, area, opacity, aggregation status, and fluorescence based on the high-resolution morphologic images as well as the fluorescence signals. Fig. 2 shows a library of particle images and fluorescence signals obtained by the analyzer. The analyzer can be used to identify outliers that occupy a small portion of the entire population yet hold a significant impact on the particle analysis.

References