Engineering the elasto-inertial flow dynamics in microfluidic devices

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Microfluidic technologies have attracted much attention since flow field can be precisely controlled for materail manipulation. Recently, the nonlinear flow dynamics occurring in polymer solutions have been engineered to mix flow streams or manipulate particulate materials such as micron-/submicron-sized particles. It was previously demonstrated by Steinberg and Groisman that the fluid flow can be turbulent even at very low Reynolds number, when the fluid is viscoelastic, which was also utilized to mix fluid streams. Our group demonstrated that the elasticity-driven flow instability can be further engineered for microfluidic mixing when both inertia and elasticity are relevant in microcontraction geometries. I will present the basic principles and several applications of the inertio-elastic flow instabilities. On the other hand, the lateral particle migration in polymer solutions, which is driven by the imbalanced normal stress difference in pressure-driven flow, has been also engineered for particle counting and sorting applications. The recent progress in the viscoelasticity-based microfluidics will be presented, focusing on the particle manipulation in extensional flow.