

Light Manipulation and Nanoparticle Sorting in Optofluidic Chips

This doctorate thesis focuses on the light manipulation and nanoparticle sorting using optofluidic and silicon photonic technologies. Specifically, in the study of light manipulation, the light propagation in diffusion-induced gradient index (GRIN) profiles is investigated and used as a signal for chemical sensing. Then the GRIN profile is optimized to design an optofluidic lens with improved focusing power. In the study of nanoparticle sorting, the particle motion in an optical field is studied for biomolecule separation.

Firstly, the light propagation in optofluidic waveguides is studied. It is found that light focuses periodically with an increasing focal length related to liquid properties. Theoretical models of the index profile and the light propagation are established to study the contributing factors to the light focal length. The influence of Péclet number and interface position on the light propagation is then investigated experimentally. The focal length is exploited to determine diffusion coefficient and monitor chemical reactions.

Secondly, an optofluidic hyperbolic secant (HS) lens is designed to improve the focusing power. The optimized index profile is derived based on coordinate transformation to suppress the optical aberrations. A microfluidic gradient generator is designed and fabricated to generate the ideal index profile. The focal lengths are investigated experimentally at different divergence angles and off-center positions. The focusing experiment with multiple light sources is also conducted.

Thirdly, the motion of nanoparticles in near-field lattices is studied for biomolecule separation. The optical field in different waveguide configurations is investigated using FDTD simulation. The chip fabrication, flow control, surface treatment and experimental setup are explained in detail. The force-field analysis is conducted to investigate the distinct force level and its influence on the particle trajectories. In the particle separation experiment, the 500-nm polystyrene particles are successfully separated out from the 200-nm, 300-nm and 500-nm particle mixtures. In the bacteria trapping and alignment experiment, the parallel trapping and alignment of *Shigella* are performed.

In conclusion, the unique light behavior in optofluidic waveguides is investigated and used for chemical sensing. Then an optofluidic HS lens is developed to improve the focusing power. Finally, nanoparticle sorting using near-field optics is studied theoretically and experimentally.