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Author(s)	Chin, Lip Ket; Shi, Yu Zhi; Zhao, H. T.; Liu, Patricia Yang; Yap, Peng Huat; Wang, K.; Wang, Gang; Liedberg, Bo Gunnar; Ser, Wee; Liu, Ai Qun
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Optofluidics: Guiding the Nanoparticles and Biomolecules with Light

L.K. Chin[1], Y.Z. Shi[1], H.T. Zhao[1], Patricia Y. Liu[1], P.H. Yap[2], K. Wang[3], G. Wang[1], B. Liedberg[4], W. Ser[1], and A.Q. Liu[1]

[1] School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798
[2] Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore 639798
[3] Institute of Biological Chemistry, Academia Sinica, Taipei 115, Taiwan
[4] School of Materials Science and Engineering, Nanyang Technological University, Singapore 639798

Abstract— **Optofluidics has recently gained huge research attentions because of its synergic manipulations of light and liquids. Several optofluidic components and devices have been demonstrated in the last 10 years, leading to its applications in guiding nanoparticles and biomolecules in the microchannel.**

Keywords— **Optofluidics, nanoparticle manipulation, micro/nanofluidics and nanophotonics.**

I. Introduction

Microfluidics represent the science and technology that process or manipulate small amount of fluids (10^{-9} to 10^{-18} liters) with dimensions of tens-to-hundreds of micrometers in microfluidic chip. Optofluidics aims to manipulate light and liquids at microscale, exploiting their interaction to create highly versatile devices that is significant scientifically and interests in biological and biomedical research areas. The novelties of the optofluidics are twofold [1]. First, liquids are used to carry substances to be analyzed in highly sensitive optical microdevices. Second, liquids is exploited to control optical microdevices, making them tunable, reconfigurable and adaptive. It is a new breakthrough research area that provides new opportunities for a wide range of traditional photonic devices, allowing tuning and reconfiguration at the micrometer scale using microfluidic manipulation.

II. Nanoparticle and biomolecule guiding

Many novel innovations have been demonstrated, such as liquid-liquid waveguide [2], liquid lens [3-4], liquid gratings [5-7] and liquid prism [8] etc. Light propagation can be tuned by varying the refractive index contrast or the curvature of the interface. These components are operated in a fast flow rate or two-phase flow conditions whereby diffusion is insignificant. Several devices have been demonstrated such as microfluidic waveguide laser [9], evanescent wave sensor [10] and cell refractometers [11-13].

Recently, diffusion between liquids in a microchannel is exploited for light manipulation. Diffusion within the liquid flow streams in the microchannel is studied to design different photonic components. When two or more miscible liquids are flowing in a microchannel, diffusion between the flow streams occur and a bidirectional gradient index profile (concentration and refractive index) is formed. We have demonstrated how lightwave can be bent in a bidirectional gradient index profile in the liquid waveguide, which supports novel wave-focusing and interference phenomena [14]. In addition, using the same approach with different bidirectional gradient index profile in the microchannel, an optofluidic Y-branch splitter with large-angle bending and tuning is demonstrated [15].

The manipulation and sorting of a small size of particle/molecule with dimensions of tens to hundreds of nanometers in a microfluidic chip is one of the most significant research approaches. In this talk, light is shaped efficiently to generate distinctive interference patterns in the optofluidic chip, which can be used to sort and assemble biological samples. For example, the optical field can be switched from the Bessel profile for particle sorting to the discrete interference patterns for particle assembly.

III. Conclusions

In conclusion, optofluidics is a perfect candidate for nanoparticle and biomolecule guiding because it is capable of not only manipulate liquid mixing and diffusion, but also shaping light propagation and optical force in the microchannel. It has high potential applications for nanomedicine, virus disease diagnosis and biomolecule studies.

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Author: Ai-Qun Liu
Institute: Nanyang Technological University
Street: 60 Nanyang Avenue
City: Singapore
Country: Singapore
Email: eaqliu@ntu.edu.sg