Optofluidic Applications of Plasmonic Heating

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Experimental setup of optofluidic guiding

Optofluidic control by using Au-NIS

- The focused light illumination on the Au-NIS
- The vapour in the relatively cold air condenses into droplets in front of the liquid–air interface.
- The droplets coalesce with the original bulk liquid body and the liquid–air interface advances.

Maximal flow speed comparison

Three factors

- Laser power
- Surface wettability and extinction peak
- Channel width

Maximum flow speed ~1600 μm/s

Fig. 1 (a) At 100 °C annealing substrate (b) In the 80 μm wide channel (c) Two laser lines

Optofluidic valve actuated with laser irradiation

The basic mechanism of this valve can be explained by Fig. 2 (a), the water being gated at the abrupt expanding region satisfy the following condition:

\[ P_w \leq P_c = 4γ_{at} \sin θ_c/D_h \]

where \( P_w \) is the water pressure, \( P_c \) is the critical burst pressure, \( γ_{at} \) is the surface energy per unit area of the liquid–air interface, \( θ_c \) is the equilibrium contact angle, and \( D_h \) is the hydraulic diameter. And the hydraulic diameter of a rectangular channel is: \( D_h = 2wh/(w + h) \)

The hydraulic diameter, \( D_h \), is a commonly used term when handling flow in noncircular tubes and channels.

Fig. 2 (a) Schematic of valving operation driven by 785nm laser. (b) Temporal sequence of a 300 μm wide microfluidic valve (c) Valve opening time versus laser power for different valve.

Optofluidic mixing

- Tracer polystyrene beads suspended in water
- Bubble generated in 0.5s
- Reduce power to sustain stable convective flow
- Laser turned off

Former used Tracer polystyrene beads

The scale bar is 40μm

Conclusion: The presented optofluidic system has made several important advances in different aspects:

- No extra functional materials are added to the sample solution, thus, avoid sample contamination;
- A wider flow guiding speed is achieved (from 0μm/s to 1600 μm/s) while with less power consumption, and the plasmonic assisted microfluidic valving is implemented for the first time;
- A position-free mixing strategy is achieved, which means we can stir the sample solution at any point of interest. This system can be an independent component to do all optical bio-sensing, and it also can be integrated to LOAD platform to improve the performance when implementing biochemical experiment.

Acknowledgement: AoE# AoE/P-02/12; CRF# CUHK/CRF/12G; GRF# 2150771