

Femtosecond Laser-induced Jet Flow for Particles Manipulation in Microfluidic Chip with Assistance of Micro-Structure

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Cell sorting is an important technique for single-cell research. Especially, micro-chip cell sorting has recently attracted attention for its potential of high-speed manipulation efficiency [1,2]. Now, we have developed a new cell sorting system combining a femtosecond laser (fs-laser) with a microfluidic chip. When an intense fs-laser is focused into liquid, an explosive evaporation of the aqueous solutions at the laser focal point induces a jet flow, which is utilized as an external force for manipulation. Herein, we proposed to modify this jet flow by making a micro-structure. In this work, we studied on fluid dynamics at micro-structure in the chip channel, and applied this to our new sorting system.

A glass-made microfluidic chip was fabricated by a conventional photo lithography and wet etching method. The microchip was set on an upright microscope, into which laser pulses from an Ytterbium femtosecond-laser amplifier (1040 nm, 400 fs, 1 MHz, <8 μ J/pulse) were introduced through a 40x water-immersed objective lens (NA. 0.8). Micro-particles as a phantom of cell were loaded into the channel. The particle motion before and after the femtosecond laser irradiation was recorded by high-speed imaging.

As shown in Fig. 1, we prepared a channel with a valley-shaped micro-structure. When the laser was focused at the inside of the valley, the bubble shape was drastically deformed by the valley structure, though the bubble shape is spherical in free-area. The bubble shape was evaluated with ratio (H/W) of the bubble height (H) to the width (W), and confirmed to have a dependence on the valley shape (Fig. 2). The result implied that directionality of the laser-induced impulsive force could be controllable in assistance of micro-structure. We will investigate further controllability of direction and intensity of the impulsive force with several kinds of micro-structures to induce jet flow for high-speed manipulation.

Reference

- [1] H. Amini and D. D. Carlo, Anal. Bioanal. Chem. 397:3249–3267 (2010)
- [2] A. deMello and G. V. Kaigala, Chem. Rev. 118, 2042–2079 (2018)

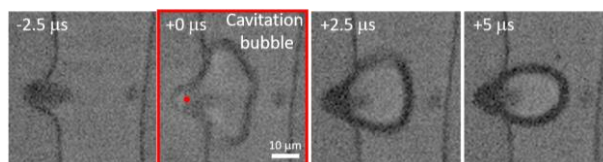


Fig. 1. Time-lapse high-speed images of cavitation bubble formation process near the micro-structure. Red spot: laser focal point.

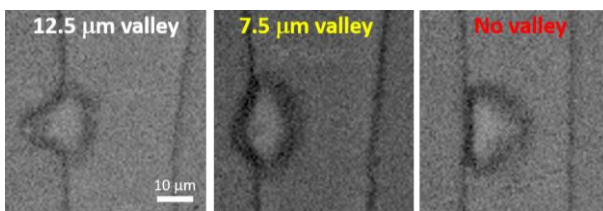


Fig. 2. Morphology of Cavitation bubble with and without assistance of micro-structure.