Marangoni Flow in Microfluidics Controlled by Laser Heating of Gold Nanoisland Films

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Gold nanoparticles absorb light efficiently at their resonant frequency and convert it to heat within several picoseconds. Strong laser irradiation onto those gold nanoparticles enables us to heat the surrounding materials locally and rapidly, which has been reported to be useful for cancer therapy, ultrasonic generation, microfluidic control, and so on. Because the gold nanoparticles can also act as sensing platforms for such as Raman spectroscopy under laser irradiation, development of the microfluidic control method with laser heating of gold nanoparticles is desirable to meet the requirements in lab-on-a-chip devices. Here, we present microfluidic manipulation techniques based on Marangoni effect controlled by laser heating of gold nanoisland films and our most recent outcomes.

By focusing a CW laser (wavelength: 785 nm) onto the gold nanoisland film immersed in water, a microbubble is generated at the laser spot. Because of the highly localized heat generation at the laser spot on the gold nanoisland film, the surface of the microbubble is exposed to steep temperature gradient. This results in generation of rapid Marangoni flows, which are induced by surface tension gradient on the gas-liquid surface with temperature gradient. Depending on the relative laser spot position against the microbubble, the flow pattern shows significant change and realizes particle sorting by their size or particle focusing (Fig. 1(a, b)). Furthermore, rapid and large temperature increase of more than several hundreds of Kelvin around the laser spot enables us to stabilize water vapor microbubble in degassed water and to generate significantly rapid Marangoni flow (Fig. 1(c)). The flow speed exceeds 1 m/s, which might be useful for microfluidic mixing.

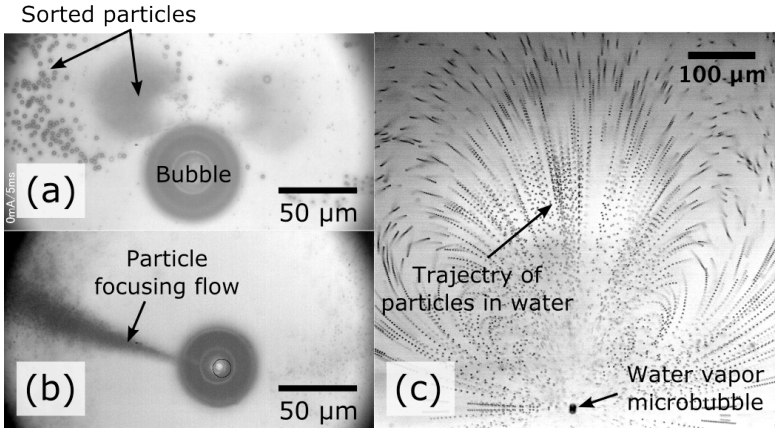

図 1: (a) Particle sorting [1], (b) particle focusing [2], and (c) microfluidic mixing [3] demonstrated on gold nanoisland films by laser irradiation.

[1] K. Namura, et al., *Appl. Phys. Lett.* **106**, 043101 (2015).

[2] K. Namura, et al., *Appl. Phys. Lett.* **108**, 071603 (2016).

[3] K. Namura, et al., *Sci. Rep.* **7**, 45776 (2017).