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Two photon polymerization integration of microlens arrays into 3D glass microchannel for cell counting

Dong Wu, Koji Sugioka, Katsumi Midorikawa

E-mail: ksugioka@riken.jp

In the past few years, optofluidic devices realized by integrating photonics with microfluidics have attracted great attentions because of their potential applications in manipulation, sensing, imaging, detection of biomaterials and so on [1]. For example, 3D photonic crystals have been fabricated by laser interference lithography on 2D open channels for refractive index sensing [2]. However, until now, there are few reports on the integration of 3D designable optical devices with high precision, in particular, no reports in the 3D embedded microchips. In this work, we proposed two photon polymerization (TPP) to integrate a typical optical device — refractive microlens and its arrays into 3D embedded microchannels which were realized by femtosecond (fs) laser assisted etching of glass (FLAE). The second harmonic (522 nm) from commercial fs laser (FCPA μJewel D-400, IMRA America; wavelength: 1045 nm; pulse width: 360 fs; repetition rate: 200 kHz) was used for both TPP and FLAE microfabrication. The height and radius of polymer microlens were 10 μm and 20 μm, respectively. In liquid environment (ethanol), the lens exhibited sharp focusing with a focal spot size of 2.9 μm and clear imaging of different letters “RIKEN”. Then, the 3D microchips integrated with an array of 7 microlenses were applied to biological cell counting which is highly desirable for biological researches. A bright focal spot can be produced by the microlens under white light incidence while the intensity at the focal spot is significantly affected when the cell passes through above the microlens. The success rate in cell detection as high as 93% was achieved. This method is simple because it does not require a complex and precise fiber coupling system.

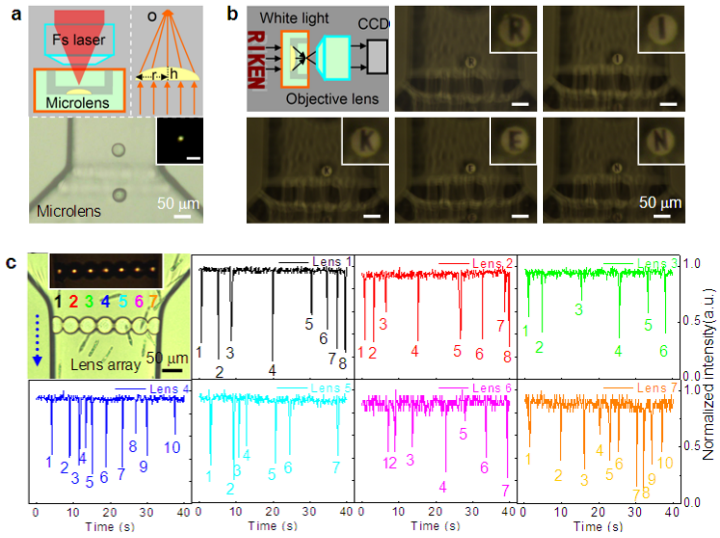

Figure 1. 3D integrated optofluidic devices for coupling-free white-light cell counting. (**a**) Schematic image of 3D optofluidic chip integrated with polymer microlens. (**b**) Characterization system and the imaging (**c**) An array of seven lenses for cell counting.

[1] K. Sugioka, *et al.*, *Lab Chip*, **12**, 3576 (2012). [2] S. Lee, *et al.*, *Lab Chip*, **8**, 388 (2008).