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High-quality metal patterning in glass microfluidic structures using water-assisted femtosecond laser direct-write ablation followed by electroless plating

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Integration of microelectric components into microfluidic chips is able to perform localized control of temperature, on-chip manipulation of biological samples, etc. To realize such integration, conventional metal patterning techniques such as metal deposition combined with planar photolithography processes are usually employed during the fabrication procedure of such integrated systems. The flexibilities of above-mentioned techniques are low due to their complexity arising from the multi-step procedure. Recently, we reported that space-selective metallization of the inside of glass microfluidic structures could be realized using femtosecond (fs) laser direct-write ablation followed by electroless plating [1]. In this paper, we demonstrate that the introduction of water during fs laser volume-writing irradiation can significantly improve the quality of sidewall metal patterning in microfluidic structures due to efficient removal of debris from the ablated regions. Figure 1a and 1b show the ablated patterns on sidewall surface using the laser volume-writing scheme in air and water, clearly indicating that the water plays an important role for high-quality ablation. Figure 1c exhibits that the water-assisted laser ablated regions of sidewall can be metalized by electroless plating with higher quality as compared with that by laser ablation in air. As applications of the developed technique, various microelectrode patterns generating different kinds of electrical fields in microchannels such as homogenous, inhomogeneous and three-dimensional electrical fields are designed and constructed for on-chip manipulation of aquatic microorganisms.

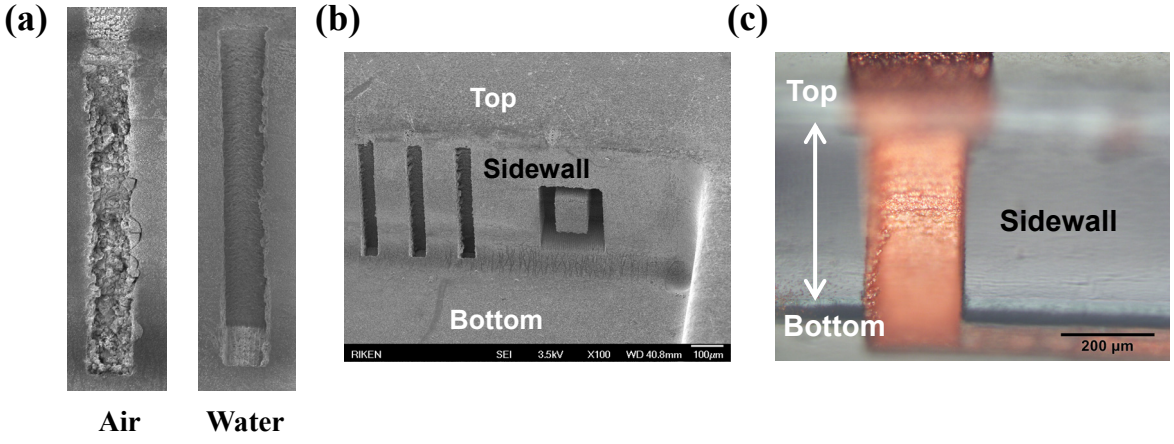

Figure 1. (a) 45º titled SEM images of ablated strip (width: 50 μm) on sidewall (height: 500 μm) surface ablated in air and water using the same volume-writing scheme (pulse energy of 3 μJ). (b) 45º titled SEM image of ablated patterns on sidewall surface ablated in water (pulse energy of 2.5 μJ). (c) 45º titled optical microscope image of a metal line formed on the sidewall surface ablated in water after electroless plating.

[1] J. Xu, *et al.*, Lab Chip **13**, 4608-4616 (2013).