INKJET-PRINTED VERSATILE MICROFLUIDIC SYSTEMS

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In this study, methods for fabrication of functionalized microfluidic systems using inkjet printing are presented. By surface modifications and inkjet printing, we have successfully fabricated microfluidic devices with microchannels, electrodes and droplet dispersion components. Owing to the desirable features of inkjet printing such as direct additive manufacturing, the methods presented in this paper are fast and easy to use in comparison with conventional fabrication methods.

To fabricate PDMS-based microfluidic channels, here we use a special surface modification, the superhydrophobic coating, to enhance the water-repelling property of the substrate and allow direct inkjet patterning. In this practice, The PDMS is first superhydrophobically coated using a commercially available spray. Then the pigment ink is printed and dried to form durable hydrophilic pattern for liquid template attachment. Through dispensing aqueous liquid on the substrate, liquid templates are self-shaped on the hydrophilic symbols. Finally, by molding on the liquid template, enclosed PDMS microchannels can be obtained directly. Besides the advantages such as rapidness and inexpensiveness, such technique is capable of layer-by-layer fabrication, enabling multilayer fabrication of microfluidic structures without manual alignment and bonding.

Apart from the microfluidic channels, inkjet printing is also capable of fabricating electrodes inside microchannels directly while conventional methods are not. For microelectrode patterning on PDMS substrate, a chemical reagent as the wettability and adhesion promoter was employed. (3-Mercaptopropyl) trimethoxysilane (MPTMS), a coupling agent of noble metal to Si-based materials, was used to modify the PDMS. The surface modification improves the surface wettability of PDMS, which decreases the evaporation time of the silver droplet solvent and effectively avoids the coalescence of adjacent droplets. Besides, the modification also provides a tight bonding between the silver patterns and PDMS. The resulting printed silver patterns exhibited good compactness, conductivity and excellent adhesion to PDMS. The work here was used to fabricate a three-electrode electrochemical sensor on PDMS successfully and the sensor was sealed in the microchannel of a microfluidic system, forming an integrated lab-on-a-chip biosensing system.

Beside aforementioned methods of constructing microfluidic components, we have also succeeded in fabricating droplet dispersion devices using inkjet printing. Similar to the liquid-template method of the microchannel fabrication, superhydrophobic substrate and hydrophilic inks were employed for Rayleigh instability induced droplet dispersion. Compared with previously reported droplet generation devices, the method proposed in this work is capable of pre-depositing reagents at the site of each droplet, and is able to trigger specific reactions such as recombinase polymerase amplification (RPA), leading to a simpler solution to controlled reactions. Meanwhile, this device no longer requires complicated droplet-generating structures and cumbersome peripheral devices, which makes it a perfect candidate for point-of-care testing (POCT)

In conclusion, we have fabricated multiple microfluidic devices with inkjet printing technique. The fabrication for a fully inkjet-printed functionalized microfluidic system is still ongoing and the results will be presented on the conference.

Word Count: 489

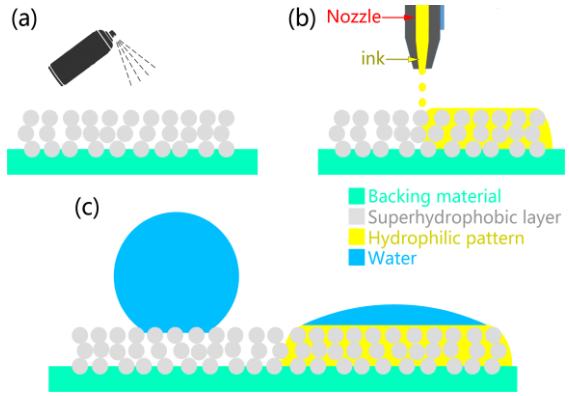

Fig. 1 schematic illustration of the superhydrophobic and hydrophilic modification of the substrate.

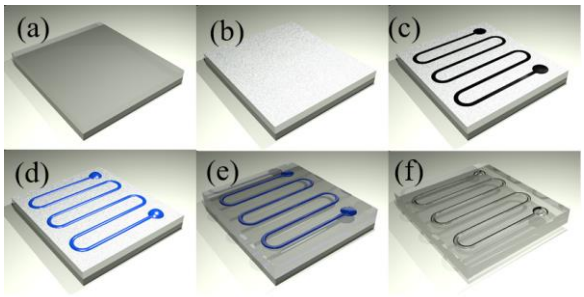

Fig. 2 Fabrication steps for a single-layered microchannel. (a) preparation of PDMS on a supporting substrate. (b) Step 1: spray coating of superhydrophobic layer. (c)Step 2: inkjet printing of hydrophilic patterns. (d) Step 3: liquid template dispensing. (e) Step 4: Liquid PDMS molding. (f) channel releasing by extracting liquid template.

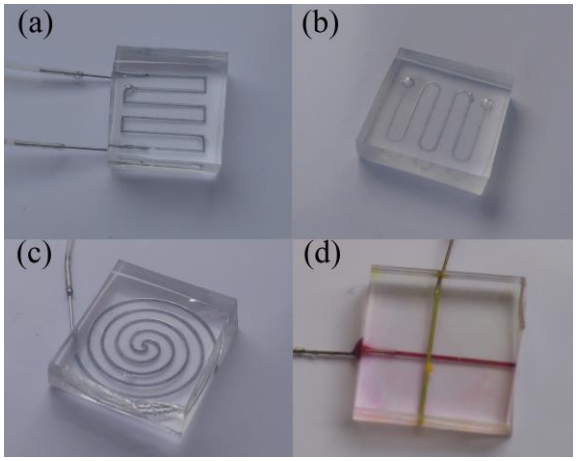

Fig. 3 Photograph of fabricated microchannels.

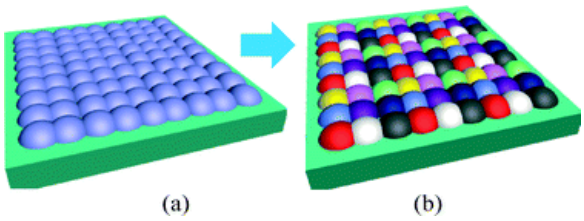

Fig. 4 multilevel matrix deposition (MMD) method to overcome the coalescence of adjacent droplets.

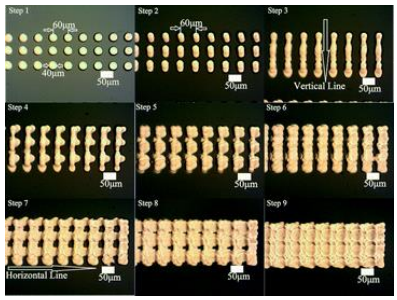

Fig. 5 MMD method printed silver patterns on MPTMS-modified PDMS illustrating the nine-step process (scale bar, 50 μm).

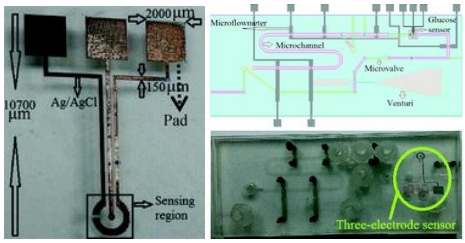

Fig. 6 Optical images of a three-electrode electrochemical sensor on PDMS chip after silver chloride (black) formation.

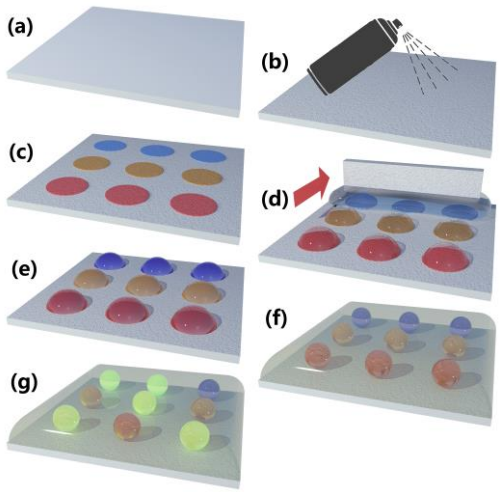

Figure 4: Fabrication and use of the device. (a) Preparation of the substrate. (b) Spray coating of the superhydrophobic layer. (c) Printing of hydrophilic symbols with premixed reagents. (d) droplets Dispersion. (e) Reagents releasing from the ink. (f) Droplets encapsulated in oil phase. (g) After incubation, the results can be directly read out through luminescence or other products.

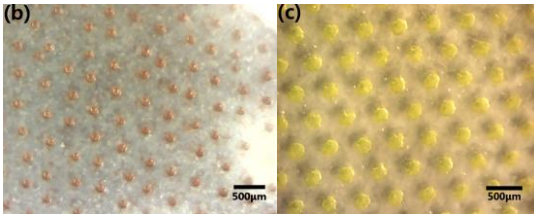

Fig. 8 Microscopic images of encapsulated droplet arrays on devices patterned with soluble ink (magenta) and insoluble ink (yellow).