International Workshop on the Fabrication and Application of Microstructured Optical Devices,
Keio Univ., Yokohama, Japan, Feb. 27-28, 2014

Laser-based printing and patterning for biological applications

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Abstract: *We present the use of pulsed lasers as patterning and printing tools for the end applications of micro-contact printing and paper-based fluidics. A fs-laser was used with a digital multi-mirror device (DMD) to structure a mould via ablation or photo-polymerisation. The patterns in this mould were then cast into polydimethlysiloxane (PDMS)-mould which was used for micro-contact printing. With the end-goal of producing a microfluidic diagnostic sensor on paper, a ns-laser was used for laser-induced forward transfer (LIFT) of proteins onto a paper substrate, whose viability was validated by a colorimetric detection assay.*

1. Introduction

Laser direct-write methodologies are highly flexible, non-contact and serial pattern generation procedures that allow a user to create patterns either on the surface or in the volume of a material of choice through point-by-point scanning of the laser beam across the material work-piece. Pattern generation can be through either addition or subtraction of the material or through modifications to its physical properties, and the scale lengths typically range from nm-mm. Here we show the usefulness and versatility of such laser-based approaches for two different applications, namely micro-contact printing and paper-based fluidics for medical diagnostics.

2. Laser-based patterning

A range of methods have been explored for creating patterns in PDMS – a material, widely used in micro-contact printing [1]. Cleanroom-based UV-lithography is one of the methods of choice for patterning PDMS, and is used to first create patterns in a master-mould, which are then duplicated by casting PDMS on it to produce a secondary PDMS-mould. We here present a rapid and flexible alternative – a mask-less, laser-based direct-write procedure that and can be used to fabricate differently shaped patterns in a single laser-pulse. Using a step-and-repeat procedure it was then possible to stitch together a 2D array of patterns over a larger area of several cm^2. This method uses a DMD as an intensity spatial light modulator to create the user-defined light pattern needed for structuring. A Ti:sapphire ultrafast amplifier (800nm, 150fs, 1kHz, and ~2mJ/pulse) was used in conjunction with the programmable DMD (Texas Instruments, DLP-3000, 608 x 684 mirror-array) to pattern a master-mould either by laser-ablation (subtractive) or multi-photon polymerization (material modification). 2D surface-relief structures created in the master-mould (Fig. 1a) were then cast to create a PDMS-mould (Fig. 1b).

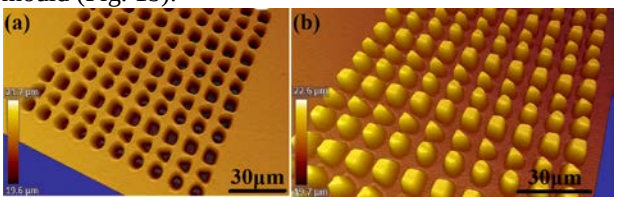

Fig. 1. Images of (a) ablated master, and (b) PDMS-mould.

3. Laser-based printing

Use of paper as a platform to build low-cost diagnostic devices was proposed by the Whitesides group [2], and since then, its use for developing such devices has been well-documented. With the end-goal of developing low-cost colorimetric point-of-care diagnostic sensors on paper, we report our results on LIFT-printing of antibodies, both untagged and conjugated with the enzyme horseradish peroxidase (HRP). LIFT is an additive direct-write technique used commonly for depositing materials from a thin donor film onto a receiver substrate. The donor (a glycerol film containing the antibodies) is pre-deposited onto a carrier (a fused silica substrate) that is transparent to the incident laser light, and photons from the laser (KrF-excimer, 248nm, 1Hz, 10 ns, and maximum energy ~400mJ/pulse) provide the driving force that transfers a small volume of the donor onto the accepting receiver (paper). The viability of the untagged (target) antibodies post-transfer was validated by an indirect colorimetric Enzyme Linked Immunosorbent Assay. HRP-tagged antibody attaches specifically to the LIFT-printed target antibody and on addition of the corresponding chromogenic substrate, the printed pixels turn blue (Fig.2).

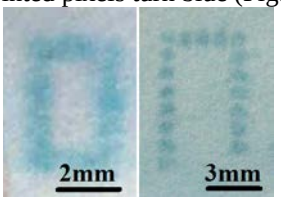

Fig. 2. Images of LIFT-printed mouse IgG after an ELISA test.

Acknowledgement

The authors thank the EPRSC, UK for funding via grants EP/J008052/1 and EP/K023454/1.

References

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