Femtosecond laser-induced patterned transfer of intact semiconductor and polymer thin films via a digital micromirror device

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The laser-induced forward transfer (LIFT) of thin films is an attractive technique to deposit materials on a size scale that can span nanometres to millimeters. During LIFT, the energy of a laser pulse is absorbed in a small volume of a thin film (*donor*) causing an explosive expansion which is used to propel a portion of the donor away from the *carrier* substrate and transfer it onto a *receiver* substrate as shown in Fig.1(a). Ultrashort laser systems can limit laser damage to remaining areas of the donor usually present using laser systems with longer (nanosecond) pulse widths.

Recently, the use of digital micromirror (DMD) spatial light modulators to dynamically project a specific object mask for printing paste-like and solid materials has increased the versatility and speed of laser-induced transfer for direct-write applications[1,2].

Here, we have extended the DMD-based laser transfer to the laser-induced backward transfer (LIBT)[3] of solid polymer donors. In LIBT, the transparent receiver is situated in the beam path to allow for the donor-side illumination of the donor-carrier sandwich as depicted in Fig.1(b). For such transparent donors, the laser energy is absorbed in a small volume at the carrier surface and causes a transfer in the opposite direction to that of the incident laser pulse.

In this parametric study, we have compared LIFT and LIBT of polymers and semiconductors in terms of repeatability, resolution, accuracy and creation of debris as shown in Fig.1(a) and Fig.1(b). For all these experiments, we used pulses with 150fs duration, 800nm central wavelength and maximum pulse energy of 1mJ, which were homogenised and directed onto a DMD acting as a dynamic image mask. The receivers were polymer-coated glass substrates and were in contact with the donors consisting of ~1µm thick films of silicon, bismuth telluride, poly (methyl methacrylate) and S1813 resist coated onto glass or silicon carriers in the case of LIBT. We have successfully transferred intact deposits from the polymer donors while the inorganic semiconductors resulted in confined, but fractured deposited features.

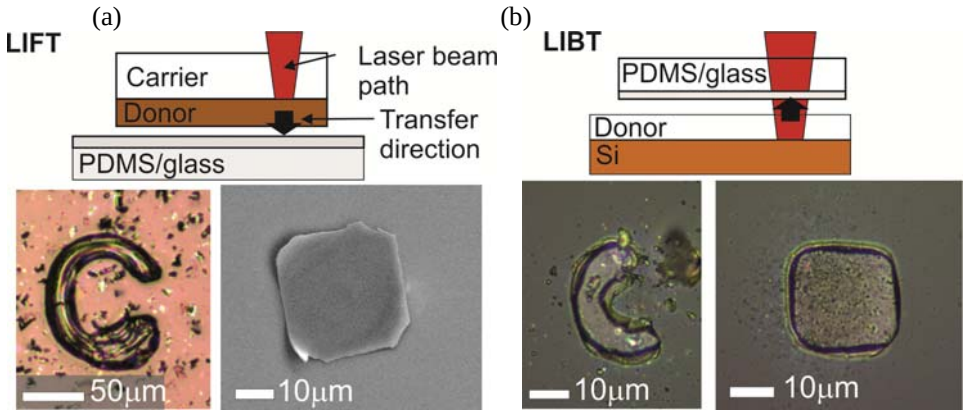

Figure 1: Experimental schematic and images of resulting deposits on receiver for (a) LIFT and (b) LIBT configurations.

In conclusion, we have demonstrated LIBT as an extension to DMD-assisted LIFT permitting the intact transfer of transparent polymeric donors films onto polymer substrates whilst minimizing the amount of debris. We believe that the LIBT of such polymers can be used in the area of additive manufacturing which may include optical structures such as waveguides.

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3) P. Papakonstantinou, N. Vainos, C. Fotakis, Microfabrication by UV femtosecond laser ablation of Pt, Cr and indium oxide thin films, Appl. Surf. Sci., **151**(3–4), 159–170 (1999).