Femtosecond Laser Induced Forward Transfer for the Deposition of Nanoscale, Transparent, and Solid-Phase Materials

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The Laser-Induced Forward Transfer (LIFT) technique [1] exists as a simple method for the direct-writing of a wide range of materials with sub-micron to 100s of microns feature sizes. A thin film of the material to be deposited (the *donor*) is coated onto one face of a transparent *carrier* substrate and transferred to another substrate (the *receiver*) placed some microns away by irradiating the carrier-donor interface through the carrier with a CW or pulsed laser. The process is inherently thermal in nature, with melting and ablation of the donor required to provide the necessary thrust for transferring material. Hence, the technique is not readily applied to the deposition of thermo-sensitive materials.

A number of closely-related forward transfer techniques of varying complexity have been developed that eliminate the need to directly irradiate the donor material, each with associated advantages and limitations. However, one very simple way to reduce thermal effects in the donor that has received relatively little attention in the literature is to use ultrashort pulses. The extremely high intensities available with sub-picosecond duration pulses allow for transfer with low pulse energies, thus limiting any thermal damage to the donor material [2]. Furthermore, direct transfer of films transparent to the laser wavelength is also possible with such laser sources by utilising multi-photon absorption in the donor or in a sacrificial protective layer [3].

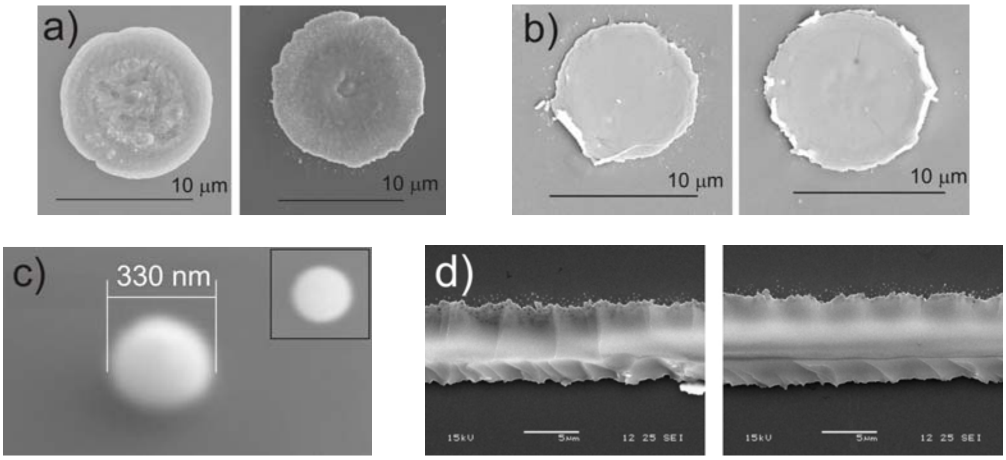

Figure 1. SEM micrographs of various key results obtained using femtosecond pulses for LIFT. Solid phase Cr transferred using multiple spatially-shaped pulses (a); transparent GdGaO transferred using multi-photon absorption in a sacrificial protective layer (b); nanoscale transfer of Cr droplets (c); silica lines deposited using forward transfer by non-thermal cracking (d).

Here we discuss the LIFT process with femtosecond duration pulses and identify areas where this process may complement the capabilities of what is rapidly developing into a highly versatile family of forward transfer microfabrication techniques. Results covering solid-phase transfer without a sacrificial layer (fig. 1(a) [2]), the transfer of transparent films (fig. 1(b) [3]), and the smallest known features obtained by LIFT (~300 nm fig. 1(c) [4]) are presented, amongst others. We will also demonstrate the transfer of material by laser-induced cracking rather than phase changes for a truly non-thermal LIFT process (d).

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