Laser microprinting of liquids

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Laser-induced forward transfer (LIFT) is probably the most extended laser printing technique. It allows printing a broad range of materials with a high degree of accuracy and spatial resolution. In the case of the LIFT of liquids, a laser beam is focused and absorbed at the interface between a transparent substrate and a thin film of a solution containing the donor material which is going to be deposited on the receptor substrate. The LIFT of liquids faces, however, an intrinsic drawback related to the preparation of the liquid donor material in thin-film form, being rather difficult to obtain uniform, thickness-controlled and stable liquid films; this drawback appears to be especially critical when large areas or very high resolutions are involved.

The laser printing of materials in a film-free way is, however, possible in the case of transparent and weakly absorbing solutions. The principle of operation of the technique relies on the highly localized absorption of strongly focused ultrashort laser pulses in the close proximity of the free surface of the liquid contained in a reservoir. This results in the generation of a bubble underneath that free surface. Once generated, the bubble expands, displacing the liquid around it. Then, a fraction of the liquid is propelled away, and collected onto a substrate. Provided that both the depth of the bubble and its pressure are the adequate ones, the expelled material is deposited on the substrate in the form of a well-defined droplet. For this to occur, both the laser pulse energy and focusing depth should be properly adjusted in order to allow liquid transfer devoid of splashing.

The feasibility of the technique has already been tested through printing microdroplets with high resolution and reproducibility, and it has also been proved that it is possible to print sensitive materials without harm in that way. However, a deep understanding of the liquid transfer process is still lacking. To this end, liquid ejection is analyzed through time-resolved imaging, a characterization technique which should help determine the mechanisms responsible for microdroplets deposition. The obtained results reveal that printing proceeds through a complex dynamics which allows explaining the main features observed in the deposits. The printing mechanism is mediated by the formation of high aspect-ratio liquid jets which dynamics is governed by the bubble generated by the laser pulse.