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# OPTIMIZATION OF THE LASER-INDUCED FORWARD TRANSFER PROCESS FOR THE PRINTING OF LIVING CELLS

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Printing techniques applied to biology have begun to develop since the 2000s and hold great promise in a near future. They are based on interdisciplinary approaches and use a combination of cells, chemistry, engineering and sophisticated protocols to create artificial tissues.

In that scope, it has been more than a decade since Laser-Induced Forward Transfer (LIFT) is studied in lab scale for its ability to print biomaterials and more specifically living cells [1], [2]. This method uses a short laser pulse to transfer tiny amounts of material from a thin film donor to a receptor substrate. Under appropriate conditions, the pulse induces the formation of a jet propagating perpendicularly to the donor substrate. The targeted material is then deposited as a droplet on the collector. It is a nozzle free printing technique, and it is considered as a suitable method to print three dimensional cellular structures with a very high spatial resolution. Combined with stem cells technology this innovative printing process opens new perspectives for the creation of complex bio-models strongly mimicking the *in-vivo* environment with numerous applications ranging from regenerative medicine to pharmaceutic study and drugs screening. However, the optimization of its performance and its use with living cells require a deep understanding of the ejection dynamic depending on several laser parameters (laser fluence, repetition rate, laser spot size, laser wavelength, pulse duration, absorption mechanism...) and of the effects of living cells on the bio-ink printability. At LP3 (Marseille-France) and in close collaboration with MMG (Marseille-France), we took advantages of our expertise in LIFT process [3] to master the printing by LIFT of living cells in good condition (high spatial resolution, high printing resolution and high cellular viability after printing).

Here, we will present the LIFT process and its optimization allowing to master the bio-ink deposition in order to create reliable ordered patterns of bio-ink micro-droplets containing stem cells with a high spatial resolution. By changing the film concentration in cells and the laser pulse energy, we can control the droplet size and the number of cells in each droplet (from tens of cells down to the single cell level). Then, we will present a viability study of the printed cells after transfer to prove the ability of this process to create relevant bio-models.

[1] J. A. Barron, et al. , « Biological laser printing of three dimensional cellular structures », *Appl. Phys. A*, vol. 79, n° 4-6, p. 1027-1030, sept. 2004.

[2] M. Duocastella et al., « Study of the laser-induced forward transfer of liquids for laser bioprinting », *Appl. Surf. Sci.*, vol. 253, n° 19, p. 7855-7859, juill. 2007.

[3] P. Delaporte et A.P. Alloncle, «Laser-induced forward transfer: A high resolution additive manufacturing technology », *Opt. Laser Technol.*, vol. 78, p. 33-41, avr. 2016.