COMSOL® Simulation of Blister Actuated Laser Induced Forward Transfer (Ba-LIFT)

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Abstract

Laser-induced forward transfer (LIFT) is a non-contact direct-write technique that enables the deposition of small volumes of material into user-defined high-resolution patterns with a wide range of structural and functional materials. There are many variations of the LIFT process, each differing in how the laser is absorbed and converted into the mechanical energy required for material ejection in order to print a broader range of functional materials without modification.

In the Blister-actuated LIFT (BaLIFT), the laser pulse energy is absorbed in a thin polymer film, generating a sealed vapour which deforms the polymer film and forms a blister. This blister drives the flow of the surround fluid, transferring the fluid free of damage.

The model is implemented in the CFD Module from COMSOL Multiphysics®. The BaLIFT model is built upon the Laminar Two-Phase Flow, Level Set physics interface. In which one of the fluids is the air and the other the fluid that is to be transferred. The blister movement is included in the simulation through the moving wall boundary condition. The components of the velocity of the moving wall are specified through experimental data for the different laser irradiation conditions. Specifying this boundary condition does not automatically cause the associated wall to move. An additional Moving Mesh interface needs to be added to physically track the wall movement in the spatial reference frame. The acceptor substrate (angle of contact) and its distance to the free surface of the fluid are included to study their influence in the printing process.

The validation of the model has been done using the pump-probe imaging technique, the temporal resolution of each frame is given by the pulse duration of the probe source, plasma flash lamps (25 ns). The laser and the probe are synchronized using a digital delay generator and controlled delays can be achieved. Changing the delay time, multiple events are recorded and a time sequence can be generated. In this work, the acceptor substrate has been included to study its influence and gap distance between donor and acceptor.

As a final result, the printability map of the BaLIFT process is presented using fluid dimensionless parameters in which different regimes are identified (no transference, individual droplet, several droplets, jetting, splashing).

Figures used in the abstract

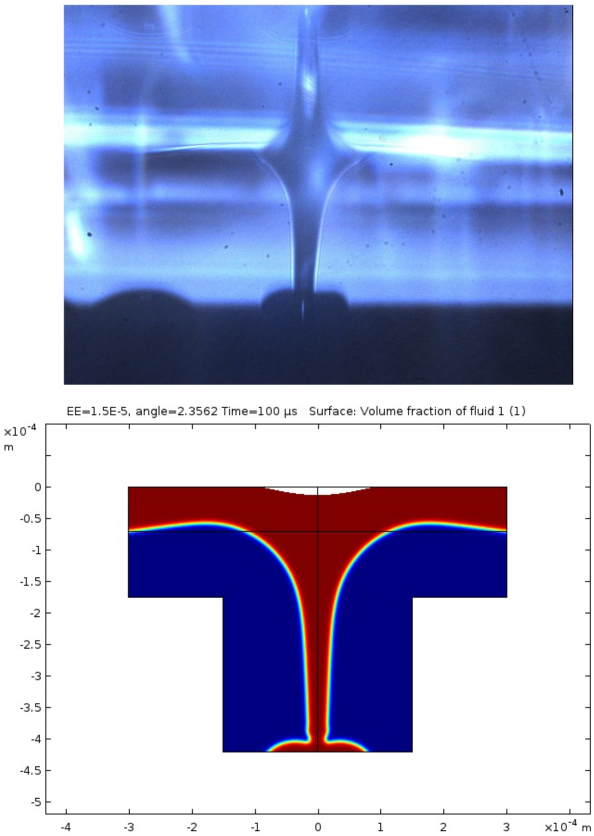

Figure 1: Ba-LIFT process with a water-glycerol mixture (Up) Experimental imaging of the process; (Down) COMSOL Multiphysics® simulation of the same process.