Double-Pulse-LIFT induced nanojets

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Laser-based nanofabrication plays today an important role in the most advanced technology developments. The necessity for increased versatility and precision has led to the development of the approach so-called Double-Pulse Laser Induced Forward Transfer (DP-LIFT) [1]. DP LIFT is a potential solution to print 2D-3D nanostructures with increased resolution [1,2].

In DP-LIFT, a long laser pulse is first applied to melt a solid thin film deposited on a transparent substrate, followed by an ultrashort laser pulse to initiate the transfer of the liquid material towards a receiver substrate. By controlling the irradiation conditions on metal films, ejections from nanodrops to liquid jets with controllable diameters, from few micrometers down to the nanometers scale can be obtained.

In this study we have investigated the transfer of copper. We found that the jetting characteristics and dynamics are governed by various factors including the shape, diameter and temperature of the melted pool created with the long pre-pulse. Numerical simulations of the temperature evolution of copper film gives an insight about the initial conditions for the interaction of the femtosecond pulse with the melted region. Time-resolved imaging of ejected copper yields direct evidence on the influence of the pool diameter and shape in the formation and break-up of thin nanojet and microjets as shown in Fig 1(a). A stable regime of nanojet and microjet separately has been found. The occurrence of nanojet has been found to be linked to a certain shape of the pool i.e., a bump in the middle and concaved between the bump and the edges as illustrated with Fig.1(b). The formation of microjet is due to the direct deformation of the film, while the nanojet formation is attributed to shockwave effects, and interactions in an appropriate system geometry controlled with the pre-pulse conditions defining the pool shape.

1(a)

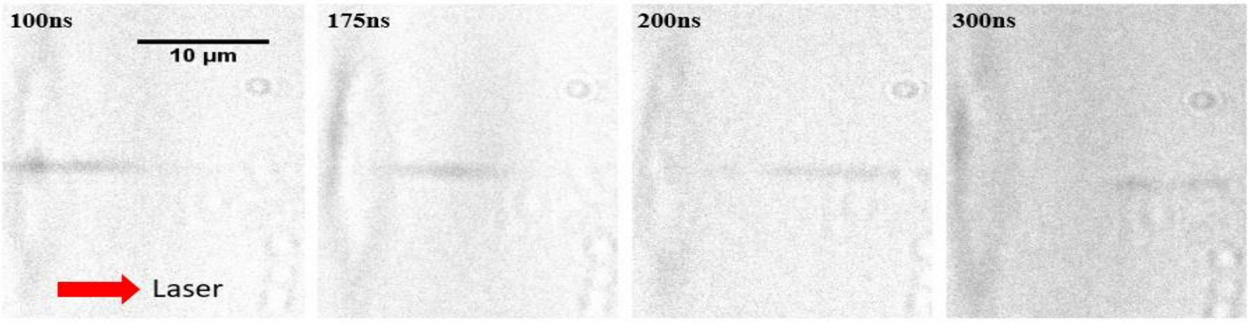
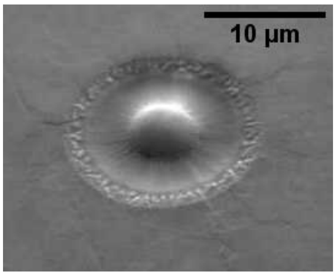


Figure 1 (a) The figure indicates the shadowgraph images captured at different flash-to-LIFT pulse delays showing the formation and breakup of nanojets for Eqcw = 2.21mJ and fs energy 9nJ



(b) Scanning Electron Microscope image of the donor film after irradiation by a pre-pulse of 200-µs duration. The observation is associated to the specific pool shape found to be a requirement for inducing nanojets.

[1] Qingfeng Li, Anne Patricia Alloncle, David Grojo, and Philippe Delaporte. Generating liquid nanojets from copper by dual laser irradiation for ultra-high-resolution printing. Opt. Express, 25(20):24164–24172, (2017).

[2] Qingfeng Li, Anne Patricia Alloncle, David Grojo, and Philippe Delaporte. Laser-induced nano-jetting behaviors of liquid metals. Applied Physics A, 123 (2017).