Liquid nanodispensing: molecules deposition and manipulation of ultrasmall droplets

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Controlled deposition of individual molecules on a surface is an important challenge in many studies in nanosciences. We present an AFM-based method for dispensing and manipulation of liquid nanodroplets on a surface. This newly developed nanoscale dispensing system (NADIS) is based on the direct transfer of liquid from a hollow AFM tip through a small aperture at its apex to the substrate by simple contact [1]. With an ink supplied from an on-tip reservoir, we can transport droplets onto a substrate in the femtoliter to attoliter range with a high droplets density (figure 1). We explored the liquid transfer mechanism from the tip to the substrate and showed that the size of dispensed droplets can be accurately and reproductively controlled by parameters such as the aperture size on the probe, the surface energy of both the tip outer wall and the sample surface [2]. By scaling down this method, we were able to deposit arrays of droplets with a diameter as small as 70 nm, which for standard dilutions contains only few molecules. Direct patterning of proteins or nanoparticles demonstrated the versatility of the method. An original deposition set-up including two AFM tips was also developed [3] in order to position the droplets on predefined structures on the surface (figure 2), a crucial point for many applications.

Due to the small dimensions of the manipulated droplets, it becomes important to address the problem of wetting and capillarity at nanometer scale, a question which remains largely unanswered. By its ability to manipulate femto- to atto-liter droplets, NADIS is a unique technique to tackle this issue, as demonstrated by the studies of capillary forces during dispensing [4] (figure 3), evaporation of femtoliter sessile droplets [5] or spreading dynamics at sub-micron scale.

References:

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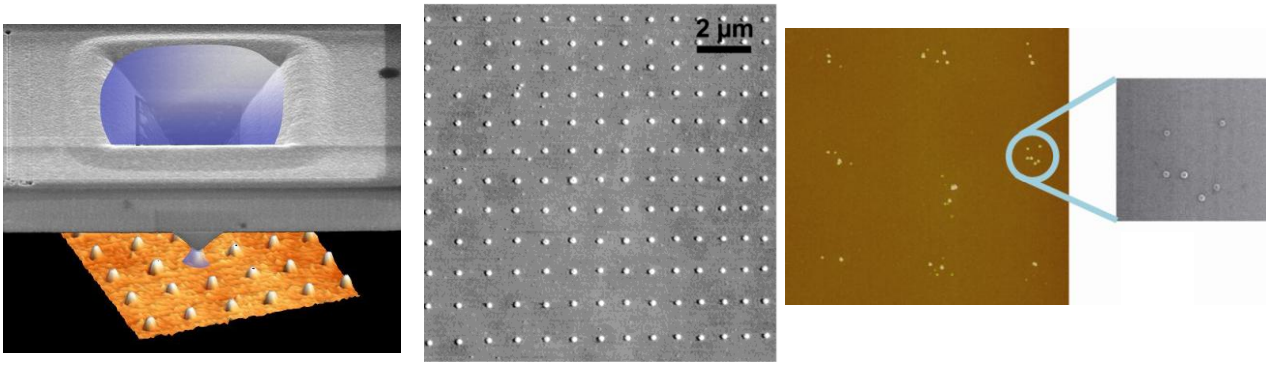
Figures:



(a) **(b)** **(c)**

Figure 1: (a) *Sketch of the liquid nanodispensing technique;* ***(b)*** *Array of deposited molecules spots with diameter 200 nm;* ***(c)*** *AFM image of an array of spots of polystyrene nanoparticules and SEM image of one spot. Each spot contains a small number of objects.*

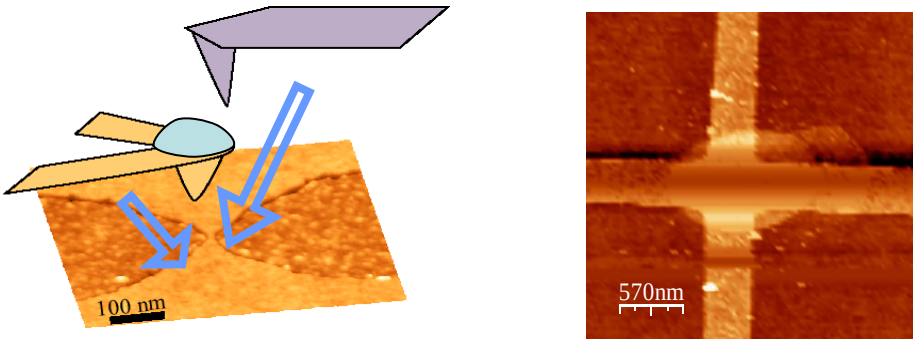


Figure 2: (a) *Schematic representation of the nanopositioning set-up including two tips: one NADIS tip for deposition and one AFM Tapping tip for imaging;* ***(b)*** *Example of droplet deposited on predefined electrodes.*

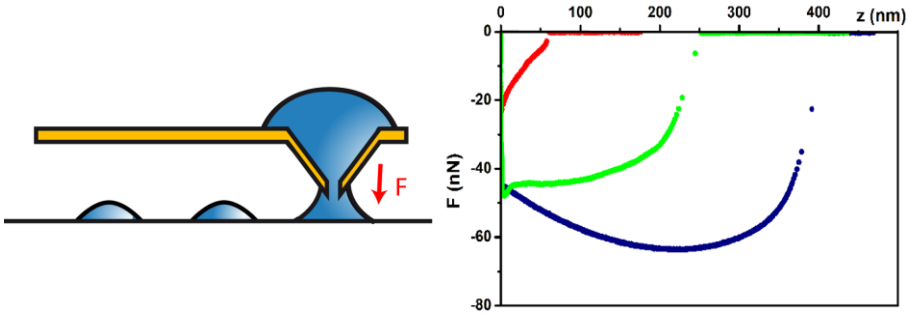


Figure 3: (a) *Schematic representation of the capillary force exerted by the meniscus during the dispensing process;* ***(b)*** *Examples of measured force curves in various conditions: hydrophilic tip with 200 nm aperture (blue), same tip made hydrophobic (green), hydrophobic tip with 35 nm aperture.*