Nanodroplet deposition and manipulation with an AFM tip

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Controlled deposition of individual molecules on a surface is an important challenge in many studies in nanosciences. In this context, a liquid nanodispensing technique (NADIS) was recently conceived to answer the new need of efficient techniques of molecule deposition. Indeed, this direct deposition method enables to pattern substrates on the nanometer scale by combining the resolution of the SPM-based lithographic methods like Dip pen lithography and the flexibility of liquid manipulation.

The principle of this technique consists in using a modified AFM tip to deposit nanodroplets (Figure 1)[1]. For that purpose, a standard hollow tip is drilled by Focused Ion Beam (FIB) to create a narrow channel at its apex (figure2a). The deposit is performed by transferring liquid from a reservoir droplet, containing the particles of interest placed onto the cantilever, to the surface through the channel during an approach-retract of the tip in force spectroscopy mode.

Channel diameters down to 35nm have been obtained enabling to dispense ultra small volumes in the femto- (10^{-15}l) to atto-liter (10^{-18}l) range which can lead to lateral dimensions below 100nm[2]. Such nanodroplets contain, for standard dilutions, only few solute molecules, opening the way to single molecules deposition. Different kinds of particles (nanoparticles, proteins…) have been deposited to create various patterns (dots arrays, lines) on different surfaces proving the flexibility of this method (figure2b and 2c).

On a more fundamental side, this technique is a unique tool to study capillarity and wetting dynamics at the sub-micrometric scale.

The analyze of the capillary forces exerted on the tip during the liquid deposition demonstrated a wide range of behaviors depending on the experimental conditions and provides a real time monitoring of the process. Moreover the simulation of these force curves with the software “Surface evolver”[3] gives a great insight on the dispensing mechanism and the capillarity at the nanoscale[4].

We also showed that the deposition of lines, realized with a nanopositioning table incorporated in an AFM, is an original method to study the dynamics of spreading at sub-micrometric dimensions and millisecond timescale. A model, developed for constant pressure, describes this injection mechanism.

In conclusion, besides its performances as a nanopatterning tools, the NADIS technique is a very efficient to probe nanofluidics phenomena.

References

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[2] A. P. Fang, E. Dujardin, and T. Ondarcuhu, Nano Letters, **6** (2006) 2368.
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Figures

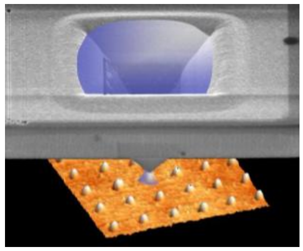

Figure 1: illustration of the deposition method NADIS

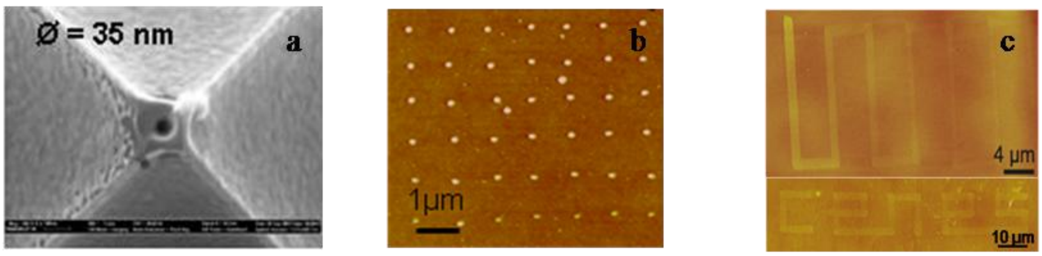

Figure 2: (a) SEM image of a NADIS tip, (b) AFM image of proteins dots array, (c) AFM images of Ruthenium complex lines