Analysis on probe-sample interaction for scanning near-field photolithography (SNP)

Zhuming Liu and Clive J. Roberts
[a] *Laboratory of Biophysics and Surface Analysis, The School of Pharmacy, The University of Nottingham, Nottingham, NG7 2RD, UK*
Yuan Zhang , John M. R. Weaver
[b] *Department of Electronics & Electrical Engineering Rankine Building, University of Glasgow, Glasgow G12 8LT, UK*
Graham J. Leggett
[c] *Department of Chemistry, University of Sheffield, Brook Hill, Sheffield S3 7HF, U.K*
E-mail: Liuzhuming@yahoo.co.uk

Scanning near-field photolithography (SNP) can overcome the Rayleigh limit and achieve high resolution. Structures of 9 nm in size have been produced using UV photo-oxidation of oligo(ethylene glycol)-terminated self-assembled monolayers on a microcrystalline gold surface in ambient environment. To reach its full potential in nanobiology led applications, liquid SNP has been conducted and produced patterns with resolution of 70 nm on resist. Cantilever-based SNP has been widely employed due to its compatibility to standard Atomic force microscopy (AFM) and its extension capability for parallel lithography. To keep the probe aperture in the near-field range of sample, the probe works in contact mode usually. However the probe working in contact mode is liable to produce mechanical scratching damage to the sample particularly for the parallel cantilever-based SNP.

To understand interaction between probe and sample and achieve better SNP, experimental force measurements are carried out. The theoretical influences of the medium on van der Waals forces, electrostatic forces, pull-off forces and hydrodynamic forces are discussed.

Results of force measurements and SNP in air and liquid lead to the conclusion that liquid environment eliminates capillary force, decreases the adhesion force significantly between tip and sample and provides an exciting method to improve SNP and its application. Smaller contact area between tip and sample attribute lower adhesion force and hence beneficial to cantilever-based SNP.

References:
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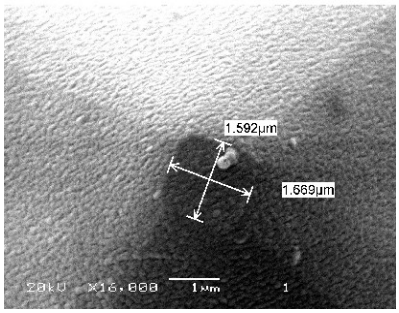

Fig.1 SEM image of end of probe

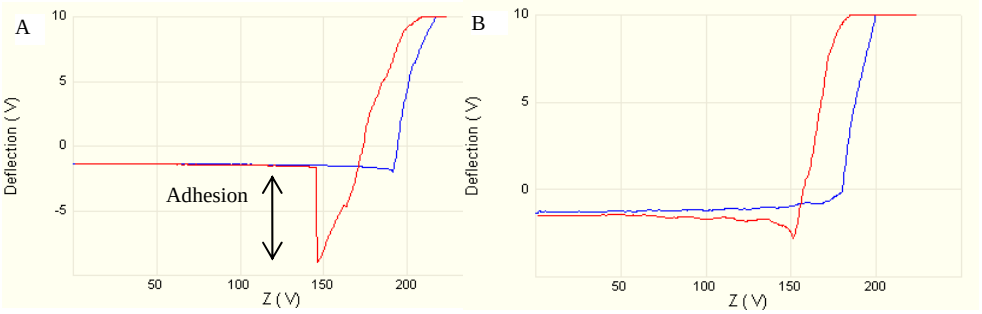

Fig.2 Force curves between tip and sample (S1805 resist) in ambient (A) and water (B)

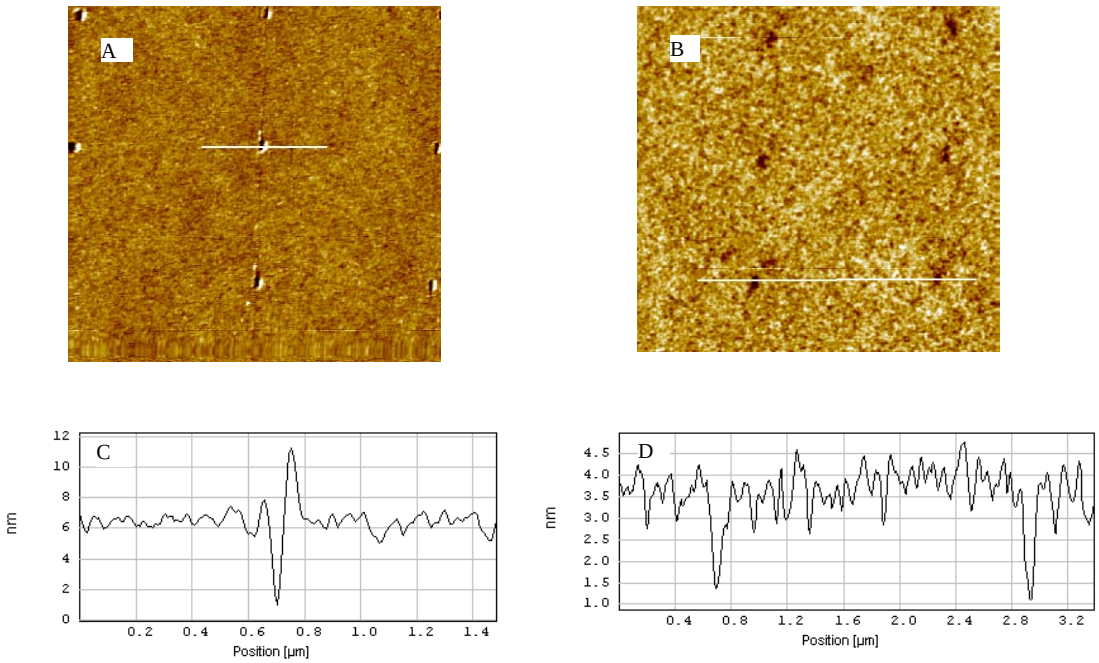

Fig.3 (A) AFM height images of patterns in positive resist produced by SNP in air and (C) cross section of dots; (B)AFM height images of patterns in positive resist produced by SNP in water and (D) cross section of dots