FABRICATION OF NANOSTRUCTURED MICRO ARRAYS BY COMBINING NANOIMPRINT-ASSISTED MICROCONTACT STRIPPING AND COLLOIDAL LITHOGRAPHY TECHNIQUES

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Methods for the accurate positioning of nanometric beads on a substrate have been developed over a number of years and range from serial AFM techniques for single bead positioning [1], to techniques for the positioning of large populations of beads in monolayer or multilayer architectures, typically from a liquid suspension [2]. Recently, approaches to the micropatterning of nano-beads based on contact printing have appeared [3-5]. Normally, in the reported contact printing based methods, the beads have to be loosely attached so that bead transfer or removal will not be inhibited. Here we present a nano-bead contact-stripping patterning method based on structured PMMA stamps and a nanoimprinter apparatus, which allows careful control of the temperature and pressure during the contact-stripping. The process successfully strips strongly attached nano-beads from substrates, to produce patterns of different geometries over large areas, and could minimise the use of surfactants in transfer printing.
Micro-contact stripping of polystyrene beads has been achieved with the assistance of nanoimprint apparatus for the production of micro-patterned areas of beads. 100, 200 and 500 nm diameter beads have been assembled on poly(acrylic acid) and silicon using spin coating and Langmuir-Blodgett techniques (Figure 1). The beads have been successfully patterned in several micro-scale configurations, defined by poly(methyl methacrylate) structured stamps, through the controlled application of pressure and temperature. Tuning the experimental conditions allows selective removal of beads to be achieved, even when strongly attached to the substrate. The rapid contact-stripping method allows patterning over large areas with good repeatability, and produces well defined bead-patterned regions (figure 2). Furthermore, the micropatterning of polystyrene nanobeads achieved by this method has been used to define large area micropatterned nanodomains with fouling poly(acrylic) acid nanospots in a non-fouling poly(ethylene) glycol background. The fouling/non-fouling contrasted areas have been produced through etching of the nanobeads followed by deposition of poly(ethylene) glycol by plasma-enhanced chemical vapor deposition. Figure 3 shows the SEM picture of the reduced nanoparticles after etching and the AFM characterization of the final nanodomes micropatterned in a 5µm wide line configuration.
A method for the micro-patterning of nano-beads at large scale based on nanoimprint-assisted contact printing has been developed which overcomes the limitation of conventional methods regarding bead-substrate adhesion. Micro-patterns of PS nano-beads have been obtained using beads of different diameters and with different levels of bead adherence to the substrate. The micropatterned nanoparticles have been used to create surfaces with nanoscale chemical contrast inside the micropatterns. It is envisioned that this highly controllable method can be applied to other non-polymeric particles and substrates, and may be used to achieve patterns at sub-micrometer scales.

References:

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Figures:

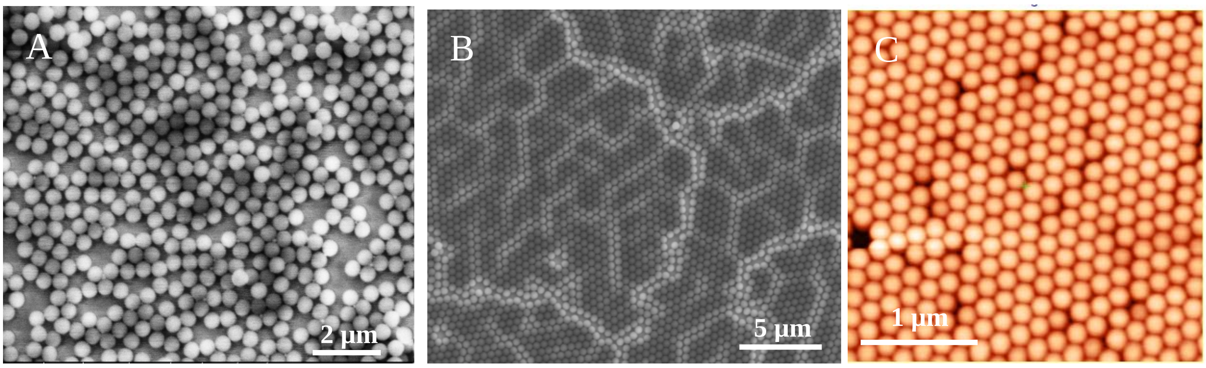

Figure 1. (a, b) SEM images of 500 nm poly(styrene) beads deposited on silicon substrates by the Langmuir-Blodgett technique (a) and by spin-coating (b). (c) AFM image of 200 nm diameter poly(styrene) beads deposited by spin-coating

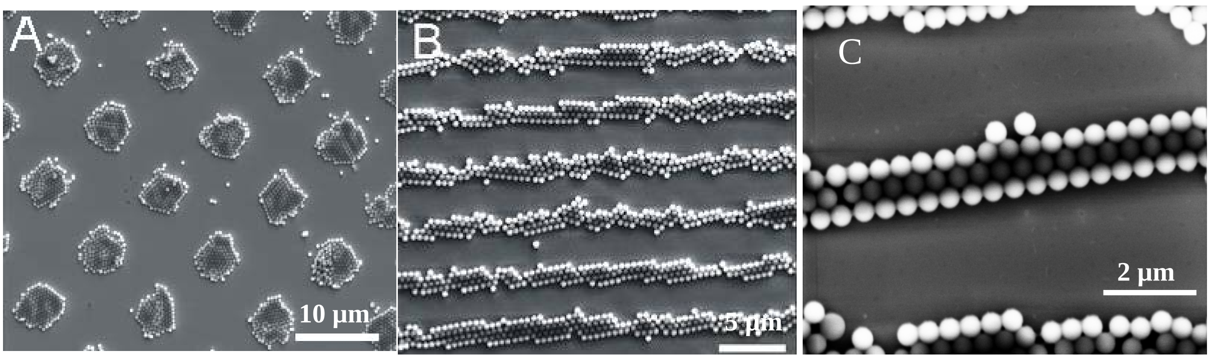

Figure 2. SEM images of 500 nm poly(styrene) beads micropatterned by NIL-assisted contact striping.

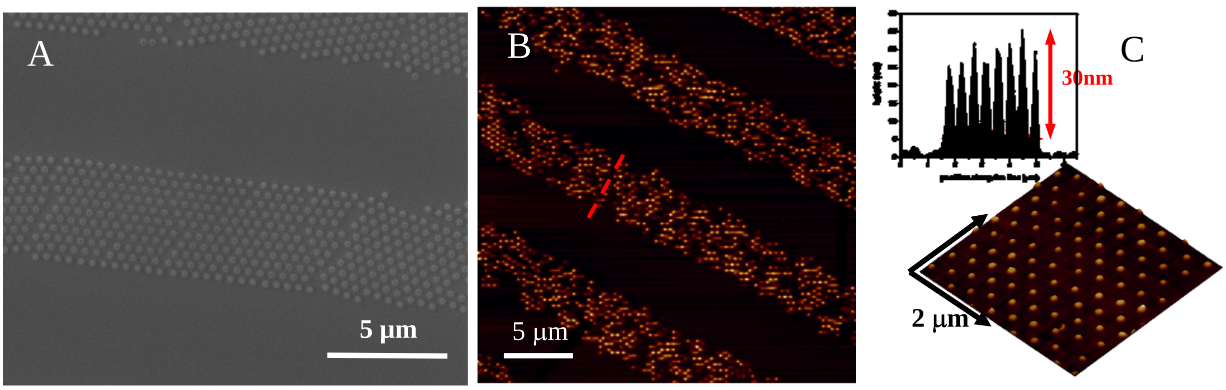

Figure 3. (a) SEM image of the etched polystyrene nanoparticles. (b, c) AFM characterization of poly(acrylic) acid nanodomes on a poly(ethylene) glycol matrix produced by NIL-assisted contact stripping and colloidal lithography, (b) shows the 30*30 µm AFM scan of the nanostructured micro-lines and (c) the height profile along the red line and the 4*4 µm AFM scan of the nanostructured area.