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Micro- and Nanoscale Patterning of Alkanethiol Monolayers on Gold using Edge-Spreading Lithography

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and Younan Xia²

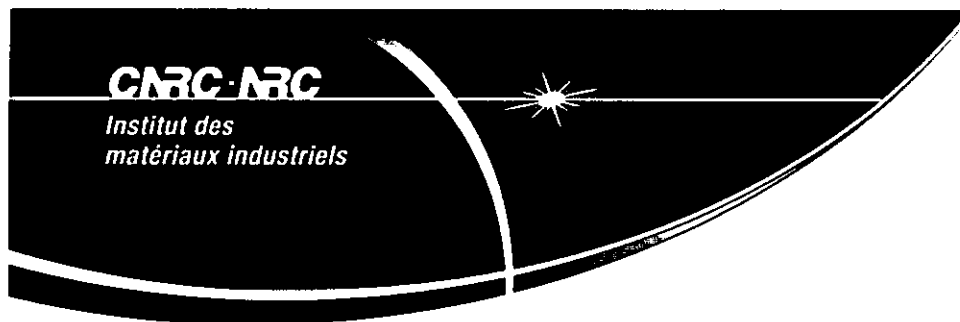
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I will describe a simple and flexible technique for patterning self-assembled monolayers (SAMs) of alkanethiols on gold substrates at 100 nanometer lengths scales and below. This technique which we called edge-spreading lithography (ESL) has two key features: a relief (or guiding) structure that has to be present on the gold substrate, and reactive spreading. The role of the relief structure is to mediate the transport of alkanethiol molecules from a PDMS stamp to the gold surface and to determine the geometry of the emerging SAM. For example, when a two-dimensional (2D) array of silica beads is used, the circular footprint of each bead produces a pattern of monolayer rings in a hexagonal arrangement. Reactive spreading is the expansion of a SAM across a surface driven by a chemical reaction between the thiol molecules and the gold substrate. The edges of the emerging monolayer thereby serve as nucleation sites that the molecules reach by diffusion. I will review the current state of the technique and its potential applications in microfabrication. A special emphasis will be given to the patterning of multiple alkanethiolate SAMs on the same substrate, and the formation of gradient SAMs over micro- and nanometer length scales.

References:

- [1] M. Geissler et al. Nano Lett. 2005, 5, 31.
- [2] M. Geislser et al. Angew. Chem. Int. Ed. 2005, 44, 3596.
- [3] M. Geissler et al. Small 2006, submitted.

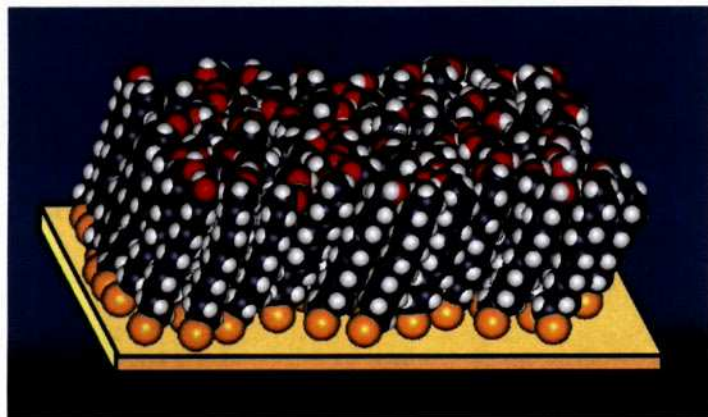
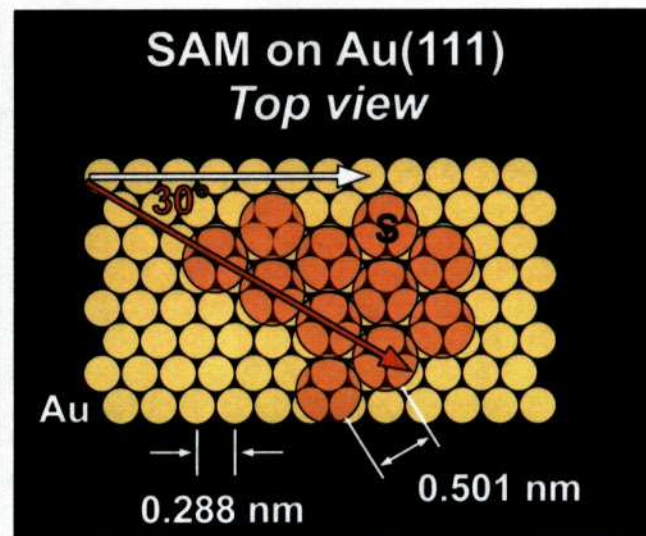
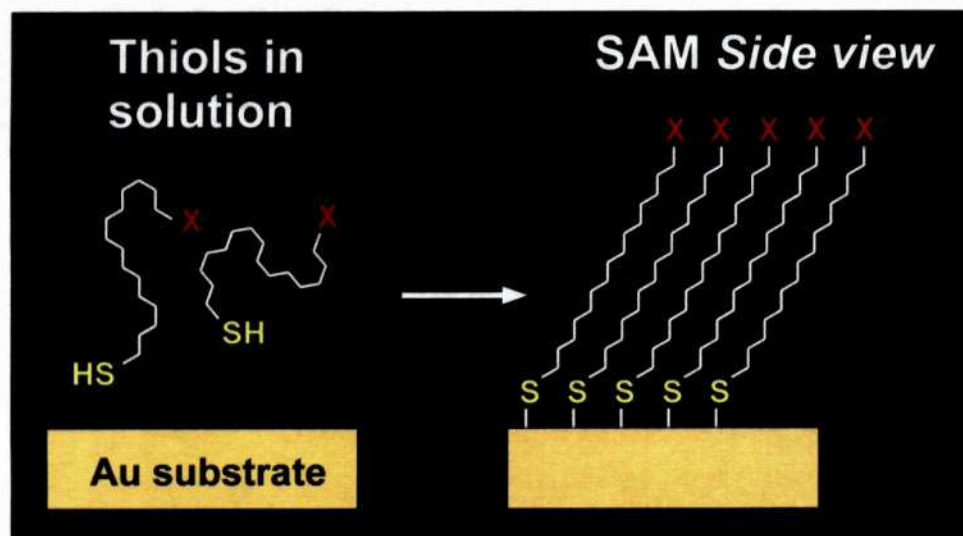


Micro- and Nanoscale Patterning of Alkanethiol Monolayers on Gold using Edge-Spreading Lithography (ESL)

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Self-Assembled Monolayers (SAMs) of Alkanethiols on Gold

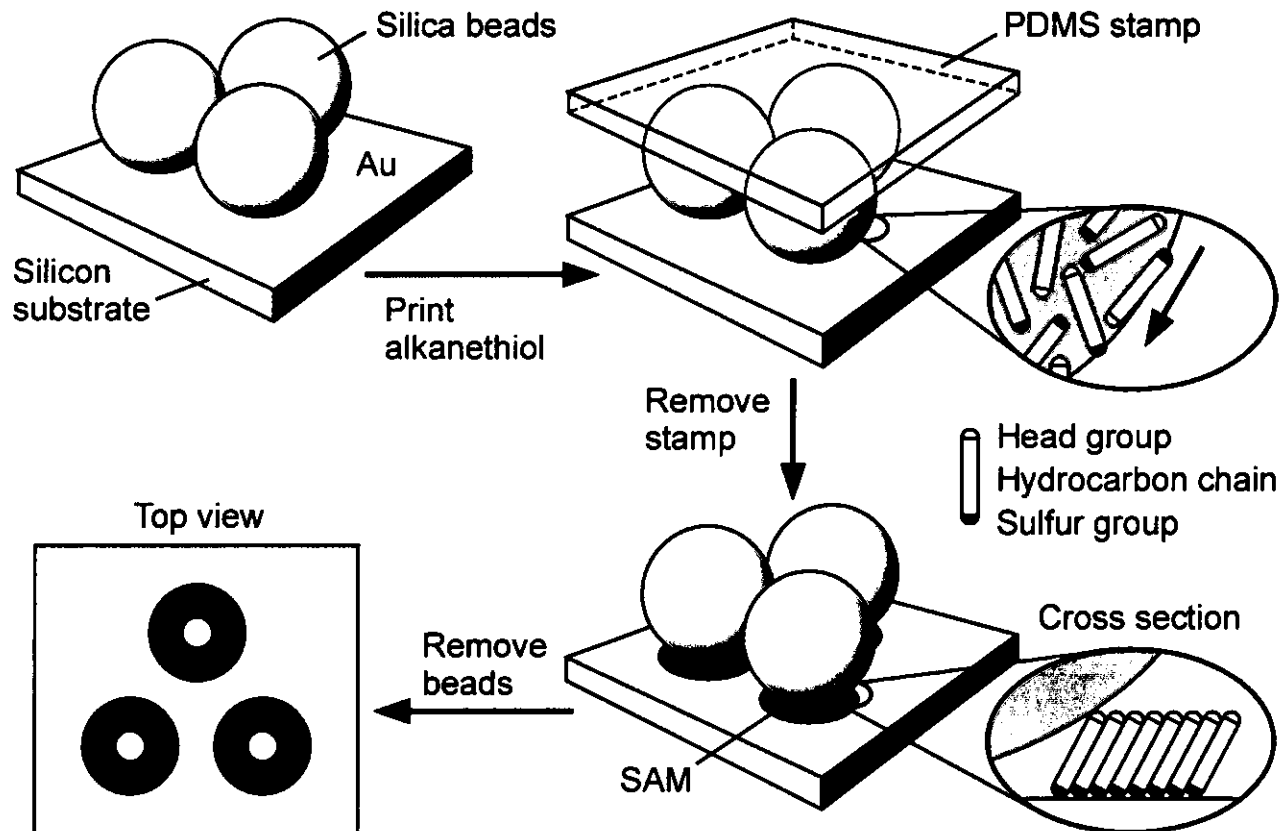


SAMs are used to alter the chemical and physical properties of surfaces for a variety of phenomena such as wetting, lubrication, and adhesion.

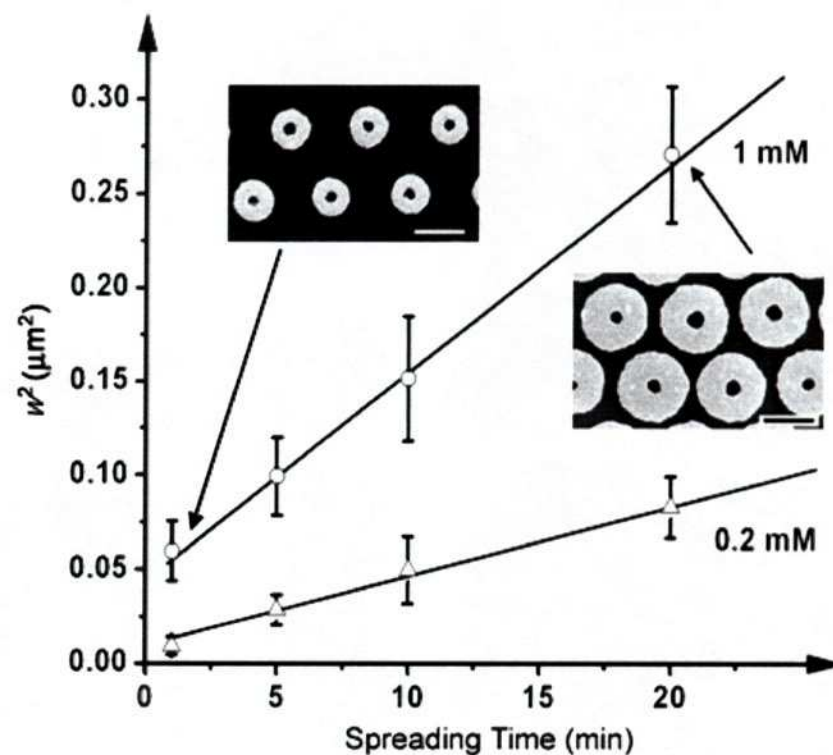
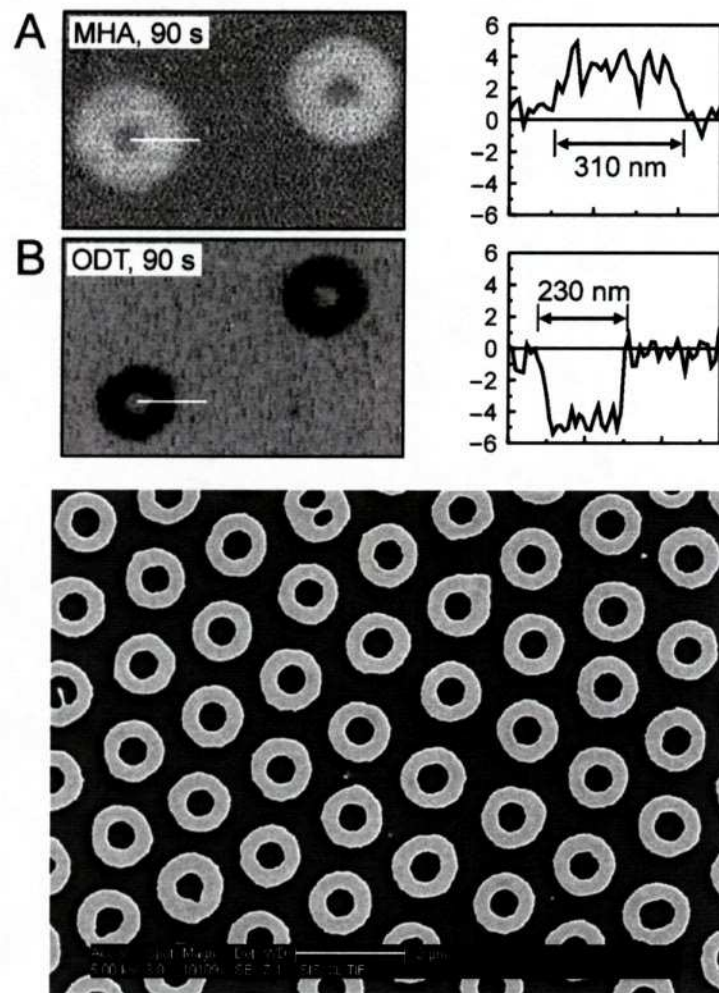
Review: J. C. Love et al. *Chem. Rev.* 2005, 105, 1103.

Principles of ESL

- Key Features:**
- 1) Relief structure
 - 2) Reactive spreading

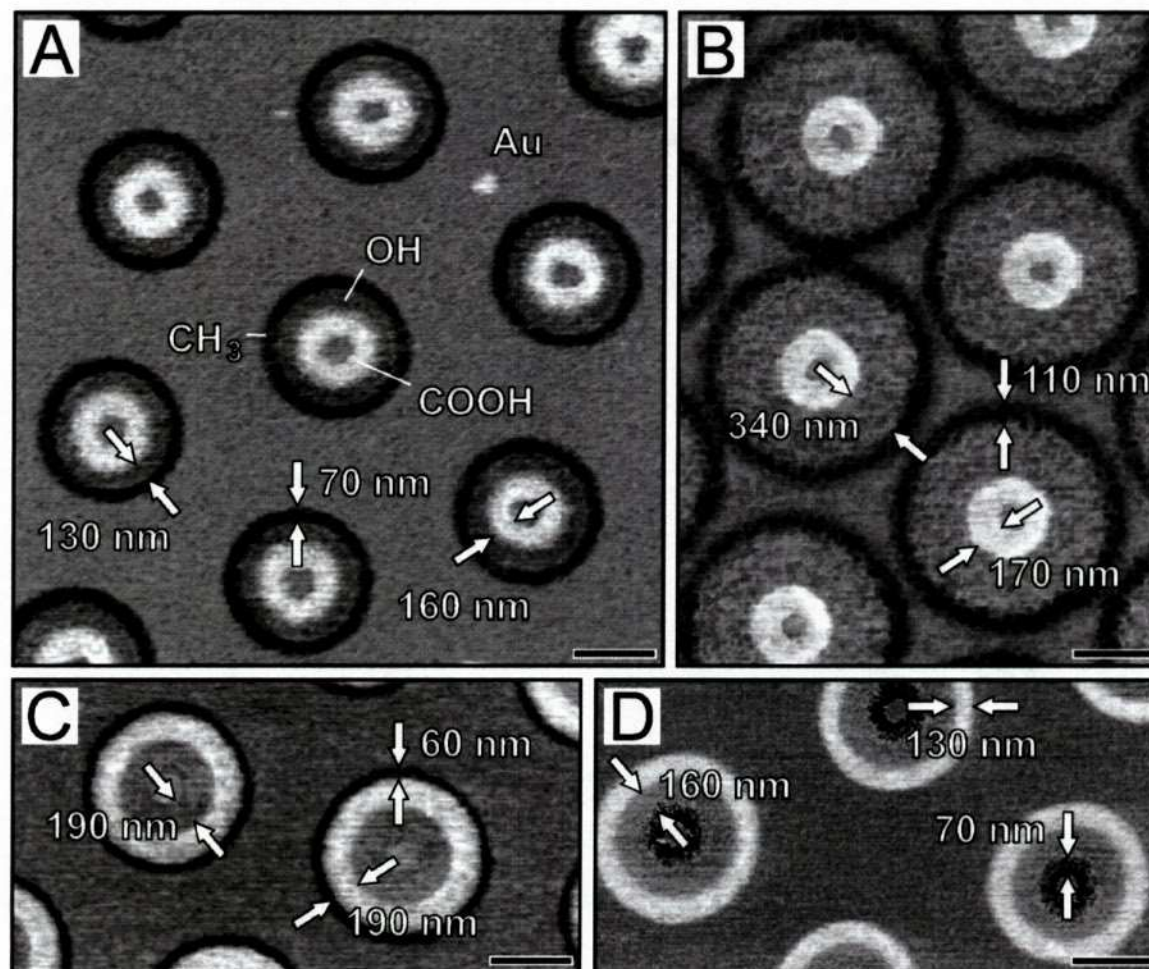


Fabrication of Gold and Silver Rings by ESL and Selective Etching

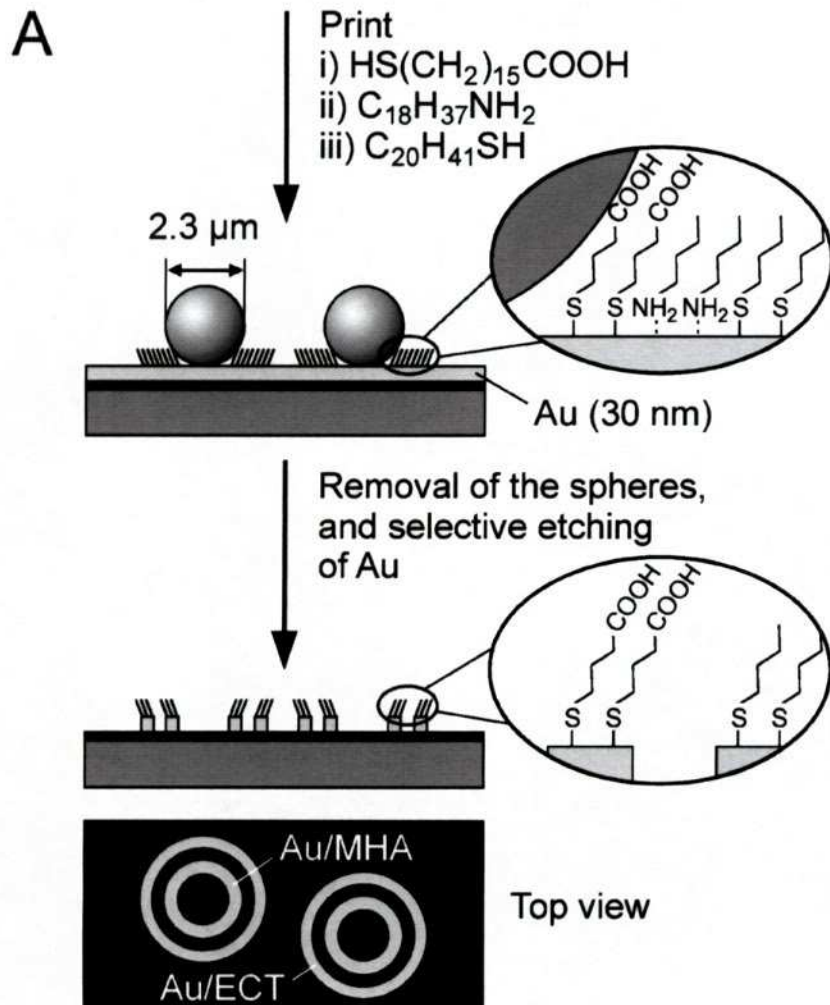


Parallel Patterning of Multiple SAMs on Gold

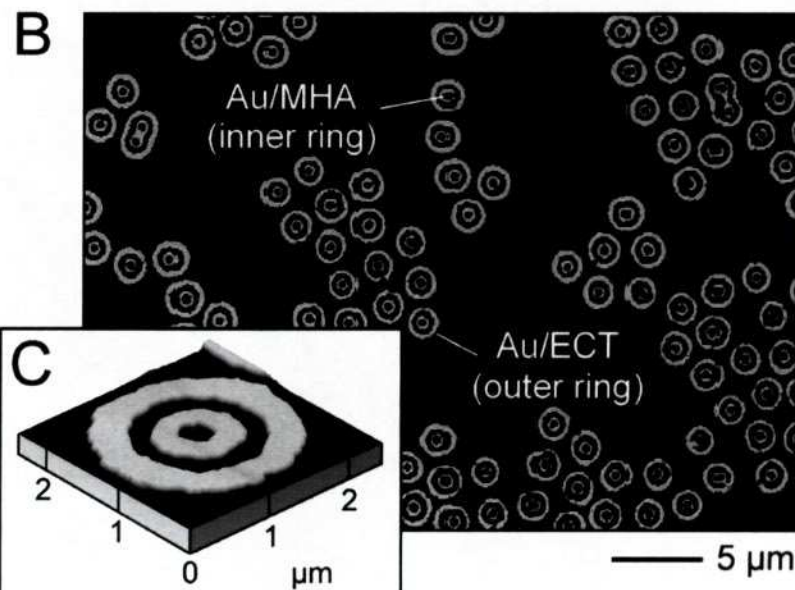
M. Geissler *Angew. Chem. Int. Ed.* 2005, 44, 3596.



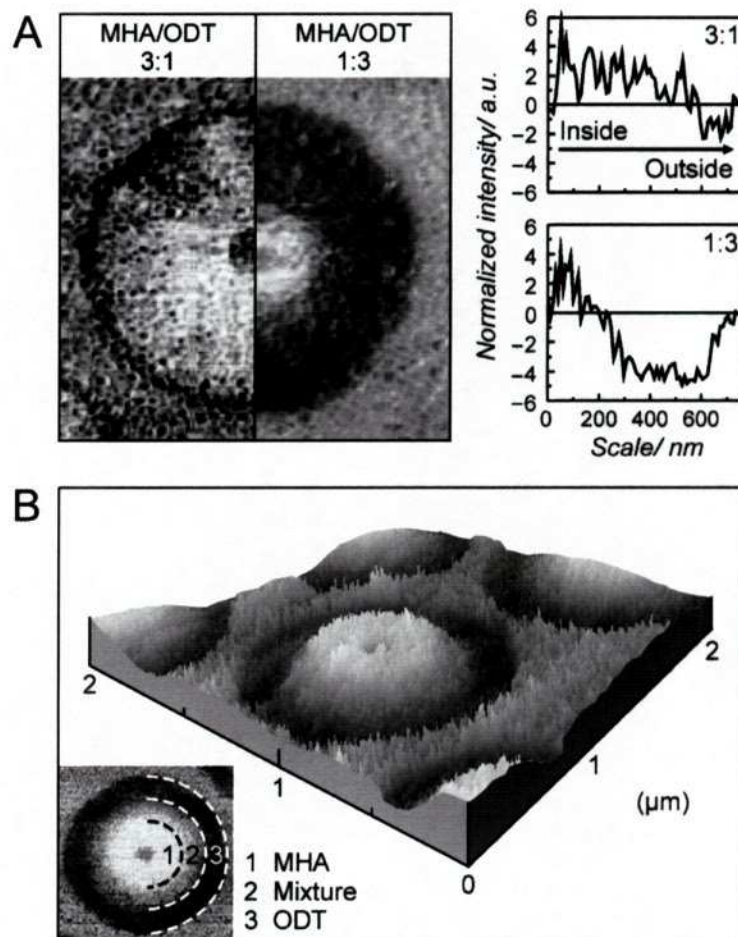
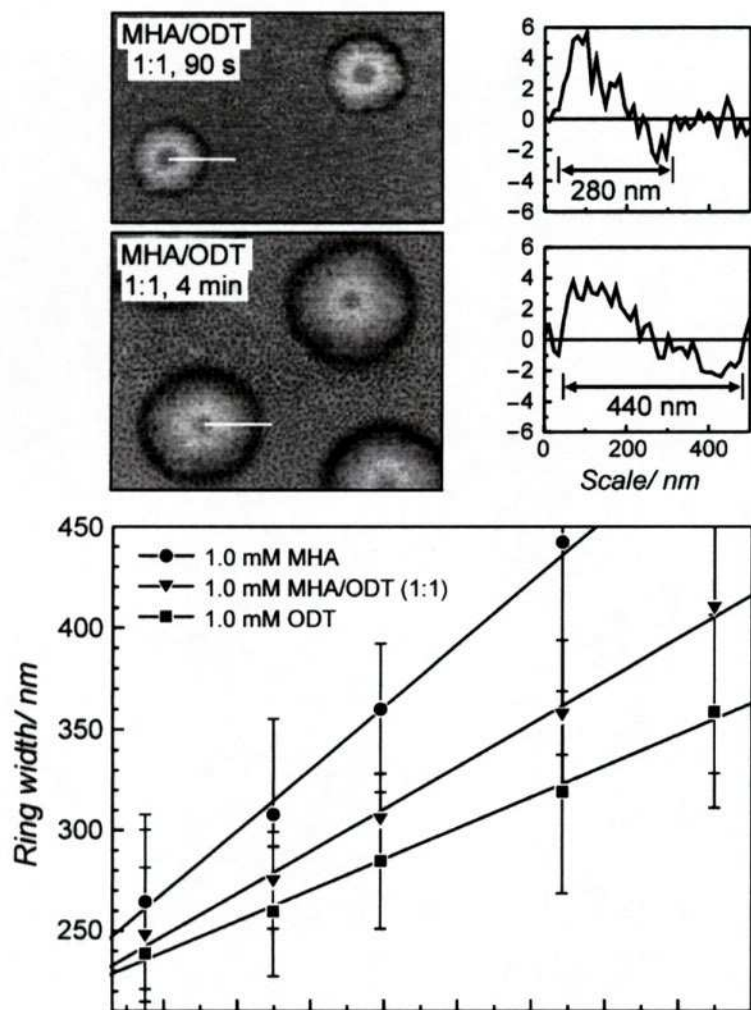
Fabrication of Concentric Gold Rings by ESL and Selective Etching



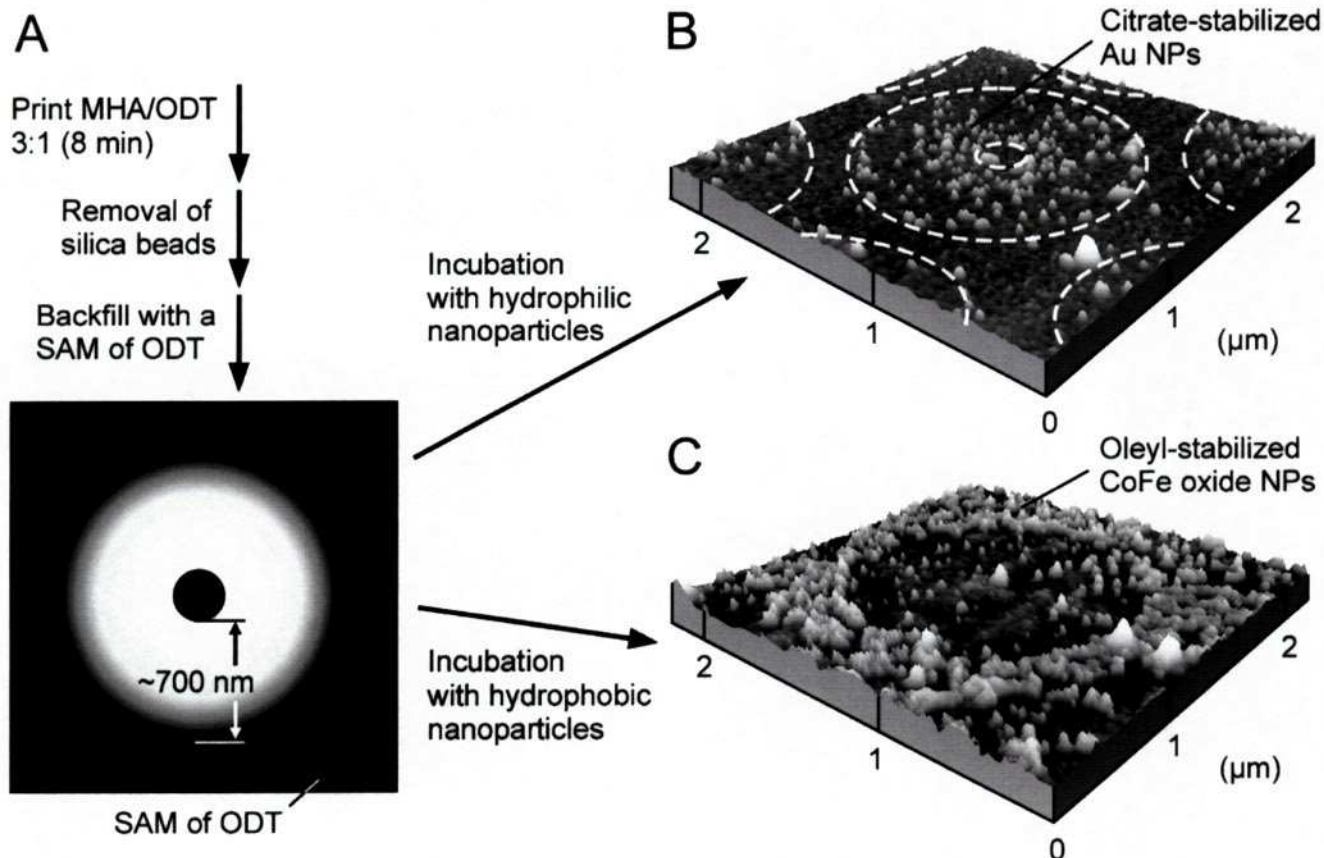
The non-thiol SAM must be robust enough to resist the displacement by thiol molecules, but should not protect the underlying gold effectively against etching.



Formation of Chemical Gradient Patterns

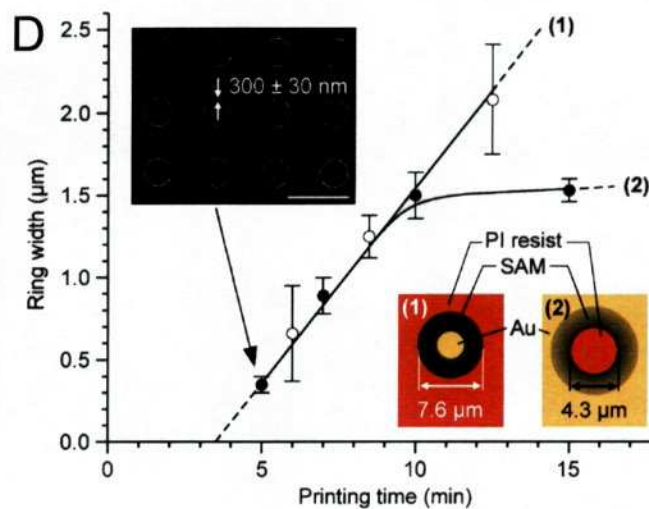
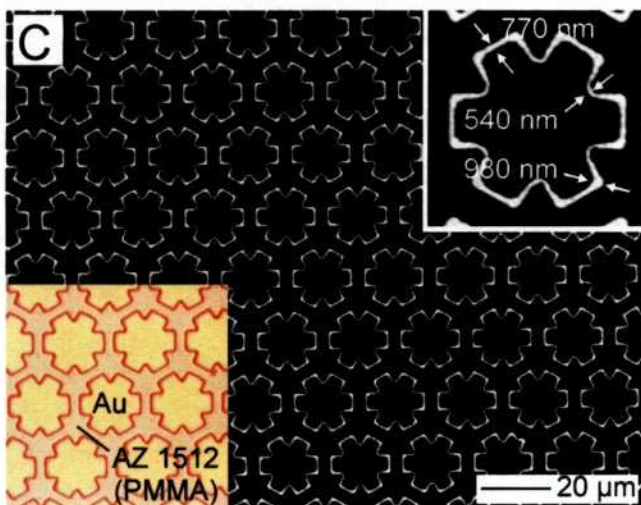
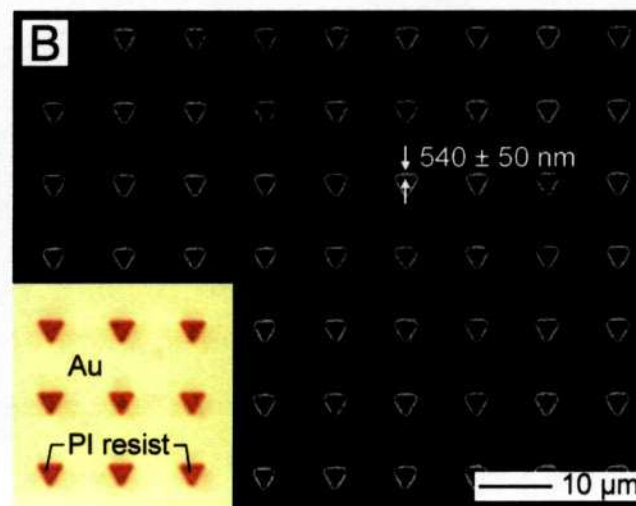
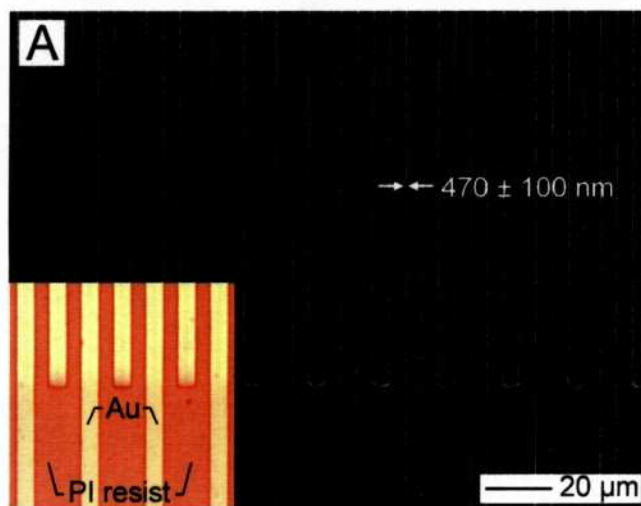


Template-Assisted Assembly of Particles onto Gradient Patterns

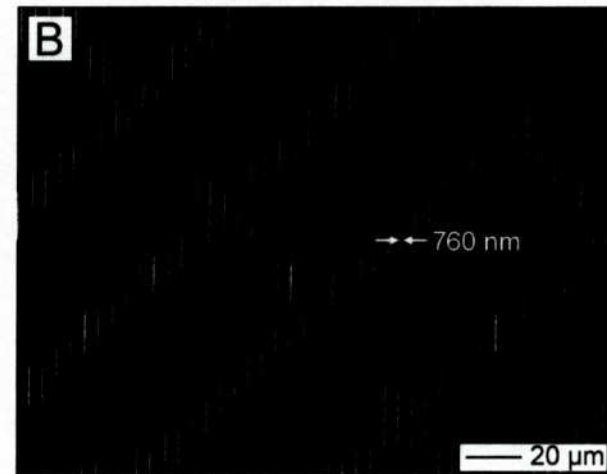
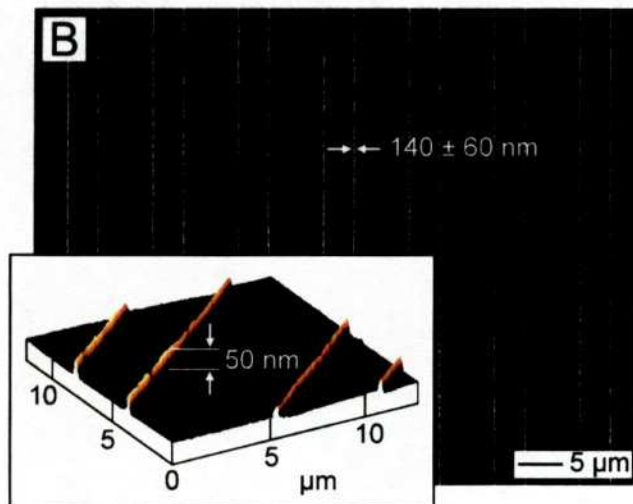
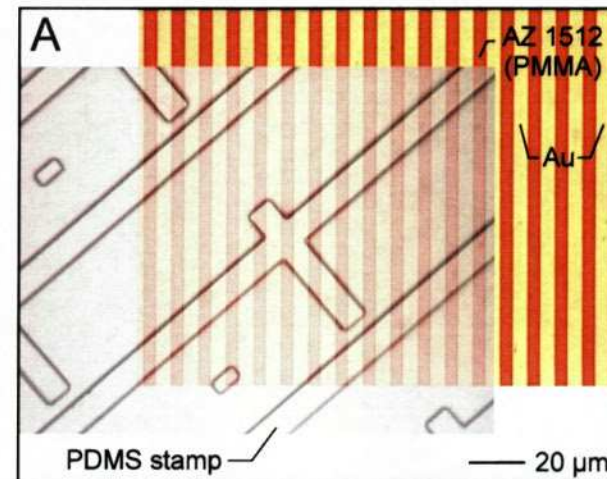
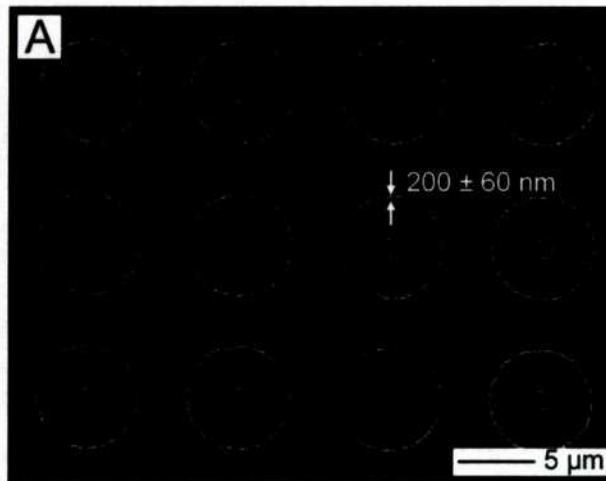


Use of Photoresist Structures for ESL

M. Geissler et al. *Nano Lett.* 2005, 5, 31.



High-Resolution Features and Use of Patterned Stamps for ESL



Conclusions

ESL can be used to pattern a variety of sub-micrometer features in an experimentally simple and convenient way.

Irregular and more complex patterns may be achieved with this technique. Besides the formation of 2D structures, 3D patterning might also be possible.

Can the technique evolve from a research curiosity to a versatile patterning methodology?

Acknowledgment

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