Self Perfection of Nanostructures– A New Frontier in Nanofabrication

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As many micro/nanopatterning methods are approaching their limits imposed by fundamental physical principles, we have been trying to develop new methods to replace them. However, so far, a new nanopatterning method developed may overcome certain weakness of the old methods, meanwhile introduces a new set of disadvantages; and no single nanofabrication method can offer all advantages that we desire.

Rather than keeping looking for a perfect new nanofabrication method, we have bean taking a drastically different approach, which accepts the defects/weakness of a known nanofabrication but explores ways to perfect the nanostructures after their initial fabrication. Over past 10 years, we have been developing a nanostructure self perfection technology, termed "self-perfection by liquefaction" (SPEL), which transitly melt nanostructures while applying certain boundary conditions to reshape the nanostructues [1-2]. Using SPEL, we have perfected nanostructures in soft materials (e.g. resists) and hard materials (e.g. Si, Cr). The self-perfection include (a) reduce the line edge roughness (LER) by 560% (3σ-LER < 1.5 nm) while having vertical sidewall and flat top, (b) reduce the linewidth (>215 % narrower) while increase line height (>210% taller), (c) reduce a trench width from 120 nm to 10 nm, (d) reduce a hole diameter from 70 nm to 10 nm, and (e) make non-circular pattern to become either nearly perfectly round cylinder or round semi-sphere (depending upon boundary conditions applied). Other self-perfection methods based on self-assembly also possible. In addition to direction patterning, these self-perfection technologies can have significant importance to make nanoimprint molds.

1) S. Y. Chou and Q. F. Xia, "Improved nanofabrication through guided transient liquefaction," Nature Nanotechnology, 3 (5) 295-300 (2008); 3 (6) 369-369 (2008).
2) Y. Liang, P. Murphy, W. Li, and S. Y. Chou, "Self-limited self-perfection by liquefaction for sub-20 nm trench/line fabrication," Nanotechnology, 20 (46) 465305 (2009).