Nanotechnology Highlight

Microfabrication with focused beams of nanoparticles

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S. L. Girshick (P.I.), W. W. Gerberich, J. V. R. Heberlein and P. H. McMurry
University of Minnesota, Minneapolis, MN

Researchers at the University of Minnesota have developed a new method for generating and depositing narrow beams of nanoparticles.[1] The Minnesota team, which includes Steven Girshick, Joachim Heberlein and Peter McMurry, professors of mechanical engineering, and William Gerberich, professor of materials science, proposes to use these nanoparticle beams to fabricate miniature parts for MEMS (microelectromechanical systems). At present a serious limitation of MEMS technology is that many types of MEMS parts quickly wear out. For example, wear is a serious problem that affects miniature gears for micro-transmissions and electrodes for micro-electro-discharge machining. Supported by a growing body of research on the mechanical properties of nanostructured materials, the Minnesota researchers believe that making such MEMS parts out of nanoparticles, or coating them with nanoparticles, can make these parts far more resistant to friction and wear, particularly if one uses materials such as hard ceramics.

In the Minnesota process nanoparticles of desired composition are synthesized by injecting vapor-phase reactants into a thermal plasma and then expanding the plasma through a nozzle. Particles nucleate in the nozzle expansion and then enter a device that consists of a series of aerodynamic lenses—basically, disks with holes in their centers—that take advantage of the aerodynamic drag on the particles to push them toward the flow centerline, a process known as "aerodynamic focusing." The Minnesota group has used this process to produce beams of particles consisting of either silicon carbide or titanium, with typical particle sizes of 20 nanometers and typical beam widths of 50 microns. They have used these particle beams to deposit needle-like "nanotowers" on stationary substrates. By translating the substrate they have deposited lines and patterns.

If this focused particle beam process is used in conjunction with standard microfabrication techniques, it should be possible to fabricate nanostructured MEMS parts, or to deposit nanostructured coatings on MEMS parts. Figure 1 shows an example, in which an array of miniature gears is fabricated by using a micro-mold, together with beam shuttering and substrate translation.

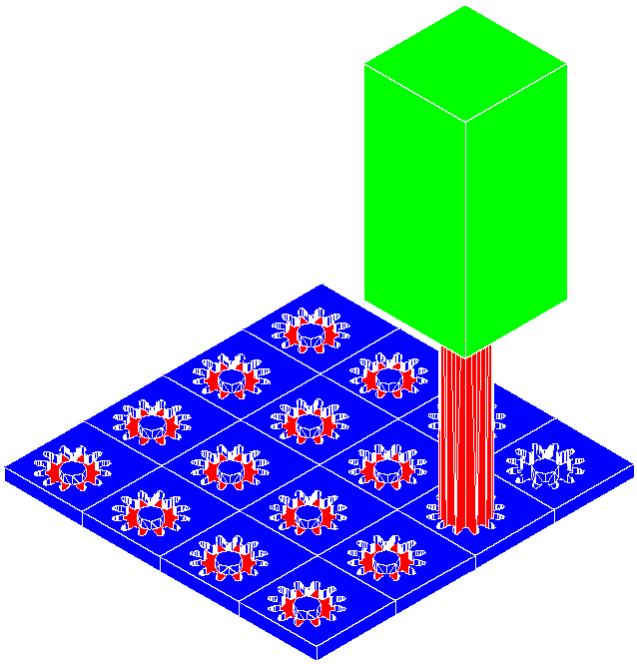

Figure 1. Array of miniature gears fabricated by depositing beam of nanoparticles into a micro-mold.

[1] F. Di Fonzo, A. Gidwani, M. H. Fan, D. Neumann, D. I. Iordanoglou, J. V. R. Heberlein, P. H. McMurry, S. L. Girshick, N. Tymiak, W. W. Gerberich and N. P. Rao, "Focused Nanoparticle-Beam Deposition of Patterned Microstructures," *Applied Physics Letters* **77**, 910–912 (2000).