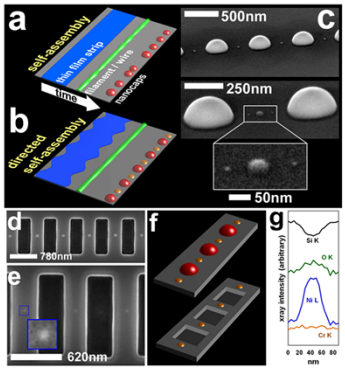
The surface assembly of metal nanoparticles using non-linear interactions in nanofabricated fluids



(a) Pulsed laser melting converts a thin strip of metal into nanoparticles: an imposed edge oscillation (b) controls subsequent fluid dynamics launching a cascading process (c) of smaller nanoparticle formation. (d-f) Ion milling removes unwanted particles. This case highlights the formation of nickel (g) nanoparticles.

Work was performed at the Center for Nanophase Materials Sciences, the New Jersey Institute of Technology and the Universidad Nacional del Centro de la Provincia de Buenos Aires.

Scientific Achievement

Non-linear fluid dynamics in nanoscale liquid metal wires was unraveled using both experiments and simulations.

Significance and Impact

Physical methods capable of producing sub-20nm nanoparticles in an ordered network are few; this successful demonstration will impact the future fusion of self-assembly methods into microelectronic fabrication.

Research Details

- Volume-of-Fluid (VoF) simulations identified a specific liquid nanowire geometry exhibiting hierarchical, cascading liquid wire fragmentation ultimately producing extremely small nanoparticles
- Subsequently, electron beam lithography was used to deposit metallic prerequisite features designed to assemble into nanoscale wires in response to pulsed laser melting yielding an experimental realization of the predicted fragmentation

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Narrative Highlight Text: Chemical synthesis methods provide means to produce high yields of metal nanoparticles with *precise radii*. Catalytic, electrical and optical applications ultimately stand to benefit from nanoparticles with sub-20nm sizes. However, approaches to *pattern* chemically synthesized nanoparticles on surfaces are fewer. As a result, physical–based methods have emerged as an alternative where nanoscale features and elements are explicitly patterned followed by physical vapor deposition to deposit the metal, often at relatively lower temperatures. Examples include conventional electron beam lithography, soft interference lithography and nanoimprint. Yet, in general, physical patterning methods yield two-dimensional (2D) nanostructures, often intended to emulate, or serve as models for, 3D features. *Thus, chemical synthesis methods provide the best control over individual nanoparticle shape while physical methods are best for organizing the model nanoparticles over large areas*. The physical assembly method reported here overcomes this tradeoff by making it possible to yield nanoparticles in a spatially controlled network *with controlled shape*.

Reference

"Hierarchical Nanoparticle Ensembles Synthesized by Liquid Phase Directed Self-Assembly"
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