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EMERGING RESEARCH FRONTS - 2009

August 2009

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N. Ravishankar & Aditi Halder talks with *ScienceWatch.com* and answers a few questions about this month's Emerging Research Front Paper in the field of Materials Science.

Article: Ultrafine single-crystalline gold nanowire arrays by oriented attachment
Authors: Halder, A;Ravishankar, N
Journal: ADVAN MATER, 19 (14): 1854-+ JUL 16 2007
Addresses: Indian Inst Sci, Mat Res Ctr, Bangalore 560012, Karnataka, India.
Indian Inst Sci, Mat Res Ctr, Bangalore 560012, Karnataka, India.

SW: Why do you think your paper is highly cited?

Our paper addresses a very fundamental problem in nanostructure growth relating to the formation of single-crystalline wires of a high-symmetry material. The problem is one of selecting one crystallographic direction/facet for growth over several equivalent directions/facets in the structure. This is what is technically called symmetry-breaking.

Although 1-D structures with twin defects that cause the symmetry breaking had been synthesized earlier, we were the first ones to demonstrate a means to achieve symmetry breaking to grow long, single-crystalline, molecular-scale Au wires without using any template.

The mechanism that we demonstrated is general (not reagent-specific) and can be extended to other systems. Importantly, it gives experimentalists access to high-quality wires of molecular dimensions (< 2 nm diameter) for the first time. These are absolutely fantastic model systems to test out several important theoretical predictions, e.g., stability of and transport through such wires and their possible use as interconnects for nanoelectronics applications.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

Our work describes the discovery of a new synthesis method and mechanism that is general and widely applicable. It brings together a variety of concepts relating to the interaction of capping agent with different crystallographic facets in crystals, possibility of selective removal of such capping agents using simple chemistry and the concept of sintering of particles that ultimately provides the symmetry-breaking needed for the growth of the wires.

SW: Would you summarize the significance of your paper in layman's terms?

We have a method to make the thinnest single-crystalline Au wires ever made with a very high aspect ratio with relatively few defects. The best efforts before that produced wires that were typically about five times thicker, 10-100 times shorter, and had a higher defect density.

Coauthor
Aditi Halder

To put it in perspective, if we were to scale our wires to a macroscopic gold chain, approximately 2 mm thick, it would be about 2 meters long. The reason this is interesting is that the wire is a single crystal with no high-angle grain boundaries.

Theoretical studies predict high stability and exotic transport behavior through such wires. Our synthesis method provides the first-time opportunity to investigate the properties of such thin wires that also have several potential applications in nanoelectronics, sensors, and catalysis, to name a few.

SW: How did you become involved in this research and were any particular problems encountered along the way?

Our group has been interested in understanding the mechanisms of formation of nanostructures as one of the major themes and particularly schemes to induce symmetry breaking to produce anisotropic nanostructures. We have been investigating templateless methods to synthesize nanowires and also methods for synthesis of plate-shaped structures.

Our research effort has led to the development of morphology diagrams to predict the conditions for formation of plate-shaped structures for the first time (*Nanotechnology,* 2008; *Biomaterials* 2008*; J. Colloid Interface Sci.,* 2009; *J. Phys. Chem. C,* 2009) and, in addition, symmetry-breaking schemes for the formation of wires. Our approach has been to apply and combine principles available from other related fields to understand mechanisms of nanostructure nucleation and growth.

SW: Where do you see your research leading in the future?

We anticipate wide use of our method and also newer methods based on our idea for the synthesis of ultrathin wires of Au and other metals/alloys. The possibility of direct measurement of transport through such wires will lead to critical evaluation of existing theories of electrical and thermal transport through such wires and possibly even lead to some newer and unexpected experimental observations.

On the application front, these wires could become the preferred interconnects of the future, due to their higher stability against electromigration, for instance. The possibility of formation of alloy wires and hybrids will further multiply the areas in which these wires will find applications.

SW: Do you foresee any social or political implications for your research?

We foresee advances in theoretical and experimental understanding of transport behavior through molecular scale wires and the use of such wires as fundamental building blocks for a variety of applications.

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KEYWORDS: INTEGRATED NANOSYSTEMS; QUANTUM CONDUCTANCE; METAL NANOWIRES; NANOPARTICLES; GROWTH; NANOSTRUCTURES; NANOCRYSTALS; ORGANIZATION; ADSORPTION; AMINES.

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