Nano World: Nanoparticle balls for silicon

June 9 2006

An international team of university and industry scientists has discovered a way to improve nanoparticles used to make advanced circuits. These findings could help improve the reliable large-scale manufacture of high quality chips, experts told UPI's Nano World.

When it comes to making advanced circuitry, the silicon wafers they are based on must be as free of defects and flat as possible. Nanoparticles made of ceria, or cerium dioxide, are some of the abrasives used to smoothen out these wafers.

As the size of the circuitry features shrink to pack more computing power into microchips, the industry has to defects down to ensure mass manufacture of chips remains viable. This remains especially true as inventors develop electronic structures only nanometers or billionths of a meter in size, the scale of molecules. The problem is that ceria nanoparticles synthesized by existing techniques are irregularly faceted crystals, the sharp edges of which are prone to scratching the silicon wafers, explained researcher Zhong Lin Wang, a materials scientist in nanotechnology at the Georgia Institute of Technology in Atlanta.

For superior performance, nanoparticles that are perfect spheres are ideal because they would act like ball bearings, polishing the silicon surface without scratching it. After three years of research, Wang and his colleagues in the United States, Britain and China have now developed a way of creating spherical ceria nanoparticles at large scales.

In tests of their spherical nanoparticles on silicon wafers, the researchers said they could reduce polishing defects by 80 percent. These nanoparticles are currently under evaluation for use in the processing of next-generation chips, Wang said. He and his colleagues describe their findings in the June 9 issue of the journal Science.

Creating spherical nanoparticles is a challenge because it takes more energy for the crystals to assume a stable, round shape than faceted ones. To overcome this challenge, the researchers incorporated titania, or titanium dioxide, into the mix. They dissolved cerium and titanium precursors in an alcohol solvent and sprayed the solution in a fine mist into a combustion chamber, where it was lit on fire and instantaneously combusted to form a nanoparticle smoke.

By keeping titanium concentrations relatively high and maintaining the flame temperature at roughly 2500 degrees C, the investigators were able to enable the crystallization of a ceria core while keeping the titania shell that developed in a molten state. This molten shell helps stabilize the surface of the crystal as it grows, helping it to reach a round shape.

"This is the first demonstration of synthesizing spherical ceramic nanoparticles that are single crystal. The approach and mechanism demonstrated here could be adopted for other oxide systems, possibly opening another field in nanoparticle research and applications," Wang said.

Beyond applications for abrasives, this approach to create architectures based on cores and shells "might have implications in cosmetics, catalysis, optoelectronics, and the fabrication of nanoscale devices from well-defined nanoparticle building blocks," said materials scientist Jeff Brinker at Sandia National Laboratory in Albuquerque.