

New nanocluster to boost thin films for semiconductors

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Oregon researchers have synthesized an elusive metal-hydroxide compound in sufficient and rapidly produced yields, potentially paving the way for improved precursor inks that could boost semiconductor capabilities for large-area applications.

The key to a "bottom-up" production of possibly the first heterometallic gallium-indium hydroxide nanocluster was the substitution of nitroso-butylamine as an additive in place of nitrosobenzene.

The substitute was identified during a comprehensive screening of potential alternatives by Zachary L. Mensinger, a doctoral student in the lab of University of Oregon chemist Darren W. Johnson. The additive acts to optimize and speed crystallization, allowing for reaction yields up to 95 percent. Comparable compounds traditionally made under caustic conditions often take months or even years to crystallize and result in low yields.

"The benefit is that we can predictably control the ratio of gallium and indium in these structures at molecular levels, which can result in the same control in the fabrication of semiconductor thin films," Johnson said. "We can tailor the properties for specific applications or for different performance levels."

Six University of Oregon and Oregon State University collaborators, working under the umbrella of the Oregon Nanoscience and Microtechnologies Institute (ONAMI), a state signature research center,

describe their findings a paper to appear in the German Chemical Society's journal *Angewandte Chemie* (Applied Chemistry) International. The research, published early online, also was performed under the auspices of a new National Science Foundation-funded Center for Green Materials Chemistry, operated jointly by the two Oregon universities.

"Researchers working in the solid-state materials community are looking at these kinds of nanoclusters as precursors for thin films and other advanced materials, but you typically cannot get them in high enough yields," said Johnson, who also is a member of the UO's Materials Science Institute. "Our synthesis, however, allows for gram-scale quantities."

The results represent a significant breakthrough in the way liquids are produced for semiconductor fabrication, said co-author Douglas A. Keszler, distinguished professor of chemistry at Oregon State and adjunct UO chemistry professor. "We now have new methods for pushing printed inorganic electronics to higher levels of performance within a useful class of materials."

Researchers in Johnson's lab have been experimenting with low-temperature production of a series of such heterometallic nanoclusters, which consist of 13 atoms and contain two different metals in the metal 13 framework, which may prove desirable for long-term applications in solid-state electronics. The nanocluster identified in the paper is labeled a Ga₇In₆ hydroxide.

"We're starting from a bottom-up approach, in that we can make these with the ratios we desire already built in," Mensinger said. "Using this nitroso compound, we get a higher yield and at a larger scale. I screened several of these compounds to narrow down the best choice. We can also re-use the nitroso compound. It is still present at the end of the reaction, so we can remove it and use it in future reactions."

While the nitroso compound produces usable amounts of nanoclusters for potential semiconductor applications and is reusable in subsequent production, it is toxic, Johnson noted. "It is great because it allowed us to make these clusters that had never been made before, but it is not truly a green-chemistry method," Johnson said. "We're looking at how it works and hope to replace it with a more benign reagent."

Source: University of Oregon

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