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**SURFACE SCIENCE**

# NANODOTS BELOW THE SURFACE

Ion-beam method forms nanometer-sized metal crystals in an insulator

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In a simple procedure developed at the University of Houston, low-energy ion beams have been used to form nanometer-sized metallic structures--quantum dots--in an insulating medium. The Texas researchers show that the technique produces well-defined microscopic composites that may be useful in all-optical switching and computing applications due to the structures' unique optical properties.

High-energy techniques are used in a number of industries to implant ions into various materials, thereby customizing their properties. Ion beams with tens of thousands to hundreds of thousands of electron volts of energy, for example, are used to modify the optical properties of certain types of glass. Similar procedures are used in semiconductor processing to tailor electronic properties.

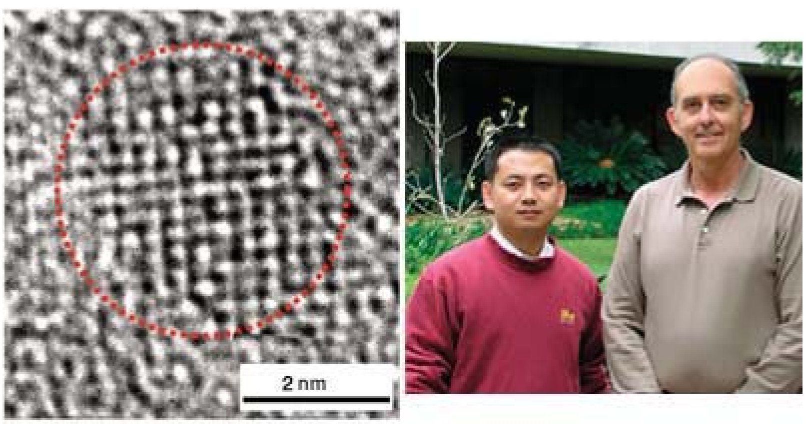
Lower energy ion-beam techniques have been developed recently for various nanofabrication processes. But typically those methods lead to structures and subsurface regions that are amorphous and spread out across a fairly large area.

Now, University of Houston chemistry professor J. Wayne Rabalais, graduate student Jian P. Zhao, and their coworkers have shown that uniformly sized titanium crystals measuring roughly 3 to 4 nm can be embedded in quartz ($SiO_2$) using beams of $Ti^+$ ions with relatively low energy--just 9 keV [*Appl. Phys. Lett,* **83,** 3590 (2003)]. The results confirm predictions and computational results published by the group previously.

By controlling experimental parameters such as substrate temperature and ion dose, Rabalais points out, the group is able to alter the size, distribution, crystallinity, and penetration depth of the titanium nanocrystals. The structure of the implanted quantum dots was analyzed using high-resolution transmission electron microscopy, and the chemical composition was determined using an X-ray method.

Dennis C. Jacobs, a chemistry professor at the University of Notre Dame, remarks that the new technique expands the set of tools available for preparing novel solid-state materials. Because the procedure can be carried out at room temperature, "the approach can be combined readily with existing nanofabrication strategies," he notes.

At the University of Illinois, Chicago, chemistry professor Luke Hanley is equally enthusiastic about the study. "It is surprising and significant that instead of residing as a continuous distribution of Ti atoms in the $SiO_2$ matrix, these atoms coalesce into approximately 3- to 4-nm crystalline structures," he tells C&EN. He adds that "it is likely that similar structures can be created in other materials by this method, making Rabalais' work an important breakthrough in nanotechnology."




**INNER CIRCLE** **The distinctive pattern inside the red circle indicates a crystalline titanium nanodot embedded in quartz.**
**UNIVERSITY OF HOUSTON IMAGE**