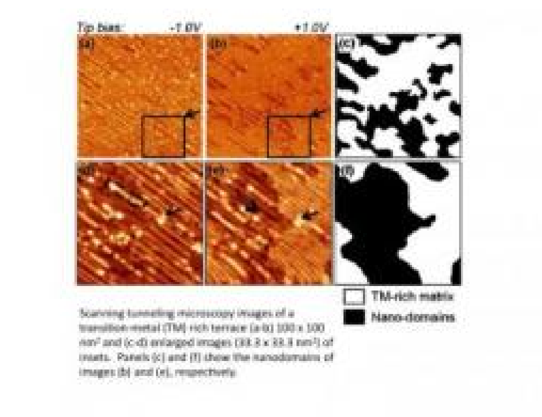
Researchers find strange new nanoregion can form in quasicrystals

February 16 2012



Scientists at the US Department of Energy's Ames Laboratory discovered a new type of quasicrystal defect. Shown here are scanning tunneling microscopy images of transition-metal quasicrystals' surface and nanodomains. Credit: Ames Laboratory -- USDOE

A team of international researchers has discovered a new type of structural anomaly, or defect, that can appear in quasicrystals, a unique material with some crystal-like properties but a more complex structure.

Pat Thiel, senior chemist at the U.S. Department of Energy's Ames Laboratory, led the international team, which includes scientists from the Institut Jean Lamour at Nancy-Université in France.

In crystals, a "defect" refers to any departure from perfect structural symmetry. While the term suggests an undesirable quality, not all defects are bad; many control or influence key material properties, such as chemical purity, mechanical strength, conductivity, color, corrosivity or surface properties. Rubies, for instance, are red due to a defect that turns an otherwise non-descript crystal into a valuable gem.

Quasicrystals were already known to have a type of defect called a phason flip, which can form at the surface. The new defect type was discovered after researchers observed mysterious nano-sized areas on quasicrystal surfaces. Unlike the phason flip, however, the new defect type extends beyond the surface region and into the bulk of the quasicrystal.

"Quasicrystals are such fascinating materials – they seem to always exhibit features that are unexpected, starting with their very existence," said Thiel, who is also Iowa State University's John D. Corbett Distinguished Professor of Chemistry.

It wasn't until 1982, in fact, when Dan Shechtman observed the seemingly impossible – a well-defined but non-repeating arrangement of atoms under his electron microscope – that quasicrystals were found to exist. It took even longer for the scientific community to accept their existence. Shechtman, a materials scientist with Ames Lab, Iowa State University and Technion-Israel Institute of Technology, won the 2011 Nobel Prize in Chemistry for his discovery.

The recent discovery of the new defect type shows quasicrystals are still yielding surprises. While the nanodomain defect isn't always present – it only occurs under certain circumstances to help balance competing energetic issues – its formation at those times enables higher-energy transition-metal-rich surfaces to be exposed rather than the expected lower-energy aluminum-rich surfaces.

Because nanostructures show promise for use in a range of applications, from medical to electronics, understanding the relationship between surface and bulk defects in materials may yield greater insights into why nanostructures are often unusually strong.

"It's already known that in nanowires, their strength is related to the fact that the surface can 'erase' the bulk defects," Thiel said. "But then eventually under extreme conditions even a nanowire can fail, and the surface seems to play a role in that event as well. So the relationship between surface and bulk defects really is very important."

Provided by Ames Laboratory