Researchers Develop Clear Picture Of 'Birth' Of Semiconductor Nanostructures

March 9 2005

University of Arkansas researchers have witnessed the birth of a quantum dot and learned more about how such atomic islands form and grow, using the ultrahigh vacuum facility on campus. This information will help researchers better understand and use materials that could lead to small, efficient and powerful computers, communication devices and scientific instruments.
Seongho Cho, Zhiming Wang, and Gregory Salamo report their findings in the upcoming issue of the journal *Applied Physics Letters*.

"We have changed the way people have to think about how nanostructures grow on a surface," said Salamo, University Professor of physics. "People had a different idea of how these islands formed, but until now there was not direct evidence."

The researchers combined the molecular-beam epitaxy machine, which creates material atom by atom, with scanning tunneling microscopy, which can observe the atoms, to witness the creation of quantum dots, or atomic islands, of indium gallium arsenide (InGaAs) atoms atop a gallium arsenide (GaAs) surface. InGaAs is a material of electronic and optical interest for properties that could enhance communications equipment, computers and electronics.

At the atomic level, a surface is characterized by small monolayer "steps." Until now, researchers believed that the first atom of a quantum dot would land at the base of the step, rather than further out towards the edge of the step. The work of Cho, Wang and Salamo shows instead that the first atom lands at the step's edge.

"An island growing from below the step edge must first build up to a height equal to the step. This is unnecessary since it could more easily just start from the top of the step," said Wang, a research professor working with Salamo.

The researchers found that the first atoms of InGaAs land side by side atop the GaAs surface and experience a strain, much like a person trying to squeeze into an already crowded line. Therefore, after a short time, it becomes easier for an InGaAs atom to land atop other InGaAs atoms instead of on the initial surface. Also, fewer atoms land on a layer as the layers build up, allowing the atoms to have more space and experience less strain. The researchers witnessed this sequential, upward, narrowing growth as they studied the formation of the InGaAs quantum dots, which ended by forming a pyramid-like structure.

This observation also is significant because it may offer a more general explanation of how other semiconductor materials behave at the nanoscale, Wang said.

"It was predicted by previous theory independent of materials, but wasn't observed for InGaAs islands before," he said.

"We do not yet have a complete picture of how these quantum dots grow," Salamo said. "But we have added to the picture."

This picture has implications that extend beyond semiconductors, he added.

"How these small structures grow and how they behave tells us about the rules that govern small structures in general," Salamo said. "Cells are small. DNA is small. Everything is composed of small structures. When you understand how things go together, they supply a library for looking at other things in science."

Source: University of Arkansas

Citation: Researchers Develop Clear Picture Of 'Birth' Of Semiconductor Nanostructures (2005, March 9) retrieved 24 April 2024 from https://phys.org/news/2005-03-picture-birth-semiconductor-nanostructures.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.