New microscope captures movements of atoms and molecules

November 22 2013

A new microscope invented at Michigan State University allows scientists to zoom in on the movements of atoms and molecules. Credit: Michigan State University

A new microscope invented at Michigan State University allows scientists to zoom in on the movements of atoms and molecules.

Electron microscopes allow scientists to see the structure of microorganisms, cells, metals, crystals and other tiny structures that weren't visible with light microscopes. But while these images have allowed scientists to make great discoveries, the relationship between structure and function could only be estimated because of static images. In the 1990s, researchers added a fourth dimension – time – by using a laser to capture images of gaseous molecules as they were reacting.

Now, Chong-Yu Ruan, MSU associate professor of physics and astronomy, has brought these "molecular movies" down to the nanoscale level, where the properties of materials begin to change. The work has applications in nanoelectronic technologies and in clean-energy industries.

Ruan's team is one of the few in the world actively developing electron-based imaging technology on the femtosecond timescale. One femtosecond is one-millionth of a billionth of a second – a fundamental timescale that atoms take to perform specific tasks, such as mediating the traffic of electrical charges or participating in the chemical reactions.

"Implementing such a technology within an electron microscope setup allows one to examine crucial functions in nanoscale devices," Ruan said. "The goal is to explore the limits where specific physical, chemical and biological transformations can occur."

Ruan and his collaborators filed a patent on the device, and he also envisions the essential components of the device being modular so they can be add-ons to an existing electron microscope, allowing scientists to extend the capabilities of these devices without building the whole device.

"An electron microscope costs between $1 million and $10 million," Ruan said. "I expect our device to cost as little as $500,000. It would allow electron microscopes to be updated with increased resolution for less money than buying a new one."

Ruan's research builds on the work of Ahmed Zewail at the California Institute of Technology. Ruan worked as a postdoctoral scholar with Zewail, who received the Nobel Prize in Chemistry in 1999 for showing how atoms in a molecule move during a chemical reaction.

Ruan is expanding the work to ultrafast electron crystallography, which allows him to look at nanocrystals, their bonds and how they're affected by their surfaces and water. He's also working to develop a radio frequency-enabled, high-brightness electron microscope.

In 2010, Ruan received a U.S. Department of Energy grant to set up his lab at MSU. In 2011, he and Martin Berz and Phillip Duxbury, MSU professors of physics and astronomy, and Martin Crimp, professor of chemical engineering, were awarded a National Science Foundation grant to begin building the device.

Ruan, Berz, Duxbury and Crimp are part of the organizing committee for the forthcoming Femtosecond Electron Imaging and Spectroscopy Conference Dec. 9-12, which will focus on the future for this field of research.

Provided by Michigan State University