New class of materials discovered; could boost computer memory

September 18 2012, by Tom Simons

From left, Evgeny Tsymbal, Yong Wang (now at the Pacific Northwest National Laboratory in Richland, Wash.) and J.B. Burton; with a portion of the Holland Computing Center supercomputer in the background.

(Phys.org)—An international team of scientists, including University of Nebraska-Lincoln physicist Evgeny Tsymbal, has discovered a new class of materials that could prove to be very useful in developing new methods of creating computer memory.

The research team, led by Christos Panagopoulos of Nanyang Technological University in Singapore, explored layered heterostructures at the atomic scale, in which different materials were deposited in layers a few atoms thick. They discovered that the new class of materials boasts a very attractive property—ferroelectricity, which may be used to create new types of data storage devices.

A ferroelectric material exhibits spontaneous electric polarization, characterized by a positive electric charge on one side of the material and negative on the opposite side. The polarization can be reversed by applying an electric field (from a battery, for example). These two possible polarization orientations make these materials attractive for developing computer memory because each orientation could correspond to 0 or 1.

"Our discovery shows a possibility that researchers could engineer properties at the atomic scale and create new, artificial materials exhibiting novel functional properties not existing in their constituents," said Tsymbal, who is Charles Bessey Professor of Physics and director of UNL's Materials Research Science and Engineering Center (MRSEC). "This significantly broadens the class of known ferroelectric materials and provides possibilities to design new ferroelectrics."

The new materials were fabricated and characterized by researchers from the Foundation for Research and Technology-Hellas in Greece, Nanyang Technological University in Singapore, and Sungkyunkwan University in South Korea. Using advanced synthesis methods, scientists were able to fabricate heterostructures by depositing atomic layers of different materials, layer-by-layer, in stacks of thickness of a few nanometers. Although neither of the constituent materials were ferroelectric, the composed heterostructures showed a pronounced ferroelectric polarization.

The nature of this phenomenon was unclear at first, but UNL scientists led by Tsymbal found the explanation of this behavior. They modeled the atomic structure and electronic properties of these materials by performing computations at UNL's Holland Computing Center, which indicated that interfaces between the constituent materials in the heterostructures were responsible for the observed novel properties.

"Crucially, our computations and analysis were decisive for the understanding of the origin of ferroelectricity in the experimentally synthesized heterostructures," Tsymbal said. "We were able to elucidate the microscopic mechanism responsible for their exciting properties."

In addition,Tsymbal said, the discovered materials exhibited magnetoelectricity, an important functional property that allows it to affect electric polarization by the application of a magnetic field.

"This functionality is especially interesting because of potential application in electrically-controlled data storage with significantly reduced energy consumption," Tsymbal said. "Our MRSEC dedicates strong efforts to study magnetoelectric materials and has international recognition in this field of research."

The findings were reported today in the Sept. 18 issue of *Nature Communications*, the Nature Publishing Group's multidisciplinary online journal of research in the biological, physical and chemical sciences.

The co-lead authors of the paper are Yong Wang, a former graduate student in Tsymbal's group and now a postdoctoral fellow at Pacific Northwest National Laboratory in Richland, Wash., and J.B. Burton, a former graduate student and postdoctoral fellow and now a research assistant professor in Tsymbal's group.

Tsymbal's research has funding support from the National Science Foundation, the Department of Energy, and the Nebraska Experimental Program to Stimulate Competitive Research (EPSCoR).

It's the seventh time in last six years that research from Tsymbal's lab has been published in of the five highest-impact interdisciplinary journals—*Science*, the *Proceedings of the National Academy of Sciences*, *Nature Nanotechnology*, *Nature Materials* and *Nature Communications*.

Provided by University of Nebraska-Lincoln