Tunneling Across a Ferroelectric

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University of Nebraska-Lincoln physicist Evgeny Tsymbal's groundbreaking identification of an emerging research field in electronic devices earned publication this week in *Science* magazine.

Tsymbal, a professor of physics and astronomy at UNL and a specialist in spin electronics at UNL's Materials Research Science and Engineering Center and the Nebraska Center for Materials and Nanoscience, identified and provided an overview on electron tunneling through ultra-thin layers of spontaneously polarized materials as an important new area for applied physics research.

In "Tunneling Across a Ferroelectric," in the July 14 issue of *Science*, published by the American Association for the Advancement of Science, Tsymbal and collaborator Hermann Kohlstedt of the Research Center in Julich, Germany, highlighted emerging research on ferroelectric tunnel junctions.

The phenomenon of electron "tunneling" through nonconductive barriers has been known since the advent of quantum physics. But Tsymbal noted in his article that new research and experimental collaboration on practical applications of the theory are becoming likely and necessary, and that new studies will open an avenue for the development of new electronic devices.

Tsymbal described ferroelectric tunnel junctions this way: Metal conducts electric currents and insulators block them. But if an ultra-thin layer of an insulating material about one nanometer thick is placed between two metal electrodes and a voltage is applied, electrons are able to tunnel through the barrier. Using a ferroelectric material as the insulating barrier layer adds new functional property to a tunnel junction because of the spontaneous polarization of the material. Ferroelectric tunnel junctions could be used for different applications such as nonvolatile memories for computers.

"Our prediction is that it's possible to change significantly the resistance of this tunnel junction by changing the polarization orientation," Tsymbal said. "That's in theory. In order to realize the prediction in practice, many things have to be done: Scientists must learn how to grow very thin ferroelectrics and control their properties. There are several experimental groups worldwide who demonstrate that this is possible."

Tsymbal and his group will continue the research to deepen the understanding of the theory in the materials and devices, and will work to join researchers at UNL in physics, chemistry and engineering to collaborate in this field.

He has visited a major computer manufacturer and finds that researchers are interested in the concept and the idea of combining ferroelectric and magnetic materials to broaden opportunities for future technologies. For example, the coupling between ferroelectricity and magnetism in a single device may yield entirely new device paradigms, such as transducers converting between magnetic and electric fields or electric field-controlled magnetic data storage.

"There are many different possibilities that we can't even imagine at the moment -- maybe 20 years from now -- which might be feasible due to additional functionalities offered by the present ferroelectric junctions," Tsymbal said.

"It's an emerging field of promising research. This article may excite people and stimulate further research on this subject. The fact that a representative of the University of Nebraska is publishing the topic in *Science* is definitely a recognition in the worldwide solid state physics research community of the expertise at Nebraska."

Much of Tsymbal's research interests are in theory of electronic transport in nanostructures. He also leads a research group in condensed matter theory and coordinates an interdisciplinary research group in the Materials Research Science and Engineering Center. His research group has also published several papers on tunnel junctions in *Physical Review Letters*, one of the most prestigious physics journals.

Source: University of Nebraska-Lincoln

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