The quest to discover new technology

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Electronic devices like smart phones, computers and mp3 players have become central pieces of everyday life and consumers have grown accustomed to seeing new and improved models every time they turn around. But continuing that trend is dependent on one thing: the emergence of new technology.

"We are approaching fundamental limits for storing information due to basic physical principles that don't allow us to use the same methods and the same technology to continue this trend," said Evgeny Tsymbal, professor of physics and astronomy at the University of Nebraska-Lincoln and director of UNL's Materials Research Science and Engineering Center.

Finding threads of possibilities for that new technology drives Tsymbal's work, which includes studying the theory of electronic transport in nanostructures. Such work has the funding support of the National Science Foundation, Nebraska Experimental Program to Stimulate Competitive Research and the Nebraska Research Initiative.

Now a team of researchers from multiple institutions, including Tsymbal and others at UNL, has made some intriguing discoveries that will aid research into identifying new technology -- the very stuff that could someday make electronic devices faster, smaller and smarter.

With the help of graduate students Karolina Janicka and Yong Wang, and postdoctoral associate Manish Niranjan, Tsymbal played a key role in a collaborative project led by Chang-Beom Eom, professor of materials science and engineering at the University of Wisconsin-Madison. Other researchers at Wisconsin, the University of Michigan, and the Argonne and Brookhaven national laboratories also contributed to findings that were published Feb. 18 in the journal *Science*.

Related findings also uncovered in collaboration with Wisconsin researchers have been published in the new issue of Proceedings of the National Academy of Sciences.

The *Science* publication is based on the team's study of how electrons behave in the spaces between oxide materials called interfaces. Oxide materials are compounds that contain oxygen and most of them are insulating, or not able to conduct an electrical current.

Previous research has found that it is possible to create a conducting interface between two oxide materials. The team's new findings build on that by explaining that electronic correlations control the interface's conducting properties.

Electronic correlations depend on how far apart electrons are distributed and determine how dynamically they move. A good analogy is to compare electrons to people in a crowded space. Both have the best chances at getting to where they're going quickly and efficiently if they can avoid collision.

By inserting a single layer of atoms into that interface, researchers found that they could control the electrons to move in tandem.

The discovery shows a possibility that researchers could engineer properties at the atomic scale and create new, artificial materials that could be used in new and exciting ways, Tsymbal said.

"This is why these particular systems are interesting, so we may scale our devices to much smaller dimensions compared to what we have at the moment," he said. "That may allow us to make smarter devices and have faster communications."

The research findings appearing in *PNAS* are similar in that they also considered electron behavior at the interface. The findings addressed how electrons behave if the interfaces are compressed or stretched.

The experimentalists at Wisconsin strained the interfaces, while Tsymbal's group used theoretical modeling to explain what was happening. It turned out that strain displaced atoms, which ultimately affected the electronic properties of the interface, Tsymbal said.

"The capability to control electric currents at the interface by strain may serve as a basis of new logic devices," he said.

Provided by University of Nebraska-Lincoln

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