New nano techniques integrate electron gas-producing oxides with silicon

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(PhysOrg.com) -- In cold weather, many children can't resist breathing onto a window and writing in the condensation. Now imagine the window as an electronic device platform, the condensation as a special conductive gas, and the letters as lines of nanowires.

A team led by University of Wisconsin-Madison Materials Science and Engineering Professor Chang-Beom Eom has demonstrated methods to harness essentially this concept for broad applications in nanoelectronic devices, such as next-generation memory or tiny transistors. The discoveries were published Oct. 19 by the journal *Nature Communications.*

Eom's team has developed techniques to produce structures based on electronic oxides that can be integrated on a silicon substrate-the most common electronic device platform.

"The structures we have developed, as well as other oxide-based electronic devices, are likely to be very important in nanoelectronic applications, when integrated with silicon," Eom says.

The term "oxide" refers to a compound with oxygen as a fundamental element. Oxides include millions of compounds, each with unique properties that could be valuable in electronics and nanoelectronics.

Usually, oxide materials cannot be grown on silicon because oxides and silicon have different, incompatible crystal structures. Eom's technique combines single-crystal expitaxy, postannealing and etching to create a process that permits the oxide structure to reside on silicon-a significant accomplishment that solves a very complex challenge.

The new process allows the team to form a structure that puts three-atom-thick layers of lanthanum-aluminum-oxide in contact with strontium-titanium-oxide and then put the entire structure on top of a silicon substrate.

These two oxides are important because an "electron gas" forms at the interface of their layers, and a scanning probe microscope can make this gas layer conductive. The tip of the microscope is dragged along the surface with nanometer-scale accuracy, leaving behind a pattern of electrons that make the one-nanometer-thick gas layer. Using the tip, Eom's team can "draw" lines of these electrons and form conducting nanowires. The researchers also can "erase" those lines to take away conductivity in a region of the gas.

In order to integrate the oxides on silicon, the crystals must have a low level of defects, and researchers must have atomic control of the interface. More specifically, the top layer of strontium-titanium-oxide has to be totally pure and match up with a totally pure layer of lanthanum-oxide at the bottom of the lanthanum-aluminum-oxide; otherwise, the gas layer won't form between the oxide layers. Finally, the entire structure has been tuned to be compatible with the underlying silicon.

Provided by University of Wisconsin-Madison