

Integration of novel materials with silicon chips makes new 'smart' devices possible

July 21 2016, by Matt Shipman

Researchers from North Carolina State University and the U.S. Army Research Office have developed a way to integrate novel functional materials onto a computer chip, allowing the creation of new smart devices and systems.

The novel functional materials are oxides, including several types of materials that, until now, could not be integrated onto silicon chips: multiferroic materials, which have both ferroelectric and ferromagnetic properties; [topological insulators](#), which act as insulators in bulk but have conductive properties on their surface; and novel ferroelectric materials. These materials are thought to hold promise for applications including sensors, non-volatile computer memory and microelectromechanical systems, which are better known as MEMS.

"These novel oxides are normally grown on materials that are not compatible with computing devices," says Jay Narayan, the John C. Fan Distinguished Chair Professor of Materials Science and Engineering at NC State and co-author of a paper describing the work. "We are now able to integrate these materials onto a silicon chip, allowing us to incorporate their functions into electronic devices."

The approach developed by the researchers allows them to integrate the materials onto two platforms, both of which are compatible with silicon: a titanium nitride platform, for use with nitride-based electronics; and yttria-stabilized zirconia, for use with oxide-based electronics.

Specifically, the researchers developed a suite of [thin films](#) that serve as a buffer, connecting the [silicon chip](#) to the relevant [novel materials](#). The exact combination of thin films varies, depending on which novel materials are being used.

For example, if using [multiferroic materials](#), researchers use a combination of four different thin films: titanium nitride, [magnesium oxide](#), strontium oxide and lanthanum strontium manganese oxide. But for topological insulators, they would use a combination of only two thin films: magnesium oxide and [titanium nitride](#).

These thin film buffers align with the planes of the crystalline structure in the novel oxide materials, as well as with the planes of the underlying substrate - effectively serving as a communicating layer between the materials.

This approach, called thin film epitaxy, is based on the concept of domain-matching epitaxy, and was first proposed by Narayan in [a 2003 paper](#).

"Integrating these novel [materials](#) onto silicon chips makes many things possible," Narayan says. "For example, this allows us to sense or collect data; to manipulate that data; and to calculate a response - all on one compact chip. This makes for faster, more efficient, lighter devices."

Another possible application, Narayan says, is the creation of LEDs on silicon chips, to make "smart lights." Currently, LEDs are made using sapphire substrates, which aren't directly compatible with computing devices.

"We've already patented this integration technology, and are currently looking for industry partners to license it," Narayan says.

The paper, "Multifunctional epitaxial systems on silicon substrates," is published online in the journal *Applied Physics Reviews*.

More information: Srinivasa Rao Singamaneni et al, Multifunctional epitaxial systems on silicon substrates, *Applied Physics Reviews* (2016).
[DOI: 10.1063/1.4955413](https://doi.org/10.1063/1.4955413)

Provided by North Carolina State University

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