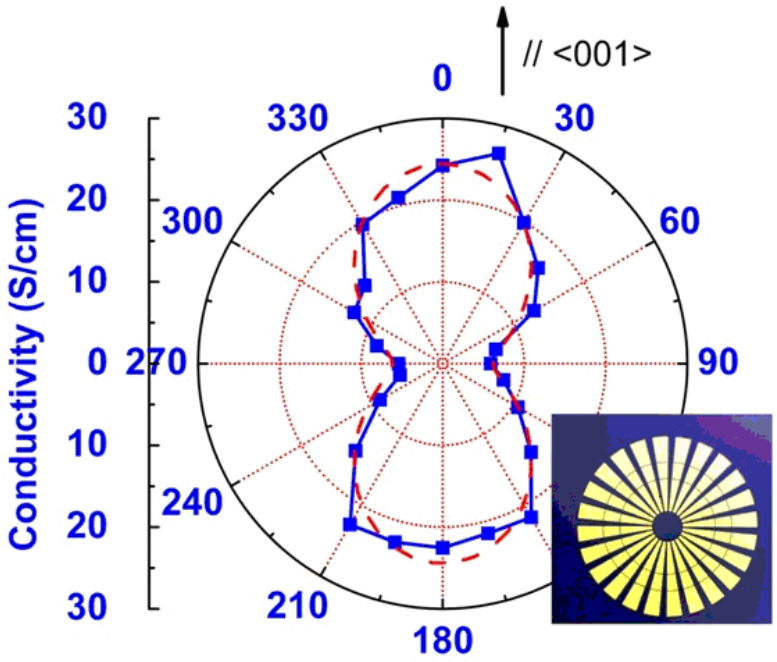
Nanoelectronics Research



Our group has a strong interest in the metal-insulator transition of vanadium dioxide (VO_2). VO_2 is a paradigm of strongly correlated oxides and shows many intriguing properties that are still not understood and remain great intellectual challenges. Learning the fundamental rules behind these correlations will pave the way toward designing and fabricating new generations of materials whose behaviors are predictable and perhaps even useful. Another focus of our research is on multiferroic thin films which are of great interest for next generation Spintronics. Multiferroic materials have the combination of magnetic, electric dipole, and/or stain ordering. The coupling between magnetization and electric polarization in the multiferroics could lead to new flexible functionalities for future logic and memory devices.

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"Pursuing the applications of multifunctional complex oxide thin films in logic and memory devices."

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Vanadium Dioxide

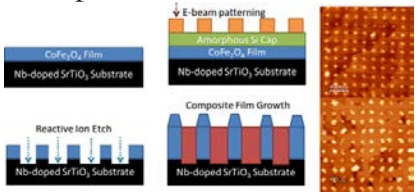
Vanadium dioxide, a strongly correlated oxide, has recently been shown to exhibit a very fast metal-semiconductor transition (MST) (<1 ps) at room temperature, triggered by current injection or electric field, the nature of which is yet to be determined. Understanding the nature of this transition is not only an intellectual challenge, but can also be of great interest in developing ultrafast and low energy electronic and optical switches. We are working to understand the effect of stoichiometry, defect chemistry and microstructure on the current-induced MST in vanadium dioxide and related doped oxides. Electrochemical synthesis methods are used due to their unique ability to control crystallinity, oxygen stoichiometry and defect density in metal oxides, as well as their capability to fabricate nanostructured materials, i.e. nanowires. We are investigating the synthesis conditions capable to produce vanadium and mixed oxides with controlled crystal structure and tunable oxygen stoichiometry, and in performing transport measurements in different geometries in order to establish a definite correlation between structural properties and the MST. In particular, we are looking at the effect of strain and doping on the MST. Finally, we are synthesizing oxide nanowires to investigate the effect of geometry and localization on the current-induced transition, with the possibility to implement them for the nano-sized electric switches.

Multiferroic Materials

An exciting development in the field of multiferroic nanocomposites was the finding that codeposition of a ferroelectric perovskite and a ferrimagnetic spinel led to the growth of a self-assembled structure in which magnetic pillars are epitaxially embedded in a ferroelectric matrix. Application of an electric field led to piezoelectric strain and a consequent magnetoelastic anisotropy that could reorient the magnetization direction in the pillars. Controlling the locations of the pillars and the lattice mismatch between the components provides an exciting opportunity to make logic and memory devices. We are currently developing the synthesis of directed assembled nanocomposites that will be used to realize ultra-low energy dissipation and non-volatile spin logic and memory devices.

RECENT RESEARCH DEVELOPMENTS

- Developed the synthesis of VO_2 on a metallic template to reduce switch voltages in nanoscale VO_2 devices.
- Developed a directed selfassembly technique to form multiferroic nanocomposites and the results were published on Nano Letters.



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RECENT GRANTS

- DOD/DTRA-Science for Novel Radiation-Hardened Electronics Materials
- Nanoelectronics Research Initiative - Phase Transition Switch based on VO_2

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