New research uncovers path to defect-free thin films

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(Phys.org)—A team led by Oak Ridge National Laboratory's Ho Nyung Lee has discovered a strain relaxation phenomenon in cobaltites that has eluded researchers for decades and may lead to advances in fuel cells, magnetic sensors and a host of energy-related materials.

The finding, published in Nano Letters, could change the conventional wisdom that accommodating the strain inherent during the formation of epitaxial thin films necessarily involves structural defects, said Lee, a member of the Department of Energy lab's Materials Science and Technology Division. Instead, the researchers found that some materials, in this case cobaltite, form structurally well ordered atomic patterns that can change their magnetic properties and effectively minimize the size mismatch with the crystalline substrate.

Epitaxial thin films, used in nanotechnology and semiconductor fabrication, are created by growing a crystal layer of one material on another in such a way that the crystalline structures align. The challenge is to grow the film coherently with minimal defects, which can have a catastrophic effect on a material's performance.

"We discovered properties that were not readily apparent in crystal, or bulk, form, but in thin-film form we were able to clearly see the atomically ordered lattice structure of lanthanum cobaltite," Lee said. "With this knowledge, we hope to be able to tailor the physical properties of a material for many information and energy technologies."

The researchers studied the material in different strain states using scanning transmission electron microscopy complemented by X-ray and optical spectroscopy. Using these instruments, the scientists could see unconventional strain relaxation behavior that produced stripe-like lattice patterns. The result is a material with useful magnetic properties and highly suitable for sensors and ionic conductors used in, for example, batteries.

This discovery and the ability to engineer the structure of materials could lead to advanced cathode materials in solid oxide fuel cells and batteries that can be charged much faster.

"Since cobaltites are promising candidates for magnetic sensors, ionic conductors and surface catalysts, this discovery provides a new understanding that can be used for artificial tuning of magnetism and ionic activities," Lee said.

More information: "Strain-Induced Spin States in Atomically Ordered Cobaltites," pubs.acs.org/doi/abs/10.1021/nl302562f

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