Patterning oxide nanopillars at the atomic scale by phase transformation

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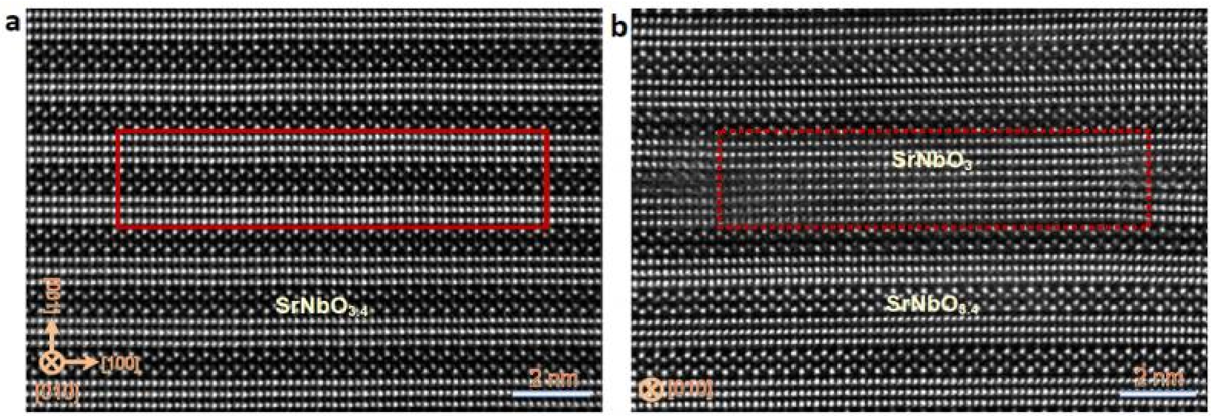

Atomic zip in SrNbO3.4. (a) HAADF STEM image taken before irradiation. The irradiation area is marked by a red open rectangle. (b) HAADF STEM image taken after the electron irradiation for ~300 s showing changes in atomic structure in the irradiated region. The zigzag-like slab in the rectangle is transformed to a chain-like connected structure, resulting in atomic merging of the two neighboring chain-like slabs. The new phase has adopted the structure of SrNbO3. The phase transformation can be well controlled with atomic precision. Credit: *Nano Letters*

Researchers at Tohoku University's Advanced Institute for Materials Research (AIMR) have carried out a collaborative study aimed at precisely controlling phase transformations with high spatial precision, which represents a significant step forward in realizing new functionalities in confined dimensions.

The team, led by Prof. Yuichi Ikuhara, applied the focused electron beam of a scanning transmission electron microscope (STEM) to irradiate $SrNbO_{3.4}$ crystals, and demonstrated a precise control of a phase transformation from layered $SrNbO_{3.4}$ to perovskite $SrNbO_3$ at the atomic scale.

Such a precise control of phase transformations opens up new avenues for materials design and processing, as well as advanced nanodevice fabrication. Full results of the study have been published in *Nano Letters*.

Background

Phase transformations in crystalline materials are of primary fundamental interest and practical significance in a wide range of fields, including materials science, information storage and geological science. To date, it remains highly desirable to precisely tailor the phase transformations in a material due to their potential impact on macroscopic properties and thus many advanced applications.

Despite decades of efforts, precisely controlling phase transformations at the atomic scale still poses a significant challenge due to the intricacies of governing thermodynamic conditions with atomic precision. Recent technical advances in aberration-corrected STEM offer fertile new ground for probing samples by a focused sub-Angström electron beam, opening an avenue for precisely triggering phase transformations.

Breakthrough

This work has demonstrated a successful control of a phase transformation from the layered $SrNbO_{3.4}$ to the perovskite $SrNbO_3$ with atomic precision by manipulating a focused sub-Angström electron beam to any selectable region.

Such a concept - of a precise control of phase transformations with an atomic spatial precision - should be, in principle, applicable not only to $SrNbO_{3.4}$/$SrNbO_3$ but also to other materials, finding applications in material processing and nanodevice fabrication.

Key points :

- Precisely controlling phase transformation with high spatial precision
- Patterning oxide nanopillars at the atomic scale by phase transformation

More information: Chunlin Chen et al. Patterning Oxide Nanopillars at the Atomic Scale by Phase Transformation, *Nano Letters* (2015). DOI: 10.1021/acs.nanolett.5b01847

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