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Reveal of Magnetic Domains and Tunable Supercell Structures in Two-dimensional Layered Oxide Thin Film via Differential Phase Contrast Imaging and Atomic-resolution STEM

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Two-dimensional (2D) layered oxides have recently attracted strong research interests due to the strong coupling effect between charge, spin, lattice and strain, which opens up great flexibility and opportunities in structure construction as well as multifunctionalities exploration [1]. In parallel, owing to the enhanced light-matter interactions effect at the metal-dielectric interfaces, plasmonic hybrid nanostructures exhibit intriguing optical responses beyond naturally existing materials [2,3]. Hence, by incorporating plasmonic metals into the 2D layered complex oxides, it can be expected to achieve versatile physical properties resulting from different material components, leading to enormous possibilities in nanophotonic and electronic devices applications.

In this talk, we demonstrate a novel self-assembled Bi_2MoO_6 (BMO) supercell (SC) structure incorporated with Au nanoinclusions by using one-step pulsed laser deposition (PLD) technique. The distribution of Au nanoparticles within BMO matrix is clarified by 3D tomography (see Figure 1b). In order to determine the magnetic domain structures within the BMO-Au nanocomposite film, we conduct differential phase contrast (DPC) STEM imaging experiment. As shown in Figure 1c and c1-c4, the ADF image and four DPC-STEM images acquired by quadrant annular detectors show different phase contrast due to the deflection of electrons when passing through the magnetic domains within the sample. The constructed magnetic field map (see Figure 1d) shows clear magnetic domain boundaries in the BMO-Au film, revealing the intrinsic ferromagnetic property of the Bi-based SC structures.

Next, atomic-resolution STEM images are taken at different locations within the BMO-Au film (see Figure 2a,c,e). The intensity line profiles based on the HRSTEM images demonstrate three different SC structures of BMO phase, as shown in Figure 2b,d,f. The formation of different types of SC structures can be explained by lattice strain resulted from the lattice mismatch between film and substrate as well as the Au nanoinclusions within the nanocomposite film, which will be discussed in detail. Overall, this study opens a new gate for developing novel 2D layered complex oxides incorporated with plasmonic metal or semiconductor phases exhibiting great potential applications in multifunctional nanoelectronics devices [4].

References:

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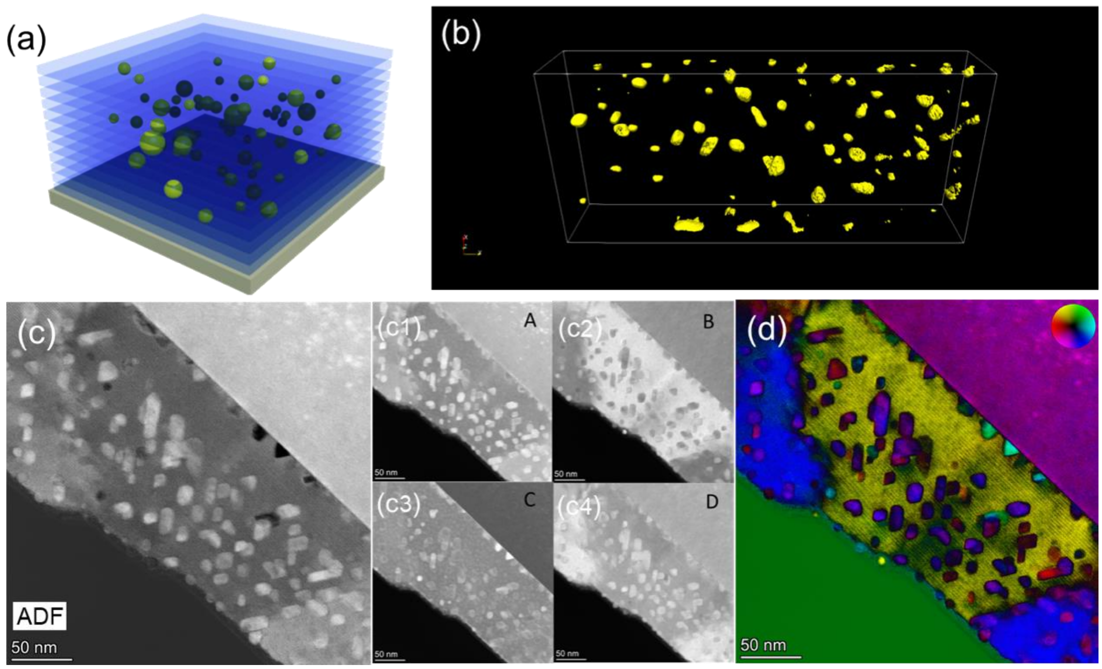

Figure 1. (a) Schematic illustration and (b) 3D tomography image of BMO-Au nanocomposite thin film. (c) ADF image and (c1-c4) DPC-STEM images acquired by four quadrant annular detectors. (d) Constructed magnetic field map for BMO-Au film obtained by DPC-STEM imaging.

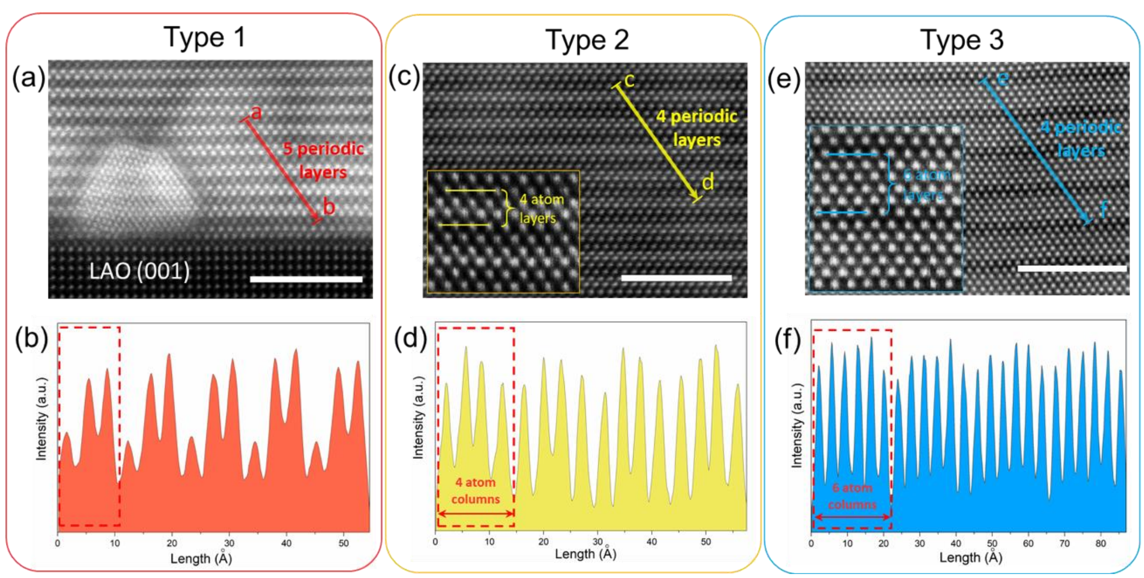

Figure 2. (a,c,e) HAADF-STEM images showing three types of supercell structures of BMO phase within BMO-Au nanocomposite thin film. (b,d,f) Intensity line profiles based on HAADF-STEM images showing the atomic periodicity of three different supercell structures of BMO phase.