Magnetizmo kaita įtakojama BO_6 oktaedrų cheminės jungties ties epitaksinių oksidų sandūra

Tuning magnetism via BO_6 octahedral coupling at epitaxial perovskite oxide interfaces

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Complex perovskite oxides have emerged as multifunctional materials of remarkable tunability and exhibit a wide spectrum of electronic properties including high mobility, magnetism and superconductivity. The perovskite unit cell is composed of A-site cation and BO_6 octahedron where central transition metal cation B is octahedrally coordinated with its oxygen nearest neighbors. Many of the properties are strongly coupled to structural distortions of the BO_6 building block. The distortions of BO_6 octahedron are comprised of rotations and/or deformations due to B-O-B bond angle variations and/or changes of the B-O bond length. In this talk I will show that these corner-sharing BO_6 octahedral distortions provide an effective way for substrate-induced stress accommodation and represent an important tuning mechanism of physical properties in epitaxial ABO_3 thin films. As an example, I will demonstrate how the mismatch strain induces octahedral distortions in epitaxial $La_{1-x}Sr_xMnO_3$ and $SrRuO_3$ thin films and how these distortions can be utilized in modifying magnetic properties of oxide heterostructures [1,2].

Due to an inherent inter-atomic coupling across the film-substrate interface the coherently strained layer is expected to acquire the octahedral rotational pattern of the underlying crystalline substrate. Such octahedral connectivity is strongly coupled to the electronic and magnetic properties and this way a systematic control of octahedral rotations and tilts at the perovskite oxide interfaces might provide a viable route for the modification of magnetic properties in these oxide materials. In the $CaMnO_3$ (CMO) perovskite, for example, that is normally antiferromagnetic, a fractional charge transfer of the order of 0.07 e-/Mn induces a canted antiferromagnetic state in the interfacial Mn. In this way, at the interface, a magnetic ground state is stabilized by a delicate balance between ferromagnetic double exchange and antiferromagnetic super exchange interactions which is highly sensitive to the local structural distortions. Therefore, creating a subtle structural modifications at the CMO interface can lead to a large changes in magnetization. Through polarized neutron reflectometry, synchrotron x-ray diffraction and x-ray magnetic circular dichroism I will show that in $(CaRuO_3)_N/(CaMnO_3)_M$ superlattices one can modify interfacial ferromagnetism by a factor of two by using a second isostructural perovskite oxide but with different octahedral rotations thus inducing a symmetry mismatch at the interface [3].

By combining two perovskites with distinct crystallographic symmetries: the orthorhombic CMO perovskite exhibiting the $a^-a^-c^+$ octahedral rotational pattern and the rhombohedral $LaNiO_3$ (LNO) exhibiting $a^-a^-a^-$ rotations the interfacial ferromagnetism can be modulated by a factor of three [4]. I will show that in LNO/CMO superlattices we can control the octahedral connectivity across the LNO/CMO interface by changing the LNO and CMO layer thicknesses as well as their relative ratio and this way effectively alter the balance between ferromagnetic and antiferromagnetic interactions in the interfacial CMO layer. The results demonstrate a new path for creating and controlling magnetic state via octahedral connectivity at the interface between two non-ferromagnetic materials with distinct crystallo-graphic symmetries.
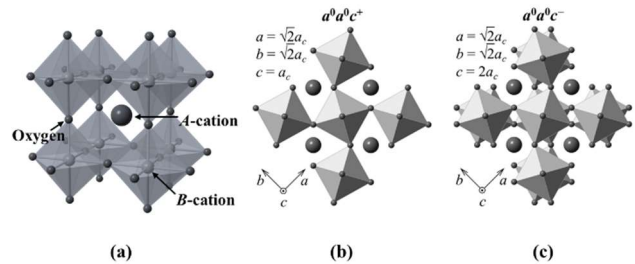

Figure 1. Schematic representation of: (a) ABO_3 cubic perovskite oxide unit cell, (b) in-phase octahedral rotations $a^0a^0c^+$, and (c) out-of-phase octahedral rotations $a^0a^0c^-$

Keywords: perovskite oxides, mismatch strain, octahedral distortions, x-ray diffraction, magnetism.

Literature

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