Towards low-dimensional complex oxides and complex twisted oxide architectures

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Abstract

Complex oxides are gifted systems that have attracted tremendous attention over the past few decades. These materials exhibit a wide spectrum of intriguing physical properties, including superconductivity, piezo/ferroelectricity, magnetism, dielectric, colossal magnetoresistance, metal-insulator transition and so on. Using modern epitaxy methods, controlling the interplays between charge, lattice, orbital and spin degrees of freedom in complex oxides allows us to design materials or architectures with new functionalities. Nevertheless, when it comes to epitaxial growth, the choice of single-crystal substrates plays a pivotal role as it establishes the fundamental template for the deposited materials. The lattice constraints and crystalline orientations of the deposited materials are dictated by the selected substrate below, thereby defining the available epitaxial degrees of freedom once a specific substrate is chosen. Hence, we have been intrigued by the possibility of achieving a different 'twist' in the realm of complex oxides and other relevant epitaxial systems.

In this talk, we utilize multiferroic $BiFeO_3$ (BFO) and strongly correlated $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) as model systems. We present an original approach to fabricate twisted lateral homostructures with various conjunction tunability, including crystalline orientation, epitaxial constrain, magnetism and phase stability. Through this work, we demonstrate that even epitaxial materials can be controllably 'twisted' in the plane, resulting in a new type of atomically sharp homojunction/interface that cannot be achieved through conventional epitaxial methods. Furthermore, we demonstrate that the twisted lateral homostructures can also be assembled by combining structurally different polymorphs. This allows epitaxial films to be precisely positioned in the plane, as if they were artistically 'woven' together. Additionally, we illustrate the feasibility of engineering orbital alignment and manipulating magnetotransport and other correlated phenomena using twisted homostructures. Throughout this talk, we will also discuss our perspective on the combination of novel oxide nanoarchitectures and synchrotron-based technologies. We aim to convince you that the discoveries from our recent works not only offer a versatile approach to develop novel low-dimensional quantum materials but also depict a new scenario for epitaxial growth.

Keywords – complex oxides, multiferroics, low-dimensional oxides, twisted homostructures, freestanding matters