A Universal Approach for Lateral Oxide Hetero-/Homostructures with Conjunction Angle Tunability – Weave Epitaxy

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Abstract

Complex oxides are gifted systems which have attracted lots of attention over past decades. These materials provide a wide spectrum of intriguing functional properties, including superconducting, piezo/ferroelectric, magnetic, high-dielectricity, ferromagnetism, colossal magnetoresistance, transparent-conducting and etc. Great efforts have been made to reveal the origin and coupling of those fascinating properties. With proper control, the interplays between charge, lattice, orbital and spin degrees of freedom in complex oxides enables us to design materials with new functionalities. The fundamental understanding of the physical origin of these phenomena is crucial in order to develop the principles for materials design and to exploit the remarkable properties of these materials for new practical devices. In this talk, we will present two of our recent developments upon optical control and advanced growth of complex oxides, which are greatly assisted by synchrotron radiation based techniques.

To date, increasing technology interest has focused on the optical control of non-volatile functional units, it is desirable to conduct efficient control over the fruitful functionalities through external stimuli. As the first part of this talk, we present ultrafast optical modulation of multifunctionalities in the template multiferroic system, $BiFeO_3$. With the application of short laser pulses, non-volatile switch of phase and correlated ferroic orders have been achieved on nanosecond and femtosecond time frames. Moreover, the configuration of optically written ferroelectric domains can be further tuned by symmetry breaking of charge distribution, taking advantages of competing elastic and electrostatic energies. Such demonstrations pave new pathways to control the intriguing physical properties through the communication between optical stimulus and different order parameters in materials, which leads to new-generation multifunctional devices nanoelectronics.

As the second part of this talk, we propose the concept of *weave epitaxy* to offer new pathways toward hetero-/homostructures with conjunction angle tunability. Such an approach allows the lateral epitaxial growth in random shape with definite conjunction angle, as if weaving two distinct single crystalline patches. The epitaxial relation between adjacent thin films can be properly controlled. The relative functionalities of adjacent epitaxial films have also been revealed and supported by theory calculation. In the end, we further demonstrate cellular weave epitaxial structures to verify the feasibility. Our results reveal new degrees of freedom offered by weave epitaxy, allowing epitaxial films to be randomly patched at particular position and with desired twist angles. This talk will conclude with a brief discussion on foreseeable challenges as well as the charming spots based on our recent progress.

Keywords – complex oxides, multiferroics, pulsed laser deposition, $BiFeO_3$, weave epitaxy