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Multiferroic heterostructures and non-volatile magnetoelectric effects

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Correlated electronic oxides have received continuing attention because of various striking discoveries, typified by the occurrence of colossal magneto resistance effect, high-temperature superconductivity, multiferroicity, exchange bias, vertical hysteretic shift, topologically anomalous Hall effect, etc. Tuning the physical properties of these correlated oxides by an external perturbation, such as a magnetic field, electric field, light illumination, or stress field, enables the investigation of exotic quantum and topological states, and the development of low-energy dissipation electronic and spintronic devices. In this work, we demonstrate the multi-field control of physical properties for perovskite complex oxide (e.g., Nd0.5Sr0.5MnO3, LaVO3, SrVO3) thin films deposited onto ferroelectric 0.7Pb (Mg1/3Nb2/3)O3-0.3PbTiO3 single-crystal substrates. Using the piezoelectric response of the substrate, the quantitative determination of the resistance change and the lateral strain of the film can be obtained. Multiple nonvolatile and reversible resistance evolution can be realized by adjusting the magnitude of ferroelastic strain. These findings demonstrate that lattice strain and physical properties of functional thin films epitaxially grown on PMN-PT substrates can be in situ, in real time, dynamically and continuously modulated via ferroelectric poling, converse piezoelectric effect, polarization rotation, and ferroelastic effect. This method can be further extended to study the intrinsic strain effects of other functional thin films. Moreover, we also found that the strain-excited effect and photo-generated (or magnetic field-generated) effect strongly correlated with each other, which is mediated by the lattice-charge-orbital coupling. Our work points to an effective strategy for realizing the coupled straintronic-optoelectronic effect in hybrid correlated oxide/ferroelectric systems and delivering multi-field tunable low-dissipation versatile electronic and photonic devices.

Recent publications

1. Ming Zheng & Pengfei Guan (2022) Electric field control of photoluminescence response in lanthanide doped ferroelectric materials: A brief review, Ferroelectrics, 598:1, 152-158

2. M. Zheng, and P. Guan, Coupled straintronic-optoelectronic effect in Mott oxide films, Nanoscale 14, 5545 (2022).

3. M. Zheng, P. Guan, Y. Qi, and L. Guo, Straintronic effect on electronic transport and metal-insulator transition in correlated metal films by electric field, Appl. Phys. Lett. 120, 161603 (2022)

Biography

Ming Zheng obtained his PhD degree from Shanghai Institute of Ceramics, Chinese Academy of Sciences. He was awarded JSPS Fellowship in 2018. In 2021, he was honored with IAAM Young Scientist Medal in recognition for his contribution to "Hybrid Electronic, Magnetic & Optical Materials". In 2022, he was honored with VEBLEO Fellow. His current research interests include functional (multiferroic, ferroelectric, magnetic and luminescent) thin-film materials and device physics. He has authored or co-authored more than 40 papers published in international reputed journals including NPG Asia Mater. (2), Adv. Mater., Nano Energy, Appl. Phys. Lett. (9), Phys. Rev. Applied (3).

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