Symmetry breaking – A peek into the field of oxide heterostructures

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The wide range of fascinating properties observed in complex oxide continue to attract great interest such as ferro-, piezo- and pyroelectricity. Such richness arises from a strong interaction between the charge, orbital, spin, and lattice degrees of freedom. Several strategies have been employed to break the lattice symmetry and expand the range of functionalities. Here, I will show how symmetry breaking offers extraordinary opportunities for observing new properties. In one example [1] I will show direct experimental evidence showing that despite the fact that bulk $SrTiO_3$ is not pyroelectric, the (100) surface of TiO_2-terminated $SrTiO_3$ is intrinsically pyroelectric at room temperature. In another examples [2] I will show how a stack of ultrathin defective oxide single-crystal layers (Gd_2O_3-doped CeO_2 (CGO) and Er_2O_3- stabilized δ-Bi_2O_3 (ESB)) yield an extraordinary electrostriction that outperforms any reported electrostrictive materials (organic or inorganic compounds). In final examples [3] I will show another recent discovery illustrating the possibility to induce a large piezoelectric response in centrosymmetric oxides. Such a high piezoelectric response from intrinsically nonpiezoelectric materials has not been observed before in centrosymmetric materials. Recently, new methods have been developed to realized freestanding oxide membranes. Inspired by the recent development in freestanding oxide membrane, and as a final example [3], I will show how we took these results to a whole new and unexplored direction – creating for the first time a new platform for assembling these ultrathin oxides freestanding membranes and twisting them into artificial heterointerfaces. This collection of possibilities offers unique opportunities for a wide range of rich world and new functionality of complex oxide and their interfaces.

[1] Meirzadeh et al. Adv. Mater., 31, 1904733 (2019),

[2] H. Zhang et al., Nature, 609(7928), 695-700 (2022),

[3] D. -S. Park et al., Science, 375, 653-657 (2022),

[4] Y. Li et al., Adv. Mat., 34, 2203187 (2022).