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In Situ Spectroscopy in Condensed Matter Physics

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Recently, many state-of-art spectroscopy techniques are used to unravel the mysteries of condensed matters. And numerous heterostructures have provided a new avenue to search for new emergent phenomena. Especially, near the interface, various forms of symmetry-breaking can appear, which induces many novel phenomena. Although these intriguing phenomena can be emerged at the interface, by using conventional measurement techniques, the experimental investigations have been limited due to the buried nature of interface. One of the ways to overcome this limitation is in situ investigation of the layer-by-layer evolution of the electronic structure with increasing of the thickness. Namely, with very thin layer, we can measure the electronic structure strongly affected by the interface effect, but with thick layer, the bulk property becomes strong. Angle-resolved photoemission spectroscopy (ARPES) is powerful tool to directly obtain electronic structure, and it is very surface sensitive. Thus, the layer-by-layer evolution of the electronic structure in oxide heterostructure can be investigated by using in situ ARPES. LaNiO3 (LNO) heterostructures have recently attracted much attention due to theoretical predictions for many intriguing quantum phenomena. The theories suggest that, by tuning external parameters such as misfit strain and dimensionality in LNO heterostructure, the latent orders, which is absent in bulk, including charge disproportionation, spin-density-wave order and Mott insulator, could be emerged in LNO heterostructure. Here, we performed in situ ARPES studies on LNO films with varying the misfit strain and thickness. (1) By using LaAlO3 (−1.3%), NdGaO3 (+0.3%), and SrTiO3 (+1.7%) substrates, we could obtain LNO films under compressive strain, nearly strain-free, and tensile strain, respectively. As strain state changes from compressive to tensile, the Ni eg bands are rearranged and cross the Fermi level, which induces a change of Fermi surface (FS) topology. Additionally, two different FS superstructures are observed depending on strain states, which are attributed to signatures of latent charge and spin orderings in LNO films. (2) We also deposited LNO ultrathin films under tensile strain with thickness between 1 and 10 unit-cells. We found that the Fermi surface nesting effect becomes strong in two-dimensions and significantly enhances spin-density-wave order. The further details are discussed more in presentation. This work was collaborated with Hyang Keun Yoo, Seung Ill Hyun, Eli Rotenberg, Ji Hoon Shim, Young Jun Chang and Hyeong-Do Kim.

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