Thin-film Nickelate Superconductivity and Electronic Structures

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This talk discusses the indispensable role of thin-film engineering in exploring nickelate superconductivity. We first examine infinite-layer nickelate films, utilizing the an operando monitored reduction technique for precise Ni 3d occupancy modulation over ultrawide ranges. This enables the mapping of detailed superconductor-insulator phase diagrams and the discovery of field re-entrant superconductivity in Eu-doped samples. Furthermore, we introduce the gigantic-oxidative atomic-layer-by-layer epitaxy technique to synthesize Ruddlesden-Popper bilayer and superstructure nickelates. We report achieving ambient-pressure superconductivity in monolayer-bilayer and bilayer-trilayer superstructures, together with an enhanced onset T_C in the bilayers. With cryogenic ultrahigh vacuum sample transfer, ARPES data reveals an underlying $d_z 2$ -related band at the Fermi level in the superconducting structures, with a nodeless superconducting gap. These findings establish the thin-film platform with atomic-layer engineering as a powerful “quantum laboratory” for driving nickelate research.