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Electronic Structure at Mott Insulator/Band Insulator Interfaces[1]

HAROLD Y. HWANG, Department of Advanced Materials Science, University of Tokyo, and Japan Science and Technology Agency

A conceptual dilemma arises in the study of oxide thin film heterostructures. The question is: how should one consider the correlated equivalent of band bending and quantum confinement? These semiconductor concepts are based on rigid single particle band diagrams, which are known to be an inadequate description for strongly correlated electrons. In addition to presenting an interesting scientific challenge, this underlies attempts to develop new applications for doped Mott insulators in device geometries. They further offer a unique approach to creating new two-dimensional states in artificial structures. Modern thin film growth techniques can be used to fabricate highly idealized oxide heterostructures on the atomic scale, allowing a direct examination of these issues. Here we present our recent study of three examples of a Mott insulator/band insulator interface. By measuring the electronic properties and using spatially-resolved electron energy-loss spectroscopy, we can deduce the distribution and response of the correlated electrons. In $LaTiO_3/SrTiO_3$, we find the charge distribution length is dominated by the strong polarizability of the lattice, arising from a nearby ferroelectric instability. In $LaTiO_3/LaAlO_3$, we demonstrate a dramatic narrowing of the charge distribution by quantum confinement. Finally, in $LaMnO_3/SrTiO_3$ we find the charge distribution can be modified by a magnetic field, reflecting the strong charge-spin coupling arising from the double-exchange mechanism.

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