【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Mathematical and physical sciences)

Title of Project : Novel electronic phases at interfaces of strongly correlated materials studied by soft x-ray dichroism with multi-degrees of freedom

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Research Area : Mathematical and Physical Sciences

Keyword : Transition-metal oxides, Interfaces, XMCD, Photoemission, Linear dichroism

【Purpose and Background of the Research】

Recently, the possibility of charge-spin-orbital ordering and the importance of spin-orbit coupling at oxide interfaces have been pointed out. Also, novel electronic states which emerge at interfaces between different kinds of ground states have attracted much interest. In this project, we investigate such novel interfacial electronic states using soft x-ray magnetic circular dichroism (XMCD), soft x-ray magnetic linear dichroism (XMLD), and related high-energy spectroscopic techniques. In collaboration with Photon Factory, KEK, we develop a versatile soft x-ray dichroism measurement system in which the direction of magnetic field and the photon polarization are independently varied.

【Research Methods】

The new soft x-ray dichroism measurement system consists of a superconducting vector magnet and a fast polarization switching undulator. We perform systematic dichroism measurements with high sensitivity and precision on oxide interfaces for which spin-orbital ordering and/or the importance of spin-orbit interaction has been theoretically predicted. In addition, angle-resolved photoemission spectroscopy and resonant soft x-ray scattering are employed to obtain complementary information.

【Expected Research Achievements and Scientific Significance】

(1) Novel electronic states of ultra-thin films and superlattices of oxides will be identified and characterized. For example, spin and orbital ordering are likely to exist in ultra-thin films of Pauli-paramagnetic metal $SrVO_3$ and ferromagnetic metals $SrRuO_3$ and (La , Sr)MnO_3.
(2) Novel electronic states which emerge at oxide interfaces and their possible spin-orbital ordering will be elucidated. In particular, mechanisms for the appearance of metallic states at the $LaAlO_3$/$SrTiO_3$ interfaces and its relationship with spin-orbit interaction will be investigated.
(3) Coexistence and competition at interfaces between different kinds of phases will be identified and their mechanisms will be clarified.
(4) The newly developed XMCD and XMLD system will become a powerful tool to investigate the local magnetic properties of anisotropic strongly correlated systems. For example, field-induced magnetism in cuprate superconductors, unusual magnetic properties of iron-based superconductors, and orbital fluctuations in Kondo systems.

【Publications Relevant to the Project】

[1] T. Koide et al., Evidence for a close correlation between the magnetic moments, lattice distortions and hybridization in $LaMnO_3$ and $La_{1-x}Sr_xMnO_{3+\delta}$: Doping-dependent magnetic circular x-ray dichroism study, Phys. Rev. Lett. **87** (2001) 246404.
[2] M. Takizawa et al., Photoemission from buried interfaces in $SrTiO_3$/$LaTiO_3$ superlattices, Phys. Rev. Lett. **97** (2006) 057601.
[3] H. Wadati et al., In-situ photoemission study of $Pr_{1-x}Ca_xMnO_3$ epitaxial thin films with suppressed charge fluctuations, Phys. Rev. Lett. **100** (2008) 026402.
[4] K. Yoshimatsu et al., Origin of metallic states at the heterointerface between the band insulators $LaAlO_3$ and $SrTiO_3$, Phys. Rev. Lett. **101** (2008) 026802.
[5] M. Takizawa et al., Remote hole-doping of Mott insulators on the nanometer scale, Phys. Rev. Lett. **102** (2009) 236401.
[6] K. Yoshimatsu et al., Dimensional-crossover-driven metal-insulator transition in $SrVO_3$ ultrathin films, Phys. Rev. Lett. **104** (2010) 147601.

【Term of Project】 FY2010-2014

【Budget Allocation】 161,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://wyvern.phys.s.u-tokyo.ac.jp/f/Research/xmcd/xmcd_en.htm
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