MAR15-2014-020833

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Depth- and momentum- resolved electronic structure at buried oxide interfaces from standing-wave angle-resolved photoemission[1]

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It is clear that interfaces in complex oxide heterostructures often represent emergent materials that possess surprising properties not associated with the parent oxides, such as two-dimensional electron gases (2DEGs), superconductivity, and magnetism. A detailed knowledge of the composition, atomic structure, and electronic structure through such interfaces is thus critical. Photomission (PES) and angle-resolved photoemission (ARPES) represent techniques of choice for such studies, but have certain limitations in being too surface sensitive and in not being able to focus specifically on buried interfaces or heterostructure layers. In this talk, I will discuss combining two newer elements of PES/ARPES to deal with this challenge: - the use of soft x-rays in the ca. few hundred-to-2000 eV regime [1], or even into the true hard x-ray regime [2], to probe more deeply into the structure, and - tailoring of the x-ray intensity profile into a strong standing wave (SW) through reflection from a multilayer heterostructure to provide much enhanced depth resolution [3]. The relative advantages of soft/hard x-ray PES and ARPES and their complementarity to conventional VUV ARPES in the ca. 5-150 eV regime will be considered [1]. As illustrative examples, by combining SW-PES and SW-ARPES, it has been possible to measure for the first time the detailed concentration profiles and momentum-resolved electronic structure at the SrTiO3/La0.67Sr0.33MnO3 interface [3] and to directly measure the depth profile of the 2DEG at SrTiO3/GdTiO3 interfaces [4]. Future directions for such measurements will also be discussed.

[1] C.S. Fadley, Synchrotron Radiation News 25, 26 (2012);
[2] A.X. Gray et al., Nature Materials 11, 957 (2012);
[3] A.X. Gray et al., Phys. Rev. B 82, 205116 (2010) and Europhys. Letters 104, 17004 (2013);
[4] S. Nemsak et al., to be published.

[1]Supported by US DOE Contract No. DE-AC02-05CH11231, ARO-MURI Grant W911-NF-09-1-0398, and the PALM-APTCOM Project (France).