Novel Trends in Synchrotron and FEL-Based Analysis
Topic Focus
Room: 312 - Session SA-MoM

Synchrotron Studies of Processes in Energy Conversion, Electronic Devices and Other Materials I
Moderator: Franz Himpsel, University of Wisconsin-Madison

8:20am SA-MoM1 Looking Into Buried Interfaces with Soft/hard X-Ray Photoemission and Standing-Wave Excitation, Charles Fadley, University of California, Davis
I will present some new directions in synchrotron radiation soft x-ray photoemission (XPS, SXPS) and hard x-ray photoemission (HXPS, HAXPES, HIKE)[1-6], with illustrative examples of applications to a range of sample types. These involve combined SXPS and HXPS studies of buried layers and interfaces in magnetic and transition-metal oxide multilayers[1,2], as well as in semiconductor junctions[3]; solid-gas or solid-liquid interfaces with high ambient pressures[5]; band-offset measurements in multilayer structures[6]; and, the use of standing waves from multilayer mirrors to enhance depth contrast in spectroscopy[1-5].

References
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2 “Interface properties of magnetic tunnel junction La0.7Sr0.3MnO3/SrTiO3 superlattices studied by standing- wave excited photoemission spectroscopy”, A. X. Gray et al., Phys. Rev. B 82, 205116 (2010).
5 “Chemical-state resolved concentration profiles with sub-nm accuracy at solid/gas and solid/liquid interfaces using standing-wave ambient-pressure photoemission (SWAPPS)”, S. Nenşak et al., in preparation

9:00am SA-MoM3 Hard X-ray Photoelectron Spectra (HXPS) of Bulk Non-Conducting Silicate Glasses, Yongfeng Hu, Q.F. Xiao, X.Y. Cui, D. Wang, Canadian Light Source, Canada, G.M. Bancroft, H.W. Nesbitt, M. Biesinger, University of Western Ontario, Canada
Bulk studies of non-conducting oxides and silicates, such as silicate glasses containing cations such as Na, K, Mg and Ca are important to obtain quantitative bulk information of bridging oxygen ( Si-O-Si, so-called BO), non-bridging oxygen ( Si-O-M, so-called NBO), and “free oxygen” ( M-O-M ). These studies have been so far limited to the XPS studies using spectrometers equipped with modern charge compensation systems, such as Kratos or ESCALAB 250Xi.1,2 Such measurements are very important for determining the chemical and physical properties of a wide variety of silicate minerals and glasses2. Synchrotron-based hard X-ray photoelectron spectroscopy (HXPS) has recently been applied to the characterization of surfaces and interfaces of advanced materials. In this work, we will demonstrate that the HXPS, without any charge compensation system, can avoid the large differential charging problems usually seen with bulk non-conductors using conventional XPS instruments. These problems are overcome by depositing a thin metal coating on the glass surface and by taking advantage of the large and variable probing depth offered by HXPS. We show that the optimal O 1 s linewidth, matching to that of the Krotos’ results, can be obtained for the non-conducting silicate glasses using HXPS. Together with the high resolution Si 1 s results, these HXPS data are critical for accurate analysis of the BO, NBO and free oxide content of these silicates.


9:40am SA-MoM5 Application of Synchrotron Radiation Based Hard X-ray Photoelectron Spectroscopy (HXPS) to Characterise Semiconductor Device Structures, Greg Hughes, L. Walsh, Dublin City University, Ireland, J.C. Woicich, National Institute of Standards and Technology (NIST), P.K. Hurley, Tyndall National Institute, Ireland
In situ hard x-ray photoelectron spectroscopy (HAXPES) is emerging as a technique which has the capability to provide chemical and electronic information on much larger depth scales than the conventional XPS. This has potential applications in the study of oxide/semiconductor and metal/semiconductor buried interfaces found in device structures, particularly after annealing cycles. In this presentation results of combined hard x-ray photoelectron spectroscopy (HAXPES) and electrical characterisation measurements on identical Si and III-V based metal-oxide-semiconductor (MOS) structures will be presented. The experimental findings obtained indicate that surface potential changes at the semiconductor/dielectricinterface due to the presence of a thin metal gate layer can be detected with HAXPES. Changes in the semiconductor band bending at zero gate voltage and the flat band voltage for the case of metal gate layers derived from the semiconductor core level shifts observed in the
HAXPES spectra are in agreement with values derived from C-V measurements.

The III-V material InGaAs shows promise as the channel material in high speed n-MOSFETs however, the issue of low resistance source/drain (S/D) contacts to InGaAs remains. A possible solution is to find a self-aligned silicide like material (salicide) to act as the S/D contacts. The search for this material has recently focussed on Ni-InGaAs, due to its promisingly low R_s and its apparent abrupt interface with InGaAs. Results of a HAXPES study of the Ni-InGaAs alloy system has been undertaken in order to determine the nature of the Ni-InGaAs interface and its evolution as a function of annealing temperature. The results show that Ni readily interacts with InGaAs upon deposition at room temperature resulting in significant inter-diffusion and the formation of NiIn, NiGa, and NiAs alloys. This information when combined with x-ray absorption spectroscopy (XAS) measurements can be used to develop a structural and chemical compositional model of the Ni-InGaAs system as it evolves over a thermal annealing range of 250-500 °C.

10:40am SA-MoM8 Correlative Probing of the Surface Chemistry and Electron Transport of Nanodevices in Operando Mode using Scanning Photoelectron Emission Microscopy, Andrei Kolmakov, National Institute of Standards and Technology (NIST)

The surface as well as interfacial properties of nanoscopic devices are intimately linked to their electronic transport properties. In addition, they have a strong dependence on their dimensions, faceting and stoichiometry. As a result, the traditional measurements on the ensembles of nanostuctures would suffer from significant averaging effects and need to be replaced with testing of individual well characterized nanostructure. In this report, we demonstrate few examples of correlative imaging, spectroscopy and transport measurements on individual working nanodevices using capabilities of modern synchrotron radiation based photoelectron microscopy. In particular, the surface analysis of the operating MEMS nanowire sensor model device being coupled with scanning x-ray beam induced current microscopy correlates real time changes in conductance of the nanowire with formation of the specific surface groups upon redox reaction. The effect of the electrodes and electroactive defects in the devices on their performance will be discussed. The perspectives of the in operando device characterization at real world pressures and temperatures will be outlined.


We present the development of a Large Area Rapid Imaging Analytical Tool (LARIAT MKII) for near edge x-ray absorption fine structure (NEXAFS) surface chemical and structural analysis. This analyzer utilizes magnetostatic and grid-less electrostatic lenses to maintain the lateral distribution of electrons into a 16 mega channel detector, allowing for a 180° collection angle for high collection efficiency enabling rapid parallel imaging. The system is in development for installation at the NIST SST beamline at NSLS II. Initial images from LARIAT MKII, currently installed at NSLS, will also be presented. The images demonstrate the system’s imaging capabilities, with resolution approaching 5 μm for C K-edge images.
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