Novel Trends in Synchrotron and FEL-Based Analysis Focus Topic
Room 103C - Session SA+AS+MI-MoM

Advances in High-Resolution Imaging Techniques (8:20-10:20 am)/Pushing the Limits with X-Ray Spectroscopy (10:40 am-12:00 pm)

Moderators: Maya Kiskinova, Elettra-Sincrotrone Trieste, Italy, Claus Michael Schneider, Forschungszentrum Juelich GmbH, Germany

9:00am **SA+AS+MI-MoM3 Applications of Novel Hard X-ray Nanoprobe in Nanoscience**, ***Gema Martinez-Criado,*** Madrid Materials Science Instititute, CSIC, Spain **INVITED**

Owing to the spatial resolution and sensitivity (i.e., signal to background ratio), nano and micro X-ray beams are emerging tools with a strong impact in nanoscience. Although the optical quality of the X-ray focusing devices has limited the progress of hard X-ray nanoprobes, recent advances in fabrication techniques have pushed the spatial resolution towards the diffraction limit. As a result, the use of nano and micro X-ray beams has begun to extend towards the atomic domain, with concomitant and continuous developments of multiple analytical tools. The study of micro/nanoscale objects, small embedded nanodomains with weak signals and/or heterogeneous structures at the nanometer scales has required the use of intense X-ray pencil beams. Additionally, stimulated by the great brilliance with reduced emittance of current third generation synchrotron sources, and new developments in X-ray detector technology, today intense nano-X-ray beams are available with a variety of focusing devices. Finally, thanks to the multiple interactions of X-rays with matter these X-ray probes can be used for manifold purposes, such as ultra-sensitive elemental/chemical detection using X-ray fluorescence/X-ray absorption, or for identification of minority phases, and/or strain fields by X-ray diffraction with nanometer resolution. In the present talk I describe how hard X-ray nanobeams are produced and exploited today for space-resolved determination of structural and electronic properties, as well as for chemical speciation of nanosized materials. Selected recent examples will range from phase separation in single nanowires to visualization of dislocations and buried interfacial defects, to domain distortions and quantum confinement effects.

10:40am **SA+AS+MI-MoM8 Extreme X-ray Flux to Probe Picosecond Dynamics**, ***Alfred Baron,*** RIKEN SPring-8, Japan **INVITED**

Inelastic x-ray scattering (IXS), *in principle*, provides a nearly ideal opportunity to probe dynamics on ps and sub-ps time scales via direct measurement of the dynamic structure factor, S(Q,ω). Such measurements are interesting in many areas of science, including fundamental understanding of liquid behavior, investigations of phonons in complex materials such as superconductors and ferroelectrics, and even to help determine the composition of the earth's interior. However, high-resolution non-resonant IXS measurements are *severely flux limited*.

Over the last 18 years, the author has spearheaded a program to increase the world capability for high-resolution IXS measurements through work at SPring-8 in Japan. This began with designing and constructing a beamline based on a standard insertion device [1] then progressed to a second beamline using 3x5m tandem small-gap insertion devices (IDs) [2], while in parallel, upgrading the earlier facility to a optimized small-gap ID. *This has successfully led to world-leading flux at workhorse spectrometers with ~1.25 meV resolution and 30 GHz onto the sample at 21.7 keV*, and up to 30 momentum transfers collected in parallel. Resolution as good as 0.75 meV [3] can be achieved at higher (25.7 keV) energy while medium resolution spectrometer provides in excess of 2 THz onto a sample with 27 meV resolution for measuring electronic dynamics.

The presentation will discuss aspects of the instrumentation for IXS, and recent sample science. On the instrumentation side, on top of "straightforward" issues such as sub-mK temperature control over >50 channels, installation of more that 30 tons of spectrometer, there were unique and new issues related to operating 3x5m tandem small- (6mm-) gap insertion devices [4]. On the sample side, the talk will highlight recent efforts in geoscience, where measurements at record pressures and temperatures have allowed us to constrain to composition of the Earth's core - both the outer liquid core [5] and the inner solid core. This will be complemented by a short discussion of a surprising phonon anomaly in YBa2Cu3O7-d, where phonon line-widths undergo a remarkable increase below the superconducting transition temperature [7] in what is perhaps the largest phonon anomaly observed to date in the absence of a structural phase transition.

[1] Baron, *et. al.*, J. Phys. Chem. Solids **61**, 461 (2000).

[2] Baron, SPring-8 Inf. Newsl. **15**, 14 (2010).

[3] Ishikawa, *et al*., J. Synch. Rad. **22**, (2015).

[4] Baron, *et al*., AIP Conf. Proc. **SRI2015** (Accepted).

[5] Nakajima, *et al*., Nat Commun. **6**, (2015).

[6] Sakamaki, et al., Sci. Adv. **2**, (2016).

[7] Baron*, et al*., in preparation.

11:20am **SA+AS+MI-MoM10 Beating Complexity through Selectivity: Anti-Stokes Resonant Inelastic X-ray Scattering for Excited State Dynamics**, ***Alexander Föhlisch,*** University of Potsdam, Germany **INVITED**

Ultrafast electronic and structural dynamics of matter govern rate and selectivity of chemical reactions, as well as phase transitions and efficient switching in functional materials. Since X-rays determine electronic and structural properties with elemental, chemical, orbital and magnetic selectivity, short pulse X-ray sources have become central enablers of ultrafast science. Despite of these strengths, ultrafast X-rays have been poor at picking up excited state moieties from the unexcited ones. With time-resolved Anti-Stokes Resonant X-ray Raman Scattering background free excited state selectivity in addition to the elemental, chemical, orbital and magnetic selectivity of X-rays can be achieved. For low symmetry systems energetically off-set signatures dominate, and for inversion symmetric systems a clear separation between ground and excited states occurs. This unparalleled selectivity extracts low concentration excited state species along ultrafast dynamic pathways. These approaches will benefit from recent advances towards non-linear X-ray matter interaction and an outlook is given how future fourier limited X-ray laser pulses will explore ultrafast dynamics.

Author Index

Bold page numbers indicate presenter