TPS 47 high energy resolution x-ray spectroscopy beamline – high energy resolution x-ray absorption and hard x-ray photoemission spectroscopy

Yen-Fa Liao (廖彥發)[1], Shih-Chang Weng (翁世璋)[1], Yan-Gu Lin (林彥谷)[1], Kuan-Li Yu (于冠禮)[1], and Jin-Ming Chen (陳錦明)[1]

[1]National Synchrotron Radiation Research Center, Hsinchu, Taiwan
liao.yenfa@nsrrc.org.tw

Abstract

Dynamic electronic structural information of materials and device is basic information to helpful toward next generation. However, an important key issue is to understand the physical and chemical properties by in situ/operando experimental environment. A normal electronic structure can be detected and determined with both synchrotron techniques - x-ray absorption (XAS) and x-ray photoemission spectroscopy (XPS), but dynamic various on complicated sample is difficult to detect by normal XAS and XPS because (1) core-hole life time boarding and low energy resolution beamline setup on normal XAS. (2) low penetration on XPS measurement at low incident photon energy. (3) high vacuum condition on XPS measurement.

Here, we propose two advantage end station - High energy resolution x-ray absorption/emission and hard x-ray photoemission spectroscopy (HAXPES). The main purpose of end station 1 is to treat on in situ/operando high energy resolution fluorescence detected x-ray absorption (HERFD-XAS) and x-ray emission spectroscopy. This experimental end station is used for experiments with high resolution monochromator and multi analyzer system. The spectrum of Taiwan users, with their scientific projects, demands a beam-line covering 3d - 5d elements heavier than titanium. This means that the photon flux must be internationally competitive in the energy range 4.5 - 20 keV, where the K edge is covered for the elements - Se, and the L3 edge for 5d elements heavier than Hf. Most importantly, HERFD-XAS measurements require high photon flux for high resolution monochromator setting. In order to meet these criteria a undulator has been chosen as insertion device on our beamline. A system of K-B mirrors will allow the beam-size at the sample to be reduced from 750 x 750 um^2 to 15x15 um^2 on user experiment. The overall design of the beamline will allow large flexibility in wide energy range and get high efficiency by multi-analyzer system, makes it unique on in situ/operando experiment of HERFD-XAS spectra. This end station will allow in-situ/operando measurements in different areas of green energy materials which will make the beamline unique.

The end station 2 (ES2) dedicated to provide in situ/operando HAXPES measurements for all user. Foe XPS, it is mature and common technique in materials analysis including in-house machine and x-ray source. XPS experiments in the soft x-ray range still dominate in the photoemission community as it offers high-resolution both in energy along with high efficiency. However, the short mean free path of the photon electrons limits the probing depth at the sample surface with few atom layers. On the other hand, XPS is an excellent measurement for the investigation of liquid/solid interfaces because it has elemental and chemical sensitivity. Taiwan Photon Source (TPS) have a possibility to provide the high photon flux and wide photon energy range in hard x-ray XPS study. HAXPES at high kinetic energies is especially valuable due to the extended mean free path of electrons at higher energies, which allows measuring liquid/solid interfaces in the presence of thicker solution layers or multi-layer thin film system with capping layer. The HAXPES experimental end station is set the high resolution monochromator to improve beamline energy resolution for experiment. HAXPES studies monitoring the electronic structure of materials that detected the photoelectrons from core level of materials will be of particular interest to understand and optimize the chemical and physical properties of these materials or interface.

This high energy resolution x-ray spectroscopy beamline at TPS receives support from Taiwan scientists and industries representing a wide range of areas such as e.g. catalysis research, energy research including e.g. solar cells, batteries and CO2 reduction materials, material science, physics and chemistry of thin film as well as the development of next generation semiconductor.