Time and Spatially Resolved X-ray Absorption Spectroscopy Beamine at TPS

Since the first X-ray absorption spectrum (Ag, Br K-edge) was observed in 1913, X-ray absorption spectroscopy (XAS) has become a powerful tool for scientific research.[1] In particular, the construction of synchrotron light source facilities has led to tremendous growth in this technology. Because of the ease of measurements, elemental selectivity, and sample friendliness (thin film, powder and solution, *etc.*), this technique covers a wide range of different scientific fields including the molecular and condensed matter physics, materials sciences, engineering, chemistry, environmental sciences, earth sciences, and biology. The user group of X-ray absorption spectroscopy has therefore grown into a large user base of synchrotron radiation research facilities. Recently, the short lived intermediate state of chemical reaction has been attracted scholarly attention. The synchrotron light source facilities in the world such as SLS[2], ESRF[3,4] and NSLS II developed time-resolved beamlines to provide the capability of time-resolution for *in-situ* measurements. NSRRC constructs a new beamline, **TPS 44A**, to provide time-resolved technique to users groups. **TPS 44A** a new generation quick-scanning is equipped with monochromator (Q-mono) which allows users to collect an extended X-ray absorption fine structure spectroscopy in ten milliseconds. It can effectively observe a change in the materials structure with this time scale, such as the influence of catalyst on the reaction process, the behavior of plants absorbing nutrients or metals from the soil. Moreover, the behavior of physical, electrical, magnetic and optical properties with the external environment can be resolved. Quick-scanning experimental technology greatly shortens the experimental time and allows new research topics to be developed.

TPS 44A uses bending magnet as a photon source with a magnetic field of 1.19 T and a critical photon energy of 7.12 keV. The optical design is a fairly conventional two stage focal condition with a collimat-

(a) (b) (c) (d)

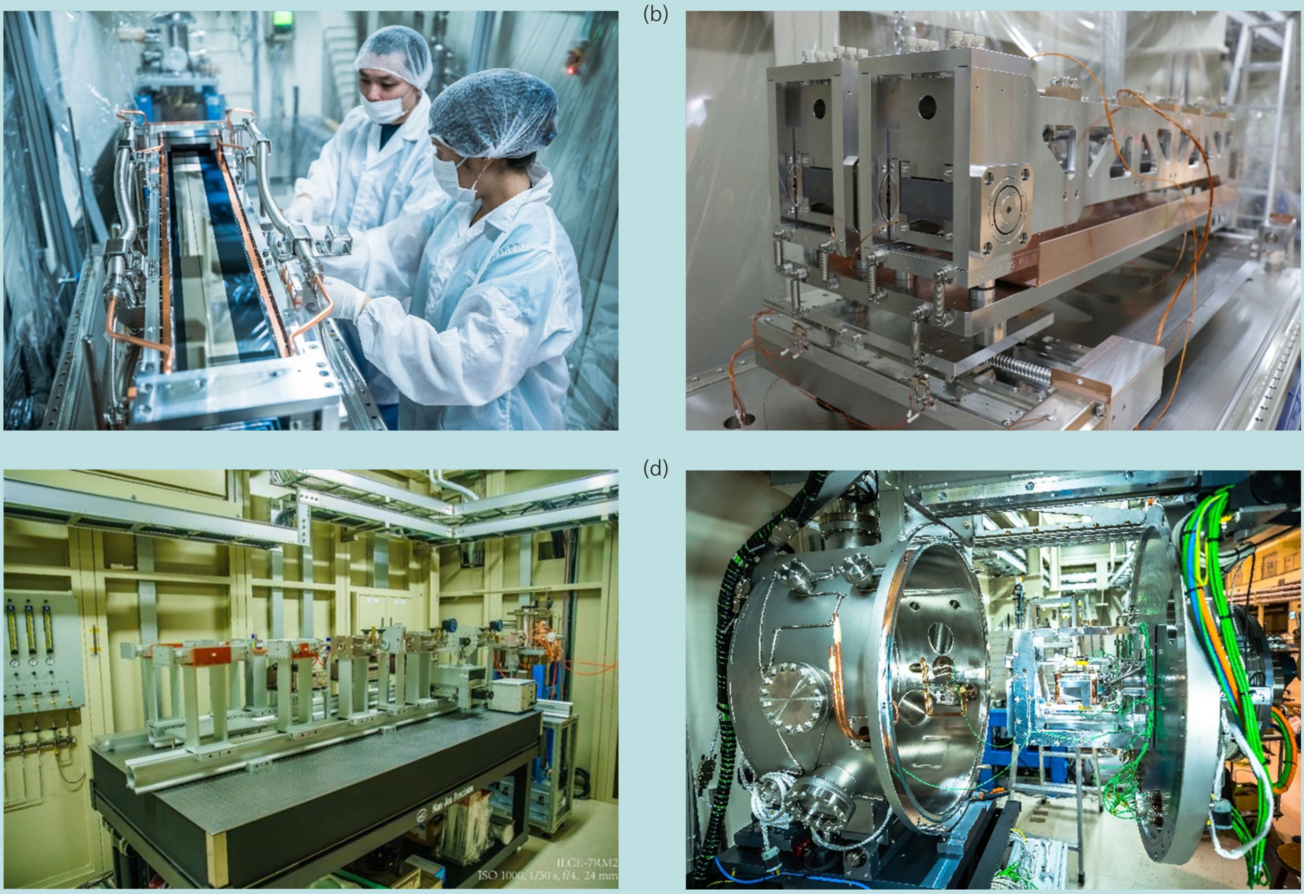

Fig.1: (a) Collimating mirror, (b) toroidal focusing mirror, (c) experiment station, and (d) quick-scanning monochromator of **TPS 44A**.

ing mirror (CM) and toroidal focusing mirror (TFM) at the 2:1 focusing condition. There are three coating on CM and two independent bendable toroidal mirror on TFM for different photon energy region, as shown in **Figs. 1(a) and 1(b)**. The Q-mono is the key component of this beamline; it is based on a Huber goniometer along with a quick scanning torque motor. It is equipped with a channel-cut crystal Si(111) to cover the accessible X-ray energy range (4.5–34 keV), shown in **Fig. 1(d)**. The acquisition rates can extend up to a hundred spectra per second, reaching a time resolution of ten milliseconds.[2] The first end-station is designed as multi-sample setting for XAS measurements. There is a high harmonic rejection mirror mounded at the front of experiment station to minimize the contamination from high energy photons. The experiment station is equipped with several gridded ionization chamber and fluorescence detector to collect data in transmission and fluorescence mode, as **Fig. 1(c)** shows. This station also provides a variety of equipment for sample environment including cryostat, cryostream, gas/liquid flowing, electrochemistry, heating and so on for different scientific topic of *in-situ* and/or *in-operendo* measurements. In addition, a set of K-B mirrors are used to refocus the beam down to 5 µm (H) × 5µm (V) in full width at half maximum at the second sample position for micro-probe experiments.

TPS 44A provides both time and spatial resolution of milliseconds and micrometers to the XAS user groups for research in a variety of fields. The experiments conducted bring new opportunities for scientific research to the academic community in Taiwan and has become an important facility for the study of basic sciences and various industrial applications. (Reported by Chih-Wen Pao)

References

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Soft X-ray Spectroscopy at TPS

The Taiwan Photon Source is presently commissioning the NSRRC-MPI sub-micron soft X-ray spectroscopy beamline **TPS 45A** for carrying out ultra-high resolution angle-resolved photoemission spectroscopy (ARPES), X-ray magnetic circular dichroism (XMCD), resonant X-ray emission spectroscopy (RXES) and X-ray excited optical luminescence (XEOL).

The beamline is a new Dragon-type soft X-ray beamline to facilitate sub-micron spectroscopy experiments with ultra-high energy resolution. The beamline uses an elliptically polarized undulator with a 46 mm magnet period (EPU46) and can provide photon energies in the range of 280–1500 eV with horizontal and vertical linear polarization, as well as left and right circular polarization. The active vertical focusing mirror (VFM) and the active grating monochromator (AGM) utilize a novel 25-actuator bender developed for ultra-high resolution soft X-ray spectroscopies. The AGM design is an upgraded version of the AGM installed at beamline **TLS 05A**.[1] The new version is exactly the same as that operational at the **TPS 41A** and is working well. From long tracing profiler (LTP) measurements, it has been verified that the surface slope error can be reduced down to 0.06 mrad full-width-root-mean-square (FWRMS) by the bender. A ray-tracing simulation has shown that an energy resolution of 5 meV can be achieved at 750 eV photon energy by using a 1200 l/mm varied-line-spacing flat grating mounted on the bender, and the beam spot size at the sample position can reach 0.5 µm in the horizontal direction and 0.4 µm in the vertical direction. A photograph of the beamline is shown below in **Fig. 1**.

The commissioning of the **TPS 45A** started in the third week of Nov, 2018 with the first light entering the hutch on 21st, Nov. Due to the high heat load on the front end optical elements, preliminary experiments have been carried out to check the beam size and energy resolution with a front end acceptance of 50 µrad × 50 µrad compared to a central cone