different energies, the detector is designed to be moveable, traveling to meet the required distance at the focusing position. **Figure 2** shows the photography of SXT endstation at **TPS 24A**.

The microscopy with some optics in the vacuum chamber is located downstream of the secondary source, sequentially with the optics of a stopper, capillary condenser, sample, zoneplate and a detector. Moreover, the location of sample is 43 m from the bending magnet source. To assist studying bio-sample in the region of interest, this endstation is also equipped with a high resolution fluorescence 3D-SIM which is located 70° off from the beam of SXT on-line correlated with SXT. **Figure 3** shows a schematic diagram of SXT correlation with fluorescence 3D-SIM. In commissioning, the photons with 520 eV are provided to image the sample. Before the image measurement, the position of capillary condenser and zoneplate has to be optimized by adjusting the movement of the stages. A phosphor screen, which is placed in the downstream of zoneplate, is adopted to monitor focused photons, those photons are collected by capillary condenser and zoneplate. Following, a spatial resolution of 50 nm Half-Pitch for standard Nested L's sample was obtained, and around 45 nm in 2D image of tungsten pin was achieved. Currently, tomography of tungsten pin sample was acquired by rotation the sample stage, and the images were reconstructed. **Figure 4** displays the 2D and 3D images of a tungsten pin sample. Soft X-ray beamline at TPS has performed preliminary commissioning results with photon energy of water window at 520 eV. To avoid radiation damage, bio-sample and its environment should be kept under cryo-condition. Therefore, some challenging missions, such as cryo-sample transferring system, cryo robot system and cryo-sample rotation, will be carried out in the coming year. (Reported by Lee-Jene Lai)

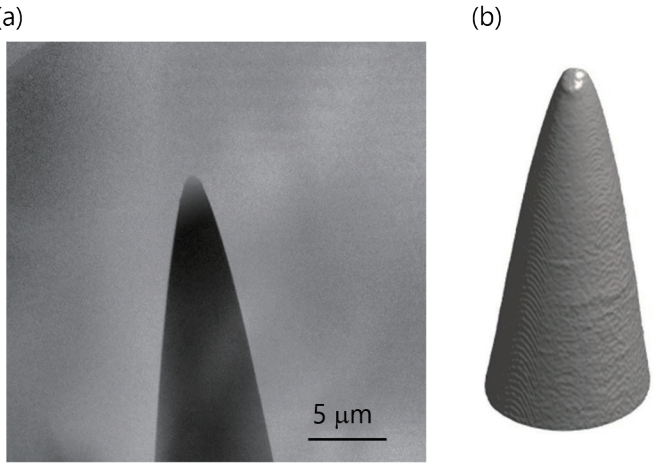

Fig. 4: Images of (a) 2D and (b) 3D of tungsten pin sample were acquired at **TPS 24A**.

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Quick-Scanning X-ray Absorption Spectroscopy Beamline at TPS

The newly constructed beamline, **TPS 44A**, conducts X-ray absorption spectroscopy (XAS) experiments, collecting X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) spectra. It is equipped with a new quick-scanning monochromator (q-mono) which provides the conventional step by step scan (s-scan) but also an on-the-fly scan (q-scan). The q-scan experimental technique facilitates the collection of XAS spectra on the millisecond timescale. This opens up the possibility of experimental measurements under in-situ/in-operando environments to monitor such things as the charging/discharging of batteries and the chemical processes within catalysts.

The constructions of **TPS 44A** was completed at the end of 2017 and opened to users in September 2018. The banding magnet with a magnetic field 1.19 T is used to produce a beam spot approximately 250 (H) × 750 (V) μm² in size with a photon flux of 3 × 10^{11} photons per second. The Ni K-edge EXAFS spectra of a Pt/Ni nanocomposite was used to test the performance of the q-scan experimental technique. **Figure 1** displays the normalized Ni K-edge EXAFS spectra obtained via both the s-scan and q-scan respectively, in transmission mode. The q-scan data were collected with the q-mono oscillating at 1 Hz for 2 minute. Two spectra were completed every second which means that 120 spectra were averaged to produce **Fig. 1** with its improved S/N ratio. The s-scan mode took about 30 minutes for one spectrum (compared to 1 minute for q-scan mode). The resultant spectra perfectly overlap in both the XANES and EXAFS regions, indicating the reliability and reproducibility of the q-scan method. The data collection time has therefore drastically decreased due to the successful development of q-scan technique, improving the operating efficiency of the beamline. The very fast data acquisition rate also reduces radiation damage seen in biological research opening up new possibilities in this area of science. The right inset of **Fig. 1** shows the Ni K-edge k-space oscillation data of Pt/Ni nanocomposite. The spectra collected *via* q-scan is much smoother than s-scan, particular at the region of k value larger than 8, indicating that the q-scan experimental technique is not only a faster way to acquire data but it also improves the data quality. The conventional measurement methods for higher and lower concentration samples are transmission and fluorescence XAS respectively. Typically, the transmission mode is not suitable for a sample with a white line edge-jump smaller than 0.1. **Figure 2(a)** presents the Cu K-edge XANES spectrum of Cu doped Pt/Ni nanocomposite after 2 minutes at transmission mode using the

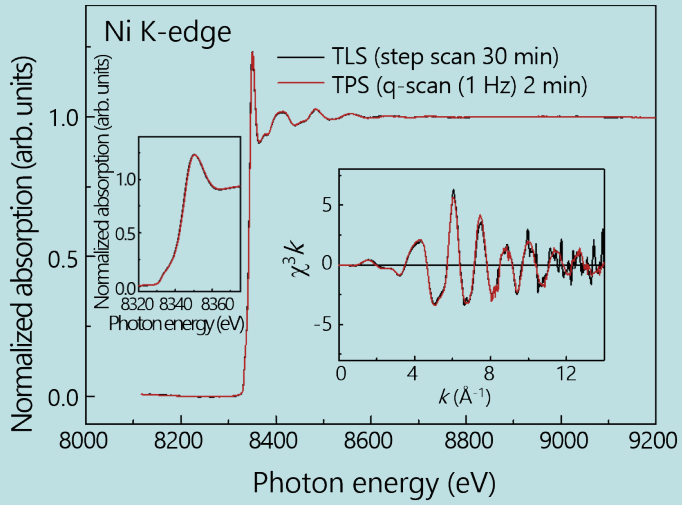

Fig. 1: The Ni K-edge XANES and EXAFS spectra of Pt/Ni nanocomposites.

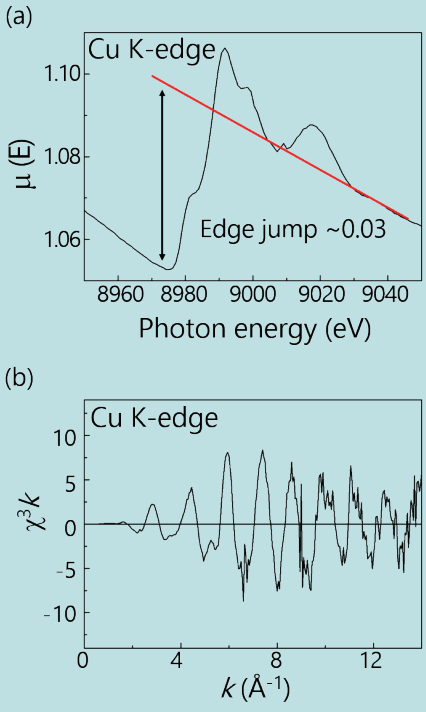

Fig. 2: The Cu K-edge (a) XANES and (b) EXAFS spectrum of Cu doped Pt/Ni nanocomposites.

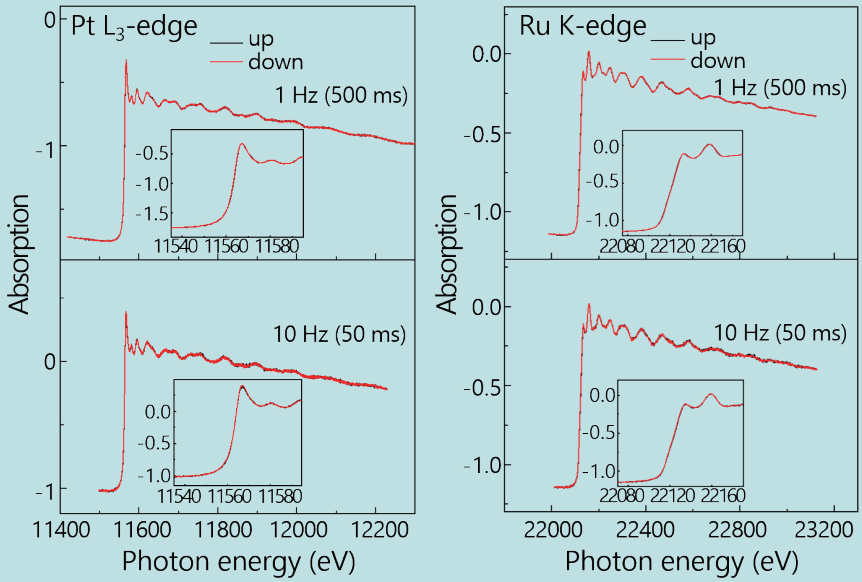

Fig. 3: The Pt L_3- and Ru K-edge XANES and EXAFS spectrum of Pt and Ru standard foil.

q-scan collecting method. The spectrum is very smooth in the XANES region although the white line edge-jump of absorption coefficient was only 0.03. The clear phase and strong amplitude of EXAFS oscillations can be seen in **Fig. 2(b)** makes the data suitable for EXAFS data processing. This study indicates that the q-scan experimental technique improves the detection limit of XAS transmission measurement.

The most important reason to develop the q-scan experimental method was to provide a time resolution technique for the study of chemical processes on the millisecond timescale. The studies of chemical reactions, such as oxidation/reduction process, ion exchange/absorption and so on are important to those studying pure and applied sciences. The Pt L_3- and Ru K-edge XANES/EXAFS spectra of Pt and Ru standard foils are used to demonstrate the stability of the q-scan experimental technique, see **Fig. 3**. The up/down spectra collected at frequencies up to 10 Hz have excellent reproducibility in both the XANES and EXAFS regions proving that **TPS 44A** can now provide a time resolution of 50 milliseconds to users. An *in-situ* test case measurement of a Zn/Cu battery during its charging/discharging cycle was carried out with a 1 Hz oscillating frequency, and the results are shown in **Fig. 4**. Bing-Joe Hwang's group, from National Taiwan University of Science and Technology, designed the Zn/Cu battery for this study. To measure the Cu K- and Zn K-edge XAS spectra, the range of photon energies scanned can go up to 2,000 eV and by optimizing the oscillating range of the q-mono, both the Cu K- and Zn K-edge spectra can be collected in one scan. Clear features relating to

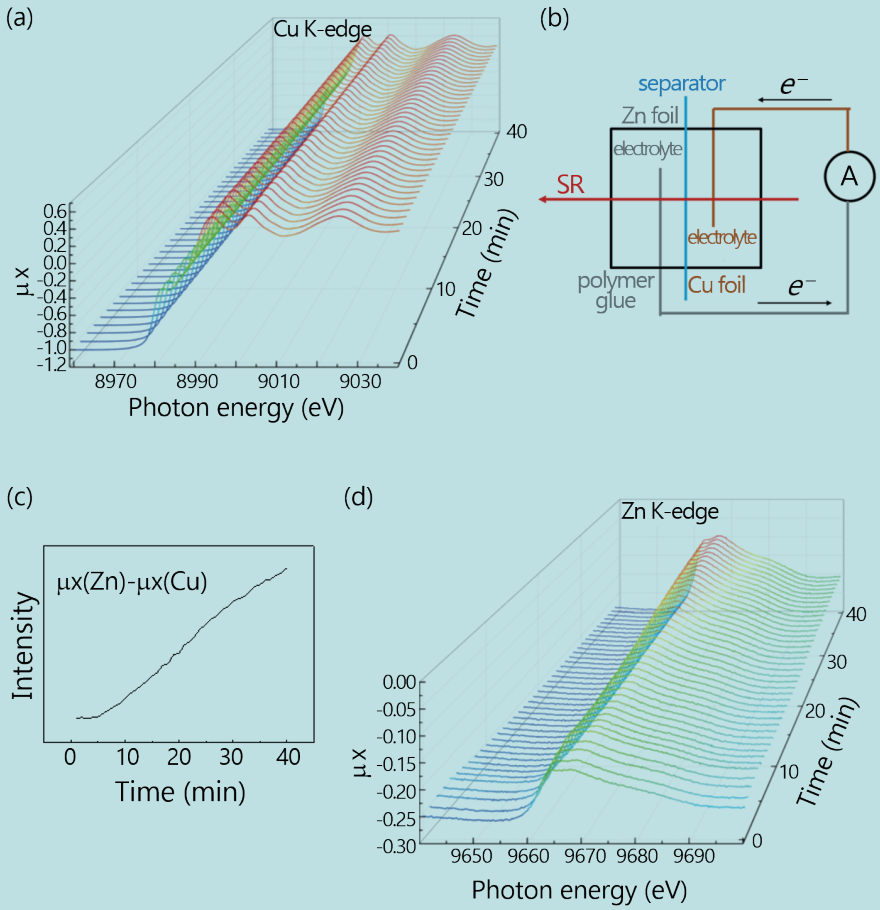

Fig. 4: The *in-situ* measurement of Zn/Cu battery at the Cu K- and Zn K-edge XANES spectra.

copper metal were found in the Cu K-edge XANES spectra (**Fig. 4(a)**), but the Zn K-edge XANES spectra (**Fig. 4(d)**) shows an increase in unoccupied 4p states of the Zn atoms during charging/discharging. **Figure 4(c)** shows the time dependence of the Zn K-edge XANES region after a background from the Cu atoms has been subtracted. The monotonic increase in intensity contains three different slopes, indicating that there are three different states at the Zn electrode. The first region is the original electrode, the second is that when Zn atoms are deposited at the electrode from the electrolyte, and the third is the releasing of Zn atoms. The atoms are released faster than they are deposited.

This test case showed that the states of Zn electrode can be observed in real time under charging/discharging conditions *via* the *in-situ*/*in-operando* XAS measurements. The experimental result provided critical information on the dynamics within the battery device not possible with the conventional XAS measurement methods. The q-scan experimental technique is therefore a new powerful tool, provided by **TPS 44A** for energy material research and chemical reactions in general. This instrument brings new opportunities for scientific research to the academic community in Taiwan and has become a very important facility for the study of both basic science and industrial/applied research. (Reported by Chih-Wen Pao)