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 microprobe 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)

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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

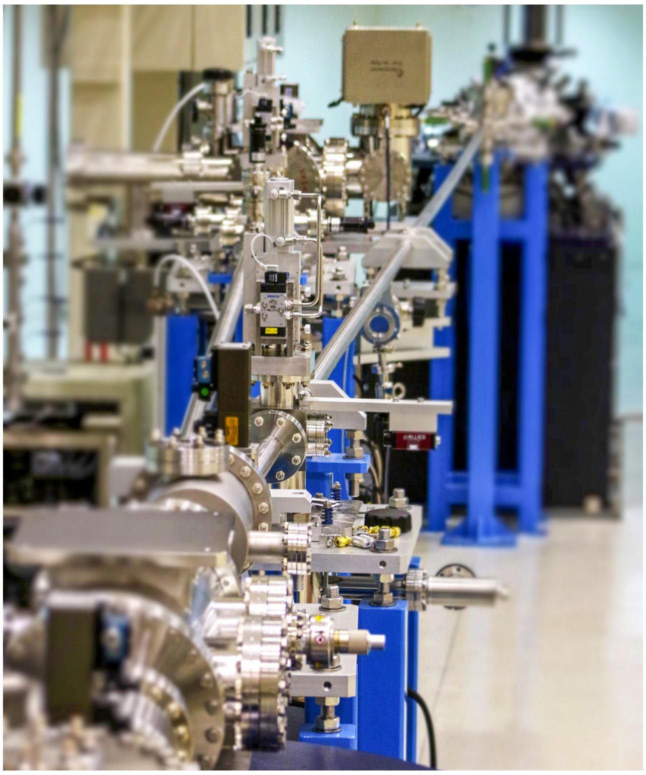

Fig. 1: Photograph of the beamline **TPS 45A**.

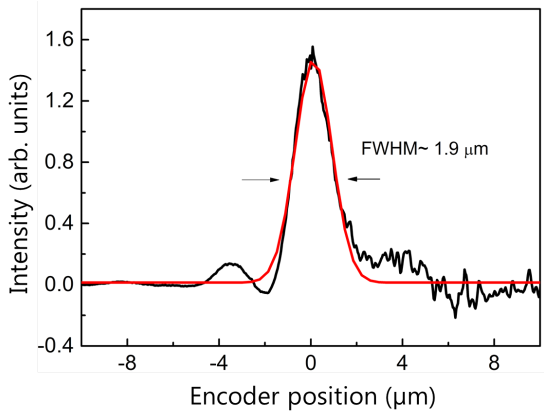

Fig. 2: Vertical beam size measured using a knife-edge.

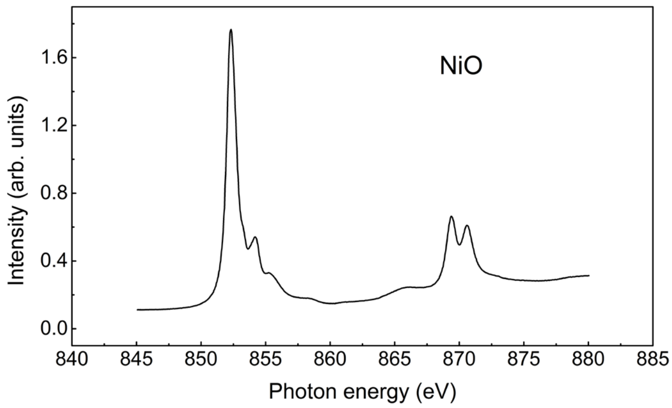

Fig. 3: The Ni L-edge X-ray absorption spectrum of NiO measured at **TPS 45A**.

full acceptance of 120 μrad × 120 μrad. Experiments were carried out at a typical photon energy set to ~850 eV. The horizontal focusing mirror was adjusted to obtain a horizontal focus of ~50 μm while the vertical focusing mirror was adjusted to obtain a vertical focus of less than 2 μm (**Fig. 2**).

Using the above obtained conditions, the Ni L_3 and L_2-edge X-ray absorption spectrum of NiO was measured and it matched nicely with the well-known spectrum of NiO (**Fig. 3**).[2]

We then carried out photoemission experiments because the energy resolution is best determined by the Fermi edge of a clean gold spectrum measured at low temperature.

After initial measurements of the Au 4*f* core level spectrum, the valence band of gold was measured to confirm the cleanliness of the gold sample. This was followed by low-temperature (T = 20 K) measurements of the Fermi edge of gold. Just before the end of the cycle on the 15th, Dec, 2018, we achieved a photoemission spectrum of the gold Fermi edge with an energy resolution of $\Delta E = 25$ meV at a kinetic energy of E ~845 eV. This corresponds to an energy resolving power E/ΔE of 33,800. These results for the total energy resolution are comparable to the best soft X-ray photoemission measurements in the world today.

The above results were obtained with a preliminary tuning of the active grating monochromator. After the long shutdown, further experiments have been planned to measure the photon flux and optimize the active grating monochromator to increase the photon flux and improve the energy resolution to the target E/ΔE of ~50000 in the first half of 2018. The Max-Planck Institute endstation (**Fig. 5**) installed on branch A has capabilities to carry out molecular beam epitaxy thin film growth, thus facilitating ARPES measurements on in-situ grown films.

Based on the encouraging preliminary results of the high energy resolution achieved, it is envisaged that ultra-high resolution band dispersions and Fermi surface mapping using soft X-ray ARPES measurements on a variety of topical materials in thin film and bulk crystal forms can be actively pursued at **TPS 45A**. Furthermore, the Tamkang University endstation (**Fig. 6**) installed on branch B has capabilities for X-ray emission spectroscopy, X-ray magnetic circular dichroism and X-ray excited optical luminescence studies. The scientific topics which can be fruitfully investigated at **TPS 45A** by the users' group include topological insulators, carbon-based nanomaterials, photovoltaic materials, transition metal and rare-earth-based strongly correlated electron systems, magnetic materials, oxide multilayers, *etc*. We look forward to a successful commissioning of the **TPS 45A** beamline and end-stations in the next few months.

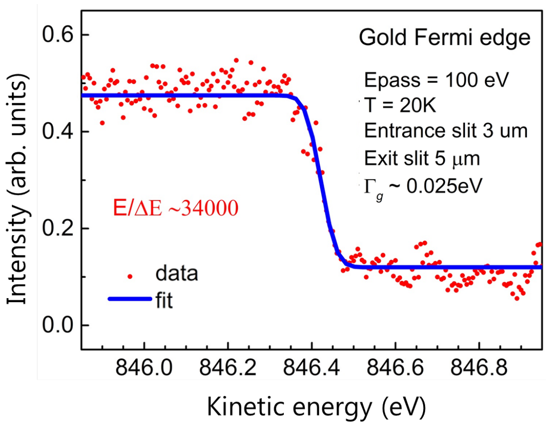

Fig. 4: The Fermi edge of gold measured at **TPS 45 A**.

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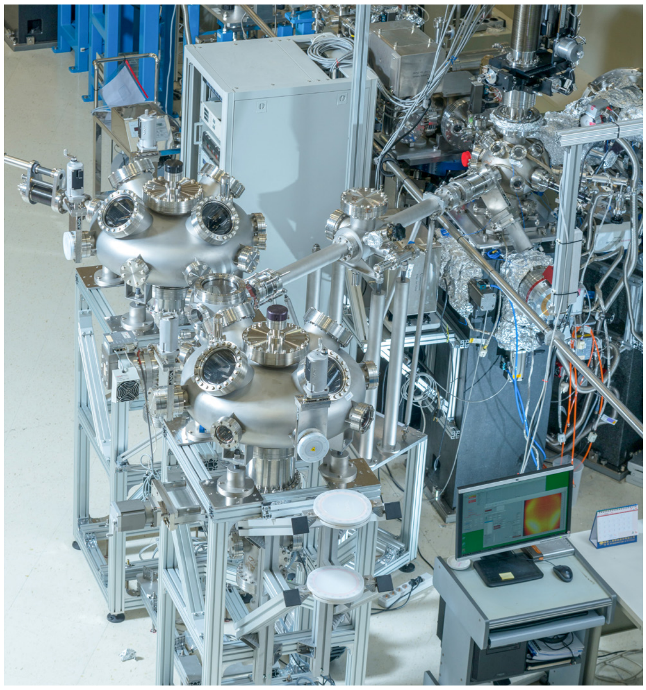

Fig. 5: The Max Planck Institute endstation installed on branch A of **TPS 45A**.

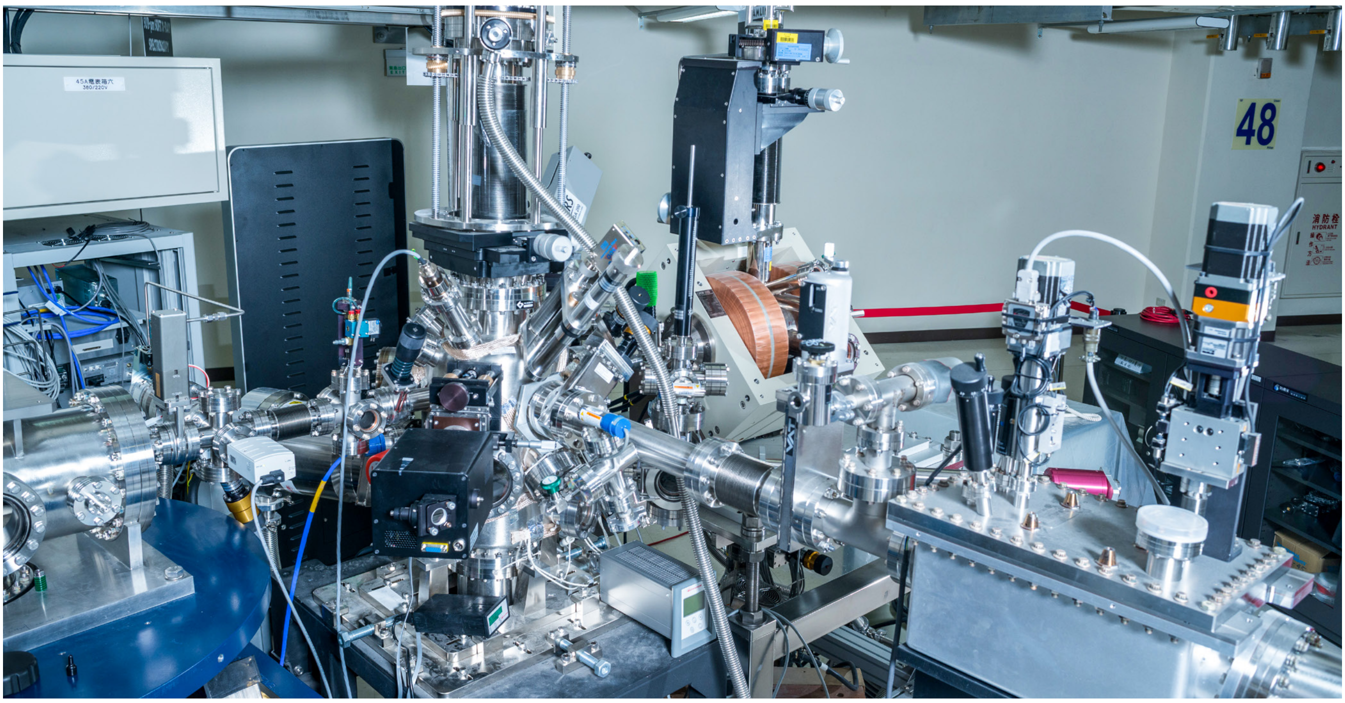

Fig. 6: The Tamkang University endstation installed at **TPS 45A**.