manipulator, imaging spin filter system, two UV light sources (mercury and helium), and the main UHV-chamber. The microscope is expected to arrive at NSRRC in December 2020.

In summary, **TPS 27A** is scheduled to start its commission in September 2020 after the completion of the beamline optics and EPU 66 installation. Both microscopy stations are to routinely record the images at a few 10's nm spatial resolution and the soft X-ray spectrum from a sub-micrometer area. With STXM's flexibility in sample manipulation and PRINS's diversity in image contrast, the **TPS 27A** soft X-ray nano-spectroscopy beamline will be a new platform bringing innovation and breakthrough to the material sciences. (Reported by Hung-Wei Shiu, Tzu-Hung Chuang, and Der-Hsin Wei)

nanoARPES Beamline

Angle-resolved photoemission spectra (ARPES) have emerged as a cardinal experimental tool to elucidate the emergence of many interesting physical properties in advanced materials, because of their unique capability to probe directly their momentum-resolved electronic structures. It allows the researchers not only to map the band dispersion and Fermi surface topology but also to understand comprehensively complicated phenomena dependent on momentum and energy in advanced materials. A central challenge in condensed-matter physics is to investigate the many-body systems in which strong interactions lead to novel ordered ground states. Examples include complex oxides, graphene-based materials, transition-metal dichalcogenides (TMD), topological insulators (TI), unconventional superconductors *etc*. These materials typically contain, however, domains or structural patterns or chemical inhomogeneities due to spontaneous phase separation or dopant or defect segregation or sample-surface mosaicity. The sizes of most such new crystals and thin films are generally smaller than several tens of micrometres. For even a crystal of millimeter size, its homogeneity is still a crucial issue. The small size of a beam spot might provide a chance to probe the electronic structure of these samples that consist of small domains. This proposal calls for the construction of a high-resolution and high-flux nanofocusing ARPES beamline.

Table 2: Parameters of VLS gratings

Energy range (eV)	20–200	50–650
N_0 (l mm^{-1})	600	1200
2θ (°)	155	160

The designs of a focusing optical system at nanoARPES beamline **TPS 39A** based on Kirkpatrick-Baez (KB) mirrors and zone-plate techniques, and of a new end station with a scanner stage, aim to enable high-resolution ARPES on a micrometre and nanometre scale. At **TPS 39A,** an elliptically polarized undulator (EPU) of period length 168 mm serves as a photon source. The operational photon energy is from 20 to 650 eV, which covers most of the VUV and soft X-ray photon energy range. The source parameters of EPU168 are listed in **Table 1**. **Figure 1** shows the optical layout of **TPS 39A**. The total length of the nanoARPES beamline is about 45 m from the center of the undulator to the hallway. An active- mirror plane-grating monochromator (AM-PGM) of a novel type developed at NSRRC is applied to increase the energy-resolving power across all photon energies. The idea originates from setting a bendable optic in front of a grating to expand the footprint of the incident beam on the grating. An increased coverage of the ruling number of the grating can increase the energy-resolving power. Also, a design of a bendable mirror can cor-

Table 1: Specifications of EPU168

Mode	Magnetic field (T)	K	E1st	Partial power within 4.4 sigma (kW)	Partial power on B1 chamber Miss steering 2 mm/0.2 mrad (W)
Horizontal linear	$B_y \leq 0.516$	$K_y \leq 8.1$	≥ 15	0.568	~0
Circular	$B_y = B_x \leq 0.223$	$K_y = K_x \leq 3.5$	≥ 39	~0	40/16
Vertical linear	$B_x \leq 0.223$	$K_x \leq 3.5$	≥ 72	0.237	3.6/2

rect the aberration and slope error of the optics. Two varied plate gratings with line spacings 600 and 1200 lines/mm will be used to meet the goal of a great resolving power. The resolving power at low photon energies exceeds 100,000, which can satisfy the requirements of ARPES. After the monochromator, the nanoARPES beamline has two branches; one has KB mirrors focusing ARPES branch with minimum spot size about 10 μm² and the other is a zone-plate-focusing ARPES branch with minimum spot size 100 nm. These two branches are separated with a deflection mirror (HPM) before the exit slits. A beamline specification of the two branches is listed in **Table 2**.

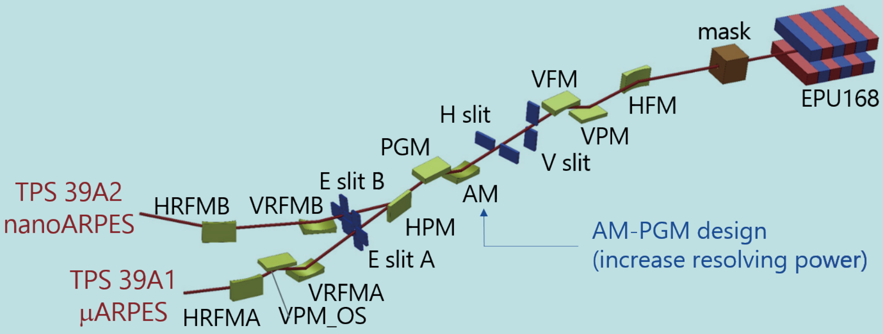

Fig. 1: Optical layout of nanoARPES beamline **TPS 39A**.

For micro-ARPES branch **TPS 39A1** (μARPES) with the KB mirror-focusing method, the endstation was led and constructed by Deng-Sung Lin (National Tsing Hua University) from a user community. The endstation was assembled in early 2018; commissioning began at the end of 2018. **Figure 2** displays the assembled end station located at port 39 of TPS. A 2D-VLEED spin detector was equipped for the endstation for spin-resolved ARPES. An energy analyzer (Scienta DA30L) with deflection mode and five-axis low-temperature manipulator can effectively satisfy the requirement for Fermi surface mapping. Before the connection to the beamline, a He-discharge lamp as a light source was used by users to undertake conventional ARPES experiments. This novel end station can allow users to conduct spin-resolved ARPES and conventional ARPES in the near future.

For **TPS 39A2** nanoARPES branch with a zone-plate-focusing method, the design of the end station began in mid 2019. A pair of KB mirrors with a bendable mechanism is placed behind the exit slit. On varying the curvature of the KB mirrors, two focusing points can be chosen arbitrarily: one focal point is set at the sample position with beam size 40 um for wide-range scanning; another focal point is set at the ZP-slit to meet the requirement of zone-plate focusing. With a zone plate of diameter 1 mm, the size of the incident beam of focal length 6 mm can be decreased to 100 nm for photon energy 150 eV and 200 nm for photon energy 50 eV. The design of the zone plate, order-sorting aperture (OSA) and sample stages was completed in 2019 December. **Figure 3** displays the design of all scanning stages in the analysis chamber of the nanoARPES endstation. The commission of all scanning stages will begin in mid 2020. (Reported by Cheng-Maw Cheng)

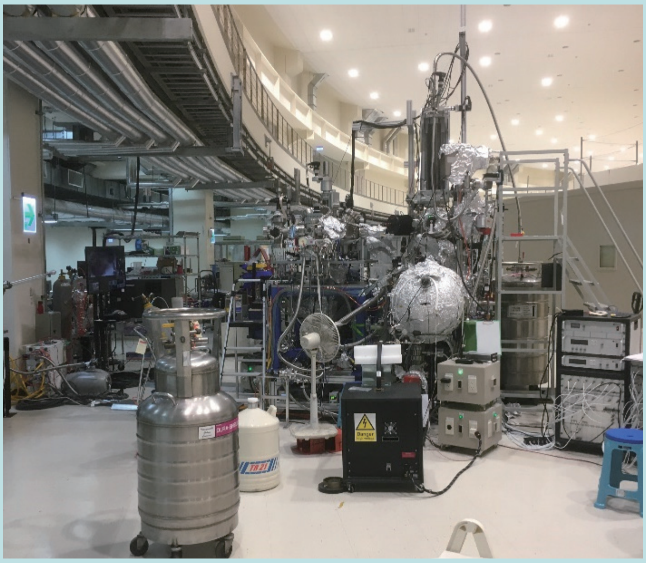

Fig. 2: Assembled endstation in the micro-ARPES branch.

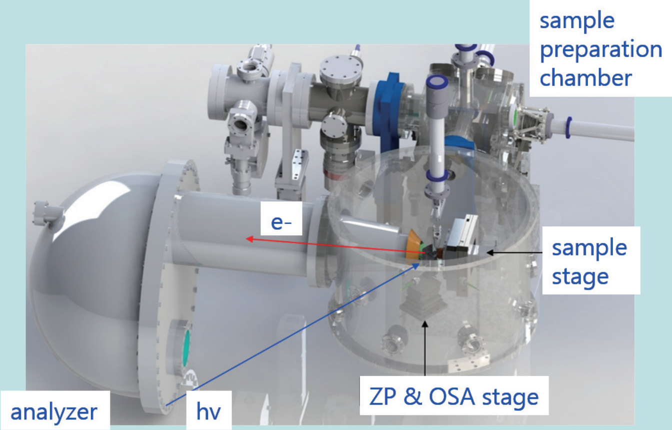

Fig. 3: Design of the zone plate, OSA and sample stages in the nanoARPES branch.