doi:10.1017/S1431927618013399
Microsc. Microanal. 24 (Suppl 2), 2018

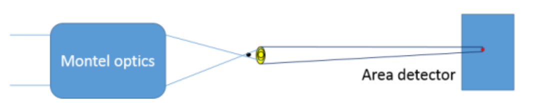
Nanoprobe Endstation with Montel optics and Resolution 50 nm at Taiwan Photon Source

Gung-Chian Yin[1*], Bo-Yi Chen[1], Chien-Yu Lee[1], Huang-Yeh Chen[1], Bi-Hsuan Lin[1], Shao-Chin Tseng[1], Xiao-Yun Li[1], Jian-Xing Wu[1], Shi-Hung Chang[1], and Mau-Tsu Tang[1]

[1.] National Synchrotron Radiation Research Center, Hsinchu, Taiwan.
* Corresponding author, gcyin@nsrrc.org.tw

The X-ray nanoprobe endstation at TPS was first commissioned in 2017 March. With entirely new approaches [1, 2], the resolution has attained 50 nm with a Montel optics setup, which is a great improvement relative to preceding attempts to implement Montel optics [3, 4]. Of three key improvements, the first is a mirror cut 45^o (V-shape) that minimizes the gap loss; the second is a polishing method [5] at the state of the art, and the third is a highly stable holder to adjust the mirror in an alignment method. This nanoprobe endstation consists of many innovations, such as the V-shaped Montel optics, a data-acquisition system of a new type with on-the-fly scanning (to be described in another presentation), a scanning electron microscope (SEM) to align the sample, and a sample stage for diffraction experiments of a new design.

The Montel optics consist of two identical plane-ellipse surfaces cut at 45^o to the normal of the surface; these two identical mirrors are placed side by side in a specially made mirror holder to ensure that the surface normal of each mirror is mutually perpendicular, and to minimize the gap between the two mirrors. We are currently able to close the gap to less than 10 μm and to ensure the perpendicularity of these two surfaces to less than ± 30 μrad according to pre-alignment methods mentioned in reference [6]. The Montel mirrors are adjusted according to a focus spot image formed by a zone plate after the focus position, as depicted in figure 1(a). The spot image, shown in figure 1(b), is magnified with a zone plate then projected to a scintillator-based area detector. The pattern of 50-nm gold spokes in the third inner circle is clearly resolved; the contrast is an absorption signal from the ion chamber.



(a)

(b)

Figure 1(a) Method to align the holder of the Montel optics. **(b)** (left) Image on the area detector. The diamond shape is the direct beam; the spot in the center is the magnified focus spot. (right) Two spots are visible (not aligned).

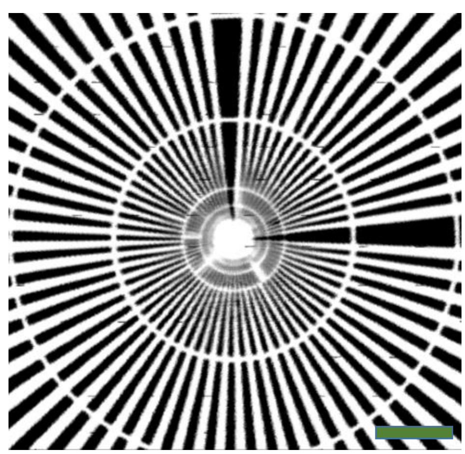


Figure. 2. The image indicates the spatial resolution to be 50 nm. The green bar has length 2 μm.

This holder [6] was originally designed with 10 automatic axes and 6 manual axes, with an optical encoder and a laser interferometer to monitor the position of the flexure structures. At the first quarter of 2017 the test result shows vibration that induces angular uncertainty ±0.6 μrad of the mirror holder. After that commissioning in the first quarter of 2017, we modified this holder by decreasing the travel range and weight to increase the resonant frequency; we have thereby achieved a much more stable holder that attains stability ±0.05 μrad.

As an efficient way to locate the sample, a SEM is installed in this endstation. For this SEM design and the requirements, the sample stage is also specially designed for a SEM and other detector. The sample stage consists of a high-speed *X*, *Y* (horizontal) stage and a custom-designed heavy-duty *Z* (vertical) stage with resolution 5 nm. On top of the sample stage, a flexure stage has three axes for high-speed scanning. With this acquisition system, the reflection mirrors are set on the flexure stages so that a change of position of the sample can be traced with the laser interferometer. On top of the flexure stage, the three-axis rotation stage is mainly for x-ray diffraction, XEOL [6,7] and the SEM. This three-axis rotation provides a flexibility to make the sample turn to the correct position for the various detectors for both x-rays and an e-beam. The SEM is useful to locate the sample for a X-ray diffraction experiment. The helium cryo-system is designed to be under the sample stage with a cooling braid link to a sample; an off-line test of this cooling system shows that 10 K is attainable. The holder of the diffraction detector is also designed for a Bragg coherent diffraction image (BCDI), shown in figure 3. These two functions will be installed in the second and third quarters of 2018, respectively; this endstation is already partially open to users at 2018 March.

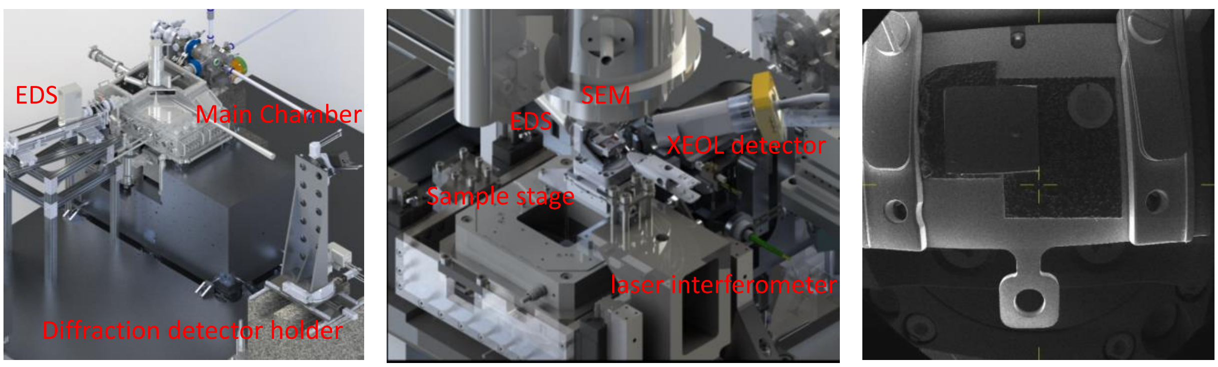


Figure 3 (left) Overview of the nanoprobe endstation at TPS, including the diffraction holder (middle), a close look at the sample stage (right), and a SEM image of the sample, which helps to locate the region of interest.

References
[1] G.-C. Yin *et al*, AIP Conference Proceedings, 1696 (2016) 020026
[2] G.-C. Yin *et al*, Proc. SPIE 9592, X-Ray Nanoimaging: Instruments and Methods II, 959204
[3] W. Liu *et al*, Journal of Synchrotron Radiation, 18 (2011) 575-579
[4] C. Liu *et al*, Applied Surface Science, 258 (2012) 2182-2186
[5] K. Yamauchi *et al*, Review of Scientific Instruments, 73 (2002) 4028-4033
[6] B.Y. Chen *et al*, MEDSI2016 Proccedings, (2017) 57-59
[7] B.-H. Lin *et al*, Applied Physics Letters 109 (2016), 192104
[8] B.-H. Lin *et al*, Optics express **26**, 2731-2739 (2018).

https://doi.org/10.1017/S1431927618013399 Published online by Cambridge University Press