

# Novel Reflective Optics and Systems for Hard X-ray Microscopy

Kazuto YAMAUCHI

Osaka University

Department of Precision Science & Technology and Applied Physics,  
Graduate school of Engineering, Osaka University.  
2-1 Yamada-Oka, Suita, Osaka 565-0871, Japan  
[yamauchi@prec.eng.osaka-u.ac.jp](mailto:yamauchi@prec.eng.osaka-u.ac.jp)

Scientific and technological researches based on synchrotron radiation (SR) X-rays are rapidly expanding with new sources such as 3rd generation SR and X-ray free electron laser sources now being constructed world widely. The X-ray beams emitted from these sources are becoming diffraction limited and getting better natures in their angular divergences, photon fluxes, and spatial coherencies. In this status, X-ray optics for focusing and imaging are playing indispensable roles and being demanded to be more precise and feasible. X-ray mirror has bigger advantages to be less chromatic, to have long working distance, and to have higher transmittance compared with other optics of Fresnel zone plates and lenses, however demanded shape accuracies of mirror surfaces are unprecedentedly high. In the last 10 years, many figuring and figure testing methods such as elastic emission machining (EEM), ion beam figuring (IBF), relative angle determinable stitching interferometer (RADSI), nanometer optical component measuring machine (NOM), and at-wavelength figure evaluation methods have been developed, and high precision mirrors having nearly diffraction-limited performances become available and are utilized cutting-edge beamlines [1-10]. I will show the latest mirror-optics of nano-focusing, adaptive focusing, and achromatic full-field nano-imaging to enhance the performance of X-ray microscopy.

This research is partially supported by Grants-in-Aid for the specially promoted research (18002009), for the scientific research (S) (23226004) and (16H06358), for promotion of XFEL research, for CREST project, and for A-STEP project from the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT).

## REFERENCES

- [1] K. Yamauchi et al., *J. Phys. Condens. Matter.* 23, 394206 (2011).
- [2] H. Mimura et al., *Nat. Phys.* 6, 122 (2010).
- [3] H. Mimura et al., *Nat Commun.* 5, 3539 (2014).
- [4] S. Matsuyama et al., *Opt. Exp.* 23, 9746 (2015).
- [5] S. Matsuyama et al., *Sci. Rep.* 6, 24801 (2016).