Synchrotron based measurement techniques for magnetic materials at new 3GeV synchrotron facility “NanoTerasu”

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A new 3 GeV synchrotron facility, “NanoTerasu,” has been launched on the Tohoku University campus in Sendai, Japan, in April 2024. The designed current and natural emittance in the accumulation ring are 400 mA and as low as 1.14 nm·rad, respectively [1]. As the first phase of facility development, ten beamlines have been constructed: seven are for membership-based use, while three are open to the public. The seven beamlines, referred to as "Coalition beamlines," operate under a new utilization system that allows members to access them by simply reserving beam time, without the need for proposal submission. With this system, experiments can typically be conducted within one to two months after reservation. If beam time is available, they can be performed in as little as three days. This enables cross-disciplinary sample evaluations in a short period by utilizing multiple beamlines with different measurement techniques. Such a membership-based beamline system also facilitates comprehensive evaluations of magnetic materials. Among the Coalition beamlines, BL14U is equipped with a twin helical undulator, where two insertion devices placed upstream and downstream generate right- and left-circularly polarized soft X-rays, respectively. The XMCD spectromicroscopy apparatus installed at the end of BL14U was originally developed at SPring-8 [2, 3]. BL08W consists of three branches for X-ray diffraction (XRD), small-angle X-ray scattering (SAXS), and X-ray absorption fine structure (XAFS) measurements, which can be used simultaneously by independent user groups. The BL08W-XRD branch is designed for powder diffraction measurements using a glass capillary, and a phase diagram study of permanent magnets is planned with the forthcoming upgrade of a furnace. X-ray micro-CT at BL10U is suitable for visualizing the three-dimensional microstructure of magnetic materials. XMCD spectroscopy of Resonant Inelastic X-ray Scattering (RIXS) in the soft X-ray regime are also feasible at BL07U. Hard X-ray Photoemission Spectroscopy (HAXPES) measurements at BL09U are capable of elucidating the electronic structure of magnetic thin films for spintronic devices [4]. On the other hand, BL02U, BL06U, and BL13U are public beamlines dedicated to high-resolution RIXS, nano-ARPES, and nano-XMCD, respectively. These public beamlines have also been open to users since March 2025. The talk will begin with an introduction to the NanoTerasu facility and the beamlines for magnetic material studies, followed by demonstration results obtained from the Coalition beamlines, a review of selected outputs [5, 6], and perspectives on magnetic material studies, particularly using XMCD spectroscopy and microscopy.

References

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