New Beamlines at TLS

To provide users with more exciting research opportunities at NSRRC, three beamlines are scheduled to open to the public at the Taiwan Light Source in 2012. The beamlines widely cover powerful experiment techniques of protein crystallography, resonant in-elastic X-ray scattering and synchrotron-radiation circular-dichroism spectroscopy. Users are encouraged to submit proposals via our user service website http://portal.nsrrc.org.tw.

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BL15A1 Protein Crystallography Beamline

In order to meet the requirement of biomedical researches, a new protein crystallography facility was designed and built by the Beamline Group and Protein Diffraction Group at NSRRC.

The light source is an In-Acromat superconducting wiggler (IASW6) insertion device. The beam will be collimated using a cylindrical collimating mirror, followed by a Si(111) Double Crystal Monochromator, and focused using a toroidal focusing mirror. In order to minimize the heat load on the Silicon single crystal, the monochromator will be cooled using a liquid nitrogen cryogenic system, which have been proved to be efficient on other similar beamlines. The energy range is 5.5 keV – 16 keV (wavelengths 2.25 – 0.775 Å). At 1 Å wavelength, the measured flux at the sample position is about 5×10^{11} photons/sec through a 200 μm×200 μm aperture.

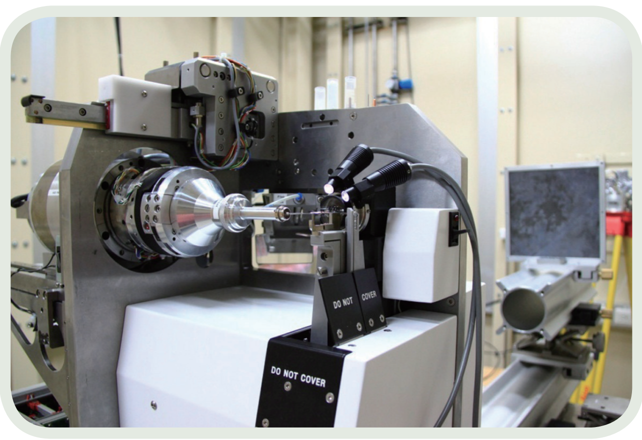

Fig. 1: BL15A1 micro-diffractometer of protein crystallography.

The equipment in the end station includes an Rayonix MX300HE CCD X-ray detector, an SSRL-style automatic sample changer, a granite heavy-duty experimental table and a high-precision micro diffractometer. The high speed and high precision air-bearing goniometer is very important for high-efficiency crystal screening and MAD/SAD phasing experiments, which is critical for a successful project in a crystallography research. The end station is fully automatic and could be run without human intervention, but could be switched into manual control on demand. Remote access is also provided to facilitate international collaborations.

BL05A Soft X-ray RIXS Beamline

Resonant inelastic X-ray scattering is a photon-in photon-out spectroscopy for measuring the energy, momentum and polarization change of the scattered photon. These changes of photon are transferred to intrinsic excitations of the material, and RIXS provides the information about those excitations. Combination of resonant technique could not only greatly enhance the scattering cross section, but also provides a unique way to determine charge, magnetic and orbital degrees of freedom on condensed matter. However, the most critical of RIXS are the collection efficiency of scattered X-ray and energy resolution. Therefore, we have constructed a RIXS beamline, which is based on the principle of energy compensation, with an active grating monochromator (AGM) and an active grating spectrometer (AGS). The active grating is an aspherical mirror with varied-line-spacing (VLS) ruling and optimized with photon energy at 800 eV. In addition to perform the experiments with resolution of momentum transfer, the spectrometer system is mounted on a rotational frame with continual angle from 0° to 130°, as shown in Fig. 2. Our recent commissioning results demonstrated that the energy resolution of BL05A soft X-ray RIXS beamline is around 115 meV at photon energy of 868 eV corresponding to resolving power of 7500. In the future, we will install a sample cryo-system with low-temperature control to study the low energy excitation across phase transition in condense materials.

This advanced RIXS beamline and end-station provide an opportunity for users to study the intrinsic momentum-dependent, low-energy response of a material.

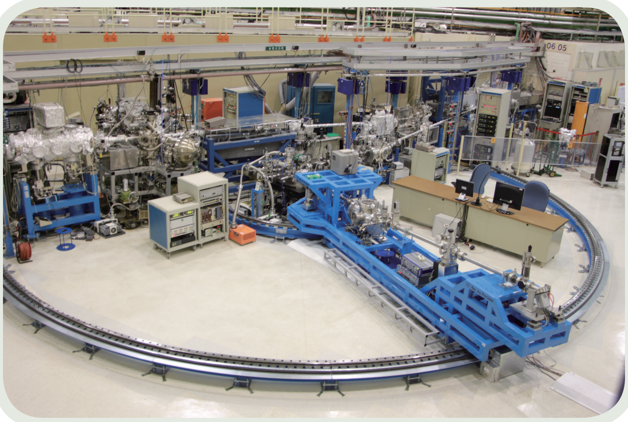

Fig. 2: BL05A- Soft X-ray RIXS beamline.

BL04C High Flux SRCD Beamline

Circular dichroism (CD) spectroscopy is a well-established technique which measures the absorption difference between left- and right-circularly polarized vacuum-ultraviolet (VUV) light by chiral molecules. In recent years, the synchrotron radiation circular dichroism (SRCD) has emerged as an excellent technique for CD measurements and many SRCD beamlines were constructed or under construction worldwide because its photon flux is three orders of magnitude higher than that of conventional CD. SRCD is indispensable for spectral region shorter than 170 nm where the water absorption effect reduces enormously the transmitted photon signals. As part of this trend, an experimental station for steady-state CD measurements was constructed and attached to the BL04B beamline at the Taiwan Light Source (TLS). To facilitate time-resolved CD measurements that require much higher photon flux, a new VUV beamline dedicated for CD measurements has been designed and is now under construction at the NSRRC. Since this new beamline needs to use the same radiation fan of the BL04B beamline, its design is under very stringent geometric constrains. Nevertheless, we are able to come up with a design which can provide a photon flux as high as the best CD beamlines in the world, e.g. the CD12 beamline at ANKA in Germany while offers simultaneously a smaller focused beam size.

The design goals of the high-flux CD beamline are (1) photon flux > 1×10^{13} photons/sec, (2) linear polarization degree > 90%, (3) spectral range from 130 nm to 330 nm, and (4) beam size at focal point < 1×1 mm^2. The maximal horizontal and vertical acceptance angle of this beamline is 30 mrad and 7 mrad, respectively, and the maximal flux from the bending magnet source is 7×10^{13} photons/sec/0.1%bandwidth at 160 nm wavelength. The beamline optical layout is shown in Fig. 3.

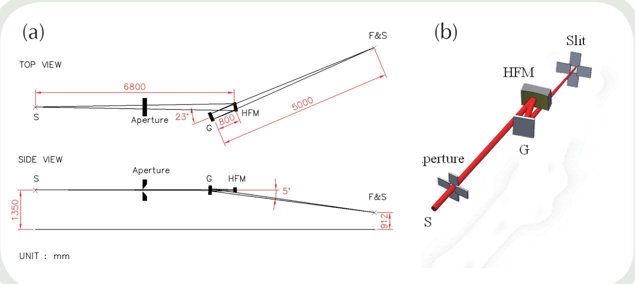

Fig. 3: (a) Optical layout of the high flux VUV-CD beamline. S: bending magnet source; HFM: horizontal focusing mirror; G: grating; F&S: focal point of 160 nm wavelength and slit position. (b) Schematic 3D diagram of optical layout.

A dynamic SRCD end station is constructing at the BL04C beamline (Fig. 3). In a kinetic mixing experiment with millisecond time resolution, an ideal technique to quantify the folding process of protein secondary structure is readily observed with stopped-flow CD spectroscopy. SRCD has the advantage of high photon flux in the far UV below 220 nm, where the CD signal differences between random coil and β-structure become very pronounced. This SRCD end station consists of a sample chamber, a temperature controller for sample cell, a data acquisition systems based on lock-in technique method and a stopped-flow device developed by Jasco Inc.. An Aviv CD spectrometer is also available for preliminary studies. All users are welcomed to apply for BL04C beamtime (ready to open for operation in 2012) through our website to perform CD measurements on this new SRCD end station, particularly those CD experts who can explore the advantages of dynamic CD spectroscopy and provide us valuable suggestions for future developments.

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