OPERATIONS

Beamline Technical Improvements

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VUV BEAMLINES

There were a number of technical VUV beamline improvements during FY 1998. In preparation for the start of user operations on the U2B beamline, an infrared microscope was purchased which, when utilizing the NSLS as a source, will perform with a 1000-fold improvement over the commercial instrument.

Recommissioning of the U3A beamline continued with special emphasis on the beam requirements for Advanced X-ray Astrophysics Facility (AXAF) X-ray mirror reflectivity calibrations in the 1000-2000 eV energy range. These requirements include adequate stability for arcsecond alignment, a sharp beam profile, less than 0.1 % beam impurity and adequate flux for energies up to 2000 eV. Monochromator upgrades continued with implementation of lookup table based tracking of monochromator crystal elements. Periodic error corrections for both crystal rotary tables were calibrated and energy scanning algorithms based on lookup table tracking were defined, debugged and implemented in a LabView monochromator control program. Adequate tracking was demonstrated using Na-β alumina crystals for the 800-2100 eV range. Scraper slits were installed downstream of the horizontally-focusing mirror to achieve a sufficiently sharp beam profile. The stability, alignment characteristics, spectral purity, and flux characteristics for the beam in the 1-2 keV range were determined to be adequate for the AXAF calibration program.

Design of the U3B diagnostic beamline was completed and bids were received for fabrication and polishing of the critical water-cooled mirror. Construction was underway on the mirror vacuum chamber and beamline support structure. The U3B beamline will provide a previously unavailable energy measurement capability for the electron beam in the VUV storage ring.

On U3C a four-reflection high order trap (HOT) developed by Hettrick Scientific was tested in order to reduce photons outside the desired bandwidth to less than 1% for instrument calibration. This system has six sets of traps covering different spectral regions up to 540 eV, and provides beam purities greater than 99% below 250 eV. A HOT optimized for U3C was designed with the intention of installing it in FY99.

As part of the DOE Facilities Initiative, spherical gratings and a moveable slit will be added to the U4A beamline, replacing toroidal gratings and fixed exit slits. The ARP chamber will be fitted with a sample transfer and load lock system. Plans for these improvements were finalized with installation expected in FY99.

In order to complete construction of the U7A soft X-ray materials characterization facility, the former facility was completely dismantled and reconstructed. The new facility incorporates a refocusing mirror (commissioned in FY98) which produces a sub-millimeter spot at the sample position. The refocusing mirror also provides a rapid means of switching the soft X-ray beam from the U7A monochromator between the surface science end station and the materials end station. Also, a sample manipulator and preparation/load lock chamber were installed which allow rapid sample entry as well as catalyst calcining and pretreating under atmospheric pressures. The new sample manipulator allows multiple (30) samples to run in an automated fashion.

The U9A NSLS storage ring vacuum R&D beamline was completed in FY98. Photon-stimulated desorption measurements were carried out on various vacuum surfaces, including KEK B-factory chambers.

To optimize signals on the U9B fluorescence spectrometer, an xyz sample positioning system was installed with more than 1 cm travel in each direction. Also, a new photomultiplier was installed to detect the intensity of light passing through the samples that are being simultaneously monitored for fluourescence. The process of upgrading the data acquisition system was underway with the purchase of new control software for the multiparameter analyzer.

The U10A infrared beamline neared completion with the installation of the front end mirror box and a diamond window to separate the UHV front end vacuum from the rough vacuum (or purge gas) used in the instruments. The Bruker IFS66v/S infrared Fourier transform vacuum interferometer was installed on the U10A beamline. Two reflectance units have been built for the interfero- meter. The first allows the use of the detector area inside the spectrometer. The second unit employs a single reflection whereby light from the sample is collected by a large mirror and then focused into an external detector. This arrangement is used almost exclusively for large, liquid-helium cooled detectors which must be located outside of the spectrometer.

The U11 beamline was used for photoionization mas spectrometry (PIMS), high resolution angle-resolved photoemission spectroscopy, and absorption spectroscopy of gases. The biology chamber quartz lens used to collect fluourescence and focus it onto the entrance slit of an emission monochromator was replaced by a custom-built off-axis toroidal mirror, thereby extending the wavelength range and improving efficiency by eliminating chromatic aberration. Also, a 1.5 Tesla room temperature electromagnet with optical access through the iron pole pieces was in the process of being fit to operate at U11 for magnetic circular dichroism experiments.

During FY 98 all major components for the U12A IR beamline were procurred with installation of the optical components and completion of the beamline vacuum envelope expected by the end of 1998. Final alignment and commisioning is slated for early in 1999.

The U13UB beamline is devoted to UV/VUV spectroscopy in the 5-30eV range. The U13 undulator/ wiggler source can be directed to either: (1) a focused white light branch with variable (0-10ns) delay, or (2) a high resolution ($hv/\Delta hv > 10^4$) monochromatic branch. The monochromatic branch, which contains the bulk of the mechanical and optical components of the entire beamline, became fully operational in June 1998.

During FY98 the U15 beamline was used primarily for studies of soft X-ray excited luminescence in doped nanocrystals. To conduct these studies changes were made to the U15 main chamber, and pumping systems. The TGM monochromator motor control unit was recommisioned. The U16B beamline was restored to an operating condition and made available to General Users during FY98.

X-RAY BEAMLINES

The first tests of a new X1A scanning transmission X-ray microscope were carried out in FY98. This microscope has kinematic mounts for exchange of its optics, and a motorized detector platform to allow rapid exchange between different detectors, and positioning of configured detectors by taking scanned images of detector alignment. In its first test, these capabilities were used to demonstrate (in collaboration with Denis Joyeux of Institut d'Optique and Francois Polack of LURE, France) Nomarski phase contrast in a scanning microscope. The successful test of the basic components of the microscope paves the way for implementation of the system in a sealed chamber for spectromicroscopy at the nitrogen and oxygen edges.

On the X1B beamline, new refocusing optics were installed and aligned. These changes should facilitate experiments requiring high brightness such as those using the soft X-ray spectrometers.

On the X3 beamline there were a number of upgrades. The X3 beamline equipment protection interlock was modified to include a front valve which was previously unprotected. The X3A1 cryogenic system was repaired to eliminate helium leaks and modified to allow continuous operation during recharge. A new 1000x1000 element CCD detector was installed in May 1998 which can be used on both the A1 and A2 stations. Progress was made in writing new diffractometer-control software in coordination with APS staff.

An Raxis-IV imaging plate detector was put into operation on the X4A beamline during FY98. The automation of the scanner resulted in a large improvement for users. A further improvement will be made in 1999 when a CCD detector is installed to reduce the turnaround time between exposures. On the X4C beamline 1.5 horizontal mradians of beam was focussed into 0.42 mm(FWHM) on the experimental table. An ADSC single cell CCD detector system was purchased and integrated with Windows driven PC software and preliminary debugging of the motion control system took place.

Further progress occured in FY98 towards running strongly polarized hydrogen-deuteride ice (SPHICE) targets at the X5 LEGS beamline. There were 3 major target production runs with the BNL dilution refrigerator and 17 Tesla magnet system presently at Syracuse University. Full size (3cm dia. x 5 cm long) HD targets with over 50% H polarization were produced and successfully extracted from the dilution refrigerator. After the first round of experiments has been completed, the SPHICE target factory will be moved to the NSLS and recommissioned in a new lab adjacent to the LEGS beamline. To facilitate the production of SPHICE targets a helium liquefier was obtained from the University of Virginia. Work also took place on the construction of a central drift chamber to expand the spin assymetry(SASY) calorimeter capabilities for charged particles (p,π^+, π^-). Final design and engineering work began and construction of several components was underway at several of the LEGS collaborating institutions. A prototype of the time projecton chamber (TPC) trigger scintillator was constructed and successfully tested. A major beamline upgrade was implemented providing a new front-end transport system capable of switching between an existing Ar- Ion laser and a new frequency-quadrupled Neodymium-Yttrium-Fluoride(Nd-YLF) ring-laser system. The combination of this new ring laser and the recent increase in the storage ring energy to 2.8 GeV has increased LEGS gamma-ray energies to 470 MeV. The first 470 MeV beam was observed in April 1998.

Stimulated by an effort to develop a facility to perform time-resolved in-situ measurements of catalytically-active materials, several changes were implemented at X7B during FY98. An externally exhausting fume hood was installed to vent both the hutch and a commercial gas cylinder cabinet, in order to satisfy safety standards for gas flow and reactivity experiments. To reduce heat loading of the monochromator crystal, graphite wafers were inserted in the beam-defining slit package located upstream of the premirror position. A new portable detector/sample trolley system was designed and constructed. The heart of the sytem is a MAR 345 automated detector system based on image plate technology. The system makes it possible to adjust the sample to detector sparation over more than a meter with 50 micron accuracy. The detector system can also be moved above and below the plane of the incident beam by 30 degrees with 0.01 degree accuracy. The entire assembly sits on a kindmatic mounting system that makes alignment of the detector system simple and reproducible. Finally, A Labview based NSLS DAC beamline control system was implemented during the second half of FY98.

Operations expanded on beamline as it became a dedicated station for X-ray footprinting. A dedicated stopped-flow mixing device was constructed and put into operation. This device enabled experiments on a 10-20 millisecond or longer timescales. The efficiency of operation of the X9B X-ray spectroscopy beamline was enhanced with software and hardware advances in beamline control. There were improvements to the AUTOFIT1.2 package which allows tue use of advanced ab initio XAS codes by users understanding structural analysis.

At X10A and X10B a new two-dimensional CCD detector(Bruker Smart 1500) was purchased to enhance real time measurements of small-angle and wide-angle scattering. A new data acquisition and analyzing system was also scheduled for installation. A Siemens FSD scintillation counter was also purchased for use at X10A and X10B. This detector handles count rates up to 10 counts per second, permitting some experiments to be performed without attenuation. A new oven was constructed for polymer stretching in order to investigate the deformation process of polymers at elevated temperatures. Conversion of the VAX beamline control system to a LINUX system was also underway.

There were a number of upgrades and replacements on the X11A beamline in the past year. The operating system on all the PRT computers was upgraded and a macro command utility was added to the data collection software to allow automatic data collection as a function of sample position, temperature, etc. The 13-element Canberra detector was serviced to optimize its performance. Commissioning and testing of a sagittal focussing system continued. A new computer controlled slit assembly was installed. A new collimating mirror was received and found to meet specifications when measured at the BNL Instrumentation Division. Design of a mirror support mechanism began.

The X13A SGM instrument was commissioned with an existing grating. Two new gratings were procured to make use of the EPW for magnetic spectroscopy development. A new crystal monochromator was developed for X13B for use with the IVUN and EPW.

A new beryllium window with two ports was installed at X15A to provide a 5 inch wide white beam with a 1 mm thick aluminum filter for diffraction-enhanced imaging (DEI), and a 1 inch wide white beam for X-ray standing wave (XSW) experiments. The hutch and beamline were reshielded for 2.8 GeV operation. A rail system was installed under the XSW chamber to facilitate switching from the XSW mode to the DEI mode.

At X15B design, construction, and full commissioning of a new room-pressure sample chamber and hutch box took place. The upgraded chamber, which complements the existing high vacuum(10^{-6} - 10^{-9} Torr) and ultra-high-vacuum (10^{-10} - 10^{-12} Torr) chambers, allows transmission or fluorescence X-ray absorption measurements in air or controlled atmosphere at room or cryogenic ($\lesssim$ 10 K) temperatures.

At X17B1, the beamline control system was upgraded by replacing the old VAX computer with a PC Linux platform running a standard software, SPEC. A 2048 by 2048 real-time CCD detector with 65 micron resolution was used scattering experiments using high energy X-rays of up to 90 keV.

A new optical lab for pressure measurement was set up near the X17C beamline. It will develop into a new Raman spectroscopy experimental lab in the future. A new electric discharge drilling machine was set up in the lab to enable users to drill rhenium gaskets for the diamond anvil cell. A new Dell XPS R 400 workstation was acquired for data analysis by users. In the future this computer will replace the micro VAX beamline control computer.

At X18B the experimental hutch was enlarged and cable feedthroughs installed to permit the use of a larger array of experimental equipment, including solid state detectors. An additional fluorescent screen was installed in the beampipe to facilitate alignment. The data collection software was upgraded. A small device was fabricated to collect a small part of the incident monochromatic beam and reflect from a standard metal sample to provide a reference spectra for thick or supported samples used for fluorescence XAS.

The most significant beamline upgrade at X19A was the replacement of the damaged zerodur mirror with a new silicon mirror. A factor of 10 improvement in throughput resulted with a significant decrease in the focused beam size. Additional diagnostics were installed for alignment purposes. At X19C an analyzer axis for the detector arm was designed and implemented. This enables detailed analysis of harmonic contamination on white beam topographs.

On the X20 beamlines filtering transformers were installed for the protection fo the more control electronics and beamline equipment safety systems. Also, new stepping motor controllers were installed for hutch and diffractometer motors. Unshielded ribbon cables were replaced with shielded ones and capacitance filtering was installed on the E500 sustem for the new controllers. At X20B New Focus Picomotors and a controller were purchased for the tilt and bend of the monochtomator crystal. Design of a vertical focussing mirror began. It will intercept approximately 2mm of the beam and give a 50 micron vertical FWHM spot at the sample position. The mirror should provide a factor of 13 increase in brightness and eliminate harmonic contamination. An IBM RS/6000 Model 590 computer was installed and upgraded to AIX Version 4.2. This will serve as a fast data analysis machine, primarily for the in-situ phase transformation studies done in real time at X20C.

At X21 commissioning and operation of a 7-element analyzer took place.

In addition to normal maintenance at the X22 beamlines, there were a number of upgrades. At X22A a new Pt-coated Si focussing mirror was installed. Also, Soller slits were upgraded for electrochemistry experiments. At X22B a new Pt-coated Si focussing mirror was also installed, the liquid surface spectrometer was upgraded and a new UHV chamber for liquid metal surface studies was completed. At X22C a new Pt-coated Si focussing mirror was returned to the manufacturer for repolishing because its roughness exceeded specifications. An azimuthal rotation stage was fabricated for use on the Franke-Heydrich spectrometer in studies of resonant orbital ordering.

At X23A2 an energy discriminating SiLi fluorescence detector was installed. Also, the data acquisition system was converted to a LabView based system to record DAFS data.

At X23B problems with the collimating mirror were settled and the beamline operated with good flux and excellent energy resolution. This allowed minor problems with the monochromator to be uncovered and fixed. The beamline computer was upgraded to a Power Macintosh to increase the speed and to take advantage of the full capabilities of the NSLS-DAC software.

At X24A a new UHV chamber for PRT members and general users was brought into operation. The chamber will have a hemispherical analyzer and precision manipulator for surface science experiments. Modifications were made to the downstream optical slit assembly to permit the use of a feedback control of the X-ray beam position over a limited range at the experiment. The position control is desirable for experiments such as EXAFS measurements or electron spectroscopy.

New toroidal collimating and focussing mirrors were received which should improve resolution at X24C by at least a factor of two and increase flux at energies above 1000 eV. The new mirrors will replace old paraboloidal mirrors that had an effective roughness of 3 nm rms and a figure slope error of about 20 microradians rms. The surface roughness of the new mirrors is 0.5 nm rms or less, and the slope errors are within 4 microradians of circular.

A new front end safety shutter was installed to permit X25 to operate at currents in excess of 350 mA (at 2.584 GeV).

At the X27A X-ray Computed Microtomography beamline, the computational speed of the reconstruction algorithm was improved by more than 10 times in FY 98. Implementation of a parallelized Pentium farm provided another factor of 8 or better improvement in reconstruction speed. More alignment and data acquisition functions were automated in 1998 for user-friendly operations. Multilayers in the X27A monochromator were replaced, as well as the Be window on the output port of the monochromator. ■