X-ray instrumentation for spectroscopic and diffraction characterization of materials

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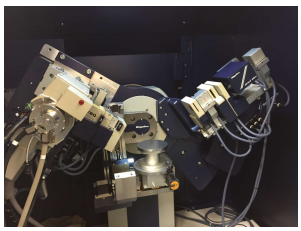
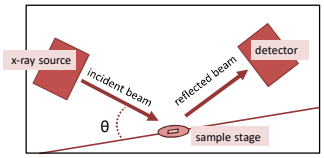
Laboratory Source



- Advanced User Guidance expert system functionality
- Multilayer mirror
- High-flux 9 kW rotating anode X-ray source
  - Cu Kα line

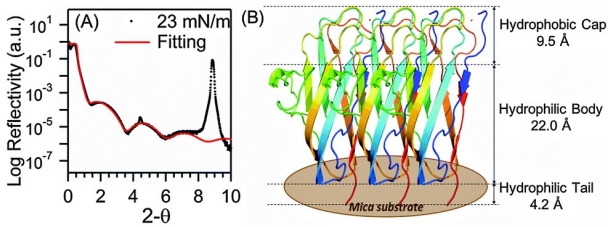
$$E = 8.04 \text{ keV}$$
$$\lambda = {}^{E}/_{hc} = 1.54 \text{ Å}$$



- HyPix-3000 high-energy-resolution 2D multidimensional semiconductor detector
- 5-axis goniometer

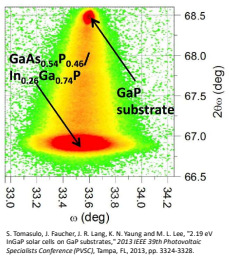
Measurements

Reflectivity



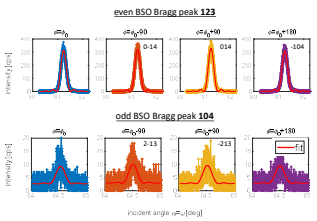
Wang, Z., Morales-Acosta, M. D., Li, S., Liu, W., Kanai, T., Liu, Y., ... Yan, E. C. Y. (2016). A narrow amide I vibrational band observed by sum frequency generation spectroscopy reveals highly ordered structures of a biofilm protein at the air/water interface. *Chemical Communications*, 52(14), 2956-2959. https://doi.org/10.1039/c5cc05743d

Reciprocal Space Maps



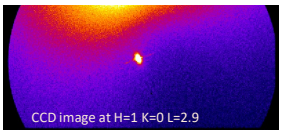
S. Tomasulo, J. Faucher, J. R. Lang, K. N. Yaung and M. L. Lee, "2.19 eV InGaP solar cells on GaP substrates," *2013 IEEE 39th Photovoltaic Specialists Conference (PVSC)*, Tampa, FL, 2013, pp. 3324-3328.

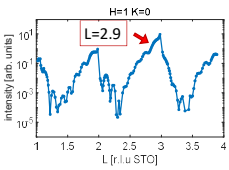
Rocking Curves



Crystal truncation rods

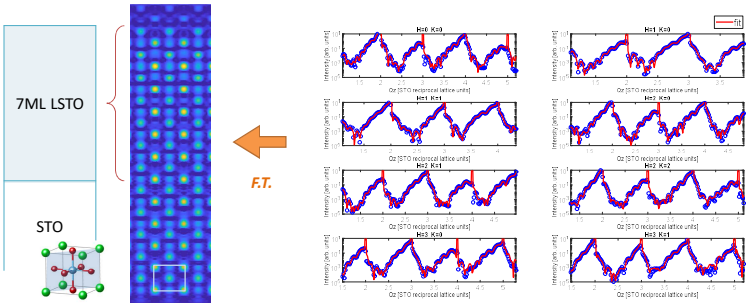
7ML LSTO on STO





- Thermal diffuse scattering
- Coherent LSTO

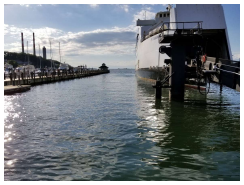
Real Space	Reciprocal Space



Synchrotron

Advantages of synchrotron radiation

- Tunable energy
- High flux
- Coherent beam



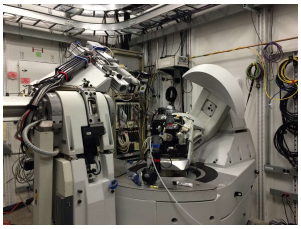
Traveling from Yale → BNL by ferry

BROOKHAVEN NATIONAL LABORATORY

National Synchrotron Light Source NSLS-II

- 6-circle diffractometer →
- **Energy Range:** 5.4-18 keV
- **Flux:** ~5x10^{12} photons/s
- **Resolution:** ~10^{-4}
- **Spot Size:** tunable down ~40 microns (V) x 400 microns (H)

Mounting sample on diffractometer



Argonne NATIONAL LABORATORY

Advanced Photon Source APS

- ← 6-circle diffractometer
- **Energy Range:** 4-40 keV
- **Flux:** 2x10^{13} photons/s
- **Resolution (ΔE/E) :** ~10^{-4}
- **Spot Size:** tunable down ~30 microns (V) x 70 microns (H)

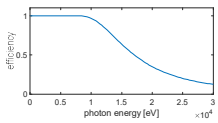
Area Detectors

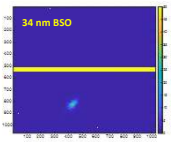
EIGER X 1M

Advantages

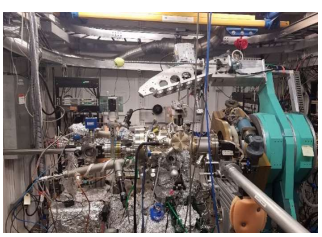
- frame rates of up to 3000 Hz
- Continuous readout with 3 µs dead time
- High spatial resolution with 75 µm pixel size
- Single-pixel point-spread function
- Hybrid Photon Counting: Direct detection of X-ray photons combined with single-photon-counting
- Count rates up to 5·10^8 phts/sec/mm^2
- No readout noise or dark current
- Extremely compact housings
- Room temperature operation of all components

Sensor: 450 µm Si

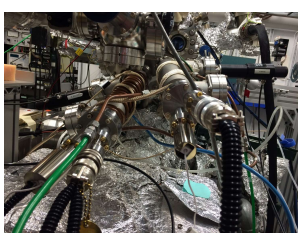




In-situ MBE



UHV chamber



effusion cells