



Argonne
NATIONAL
LABORATORY

... for a brighter future



U.S. Department
of Energy

UChicago ►
Argonne_{LLC}

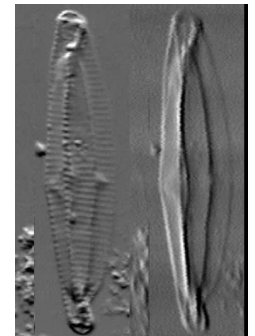
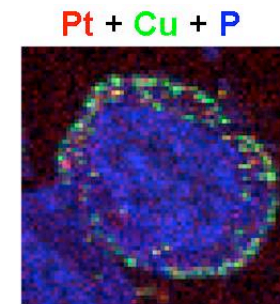
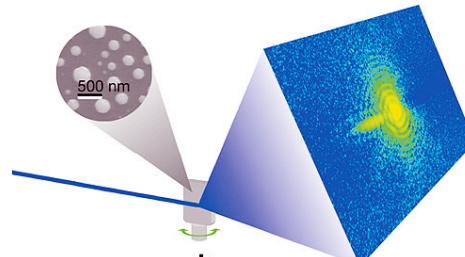


U.S. DEPARTMENT OF ENERGY

A U.S. Department of Energy laboratory
managed by UChicago Argonne, LLC

APS Renewal: Imaging Instruments

Barry Lai and Jörg Maser



Charge to Instrumentation Group Organizers

- Gather and organize information regarding instrumentation
- Synthesize proposals into a coherent picture that describes the instruments and techniques
- Identify instruments and techniques that should be built and developed
 - We **will** present a summary of the instrumentation/techniques and put these in perspective.
 - *We will **not** make recommendations as to what should and should be built in this forum. This will be part of the ongoing discussion*
 - *We **will** point out where we see current strength, needed investments, and potential overlaps.*
- Disclosure: Of course we have prejudices - nanofocusing, tomography, coherent techniques. We tried to be balanced. This forum will provide added balance

Imaging Instruments

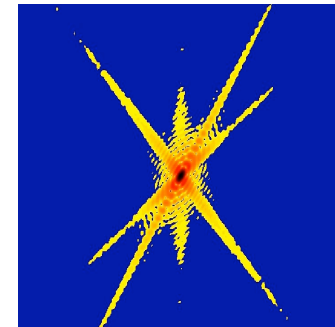
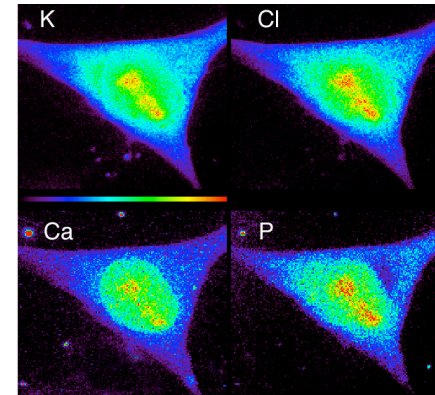
■ Scanning Probes

- Microprobe
- Nanoprobe

■ Full Field Imaging

- Micro-imaging
- Nano-imaging

■ Support and Infrastructure



Current Capabilities and Proposed Upgrades - Microprobes

System	Spatial Resolution	Science Thrust	Comments
* 8-BM: High throughput trace element analysis	~ 30 μm	Life sciences	Complementary to: 2-ID, BioCAT, Bio-Nanoprobe
* 13-ID-C: Dedicated microprobe (2.3-23 keV, canted ID)	0.25-4 μm	Geo-science	
* 16-ID: HP microprobe, (canted ID)	0.5-1.0 μm	Geo-science, materials science	Complementary to: S6, S13, S11, S20, S30
* 18-ID: second tandem undulator for bio microprobe	~ μm	Biology	Main thrust of 18-ID: fiber diffraction, SAXS. XRF μ -probe complementary to other XRF/XANES microprobes
* 20-ID: Dedicated micro-XAFS, canted ID, spectroscopy emphasis	0.5-10 μm	Environmental science, Geo science, materials science	Complementary to 13-ID

* Proposal submitted

Current Capabilities and Proposed Upgrades - Nanoprobes

System	Spatial Resolution	Science Thrust	Comments
* 7-ID-C: Nanoprobe with ps resolution	100 nm	Materials science, chemistry	Unique capability
* 2-ID Nanoprobes: cryo-XRF (2-20 keV), XRF (5-30 keV), XRD (5-30 keV)	50 nm	Life/environmental science, materials science	Cryo-XRF complementary to proposed BNP. μ -XRD complementary to 26-ID, 34-ID.
* 26-ID: Nanoprobe Heating/cooling stage	30 nm	Materials/Nanoscience	Unique capability.
* BNP (5-30 keV)	20 nm	Life science	Unique capability.
* 34-ID: 3D diffraction micro- and nanoprobe (canted ID)	20 nm	Materials science	Unique capability. Complementary to 2-ID, 26-ID
+ X-STM	20-70 nm	Materials science	Unique capability.
* 26-ID: MLLM	Sub-10 nm	Materials/Nanoscience	Unique capability.

* Proposal submitted + Current capability

Current Capabilities and Proposed Upgrades – Micro-imaging

System	Spatial Resolution	Science Thrust	Comments
* 1-ID: High energy diffraction microscopy	~ μm	Materials sciences	40-90 keV
* 32-ID-B: Ultra-fast imaging (second ID)	~ μm	Materials sciences	Complementary to 7-ID
+ 32-ID-C: Phase contrast imaging	~ μm	Life science, materials science	Unique capability
* AXI CDT: long beamline for phase contrast imaging	~ μm	Life science, materials science	200-m long beamline, possibly by extending 32-ID
* 7-ID-B: Pump-probe phase-contrast imaging	~ μm	Materials science, chemistry	100-ps resolution. Unique capability
+ 13-BM: microtomography	~ μm	Geo/environ. science	Dedicated facility
* 2-BM: Micro and nano tomography	0.1-1.0 μm	Life science, materials science	Dedicated facility
* BM: High energy tomo.	~ μm	Materials science	White or multilayer mirror
* 5-BM-C: Microtomo.	~ μm	Materials science	

* Proposal submitted + Current capability

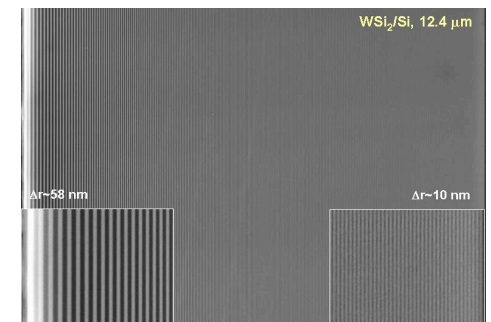
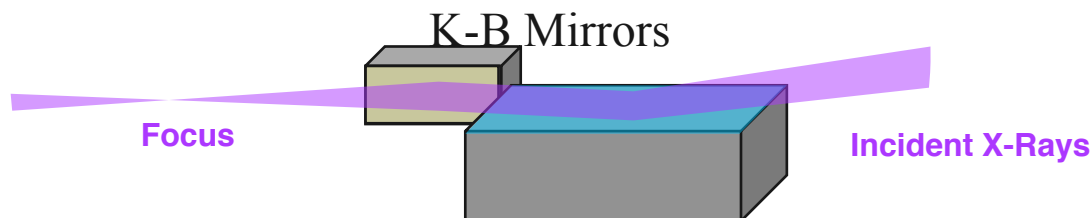
Current Capabilities and Proposed Upgrades – Nano-imaging

System	Spatial Resolution	Science Thrust	Comments
+ 32-ID: TXM	30 nm	Life science, materials science	Dedicated facility
+ 26-ID: Nanoprobe	30 nm	Materials science /Nanoscience	
* 33-ID: x-ray reflection interface microscopy	30 nm	Surface/interfacial science	Unique capability
* 34-ID-C: dedicated Bragg CDI facility	5-50 nm	Life science, materials /nano science	Unique capability
* AXI CDT: intermediate energy forward CDI, hard x-ray Bragg CDI	5-50 nm	Life science, materials /nano science	34-ID-C may move to AXI
+ 4-ID-C: time-resolved cryo-PEEM	10-50 nm	Materials science	Unique capability

* Proposal submitted + Current capability

Support and infrastructure

- Sample environment (HP, cooling/heating, magnet, in-situ.....)
 - High pressure, high fields
 - Cooling/heating
 - In-situ...
- X-ray Optics R&D:
 - Continued fabrication/modeling/testing R&D for diffractive, reflective optics
 - Characterization capability: beamtime for testing/Characterization beamline
- Nanopositioning R&D
 - Develop approaches for Nanometer-level positioning
 - Integrate positioning *and* controls aspects
 - Turn R&D systems into engineered and deployable designs



Support and infrastructure, cont'd

- Detectors:
 - Higher Efficiency, larger solid angle, higher throughput
 - Detector support (calibrated I_0 detectors, software support)

- Correlative imaging
 - Electron, optical, IR
 - Immunolabeling
 - Scanning Probe

- ***Software, Software, Software***

Comments

- High pressure sample environment has proliferated to many existing beamlines and proposed upgrades.
- APS offers unique timing structures for imaging of dynamics.

Summary

- APS has a strong microscopy and imaging community. Proposed upgrades and existing facilities will:
 - offer complementary and unique suites of imaging instruments
 - cover length scale from **cm** to **nm**, with different modality, sample environment, and time resolution
 - critical for the two Renewal **themes** and many of the science **cases**
- It is important to extend our lead in nanofocusing and nanoimaging (nanopositioning), while incorporating more **3D** capabilities.
- It is important to strengthen imaging programs (propagation/phase and coherent diffraction) to be worldwide competitive
- The success of imaging programs at the APS will depend in part on the availability of customized sophisticated **software** for image reconstruction, processing, and analysis.