Development of the PtychoProbe Beamline for the Advanced Photon Source Upgrade

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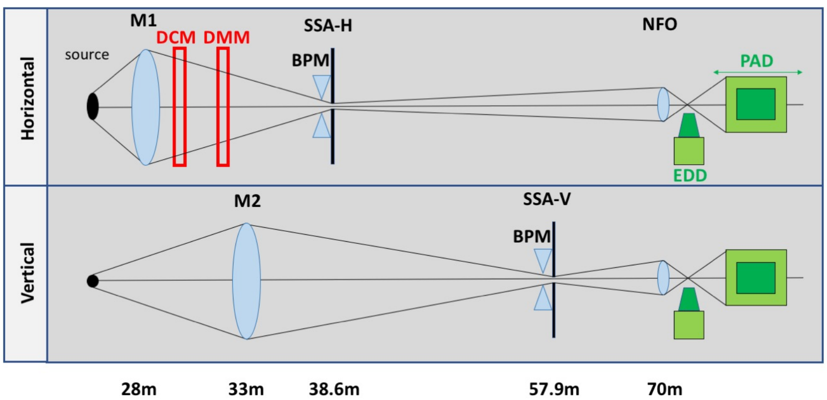
The multiscale and multi-modal understanding of advanced materials via x-ray microscopy has been recognized as one of the great challenges of science end engineering in the coming decades. It will lead to dramatic changes in the ways materials, devices, and systems are understood and created. The goal of the PtychoProbe (Ptychography + Nanoprobe) beamline is to realize the highest possible spatial resolution in x-ray microscopy both for structural and chemical information with scan rates up to 1,000 times faster than currently possible. This will enable visualization across all relevant length scales, nanoscale, mesoscale, and macroscopic, using a single experimental technique. The unprecedented brightness of the future multi-bend achromat lattice for the Advanced Photon Source will be exploited to produce a nanoscale beam of focused hard X-rays (e.g., 5 nm in size) to achieve the highest possible sensitivity to trace elements. Ptychography will be used to further improve the spatial resolution for structural components to its ultimate limit at the 1-nm-scale, only limited by the radiation hardness of the sample. The proposed beamline will enable high-resolution two- and three-dimensional imaging of thick objects, and bridge the resolution gap between contemporary x-ray and electron microscopy. Pushing x-ray microscopy into the nanoscale is crucial for understanding complex hierarchical systems on length scales from atomic up to meso and macroscales, and time scales down to the microsecond level, and is applicable to scientific questions ranging from biology to earth and environmental materials science, to electrochemistry, catalysis and corrosion, and beyond.



Optical layout of the PtychoProbe beamline. Dynamically bendable mirrors (M1: horizontal, M2: vertical) focus the x-ray beam onto the secondary source aperture (SSA) that consists of a horizontal (SSA-H) and vertical (SSA-V) pair of slits with integrated beam positioning monitor (BPM). Depending on the experimental needs, the beamline utilizes a DCM for high energy resolution or a DMM for high flux. The nanofocusing optic (NFO) will be located at 70 m. Energy dispersive detectors EDDs are utilized for the detection of x-ray fluorescence from the sample. A movable pixel-array detector (PAD) can be positioned between 70.1-75 m attached to a variable length evacuated flight pass.