The APS Upgrade Beamline White Paper

Coherent Surface Scattering Imaging (CSSI) Beamline for Unraveling Mesoscopic Spatial-Temporal Correlations

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From energy production and storage to dynamics in biomembranes and cells, from self-assembled hierarchical structures to fluid flow in confined geometries, natural and man-made processes around us exhibit structure and dynamics on nanoscopic to macroscopic length scales and on nanosecond to hours time scales. At the center stage of the scientific topics, surface/interface phenomena are of great interest to scientists in a variety of fields. The challenge topics at surfaces and interfaces include but not limited to evolution of biological membranes and supramolecules in aqueous environment, thin film and quantum dot growth, assembly of planar and three-dimensional (3D) polymer nanocomposites, and 3D nanoscaled electronics using additive manufacturing. In decades, much progress has been made in the development of hard x-ray sources and tools including those at storage-ring sources such as the APS. Among all, grazing-incidence x-ray scattering (GIXS) and x-ray photon correlation spectroscopy (XPCS) exhibit unique advantages for exploring the surface/interface problems that are challenging to solve using other imaging techniques dynamics probes. Recently storage-ring sources with brightness increase by a factor of 100 to 1000 have been proposed and such a high-brightness and -coherence source is the cornerstone of the APS upgrade. The x-ray beams from the upgrade source possess a large coherent fraction, well suited for measuring the spatiotemporal evolution of structures in complex systems with the highest precision. Coherent x-ray based surface imaging techniques provide ideal tools to directly observe surface/interface structures and their dynamics responding to changes in external conditions. A new beamline for coherent surface scattering imaging (CSSI), taking advantage of the much improved x-ray beam coherence, is proposed, for probing and understanding mesoscopic spatial-temporal correlations by integrating the coherence-based surface x-ray probe with state-of-the-art coherence-preserving optics, and advanced x-ray detectors.