Structure and Dynamics of Biological Systems

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Purpose

Integrate five emerging technologies to permit multimodal and multiscale spatial, temporal, and chemical analysis of biofilm organization, cellular nanotoxicology and enzymatic energy transduction.

Expected Outcomes

1. *Coherent X-ray Diffraction @ LCLS* - Femtosecond diffract-and-destroy methods for atomic resolution structure determination; observe dynamics using a pump-probe regime.
2. *Dynamic TEM* - Assess diffract-and-destroy compatibility with micro- and nanosecond single-shot electron pulses. Acquire real-time movies.
3. *Atom Probe Tomography* - Reconstruct 3-D protein crystal structure. Extend APT to more complicated biomaterials in embedded or cryo-state.
4. *In situ TEM/SEM/ToF-SIMS – Develop* flow cells for cross-platform use; Improve *in situ* TEM spatial resolution; probe chemical changes at biofilm/substrate interface.
5. *Nano-SIMS* - Robust analysis of biological systems; Cryogenic capability for imaging optimally preserved samples.

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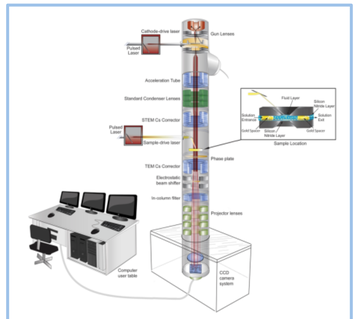
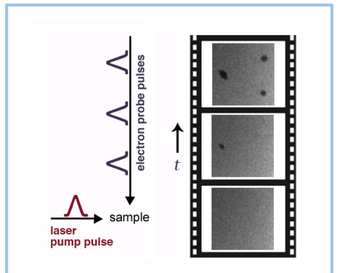
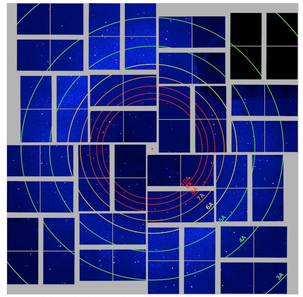
Research Design



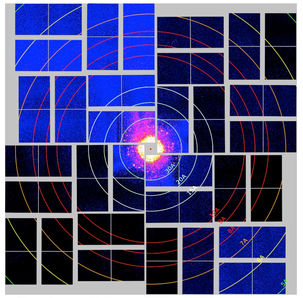
2nd generation Dynamic TEM



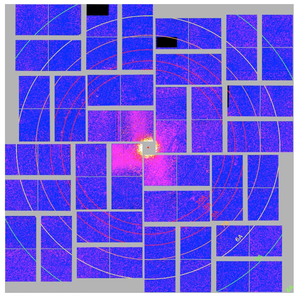
Schematic of pump-probe experimental regime for acquiring movies with Dynamic TEM



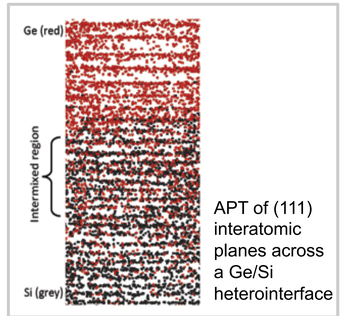
(Left) 50 fs coherent x-ray diffraction from a 3-D microcrystal



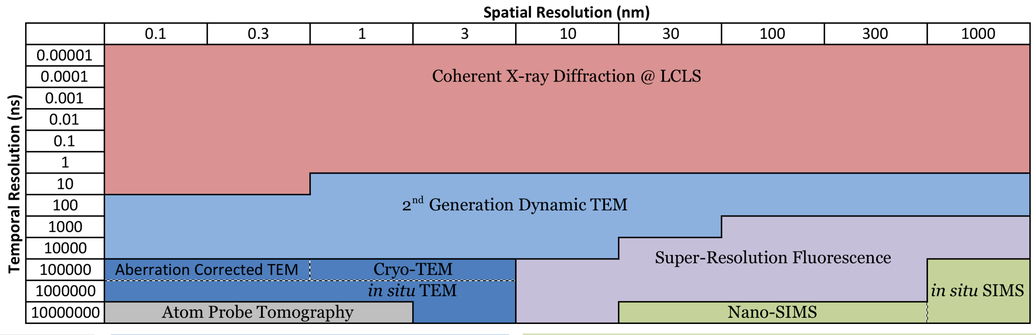
(Center) 50 fs coherent x-ray diffraction from a 3-D nanocrystal

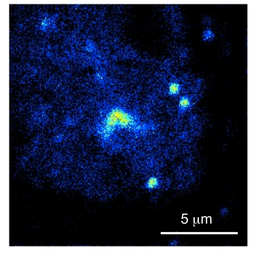


(Right) First ever coherent x-ray diffraction from a 2-D protein crystal

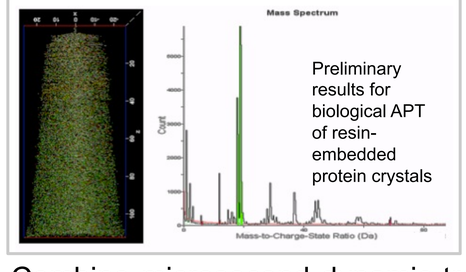


APT of (111) interatomic planes across a Ge/Si heterointerface

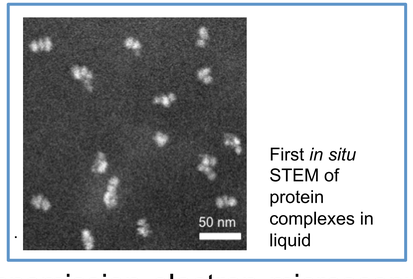




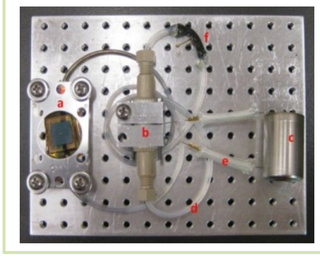
Nano-SIMS image of UO^+ distribution

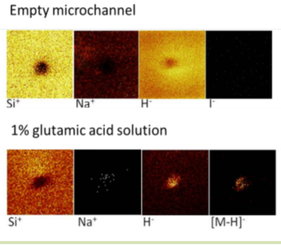


Preliminary results for biological APT of resin-embedded protein crystals



First *in situ* STEM of protein complexes in liquid





(Left) Assembly of the liquid interface for *in situ* SEM/ToF-SIMS.

(Right) ToF-SIMS imaging of liquid surface (10x10 µm²)

Combine microsecond dynamic transmission electron microscopy with femtosecond coherent x-ray diffractive imaging, *in situ* and cryogenic secondary ion mass spectrometry and atom probe tomography to interrogate the structure and dynamics of biological systems.