

In Situ X-ray Studies of Nanostructure Creation

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Nanostructure Synthesis

After synthesis:

- **First question: What did we make?**
 - Characterize: morphology, composition, crystal structure, strain ...
- **Second question: How do we get what we really wanted?**
 - Understand synthesis process
 - For key processes, it will be worthwhile to have research programs on synthesis
 - X-rays and neutrons: allow *in situ* experiments

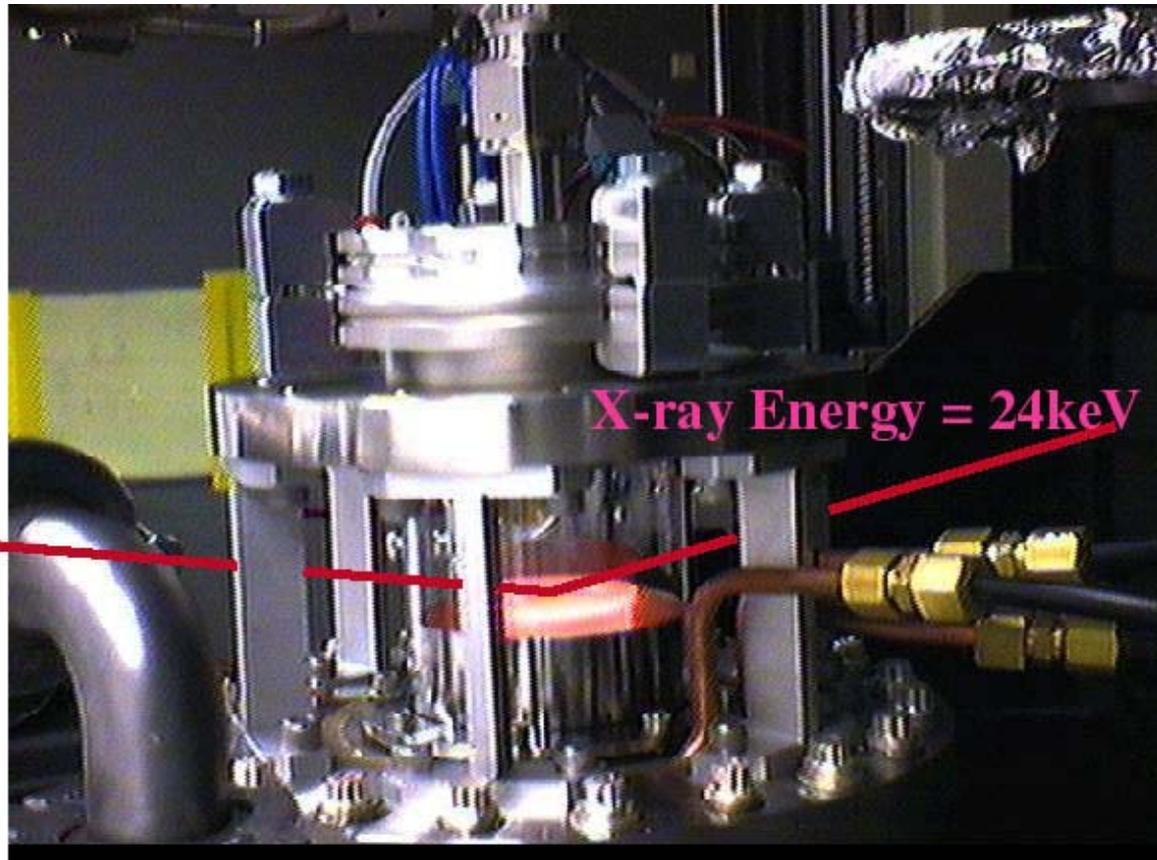
Understanding Synthesis Processes

- **Some of the greatest challenges in nanoscience are in understanding and optimizing the synthesis and patterning processes needed to create nanostructures**
- **Highly-controlled synthesis and nanoscale patterning processes are needed for a variety of materials far beyond current (e.g. semiconductor) nanofabrication: complex oxides, bio-inorganic composites, magnetic materials, etc.**
- ***In situ*, atomic scale observation of processes such as chemical vapor deposition, atomic layer deposition, reactive ion etching, and aqueous solution deposition and etching will direct their development and optimization for new materials**

X-ray and Neutron Techniques: Ideal for In Situ Studies

- **X-ray and neutron techniques can penetrate environments and overlayers to obtain atomic scale information during synthesis**
- **Synchrotron x-ray techniques can observe tiny volumes and image at nanoscale resolution**
- **X-ray scattering and spectroscopy are ideally suited to providing the first *in situ* observations of the atomic scale mechanisms of nanostructure creation**

Example of Current Work: In-situ X-ray Characterization of Film Growth

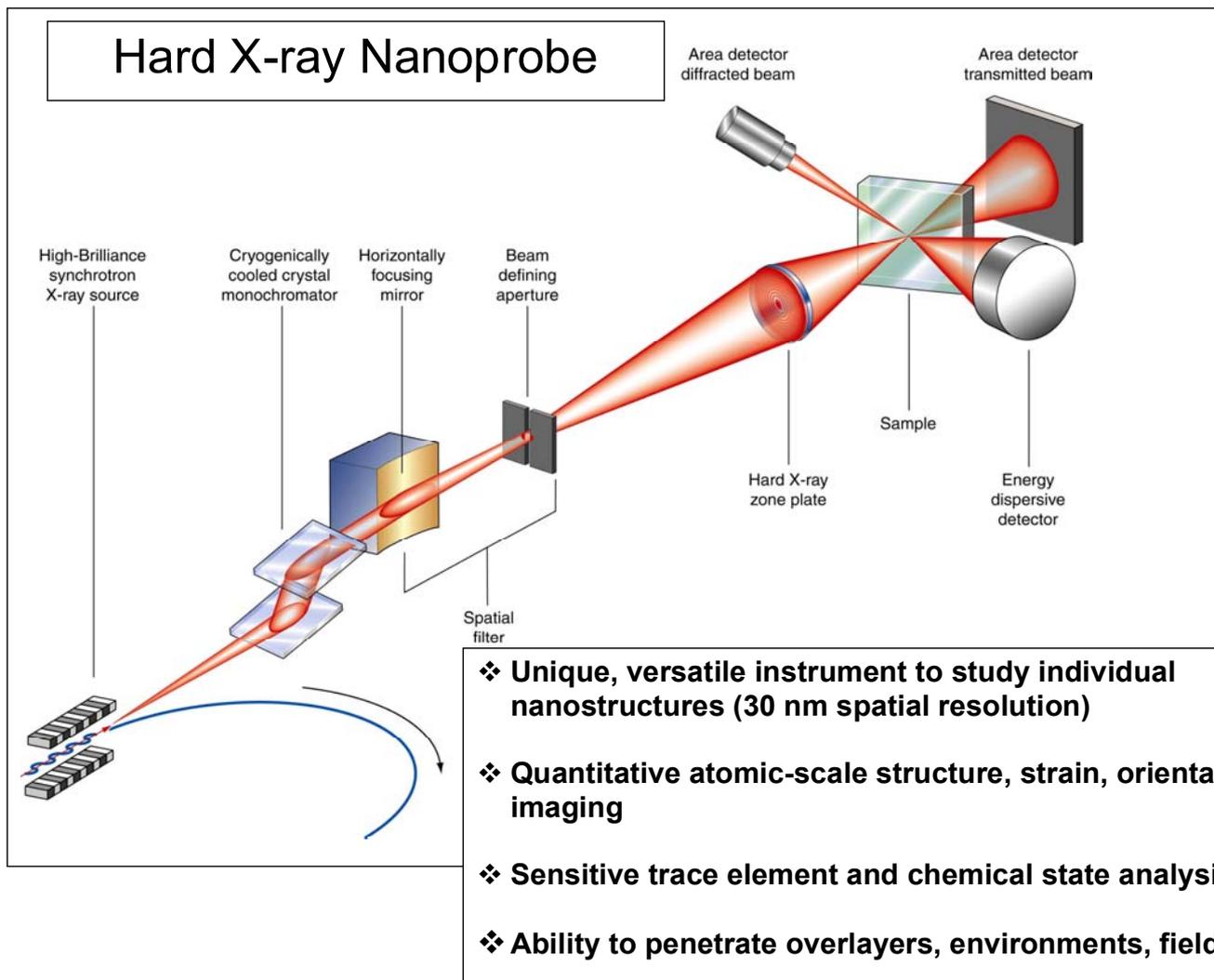


In current experiments, penetrating hard x-rays allow real-time studies of surface and film structure during growth

In future, need to study more complex morphologies

*ANL Materials Science Division and
Advanced Photon Source*

Hard X-ray Nanoprobe will Enable Imaging during Nanostructure Synthesis



What is needed?

Investment in beamlines:

- **High resolution hard x-ray imaging optics**
 - 1 nm is within reach
- **Ability to carry out *in situ* processing studies**
 - Experiments typically long term, need dedicated equipment, not suited to automation
- **Good example of science driving facilities, with partnership between Nanocenters and x-ray/neutron sources**