X-Ray Microbeam and Nanobeam Probes for Materials Science
Andrew Allen

The need for information at the nanometer and micrometer length scales in many areas of materials science requires new characterization tools to understand microstructure/property relationships. By combining the brilliance of a third generation synchrotron radiation source and cutting edge x-ray optics x-ray beams as small as 100 nm x 100 nm can be formed. These beams can be used to interrogate a wide variety of otherwise inaccessible microstructure/properties relationships through three-dimensional x-ray diffraction and x-ray fluorescence measurements.

Synchrotron Radiation Micro- and Nano-tomographic Imaging
David Black Andrew Allen

The properties of high brilliance synchrotron radiation sources provide many unique opportunities to image the microstructure of a wide range of materials. MSEL uses beamlines at the Advanced Photon Source that provide opportunities in x-ray imaging including x-ray diffraction topography, phase contrast imaging, USAXS imaging. Current emphasis is on development of a three-dimensional imaging capability with resolution below 100 nm.

Synchrotron Radiation Studies of Surfaces, Interfaces, and Electronic Materials
Joseph Woicik

Extended x-ray absorption fine structure, x-ray diffraction, diffraction anomalous fine structure, x-ray standing wave, and high-resolution photoelectron spectroscopy are used to probe the geometric and electronic structure of surfaces, interfaces, and electronic materials.

Microstructure Characterization Using X-Ray and Neutron Scattering
Andrew Allen

X-ray and neutron beams are among the best research tools for characterizing microstructures and microstructural phenomena (from 0.1 nanometers to 10 micrometers) available to science. The Characterization Methods Group operates x-ray beam stations at the National Synchrotron Light Source Opportunities exist for cutting-edge measurements in ceramic science, biological and polymer materials, materials chemistry, semiconductor science, superconductivity, and metallurgy. Unique experimental capabilities include high-resolution ultra-small-angle x-ray scattering and a high-temperature furnace for *in situ* small-angle neutron scattering. Additionally, x-ray microtomography and state-of-the-art computer modeling capabilities provide unique opportunities for utilizing microstructure visualization as a basis for property prediction.

Ultra Soft X-Ray Absorption Spectroscopy: Chemistry and Structure at the Surface and Bulk of Diverse Materials
Daniel Fischer

Our synchrotron-based low Z (C, N, O, F) ultra soft x-ray absorption spectroscopy technique addresses a range of chemical and structural problems from monolayers to bulk materials (including polymers and diamond), even in the presence of a reactive gas atmosphere. Numerous bulk materials characterization research opportunities exist, including the bonding chemistry of the buried metal polymer interface, electronic structure of high T_c materials, and *in situ* reactive chemistry of powder catalysts. Other research opportunities exist in surface chemistry studies of various self-assembled monolayer systems, proteins adsorbed on polymeric biomaterials for medical implants, and *in situ* surface chemistry of metal single crystals. These opportunities offer the chance to develop and utilize world class soft x-ray instrumentation such as an ultrahigh resolution, and high-intensity, spherical grating beamline coupled with a unique wavelength dispersive, large solid angle, focusing multilayer mirror, soft x-ray fluorescence detector.

Crystallographic Texture in Thin Film and Bulk Materials
Mark Vaudin John Blendell

The crystallographic texture of technologically important materials frequently has a strong effect on their properties. Exploiting texture to optimize properties requires that accurate texture measurements be made. We are developing techniques that use conventional powder diffractometers for measuring axisymmetric texture in both thin film and bulk materials. One research objective is to provide fast, accurate x-ray diffraction tools for measuring crystalline texture in thin films, including measuring the relative abundance of textured grains in films that may have bimodal (or multimodal) texture distributions. There are a number of other possible areas of work. Correlation of the corrected texture profiles with Rietveld analysis of complete θ-2θ scans would allow the limited range of 2-circle measurements to be extended to all orientation space. Measurements of non-axisymmetric texture can be carried out using the neutron facility at NIST. Similar x-ray measurements in the Ceramics Division will be possible with new equipment being purchased. In the area of microtexture, orientation mapping (also known as orientation imaging microscopy, or electron backscatter diffraction - EBSD) is being applied to a number of materials systems and proposals in this area are invited. Our EBSD on a high-resolution field emission SEM enables microtexture measurements on fine-grained thin films, which is important in areas such as FeRAM and other microelectronic and optical applications.

Functionally Gradient Microstructure Characterization for Fuel Cell Development
Andrew Allen Daniel Fischer

Control of microstructure and chemistry is of primary importance in determining the performance and viability of solid oxide fuel cell (SOFC) and polyelectrolyte membrane fuel cell (PEM) systems. The relevant scale range for void and phase microstructure, as well as for chemical site reactivity (combustion, reforming, corrosion, etc.), extends down to the nanometer size regime. In this context, we seek to gain a full 3D quantitative characterization of the void and phase microstructures as a function of position through the entire system, to understand quantitatively how these microstructures may be controlled by processing, to gain a similar quantitative understanding of how the microstructures govern the performance properties, and to understand how the microstructures change during service life. These issues apply to the anode, cathode and electrolyte layers, to the interfaces between the electrolyte and electrodes, and to any separate fuel-reforming material where the microstructure needs to be related to the reaction site kinetics and to changes in site reactivity during service life. This opportunity will address these interconnected issues by utilizing unique instrumentation, developed by NIST and its collaborators, and located at the nation's major synchrotron research facilities and at the NIST Center for Neutron Research.