Adam Hitchcock Extended Abstract

I will describe results from two ongoing projects where synchrotron-based soft X-ray scanning transmission X-ray microscopy (STXM) [1] and electron energy loss (EELS) in an aberration corrected (S)TEM are being used for nano-scale characterization of energy materials. The study of proton exchange membrane fuel cells (PEMFC) is a collaboration with the Automotive Fuel Cell Cooperation (AFCC), which is doing R&D to achieve specific performance improvements and cost reductions aimed at commercially viable introduction of hydrogen-based fuel cell vehicles into the passenger car market later this decade. The investigation of defects and chemical functionalization of carbon nanotubes is currently more fundamental in character, but has great potential for impact in energy materials.

Fuel cells: STXM at the C 1s, N 1s, O 1s, Co 2p and F 1s edges was applied to membrane electrode assemblies (MEAs) of PEMFC before and after being subjected to a specific drive cycle simulating the operation of a fuel cell vehicle (FCV) [2]. Post-mortem studies of CCM samples were carried out to determine the degree of Pt dissolution in the membrane. STXM results were complemented by SEM and TEM imaging and X-ray fluorescence analysis (EDX). This study is giving new insights into the mechanisms of catalyst degradation.

Carbon nanotubes: The exceptional physical, mechanical, and electronic properties of CNTs are the basis of much optimism about their potential for incorporation in advanced technologies. However, these properties are sensitive to structural defects and surface chemistry of the CNT. [3] C 1s spectra and X-ray linear dichroism (XLD) measured by STXM from individual multi-walled (MWCNT) and bundles of single walled (SWCNT) are being used to study their structure and chemistry. XLD at the C 1s □ π* peak (285 eV) is very strong in perfect structures. Its magnitude may be a way to map distributions of sp^2 point defects along individual CNT structures [3]. We are exploring q-dependent EELS in an FEI TEM equipped with aberration corrected optics to take this spectroscopic sensitivity to defects to a much finer spatial scale. So far, the q-dependence of the C 1s □ π* peak (285 eV) EELS peak is much less, even for samples where strong XLD exists, and in geometries where the direct analogy of EELS and NEXAFS would be expected to give similar results. In addition to using the □* XLD to map sp^2 defects in CNT, C 1s, N 1s and O 1s spectromicroscopy is being used to investigate functionalization chemistry of individual CNT [4]. Through several collaborations, we are using STXM spectromicroscopy to assist development of CNT-based devices which require specific chemical and structural properties.

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3. E. Najafi et al, A. Small 4 (2008) 2279.
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