Exit Wavefunction Reconstruction

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Indirect methods for improving the resolution attainable in the TEM *via* image reconstruction of focal or beam-tilt series of images are now realising the promise they have long offered. This technique simultaneously recovers the complex specimen exit plane wavefunction and fully compensates for all measurable lens aberrations. Using an aberration corrected TEM and a tilt azimuth data acquisition geometry it can be shown that electron optical aberration correction and exit wave reconstruction enables the recovery of super resolved information beyond the axial information limit. In many cases the resolution improvement achievable is now limited by the sample and not by instrumental parameters.

Single Shot Nanosecond Imaging in the Dynamic TEM

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Directly observing dynamic processes that occur on the micro- and nanosecond timescale is not possible with conventional Transmission Electron Microscopes. The Dynamic Transmission Electron Microscope (DTEM) couples a pump-probe laser based experimental approach with the column of a conventional TEM to allow single shot imaging of dynamic events with nanosecond temporal and nanometer spatial resolution. This paper reviews the experiments that have been performed on the first-generation DTEM at Lawrence Livermore National Laboratory and describes future design improvements for a second-generation microscope aimed at future research plans in the area of biomolecular imaging.

An Appraisal of High Resolution Scanning Electron Microscopy Applied To Porous Materials

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Nanoporous materials such as zeolites and mesoporous silica crystals have attracted a lot of attention in recent years. In particular, the incorporation of various materials such as organic molecules, or metal nanoparticles and other inorganic compounds within their pores which give rise to fascinating new functions. For such materials, it is essential to determine their structure, composition and mechanisms of growth in order to maximize their utility in future applications. Recent progress in the performance of SEM is enormous, especially in low energy imaging where we can now directly observe fine surface structures of porous materials even those that are electrical insulators. Furthermore, by precise filtration and detection of emitted electrons by their energy, we can selectively obtain different types of information such as material composition, location of particles inside or outside the pores etc. The physical processes and technologies behind this precise tuning of landing and detection energies for both impact and emitted electrons, respectively, are explained and illustrated using a number of porous materials including zeolite LTA, SBA-15, SBA-16, zeolite LTL, FDU-16 and Au@TiO_2 ' rattle spheres,' along with comparisons with other techniques such as atomic force microscopy (AFM) and transmission electron microscopy (TEM). We conclude that, by using extremely low landing energies, advanced sample preparation techniques and through a thorough understanding of the physical processes involved, HRSEM is providing new and unique information and perspectives on these industrially important materials.

Observation of Membrane Proteins Through An Electron Beam

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Technological and instrumental advancements in electron microscopy have facilitated comprehension of structures of biological components. For example, electron crystallography of membrane proteins is now an established technique to analyze their structures in lipid bilayers which are close to the natural biological environment. By utilizing JEOL cryo-electron microscopes with originally developed helium cooled specimen stages, structures of membrane proteins were analyzed at a resolution better than 0.3 nm. Here some examples, such as water channels and gap junction channels, are discussed by focusing on their biological mechanisms through structural analyses of membrane proteins. Based on observation of structures of membrane proteins through an electron beam, we are trying to establish a new research field named structural physiology.

HR-TEM of Carbon Networks
- Towards Individual C-C Bond Imaging -

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Here we show some examples for atomic-level characterization of carbon nanostructures by means of a Cscorrected HR-TEM operated at 120 kV. *In situ* imaging of the hexagonal network of carbon nanotube enables us to visualize the active topological defects, such as pentagons and heptagons, which are responsible for the plastic deformation of carbon nanotube. A single atomic chain of conjugated carbon (...-C=C-C=C-...) has been also successfully imaged and the *cis-/trans*-isomerization of retinal molecules is clearly identified. Individual molecular imaging has been also demonstrated for fullerene molecules and their derivatives. The structure and orientation of C_{60} and C_{80} molecules can be successfully identified at a single-molecular basis. Some recent progress for *in situ* observation of the carbon nanotube/fullerene growth and the defect dynamics is also presented.

Studies on Natural Antioxidant Derivatives: Enhanced Radical-Scavenging and Reduced Prooxidant Activities

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Natural antioxidant derivatives contained in functional foods and supplements, which are effective for preventing diseases caused by lifestyle, possess a variety of biological effects. These effects exhibit radical scavenging for oxidative stresses that are causes of cancer and cardiovascular disease, thus producing a preventive effect for the stresses. However in recent years, it has been reported that some compounds of natural antioxidant derivatives having high radical scavenging activity, such as some kinds of polyphenol, exhibit toxicity. Under this circumstance, the search and development of more-effective and safer preventive materials have been desired. In this study, we examined the enhancement of antioxidant properties and structural modification that is effective for reducing toxicity, using a typical natural antioxidative derivative of catechin and resveratrol.

Planar catechin can be synthesized by one-step chemical modification from natural catechin. By immobilizing 3D structures of the entire molecules to a plane, we succeeded in dramatically enhancing the antioxidative properties and also in reducing the prooxidant property, which is considered to be the main toxicity, compared to that for natural catechin. Planar catechin also exhibits a strong virucidal effect and a proliferative suppression effect on cancer cells; therefore, this compound is expected to have clincal usefulness for clinical use. Resveratrol exhibits a variety of biological effects such as an antioxidative ability, which are effective for chemoprevention of cancer. In addition, it has been revealed that this compound can extend the lifetime of cells. Thus, resveratrol has been attracting much interest as an anti-aging compound. However, resveratrol exhibits genotoxicity *in vitro*, and also the 4'-hydroxyl group, which is the active center of antioxidation, acts as the active center of activation for genotoxicity. Since the antioxidative property and toxicity derive from the same structure, derivatization was a very difficult task. But in this study, by introducing a methyl group into an ortho position of the hydroxyl group, we achieved a successful enhancement of the antioxidant ability dramatically. Furthermore, we completely eliminated the genotoxicity of the 4'-hydroxyl group.

In functional analysis, structural modification and molecular designing of antioxidant derivatives, it is essential to analyze radical scavenging activities and their reaction mechanism as antioxidative derivatives. In this study, we used ESR, which is the only instrument capable of directly observing radicals, for the evaluation of compounds as antioxidative derivatives.

Development of Nanoimprint Mold Using JBX-9300FS

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Nanoimprint attracts attention as a mass production technique in nano-scale fabrication. One of the key issues of nanoimprint is mold fabrication; because its resolution limit depends on mold. Since electron-beam (e-beam) writers for semiconductor photomask fabrication have difficulties in writing such a very fine pattern, we introduced a JEOL JBX- 9300FS. As a result, the trial production of the 22 nm half pitch nanoimprint mold for the CMOS process development TEG has become possible. Furthermore, using this accomplishment, we have been developing the mold fabrication processes for patterned media. In this paper, we demonstrate that the JEOL JBX-9300FS is an effective electron-beam writer for the mold fabrication with a pattern of 30 nm or less.