Advanced electron microscopy for structural characterization of materials.

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The structural characterization of materials is necessary for better understanding the influence of their atomic structure on physical properties. A transmission electron microscopy (TEM) is one of the most informative methods for determining the atomic structure of thin films and nanoparticles. New methods of TEM and microanalysis have appeared in the last decade owing to development and implementation of correctors of spherical aberration. The spatial resolution of TEM with an accelerating voltage of 300 kV, achieved a resolution of 0.05 nm which is 3–4 times better than the point-to-point resolution of conventional TEMs. In particular a corrector employed in scanning transmission electron microscope (STEM) allows us to form an electron probe with a diameter of less than 0.1 nm. Such an electron probe can be used for atomic resolution electron energy loss spectroscopy (EELS) and/or energy dispersive X-ray (EDX) analysis. On another side, many materials are very sensitive to electron irradiation and the structure can change significantly during the experiment.

The application of different conventional and advanced TEM techniques will be illustrated with several examples. In situ transformation of nanodiamond particles into carbon onions was revealed by high resolution TEM and EELS (figure below). A structural analysis of hexagonal $LuFeO_3$ orthoferrites (doped and undoped) has been done using high resolution STEM and atomic resolution EDX analysis (ChemiSTEM technology). Finally, the Na^+/vacancy ordering in Na_xFePO_4 (x>0.6) was analyzed by means of electron diffraction, HRTEM, HRSTEM, image simulations and DFT calculations.