X-ray Microscopy: Prospects and Current Developments

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The properties of x-rays that give them their special role in microscopy are short wavelengths – which allow high spatial resolution, high penetrating power, and a near absence of impedance mismatch at interfaces, which is important for imaging of thick specimens. X-ray energies suited for microscopy span K-shell and L-shell resonances of many elements of the periodic chart providing natural contrast mechanisms, as well as chemical bond mapping. Therefore, in several countries in recent years, there have been a considerable number of developments of x-ray microscopes and scanning x-ray microscopes, especially those using zone plate optics and synchrotron-radiation sources. Besides systems working with x-rays at energies between the carbon and oxygen K edges at 284 eV and 534 eV, respectively in the so called water window, systems are under development for harder x-rays in the keV-region. X-ray microscopy is currently being used for investigations in biology, medical research, colloid physics, and soil sciences, as well as in material research (for example, to study polymer structures or magnetic domain structures in magnetic material). Especially for biological applications, cryo x-ray microscopy is of importance. It has been shown that chemically unfixed biological specimens in a vitrified state are able to tolerate a radiation dose of up to 1010 Gray without observable structural changes. This allows x-ray microscopic tomographic imaging to reveal the 3-D structure of such specimens. To obtain information about the localization of proteins, especially in cell nuclei, metal-conjugated antibody probes can be used. It is a major challenge in the field to combine antibody labeling with cryo and tomography techniques.