X-ray Holography

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The analysis of Bragg peaks provides structure information averaged over a large number of unit cells. However, the characteristic properties of many substances are related to local atomic deviations from the average structure. A common method for the study of short-range ordering is x-ray diffuse scattering. In general, various structural models are built in order to seek the best agreement between simulated and experimentally measured intensities. X-ray fluorescence holography with atomic resolution (XFH) offers a different method for imaging the average neighborhood of the atoms of a selected element. XFH overcomes the phase problem inherent to diffraction, but suffers of experimental difficulties resulting from the fact that the holographic oscillations are very small relative to the background (accuracy of the order of 0.1% has to be achieved in order to get images of individual atoms) and the holograms are masked by strong Kossel line patterns. X-ray diffuse scattering holography (XDSH), using anomalous scattering from the atoms of the selected element measured on a spherical surface in the reciprocal space provides a higher signal-to background ratio and eliminates the masking of holograms by the Kossel line patterns. The use of XDSH makes the holographic experiment easier. Three-dimensional information on atomic arrangement can also be obtained from a monochromatic pattern based on the Helmholz-Kirchhoff integral theorem, where the advantage given by the possibility of collecting all the required data on a position-sensitive detector in one shot opens new perspectives for studies of fast physical or chemical processes in three dimensions. The reduced exposure time can also avoid radiation damage of organic specimens, and, in conjunction with an ultra-bright beam from the next generation of X-ray free-electron lasers, makes the method suitable for structural studies with individual atomic clusters. This approach can also be used, by observing the thermal diffuse scattering or order diffuse scattering from both non-crystalline samples and `imperfect' crystals, for the investigation of short-range ordered arrangements of atoms.