Fluctuation x-ray microscopy: a novel approach for the structural study of disordered materials

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Materials research has increasingly focused on developing a better understanding of the disordered state of matter. Many x-ray techniques exist to probe long- and short-range order in matter, in real space by imaging and in reciprocal space by diffraction and scattering. However, the characterization of medium-range order (MRO) is a long-standing problem that current x-ray techniques cannot effectively probe.

We have developed fluctuation x-ray microscopy (FXM) based on fluctuation electron microscopy [1]. This novel approach offers quantitative insight into medium-range correlations in materials at nanometer and larger length scales. FXM examines spatially resolved fluctuations in the intensity of x-ray speckle patterns. Measuring the speckle variance as a function of scattering vector and illumination size produces a fluctuation map that reveals MRO and correlation lengths. FXM can explore MRO and subtle spatial structural changes in a wide range of disordered materials from soft condensed matter to nanowire arrays, semiconductor quantum dot arrays and magnetic materials.

FXM has been demonstrated at micron correlation length scales in studies of a model system comprising polystyrene latex spheres [2]. The theory underlying FXM, the data analysis and the quantitative determination of MRO correlation lengths are discussed. Efforts to develop FXM to study MRO with correlation lengths down to 50 nm are presented.

References

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