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Dynamical Diffraction Model for Analyzer-Based Imaging

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The analyzer-based imaging (ABI) is one of the most sensitive phase-contrast methods for weakly absorbing objects with low background due to high angular selectivity of analyzer crystal to scattered radiation. The most of the common approaches of ABI modelling are based on the approximation of geometrical optics for scattering in the non-crystalline sample and even in the analyzer crystal. At the same time, more rigorous theories for describing the radiation diffraction in the analyzer crystal, for example, based on the use of point spread functions are applied. However, these theories often use the formulas based on approximation, which valid only for smooth displacement fields and, therefore, cannot be quantitatively correct for describing the X-ray diffraction on the analyzer crystal with microdefects.
We propose another approach for theoretical description of ABI images that is based on a rigorous theory of multiple (dynamical) scattering in the non-crystalline sample, as well as in the monochromator and analyzer crystals. The corresponding theoretical model allows taking into account complete multiplicity of X-ray scattering in the single crystals, as well as in the non-crystalline sample. Calculated profiles of intensity, obtained in terms of the proposed theoretical model, are in a good agreement with the previously published calculated results and experimental data for the model objects. In addition, suggested approach allows taking into account structure imperfections in crystals of both the monochromator and the analyzer, which can cause great influence on the reflection curve and consequently on the resulting image.

Type of presence

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