Scattering Contrast in Diffraction Enhanced Imaging*

Zhong Zhong
National Synchrotron Light Source, Brookhaven National Laboratory, Upton, New York, USA

D. Chapman
Illinois Institute of Technology

R. E. Johnston and E. Pisano
University of North Carolina

D. Sayers
North Carolina State University

W. Thomlinson
National Synchrotron Light Source

D. Washburn
University of North Carolina

Diffraction enhanced imaging (DEI) is a recently developed imaging technique for radiography of a thick, highly absorbing object. In a DEI experiment, a fan beam of monochromatic x-rays is generated by a double-bounce crystal monochromator. This beam then traverses through the sample and is diffracted by an analyzer crystal. In addition to the absorption of x-rays as a contrast mechanism, DEI is sensitive to the refraction contrast and scattering contrast. The refraction of x-rays by the sample causes the x-rays to deviate from the original direction by an amount on the order of 0.1 micro-radians. When the analyzer is tuned to the shoulder of the rocking curve, this refraction results in a change of intensity of the diffracted x-rays, giving rise to the refraction contrast. The scattering contrast is due to rejection or acceptance of small-angle scattering from the sample. The range of angles which can be accepted by the analyzer is on the order of micro-radians. Therefore, the analyzer is sensitive to small-angle scattering at the micro-radian level, corresponding to the sub-microscopic structure of the object being examined. Scattering from the sample can be rejected when the analyzer is on the peak of the rocking curve. This scattering intensity, which would normally appear in the image, is missing and appears as absorption in the image. Conversely, the scattering intensity is picked up when the analyzer is off the peak position. Thus DEI can be optimized to either reject or pick up the scattered x-rays for a specific type of small-angle scattering. The intensities measured with the analyzer on the top of the rocking curve show the extra absorption due to DEI scatter rejection in images. A study of a mouse around the chest region was performed using a silicon [333] monochromator and analyzer at 18 keV. The absorption in the DEI peak image is enhanced relative to a normal radiograph by a factor of 2.3 for a typical body region, as compared to a corresponding factor of 5.6 for the lungs. The enormous enhancement of contrast of the lungs demonstrates the sensitivity and tissue specificity of DEI not normally observed in radiography.

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