Exploration of the Coherence Properties of the Sector 34 Beam

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Introduction

The side branch of the newly installed sector 34-ID beamline at the APS, which feeds the 34-ID-C station, is dedicated to the science of coherent x-ray diffraction (CXD). The basic optical configuration consists of a side-deflecting, liquid-nitrogen-cooled mirror and a diamond (111) double-crystal monochromator [1]. The experiment discussed here was an attempt to establish procedures for documenting the coherence properties on the new beamline in the most convenient way.

Coherence is a complicated subject with many relevant parameters. The ones we are concerned with are those that affect the outcome of a CXD experiment. We have found [2] that images of small crystals obtained with CXD on the 33-ID beamline are contaminated with a “hot spot,” which is attributed to a mutual coherence function with more than one component. The most likely source of additional contributions to the mutual coherence function is scattering from a beryllium window located 6 m before the sample in station 33-ID-D [3]. Until now, we have not found a way to measure this coherence function other than to carry out a CXD experiment.

Related to the coherence issue is the phenomenon of fine “structure” in the incident beam. Whereas the spatial distribution *intensity* of the beam on a micrometer scale can be measured by a high-resolution detector, it is the distribution of phase shifts within the beam that is expected to be more important with regard to the outcome of a CXD experiment.

Methods and Materials

Here we performed a simple test of the homogeneity of the phase structure by examining the changes in the diffraction pattern from a gold crystal about 1 µm in size while it was translated across the beam. The resulting diffraction pattern was recorded for a series of micrometer-sized steps, scanning in the horizontal direction (Fig. 1) and vertical direction (Fig. 2).

Results

According to classical optics [4], coherence is measured in terms of the visibility of the fringes that occur by interference of waves emanating from two distinct locations. The fringes in our diffraction pattern (e.g., on the right side) are believed to come from facets on opposite sides of the crystal used as a probe. The contrast within these fringes is seen to change substantially as the sample is moved across the beam.

Discussion

We conclude that there are significant inhomogeneities in the phase structure of the beam at 34-ID-C. Further work is planned to learn whether this is related to imperfections in the mirror, the monochromator, or something else.

Acknowledgments

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References

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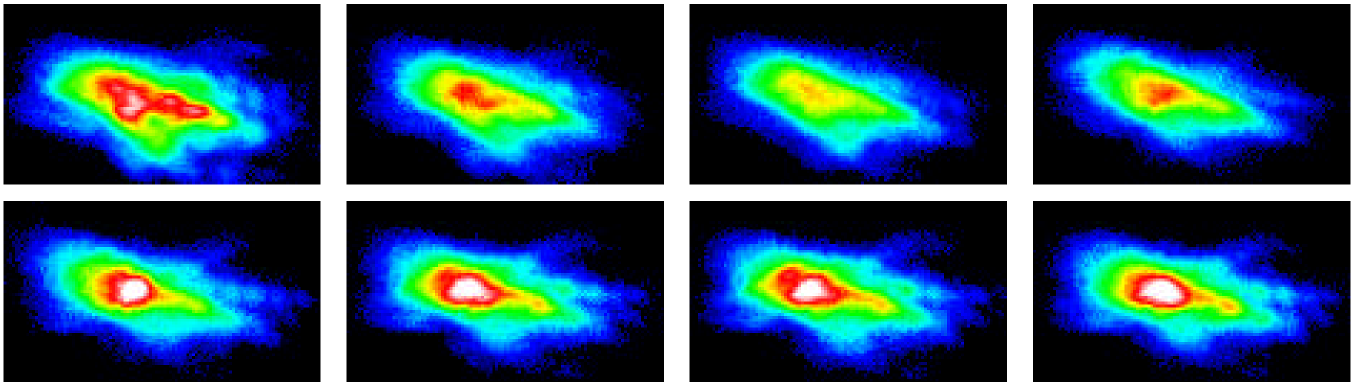

FIG. 1. CXD patterns recorded from the (111) Bragg reflection of a 1-µm gold crystal as a function of position in the beam. The crystal was translated by 5 µm in the horizontal direction between each frame.

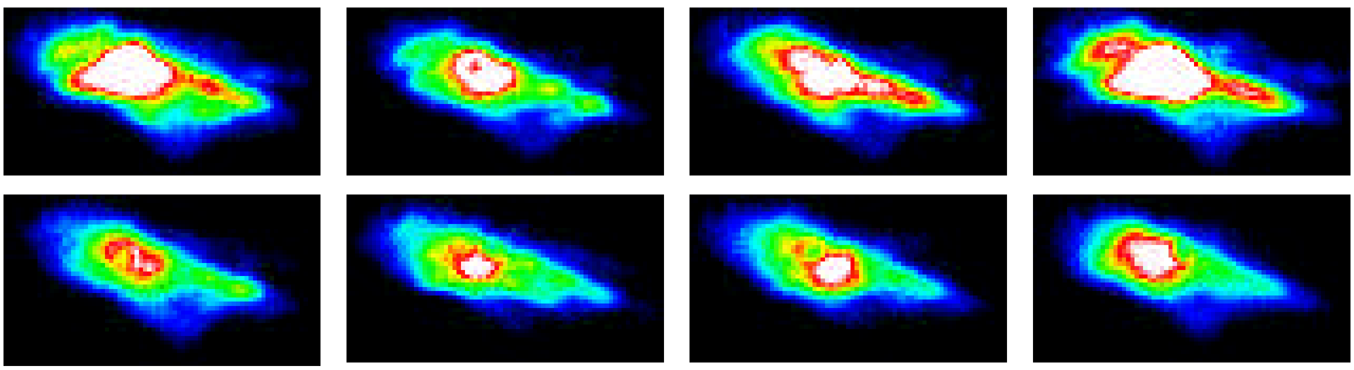

FIG. 2. CXD patterns recorded from the (111) Bragg reflection of a 1-µm gold crystal as a function of position in the beam. The crystal was translated by 2 µm in the vertical direction between each frame.