Measurement of a Speckle Pattern from Fe_3Al Illuminated by a Focused Beam

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Speckles are produced by scattering of coherent light from disordered systems. Using a new focussing zone plate setup at the I-Hutch of the 8-ID beamline, we have measured static speckle pattern from Fe_3Al at room temperature.

The single crystal of Fe_3Al used in this experiment was slightly off-stoichiometric (27.1 at.% Al) and has a continuous order-disorder phase transition between the B2 and DO_3 structures with a critical temperature T_c near 824 K. The transition involves the ordering of Fe and Al atoms on sublattices of the B2 structure. When quenched below T_c, the system orders as the domain walls separating ordered domains anneal away. This process is controlled by the diffusion of Fe and Al, which is is an activated process. These domain walls can be frozen in place by quickly quenching to room temperature. The different domains result in different phase shifts in the diffraction of x-rays and lead to a speckle structure superimposed on the broadened (1/2 1/2 1/2) superlattice peak.

The zone plate setup used for this experiment is desribed in an earlier report. In summary, the zone plate has a diameter of 257 µm and a focal length $f \approx 40$ cm. A 27-µm order sorting aperture (OSA), placed at ≈ 8 cm from the focus, selects the first-order focussed beam. The detector used is a Princeton Instruments direct-illumination CCD camera placed 1 m downstream from the sample.

Figure 1 shows the speckle pattern from the (1/2 1/2 1/2) superlattice peak in Fe_3Al at room temperature, produced by an x-ray beam of 100 µm × 200 µm (horizontal by vertical) incident on the zone plate. We used monochromatic x-rays of energy 7.66 keV. The measured focal spot was ≈ 1.2 µm (in both horizontal and vertical directions). The CCD image was split into small boxes of size 10 × 10 pixels. For each box, a spatial cross-correlation function was calculated and fit to a Gaussian to measure the speckle width and contrast factor. The averaged speckle size versus focal distance is plotted in Fig. 2. As can be seen, a smaller beam (at focus) results in larger speckles and a lower contrast factor.

In conclusion, we have measured the speckle size and contrast factor of a beam focussed to micron sizes by a Fresnel zone plate. We measured a contrast factor of ≈ 4% at focus.

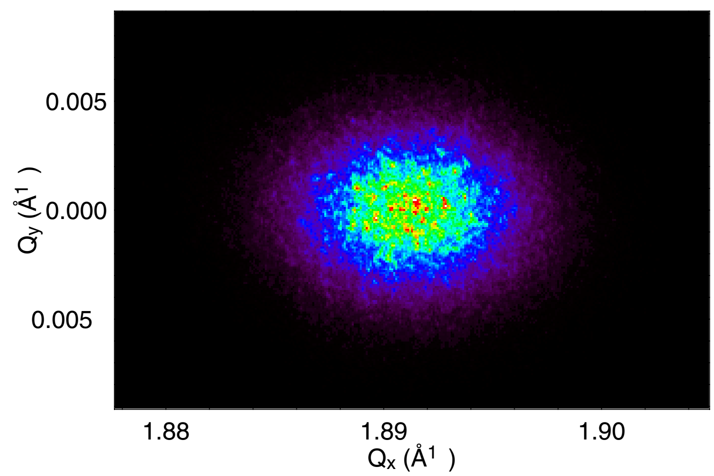

FIG. 1. Speckle pattern from the (1/2 1/2 1/2) superlattice peak of Fe_3Al at room temperature. The peak is centered at a 2θ of 28.4ºC.

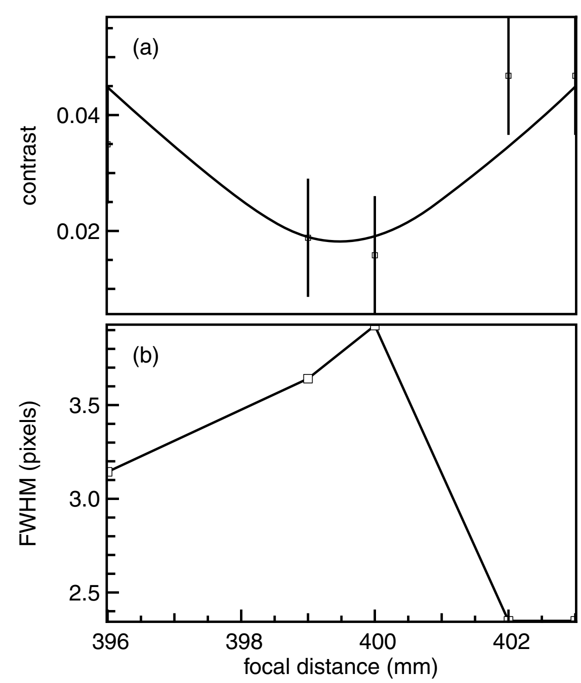

FIG. 2. Speckle contrast factors (a) and widths (b) versus focal distance; the solid line (a) is a guide for the eye.

Acknowledgments

Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38. We thank Harold Gibson for his expert assistance.