Streaked coherent x-ray diffraction from antiphase domains in Cu_3Au thin films

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Coherent x-ray diffraction (CXD) patterns were obtained at the UNI-CAT 33-ID beamline. Roller-blade slits [1] were used to produce a coherent beam of approximately 2 microns dimension. The diffracted beam was detected by a Princeton Instruments direct-reading CCD detector at the end of a 2.5 m 2θ arm.

The thin film samples of Cu_3Au with (111) orientation were grown by R. Appleton and C.P. Flynn at the University of Illinois using molecular beam epitaxy. A strongly modulated speckle pattern was observed, as found in previous work [2]. One new finding was that under certain diffraction conditions, the pattern became strongly streaked and tilted. Both the streaking and tilting effects were found to be highly dependent on the diffraction geometry, with the most pronounced streaking occurring under grazing *exit* conditions.

The streaking behavior is understood to be caused by a strong asymmetry in the sample volume probed. Careful annealing of the sample just below its order-disorder phase transition led to the formation of large antiphase domains about 1000 Å in size. However, the limited penetration of the coherent x-ray beam into the Au-rich sample means that a volume 5 microns wide by only 0.1 microns deep was probed. Therefore, the CXD pattern, understood to be the Fourier transform of the electron density of this entire volume, consists of a set of rods pointing along the film's surface normal direction.

To see how the observed pattern becomes streaked and tilted, it is necessary to perform the geometry-dependent projection called the Ewald construction. The momentum transfer vector, OQ, which bridges the tips of the incident (k_i) and exit (k_f) wavevectors, remains constant while the geometry varies from 'grazing-incidence' via 'symmetric' to 'grazing exit.' The Ewald sphere is formed by varying the *direction* of k_f while keeping its length fixed. Only in the 'grazing exit' case does the sphere run tangent to the rods of diffraction from the sample.

The Ewald construction thus yields the tilted steaks observed. The incidence-angle dependences of both the streak lengths and tilt angle are explained quantitatively by this description [3].

References

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