ESRF

MONOCHROMATIC BEAM DIFFRACTION TOPOGRAPHIC STUDY OF THE HELI-FERROMANETIC PHASE COEXISTENCE IN MnP

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Report:

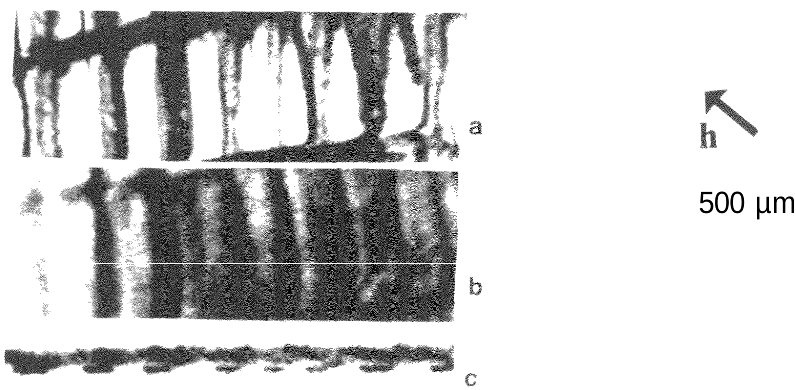
The coexistence of two magnetic phases in a given single crystal sample leads to a rich variety of situations which were only scarcely investigated experimentally. X-ray diffraction topography is a valuable tool for the investigation of magnetic phase coexistence: indeed the interfaces can be observed through the change in lattice distortion, related to magnetostriction, between neighboring phases.

MnP is helimagnetic for $T<T_S$ = 47K, and ferromagnetic, with easy magnetization axis along c (convention a>b>c) in the temperature range $T_S<T<T_C$ = 29lK. Rather small fields (<0.3 Tesla) applied along c induce, for $T<T_S$, a transition to the ferromagnetic phase. The helimagnetic-ferromagnetic transition is associated with a variation of distortion between the phases in the 10^{-5} range.

The experiments were performed using either a 'white' synchrotrons radiation beam or a monochromatic beam from a steady, or vibrating, 220 reflection of a silicon monochromator. The use of Sofretec cameras fitted with scintillators allowed the real-time observation of the phase coexistence. The sample was cooled in a helium closed-circuit refrigerator. A remote controlled film-holder was set on the diffracted beam path, between the crystal and the video camera, to record the tomographs without shutting the synchrotrons beam off. This proved necessary in white beam because the presence or absence of the beam modifies substantially the temperature of the sample. Kodak Industrex SR film was used.

The interfaces were found to display various shapes (plane, zig-zag, stripes) depending on the thickness and orientation of the crystal, the temperature and the applied magnetic field. This corresponds to a competition between the various energy terms involved in the transition. In the field driven case the magnetostatic energy is dominant, and the observed pattern minimizes this energy term.

What is completely new, from the technical point, is that the flux is big enough at the ESRF to perform monochromatic beam 'real time' experiments More details can be obtained by taking advantage of the possibilities of this technique. Fig. 1 tomographs show a detail of the field driven transition, using either a) a small $(\Delta\lambda-\Delta\theta)$ window: only the ferromagnetic region is in Bragg position on the topograph, or b) a larger $(\Delta\lambda-\Delta\theta)$ window, obtained by vibrating (=100 Hz) the monochromator, and c) a section topograph corresponding to the a) sitiation, whichs shows the location of the ferromagnetic bands within the crystal bulk.



Fig,l: Monochromatic beam tomographs $(\lambda \cong 0.3$ Å) recorded during the heli-ferromagnetic phase transition in a 0.4 mm thick (010) MnP, performed by using the a) 220 reflection from a steady silicon monochromator b) same, but vibrating monochromator. A section topograph corresponding to the case a) is shown on c: it indicates that the ferromagnetic regions are mainly located in the neighbourhood of the surfaces.

The aim of the proposal was to apply this 'real time monochromatic diffraction topography' technique to the investigation of the triple point coexistence in MnP. We had no time to perform that, and we will request more beamtime through a new proposal.