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| | Experiment title: Temperature study of phason fluctuations in the i-AlPdMn quasicrystal by coherent X-ray diffraction | Experiment number: HS-1053 |
| Beamline: ID20 | Date of experiment: from: 26/10/99 to: 1/11/99 | Date of report: 26/02/2001 |
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Report:

Quasicrystals are long range ordered structure which lack translational invariance. In the AlPdMn system, the icosahedral phase can be obtained as large single grains with a high degree of structural perfection: their diffraction pattern present Bragg peaks which are only slightly larger than the instrumental resolution when measured on a high resolution set-up [1]. Similarly to other incommensurate structures, quasicrystals have new long-wavelength modes called phasons. At the atomic level this corresponds to the possibility for an atom to occupy two nearby positions having almost an equivalent local environment [1]. Longwavelength phason correlations lead to diffuse scattering beneath the Bragg reflections having a characteristic intensity distribution [2]. Such a diffuse scattering has been observed in the i-AlPdMn phase whose intensity distribution and shape anisotropy can be explained using the generalised elasticity of quasicrystals and considering only longwavelength phason fluctuations [3].

Unlike displacive modulated structure, but similarly to composite incommensurate structure, phason modes are not collective modes but rather diffusive modes in the icosahedral phase. This means that a mode with a given wavevector q is expected to follow an exponential time decay with a q^{-2} dependence of the characteristic time decay.

The purpose of the experiment was to measure the time dependence of phason fluctuations, as a function of the temperature using coherent X-ray diffraction. In effect, as shown in a previous experiment [4], when coherent X-ray is used to measure the diffuse scattering large intensity fluctuations, known as speckle patterns, are observed in the

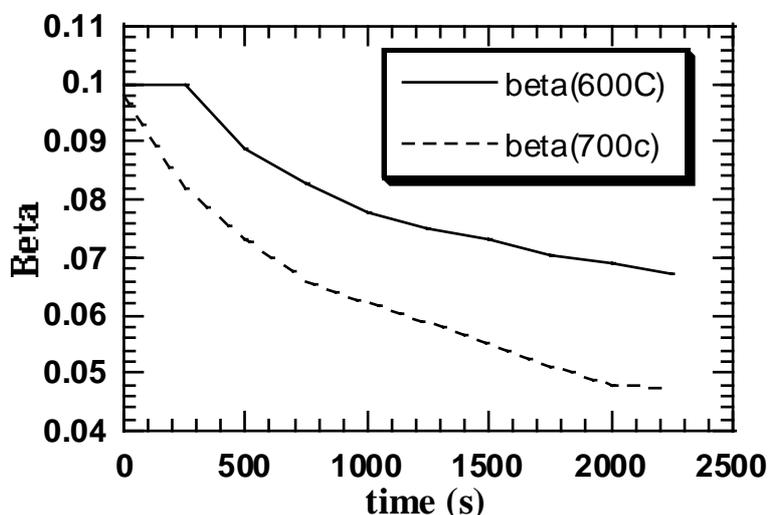
diffraction pattern. A measure of the time dependence of the speckle pattern is thus a direct measure of the time decay of phason fluctuations.

The coherent X-ray beam was produced by focussing optics located on ID20. The incoming energy of the beam (7.6 keV) was selected by a double Si (111) monochromator crystal with sagittal focussing. A 10 μm diameter pinhole provided a coherent beam. A Princeton Instrument direct illumination CCD was used as a 2D photon counter using a droplet algorithm and was located 1.8 m away from the sample. With this setting a 40% coherence was achieved with a flux equal to 710^8 photons/sec at the sample position (200 mA beam current). We worked in reflection geometry on a single grain of the AlPdMn phase whose surface was perpendicular to a 5-fold axis. The sample was placed in a furnace under a good primary vacuum and heated up to 700°C. Diffuse scattering pattern around two Bragg reflections have been recorded each 50°C between 500°C and 700°C. 500 frames of 2 or 5 seconds were recorded for each position, depending on the intensity of the diffuse scattering.

We encountered a number of experimental difficulties which made the interpretation of the data difficult. The first and most important one is the face stability: rapidly, above 450°C, the surface of the icosahedral phase became rough at a scale of a few micrometer. This phenomenon is known from surfaces studies, and yet unexplained since the 5-fold face is a stable face for the i-AlPdMn phase. Terraces and voids with characteristic scales of the order 1 to 10 μm formed above 450°C, producing interference fringes in the diffuse scattering when going too close from the Bragg peak. The second problem was an intensity instability caused by a temperature fluctuation of 2° in the cooling water used for cooling the bottom of

the sample holder. Modifying the water circuit allowed to solve this problem during the last two days of the experiment.

Nevertheless some results could be extracted from diffuse scattering measured around the 7/11 reflection. As shown on the figure there is a clear decay of the apparent coherence (beta) measured as a function of the time. As expected the time decay is smaller at 700°C than at 600°C, in agreement with a thermally activated process.



References

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