An order-disorder phase transition in Al-Ni-Co decagonal quasicrystals by anomalous-X-Ray scattering

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Introduction

Al-Ni-Co (ANC) system is well known to be decagonal quasicrystals, which have two-dimensional quasiperiodic planes. The structures of ANC depend both on the Ni and Co concentrations and temperature extensively.

In complicated ANC system, it was found that atomic short-range order (SRO) exists by the analysis of the anomalous-X-ray diffuse scattering in $Al_{70}Ni_{15}Co_{15}$ [1]. The diffuse scattering was derived from the random phason strain, which can be coupled with SRO. Further quantitative analysis shows that $Al_{70}Ni_{15}Co_{15}$ has only one kind of a pair correlation function, Ni-Co.

The structure of $Al_{72}Ni_{20}Co_8$ is interpreted as an atomic decoration of the ideal Penrose tiling. Therefore, we can obtain the pure SRO diffuse scattering without the effect of the random phason strain.

Experimental

The diffuse scattering measurements were performed on the BL-4C of the Photon Factory at the High Energy Accelerator Research Organization in Japan. A cylindrical focusing mirror is placed in front of a double monochromator of Si (111). The specimen was mounted on a four-circle diffractometer (Huber 5010). Air scattering was minimized by He filled beam paths. Fluorescence of the scattered beam from the specimen was reduced using a curved highly orientated pyrolytic graphite (002) (Panasonic Co.). The incident X-ray energy was calibrated to within 1 eV using Co foil. The incident X-ray energies were chosen at 7.686 keV near Co K-edge, 8.304 keV near Ni K-edge and 8.098 between them. A high temperature furnace (Mac Science Co.) has two hemispherical Be windows, whose thickness is 1 mm each. In order to analyze the diffuse scattering quantitatively (electron units per atom), we measured the several integrated intensities of a standard powder sample of Ni.

Results and discussion

Figure 1 shows the distribution of the SRO diffuse scattering, where broad peaks are distributed around the superstructure positions only on quasi-periodic planes [2]. The correlation length was estimated to be 2.6 nm approximately. By quantitative analysis, SRO consists of three kinds of pair correlation functions, between Al-Ni, Ni-Co and Co-Al. Each distribution of the SRO diffuse scattering was isotropic. $Al_{72}Ni_{20}Co_8$ has no phason strain. It is also supported by the fact that $Al_{72}Ni_{20}Co_8$ has no $|G^{\perp}|$ dependence of full width at half maximum (FWHM) of Bragg reflections.

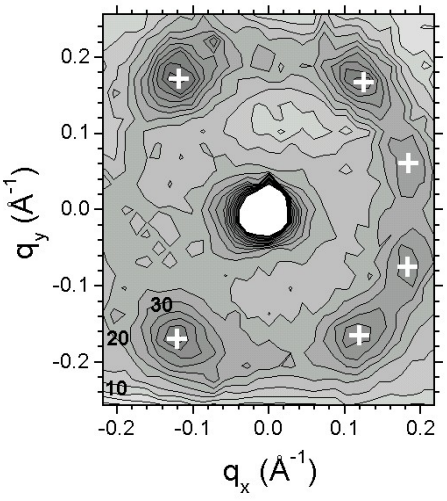

Fig. 1 Diffuse scattering on quasiperiodic plane.

At 965 K ($<T_c$), w eak $|G^{\perp}|$ dependence of FWHM of Bragg reflections appeared [3]. This suggests that weak phason strain appears even in an order-disorder transformation of a perfect quasicrystal. Also, $|G^{\parallel}|$ dependence of those was observed on ordering process. We interpret the ununiform deformation is introduced by the creation and growth of S1-domains below T_c.

References

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