Structural Fluctuation in a Disordered Ternary Alloy

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Analysis of diffusely scattered x-ray intensities from crystalline materials is very important in disclosing the structural fluctuation.

A typical fluctuation can be found in alloys, in which different atomic species almost randomly occupy the lattice sites with a short-range order (SRO), causing a diffusely scattered intensity in the diffraction pattern. A number of reports have so far been accumulated particularly in binary alloys.

Very few studies have been reported, however, on multi-component alloys because of a difficulty in analyzing the overlapped diffuse scatterings due to several kinds of spatial correlations between different atomic species, for example, AB, BC and CA pairs in an A-B-C ternary alloy. Energy tunability of the synchrotron radiation enables us to identify the atomic elements in materials by use of the anomalous dispersion effect (ADE). The anomalous scattering method base on ADE was first applied to a SRO Cu_2NiZn alloy by Hashimoto, et al. for separating the overlapped intensities.

The SRO diffuse intensity is proportional to the square of the difference between a pair of atomic scattering factors for different atoms. The intensity from the neighboring atoms in the periodic table is generally not recognizable. ADE enhances the difference of scattering factors, and gives appreciable anomalous diffuse scattering. It was this contribution of ADE that made the Cu_2NiZn study successful.

If a ternary alloy contains an element with very different atomic number from the others, the scattering intensity will be contributed mainly from the normal scattering factors, decreasing the intensity contrast among the different radiation energies. We challenged the difficulty of analysis by adopting a SRO Cu_2NiPt alloy. This alloy is also physically interesting, because the three kinds of binary alloys made of a pair of elements, Cu-Ni, Ni-Pt and Pt-Cu, have perfectly different SRO properties, that is, the Warren-Cowley α parameters for the nearest neighboring pairs are positive, negative and zero, respectively. This difference was supposed to cause some diffuse maxima at separated positions in reciprocal space, easing the analysis.

In the present work, an ingot of Cu_2NiPt was cut into a plate-like shape, annealed at 650°C, and then quenched into water. This sample was found to give diffuse scattering maxima at both the X and Γ points on the Brillouin zone boundary with $CuK\alpha$ by using an in-house rotating anode generator.

At BL02B1 diffuse scattering measurements were tried with the use of the 7-axes diffractometer with a few wavelengths near the absorption edges of the atoms. However they unfortunately ended in a failure. The observed intensity was unexpectedly too weak to determine the distribution within the machine time given. The weakness in intensity is thought to arise from the synchrotron radiation intensity itself in a lower energy range, the relatively long beam-path in air around the sample, high noise-level due to the fluorescence from the sample, and small sample size or finely collimated incident radiation.

In order to reduce the fluorescence background we then replaced the scintillation detector by the solid state one with which the experimental station is equipped. But the detector happened to be out of order, that is, not to have a high energy resolution enough to resolve the elastic radiation and the fluorescence.

We thus expect the apparatus to be maintained in order, and to check the functions at regular intervals besides the operating time. It is important to enable the anomalous scattering method on the 7-axes diffractometer by making a great improvement.