Evaluation of atomic arrangement around Cu in Fe-Si alloy by X-ray fluorescence holography

Kouichi Hayashi[1] (1301), Tetsutaro Hayashi[1] (0013000), Yukio Takahashi[1] (6398), Suzuki Shigeru[2] (8501) and Ei-ichiro Matsubara[1] (4932)

1 Institute for Materials Research, Tohoku University, Katahira, Sendai 980-8577
2 Institute for Multidisciplinary Research for Advanced Materials, Tohoku University, Katahira, Sendai 980-8577

The Fe-Si alloy system is important in steel production because silicon is often added to high-strength steel, heat-resistant steel, etc. Generally, this material includes ppm order impurity elements, such as, P, Mn, Cr, Cu and Sn. In particular, it is known that Cu and Mn play an important role in grain growth of Fe-Si alloys. Therefore, the chemical structures around these elements are of great interest in control and design of Fe alloys. X-ray fluorescence holography (XFH) provides 3D atomic images around fluorescing atoms. Here, we evaluated local structure around Cu in Fe-Si alloy using the XFH.

The concentration of Cu in the Fe-Si alloy sample is 0.073 %. Incident energies were 19.0-22.0 keV with 0.25 keV steps. The data was collected in the so-called inverse mode. The Cu Kα (8.02 keV) X-ray fluorescence via a toroidally bent graphite analyzer was detected by an avalanche photo diode. The count rate of the X-ray fluorescence was about two millions cps. The fluorescence intensities were measured as a function of azimuthal angle ϕ and polar angle θ within the ranges of $0^\circ \leqq \phi \leqq 360^\circ$ and $0^\circ \leqq \theta \leqq 80^\circ$. The x-ray exit angle was fixed at 45°.

We recorded 13 holograms at different energies in this experiment. Multiple energy reconstruction by the Helmholtz-Kirchhoff transformation modified according to Barton was applied to these hologram data. The real space image of the (001) plane was depicted in Fig.1. The circles added in the Fig.1 indicated the theoretical atomic positions of the Fe alloy single crystal (bcc structure). Since the reconstructed atomic images fit these circles, it was revealed that most of the Cu atoms substituted for Fe site.

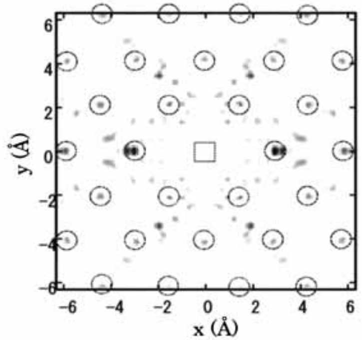

Fig. 1 atomic image around Cu in Fe-Si alloy.

Structural evaluation of ZnO single crystal by XFH

Tetsutaro Hayashi (0013000), Yukio Takahashi(6398), Kouichi Hayashi (1301), Toetsu Shishido and Ei-ichiro Matsubara(4932)

Institute for Materials Research, Tohoku University, 2-1-1 Katahira, Sendai 980-8577,Japan

X-ray absorption fine structure (XAFS) studies using X-ray excited optical luminescence (XEOL) have been performed by some researchers. This phenomenon can be utilized to X-ray holography. Therefore, we planed to measure the holography by detecting optical luminescence. The sample was ZnO single crystal which emits 510 nm visible lights by X-ray irradiation. First, we carried out the experiment of X-ray fluorescence holography (XFH) before X-ray luminescence holography (XLH).

Incident energies were 12.0-14.0 keV with 0.50 keV steps. The data was collected in the so-called inverse mode. The Zn Kα (8.64keV) X-ray fluorescence via a cylindrical bent graphite analyzer was detected by an avalanche photo diode. The countrate of the X-ray fluorescence was about two millions cps. The fluorescence intensities were measured as a function of azimuthal angle ϕ and polar angle θ within the ranges of $0^\circ \leqq \phi \leqq 360^\circ$ and $0^\circ \leqq \theta \leqq 80^\circ$. The x-ray exit angle was fixed at 45°.

We recorded 5 holograms at different energies in this experiment. The hologram data was depicted in Fig.1. Multiple energy reconstruction by the Helmholtz-Kirchhoff transformation modified according to Barton was applied to these hologram data. The real space image was depicted in Fig.2. The atomic images were fine, and artifacts, which were obvious at the reconstruction from the single XFH, were suppressed to some extent. After this experiment, we intended to conduct the experiment of XLH of ZnO. But we couldn't do it because beam was dumped.

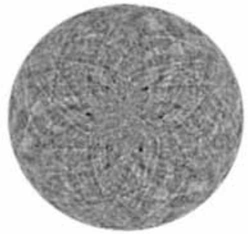

Fig.1 X-ray hologram at 14.0 KeV.

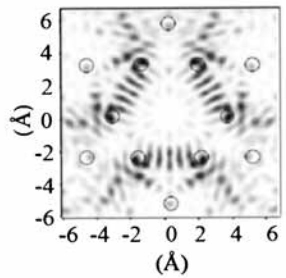

Fig.2 Reconstructed image. (0001) plane.