TOKAI CROSS Experimental Report J-PARC	提出日 Date of Report July 5th 2012
課題番号 Project No. 2012A0123 実験課題名 Title of experiment Characterization of the Morphology and Chemical State of Magnetic Element in Soft Magnetic Nanogranular Film using Small-Angle Neutron and X-ray Scattering 実験責任者名 Name of principal investigator Yojiro Oba 所属 Affiliation Kyoto University Research Reactor Institute	装置責任者 Name of responsible person Dr. Jun-ichi Suzuki 装置名 Name of Instrument/(BL No.) TAIKAN (BL-15) 実施日 Date of Experiment May 13th 2012

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Co-Pd-Si-O nanogranular film

Co-Nb-O nanogranular film

Si substrate

Glassy carbon

2. 実験方法及び結果 （実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

In this study, we investigated the nanostructures of soft magnetic nanogranular films. The nanogranular films were deposited on single-crystal Si substrate using a radio frequency magnetron sputtering method. The thicknesses are 1.95 μm for Co-Pd-Si-O films and 4 μm for Co-Nb-O films. For small-angle neutron scattering (SANS) measurement, several tens of films (26 pieces for Co-Pd-Si-O and 24 pieces for Co-Nb-O) were stacked.

SANS measurements were performed at room temperature. The incident beam was collimated by 8.4 mm x 8.4 mm slits. In order to separate the magnetic and nuclear scattering contributions, a magnetic field of 0.5 T was applied using a permanent magnet.

In the q_x-q_y two dimensional SANS patterns, several spot-like scattering are observed. Here, x, y and z directions correspond to the direction parallel to the magnetic field, perpendicular to the magnetic field and the incident beam direction. The momentum transfer q is equal to $(4\pi/\lambda)\sin\theta$. The parameters λ and θ are wavelength and scattering angle, respectively. These spots appear even in the SANS patterns of the Si substrates. Hence, they are probably caused by the multiple Bragg diffraction of the Si substrates.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

Then, we converted the SANS patterns into I-q profiles. At present, the shorter wavelength was simply ignored to avoid the effects of the multiple Bragg scattering. The profiles are normalized by the thickness of the samples. Glassy carbon was used as the standard for absolute intensity calibration. The normalized profile of the Co-Pd-Si-O films well agrees with the previous data measured at the other SANS instrument (mf-SANS) installed in JRR-3 (Fig. 1). This indicates that wavelength dependency of scattering properties, such as transmission rate is well corrected. The profile perpendicular to the magnetic field shows a clear peak around q=1.6 nm^{-1}, while the profile parallel to the magnetic field shows very weak scattering without clear peak. The feature of the perpendicular profile is similar to the SAXS profile. This indicates that the shape and size of the magnetic regions correspond to those of nanoparticles in the films. Therefore, most of Co added in the films probably forms the nanoparticles.

On the other hand, the profiles of the Co-Nb-O films show clear difference from the SAXS profile. This probably reflects the difference in the magnetic structures from the chemical structures. For example, if the magnetic nanoparticles have magnetically weak interface due to surface effects, this difference can be explained. Compared to the Co-Pd-Si-O films, the SANS profile of the Co-Nb-O films perpendicular to the magnetic field has broad peak. This suggests that the magnetic structures have wide size distribution.

In conclusion, we successfully observed the SANS profiles of the soft magnetic nanogranular films. The SANS profiles of the Co-Pd-Si-O films are similar to the SAXS profiles, while the SANS profiles of the Co-Nb-O films does not correspond to the SAXS profiles. This difference is probably attributed to the difference in the magnetic structures from the chemical structures.

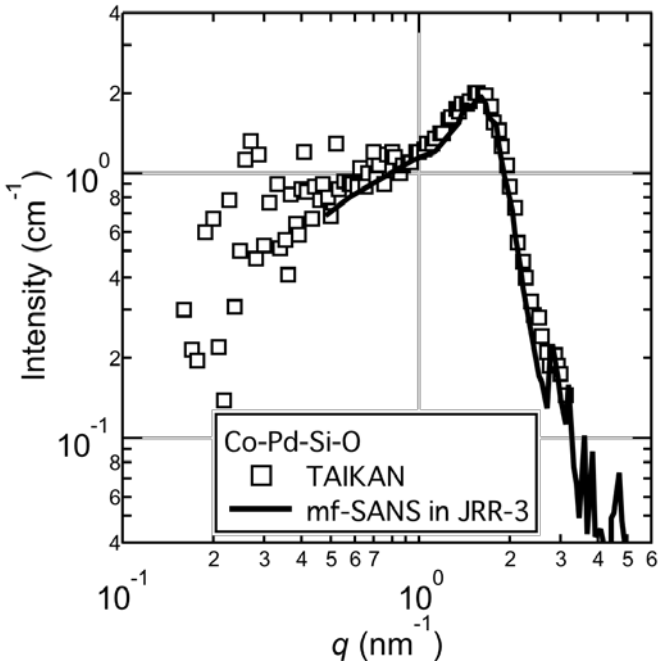

Fig. 1 I-q profiles of Co-Pd-Si-O nanogranular film perpendicular to magnetic field. The circles are the present data. The solid line is the data of same sample measured at the other instrument (mf-SANS) installed in JRR-3.