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Evaluation of spin, orbital and total magnetic moments of Pd_3Co by X-ray magnetic diffraction

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Introduction

It is known that artificial-lattice multilayer Pd/Co shows perpendicular magnetic anisotropy. Wave-functions of Pd-4d and Co-3d electrons may play a key role for the magnetic property. The aim of the present study is to examine magnetic properties of Pd-Co alloy system. We measure the spin and orbital magnetic form factor of Pd_3Co single crystal by the X-ray magnetic diffraction (XMD) experimental technique.

Pd_3Co belongs to the alloy group of Cu_3Au type crystal structure that exhibits order-disorder phase transition. The sample crystal in the present study is revealed to be in the disorder state by the preliminary X-ray diffraction experiment.

Experiments

The XMD experiment was made on the beamline 3C. Elliptically polarized white X-rays were irradiated on the crystal and the X-ray intensities diffracted with 90º scattering angle were measured with a pure-Ge SSD. Magnetic field was applied to the sample crystal with an electromagnet that produced 2.15T.

By setting the angle α between the incident X-ray direction and the sample magnetization to 0° and 135° we measured the spin and orbital magnetic form factor ($\mu_S(k)$ and $\mu_L(k)$), respectively.

Results and Discussion

Observed spin and orbital magnetic form factors for 22 reciprocal lattice points are shown in Fig. 1 and Fig. 2, respectively. Those form factors were fitted with theoretical values of $\langle j_0 \rangle$ and $\langle j_2 \rangle$ for Co-3d orbital and Pd-4d orbital under the dipole approximation tabulated in the literature.[1)] Here, $\langle j_n \rangle$ is the radial integral of the wavefunction of 3d or 4d orbital multiplied with the n-th spherical Bessel function. We used those values for Co^+ and Pd^{+4} ions on trial.

The fitting procedure has resulted in the following values. As shown in Fig. 1, the spin moments of Co and Pd per formula unit (Pd_3Co) are 1.57μ_B and 0.62μ_B, respectively. As shown in Fig. 2, the orbital moments of Co and Pd per formula unit are 0.71μ_B and 0.12μ_B, respectively. Total spin moment is 2.19μ_B/f.u. and the total orbital moment is 0.83μ_B/f.u. Then the total magnetic moment is obtained as 3.02μ_B/f.u. The last value is comparable to the magnetic moment of the present sample, 2.93μ_B/f.u., observed by the magnetization measurement.

As a result, we have succeeded in obtaining the values of spin, orbital and the total magnetic moments of Pd_3Co by the X-ray magnetic diffraction experiment. In the near future we have a plan to study distribution of the spin, orbital and the total magnetic moments in real space by using Fourier transform of these form factors.

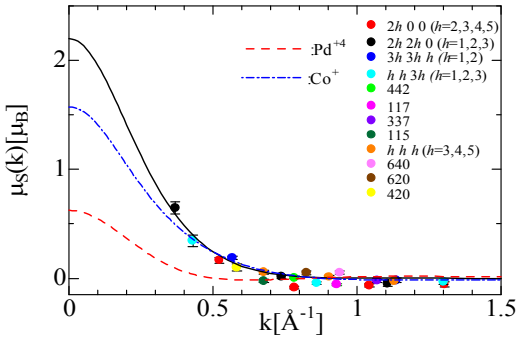

Fig.1 Spin magnetic factor

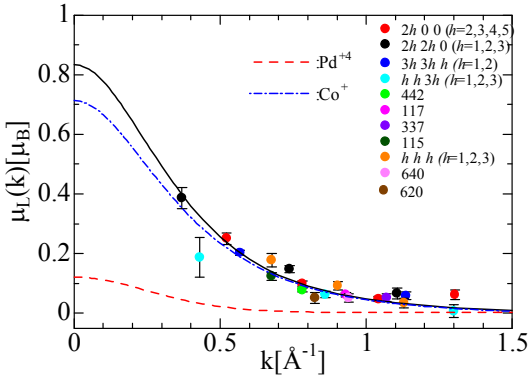

Fig.2 Orbital magnetic factor

Reference

1) International Tables for Crystallography Vol. C, (Kluwer Academic Publishers, Dordrecht, 1999).

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