Pressure variation in Pt $L_{2,3}$-edge XMCD spectra of ordered Fe_3Pt and disordered $Fe_{72}Pt_{28}$ alloys

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In Fe_3Pt alloy Fe magnetic moment changes from high-spin state (HS) to low-spin state (LS) with increasing temperature. The HS-LS transition is one of the triggers that lead the invar effects. In disordered $Fe_{72}Pt_{28}$ alloy, a pressure-induced magnetic transition is also observed [1,2]. Since the magnetization and the Curie temperature of these magnetic transitions depend on stoichiometry and on a structural long range parameter S, it is considered that the magnetization of Pt is important as well as that of Fe for understanding the magnetism of Fe-Pt alloy.

In order to probe the magnetic state of Pt, we measured Pt $L_{2,3}$-edge x-ray magnetic circular dichroism (XMCD) of Fe_3Pt ordered alloy and $Fe_{72}Pt_{28}$ disordered alloy under high-pressure. To apply pressure, diamond anvil cells were employed, and ruby fluorescence method was used for pressure determination. The pressure dependence of spin angular momentum $\langle Sz \rangle$ and orbital angular momentum $\langle Lz \rangle$ of Pt atom can be studied by means of the sum rules and XMCD measurement.

Figure is a plot of integrated intensity of XMCD signal at Pt L_2 and Pt L_3 edge as a function of pressure. XMCD intensity of both edges shows a plateau up to 0.8 GPa, and abruptly decreases above 0.8 GPa, and finally vanished above 3.5 GPa. Since a mixture of HS and LS was reported as the magnetic state at ambient pressure, it is speculated that the population of LS state increase with pressure above 0.8 GPa. The disappearance at XMCD signal above 3.5 GPa corresponds to that the Fe_3Pt transforms to non-ferromagnetic state. The magnetic transition is considered to be 2nd order, because the transition is reversible and a hysteresis loop is not observed. The pressure dependence of disordered $Fe_{72}Pt_{28}$ was similar to that of ordered Fe_3Pt. Estimation of $\langle S_z \rangle$ and $\langle L_z \rangle$ is now in progress.

The pressure dependence of XMCD of disordered $Fe_{72}Pt_{28}$ was first measured by Odin *et al.* at Pt $L_{2,3}$-edge [1]. They reported a large hysteresis loop and the stability of ferromagnetic state up to 20 GPa, and they pointed out that their XMCD results was in contradiction to the observation by Mössbauer spectroscopy measurement [2]. It should be noted that our result of the non-ferromagnetic state above 3.5 GPa is well agree with the observation of Mössbauer spectroscopy measurement [2].

References
[1] Odin et al., J. Appl.Phys. **83** (1998) 7291 and Odin et al., Philo. Mag. B **80** (2000) 155.
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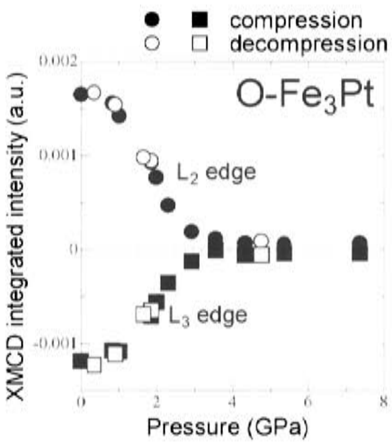

Figure: Pressure variation of Pt-$L_{2,3}$ edge integrated XMCD intensity of ordered Fe_3Pt. The integrated intensity is normalized by the edge jump of x-ray absorption profiles.

XMCD Spectrum in Ferromagnetic FePt Nanoparticles

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Nanometer-sized FePt particles have attracted a great interest as a candidate for high-density magneto-recording material. Indeed, nanoparticle of FePt alloy can be synthesized using a liquid process [1]. Furthermore, to realize ferromagnetic state from super-paramagnetism of as-grown particles, it should be subjected to chemical ordering and reduction under suitable thermal condition. The nanoparticles eventually possess a high-coercive force up to about 10kOe [1]. However, there has been a little amount of information on the mechanism of such high-coercivity. Then, we aimed to compare the magnetic states in the nanoparticle annealed at different temperature in a hydrogen atmosphere.

FePt nanoparticles used in this work are summarized in Table-I.

Table-I. FePt nanoparticles.

Sample	Thermal Treatment	Size	Magnetism
A	as-grown	3nm	SP
B	annealed at 200°C	--	SP
C	annealed at 300°C	--	SP
D	annealed at 500°C	>7nm	F
E	annealed at 600°C	>7nm	F

(SP: super-paramagnetism, F: ferromagnetism)

The relevant binary alloy was made by Ar arc-melting furnace and subjected to the suitable thermal treatment for chemical ordering. Disordered alloy has fcc structure, and ordered one has the $L1_0$-type superstructure. The Pt L-edge dichroism was recorded in transmission mode by the helicity modulation method.

Figure 1 shows the Pt $L_{2,3}$-edge XMCD spectra in the FePt nanoparticles subjected the different thermal treatment. As the thermal treatment was made at higher temperature, the dichroic signal increases the intensity. This means that the ferromagnetism is stabilized by the annealing in a range of 300-500°C, which is probably ascribed to a metallization of the nanoparticles by the chemical reduction. This trend is clarified by the variation of magnetic moments with the annealing condition and a comparison with those of the alloys, as shown in Fig.2. The magnetic moments were estimated using the magneto-optical sum rules [2] in the conventional manner. The magnetic state in the ordered FePt nanoparticles is similar to the chemically disordered FePt alloys, which characterizes the magnetic properties of the FePt nanoparticles.

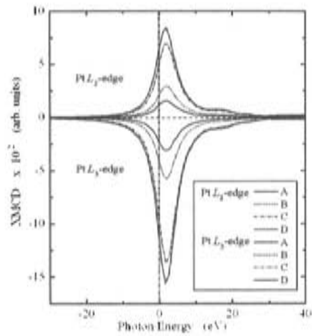

Fig.1. Pt L-edge XMCD in the FePt nanoparticles.

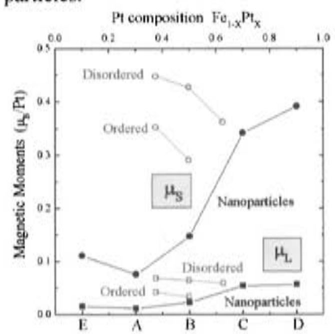

Fig.2. Spin (μ_S) and orbital (μ_L) moments per Pt atom. Closed symbols represent the data of the nanoparticles and open symbols for the ordered and disordered alloys.

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