Pt 5*d* Magnetic States in Ordered Fe-Pt alloy under High Pressure Probed by the Pt $L_{2,3}$-edges XMCD

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Introduction

Fe-Pt alloy shows a wide variety of magnetic properties and crystal structures depending on the chemical composition. Although ordered Fe_3Pt (O-Fe_3Pt) and ordered $FePt_3$ take the cubic $L1_2$-type crystal structure, they stabilize different magnetic states, *i.e.* the ferromagnetic state and the antiferromagnetic state, respectively. On the other hand, ordered FePt (O-FePt) takes the tetragonal $L1_0$-type crystal structure and shows a hard magnetic property due to a large uniaxial magnetic anisotropy.[1] The unit cell of the ferromagnetic O-FePt (a=3.85 Å, c=3.72 Å) has larger volume than that of the ferromagnetic O-Fe_3Pt (a=3.73 Å) at ambient condition.

To understand the relationship between the magnetic property and the crystal structure of the Fe-Pt alloys, pressure dependence of the magnetic state is one of the most fundamental issues. Since the Fe 3*d*- and Pt 5*d*-electronic states are strongly correlated with the nearest neighboring atoms, the applied pressure effectively affects their electronic states and may result in a modification of the magnetic state in the system. In this study, we compare the pressure variation of the Pt 5*d* electronic states in the ferromagnetic O-Fe_3Pt and O-FePt alloys by means of Pt $L_{2,3}$-edges X-ray magnetic circular dichroism (XMCD). The Pt $L_{2,3}$-edges XMCD is a useful technique for probing the ferromagnetic state under pressure because of small X-ray absorption by a pressure cell.

Experimental Procedure

X-ray absorption spectroscopy (XAS) and XMCD experiments under high pressure were carried out using the helicity-reversal method on the beamline 39XU at SPring-8. A diamond phase retarder was employed to produce the circularly polarized beam. Diamond anvil cells (DAC) were used for applying pressure. In order to magnetically saturate the sample, the high magnetic field of ±10T was applied to the O-FePt powder. For this measurement, a tiny DAC, 23.8 mmϕ × 47 mm in length, was inserted into a superconducting electromagnet. The magnetic field of ±0.6 T was applied to the O-Fe_3Pt powder sample. All the measurement was done at room temperature.

Result and Discussion

Figure 1(a) shows the pressure variation of the Pt L_3-edge XMCD spectrum of O-Fe_3Pt. In the compression process, the negative XMCD amplitude abruptly decreases from 0.8 GPa and disappears at pressures above P_t=3.5 GPa. Hence, the Pt 5*d* magnetic moment of O-Fe_3Pt is easily suppressed with increasing pressure. As the applied pressure is released, a reversible pressure variation of the XMCD spectrum is observed; O-Fe_3Pt transforms from the ferromagnetic state to a paramagnetic state due to a pressure-induced 2nd order transition. It is noted that the ferromagnetic state of O-Fe_3Pt disappears at much lower pressure than P_t=20 GPa of disordered $Fe_{72}Pt_{28}$ reported by Odin *et al.*[2,3]

On the other hand, the pressure variation of the Pt L_3-edge XMCD in O-FePt is different from that in O-Fe_3Pt. As shown in Fig. 1(b), the XMCD of O-FePt exhibiting intense amplitude of about -0.13 indicates the presence of a large Pt 5*d* magnetic moment. Furthermore, the intense XMCD amplitude remains even though the applied pressure reaches up to 20 GPa. Therefore, the Pt 5*d* magnetic moment is almost maintained at the maximum pressure, and no pressure-induced magnetic transition is recognized. This result evidences a highly stabilized ferromagnetic state of O-FePt under pressure.

Conclusion

We have successfully measured the pressure variation of the Pt $L_{2,3}$-edges XMCD spectrum indicating an obvious difference in the Pt 5*d* magnetic states of O-Fe_3Pt and O-FePt under pressure. This result gives an evidence that the ferromagnetic state strongly depends on the crystal structure of the Fe-Pt alloy. It is considered that the high stability of the ferromagnetic state of O-FePt may be attributed to the large volume of the unit cell compared with that of O-Fe_3Pt. Since the spin-polarized Pt 5*d* electronic states are induced by the Fe 3*d* magnetic states, the obtained results are strongly related to pressure dependence of Fe 3*d* magnetic states in O-FePt and O-Fe_3Pt alloys.

References

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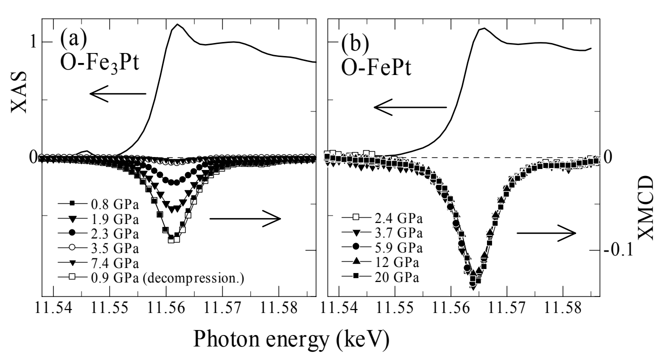

Figure 1(a)(b): The Pt L_3-edge XAS (upper parts) and pressure dependence of the Pt L_3-edge XMCD spectrum (lower parts) of (a) O-Fe_3Pt and O-FePt (b).