SUMMARY OF Ph.D. DISSERTATION

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Title

Ferromagnetism induced by strain in Pd nanoparticles

Abstract

Recent researches have reported the appearance of ferromagnetism in the nanoparticles of Pd, which is paramagnetic in bulk state. These reports give a novel perspective that magnetism is controlled by the formation of nanoparticles. Provided that the mechanism of ferromagnetic ordering in the nanoparticles is clarified in detail, new magnetic materials, that exceed the category of an existing material, can be developed. In this study, the origin of this ferromagnetism was experimentally discussed.

Chapter 1 summarizes the background and shows the purpose of this study.

Chapter 2 describes the theoretical background of the magnetism in bulk metals and reviews the previous studies.

Chapter 3 describes the results of X-ray magnetic circular dichroism (XMCD) measurements. The X-ray absorption spectra showed the electron transfer from 4*d* bands to the bands with higher energy. This probably brings about the large density of states at Fermi level and contributes to the onset of the ferromagnetism. In the XMCD spectra, the XMCD peaks at Pd $M_{2,3}$ absorption edges were observed. This is the clear evidence of the magnetic moment in pure Pd. The analyses using the sum rules present that the contribution of the orbital magnetic moment in the Pd nanoparticles is almost the same as that in 3*d* transition metals and it essentially disappears.

Chapter 4 describes the results of X-ray diffraction experiments and discussion about the effects of the crystal structure and defects on the magnetism in the Pd nanoparticles. In the Pd nanoparticles exposed to air, the spontaneous magnetization increases with increasing in inhomogeneous strains. This result provides that the ferromagnetism arises from the strains in the Pd nanoparticles.

Chapter 5 describes the results of the small-angle neutron scattering experiments. The magnetic scattering from the magnetization of the Pd nanoparticles was observed using the polarized neutron. The magnetic scattering is interpreted based on the shell model which includes the ferromagnetic core and weakly magnetic shell. This suggests that the ferromagnetism of the Pd nanoparticles exists in the core region. The shell region is corresponding to the region where the ferromagnetism disappears with the adsorption of air. The thickness of the shell region was estimated to 4.8 nm.

Chapter 6 summarizes the results of this study.