Magnetic and Electronic property of transition metal phosphides interface of Ni_xP/Fe_2P

Naoyuki Maejima[a,b,c], Yuma Kuwabara[a], Tomoya Yoshida[a], Takahiro Ota[a], Yuki Shimato[a] and Kazuyuki Edamoto[a,b]

[a] *Coll. Sci., Rikkyo Univ., Tokyo 171-8501, Japan.*
[b] *Research Center for Smart Molecules, Rikkyo Univ.,Tokyio 171-8501, Japan.*
[c] *Institute for Molecular Science, Okazaki 444-8585, Japan.*

Transition metal Phosphide with Fe_2P-type structure is promising candidates for magnetic refrigerant materials.[1] $(Fe_{1-x}Ni_x)_2P$ exhibit ferromagnetic properties at room temperature for $x < 0.8$. The Curie temperature decreases with increasing x and it exhibit a Pauli paramagnet behavior for $x>0.5$. [2] The Curie temperature can be controlled by adjusting the ratio of Fe and Ni. Additionally, experimental and computational studies suggest that the magnetism of $(Fe_{1-x}Ni_x)_2P$ involves mainly the Fe sites and little or no Ni sites. [3] The change in the magnetic properties is consider to involve a change in electronic state due to the Fe and Ni substitution. However, there are few experimental investigations of magnetic properties and electronic states about the same system.

Recently, we have succeeded in fabricating Ni phosphide thin films on Fe_2P substrates. In generally, surfaces and interfaces often exhibit different magnetic properties from those in the bulk. It is interesting that the new magnetic properties will appear or not in this transition metal phosphide thin film and interface, however there is few reports about the magnetic properties of this kind of materials. In this study, we investigated the magnetic and electronic properties of the thin films and interfaces of Ni_xP/Fe_2P samples using X-ray magnetic circular dichroism (XMCD) and X-ray photoelectron spectroscopy (XPS) measurements.

$Fe_2P(10\text{-}10)$ were cleaned by cycles of Ar^+ ion spattering (0.5 keV) and 750°C annealing. The cleaned surfaces showed c(2x2) Low energy electron diffraction (LEED) patterns. Ni atoms were deposited on the Fe_2P clean surface at 500°C, which induces phosphorization of the film owing to surface segregation of P atoms from the bulk.[4] The thickness of thin film was controlled by amount of Ni. Prepared Ni_xP/Fe_2P samples exhibit c(2x2) LEED pattern. The XMCD measurement of $Fe_2P(10\text{-}10)$ and $Ni_2P(10\text{-}10)$ clean surfaces and Ni_xP/Fe_2P thin film samples were performed at BL14 of HiSOR at room temperature. The XPS measurement of those samples were performed at BL5U of UVSOR and BL3B of PF.

Firstly, we measured Fe L edge and Ni L edge XMCD spectra of the Ni_xP/Fe_2P sample. The thickness of nickel phosphide layer was estimated 5Å. The Fe Ledge XMCD signal obtained from the Ni_xP/Fe_2P sample was significantly increased from that of clean Fe_2P substrate sample. Ni phosphides such as Ni_2P, Ni_3P, and NiP_3 are paramagnetic,[5] and Ni_2P substrates did not show XMCD signals. On the other hand, Ni_xP/Fe_2P samples showed XMCD signals at the Ni L edge. The peak top energy of the Fe L_3 edge of the thin film sample is lower than that of the Fe_2P clean surface and the peak top energy of the Ni L_3 edge of the thin film sample is higher than that of Ni_2P clean surface.

Secondly, we measured Fe L edge XMCD spectra obtained from various thickness Ni_xP/Fe_2P samples as shown in Figure1. Thickness dependence of XMCD signal was confirmed. These results indicated that the interaction between the thin film and the substrate changed the Curie temperature of the substrate and magnetic property of Ni phosphide thin film.

Combining XMCD and XPS results, we will discuss about this relationship of magnetic and electronic properties Ni_xP/Fe_2P samples.

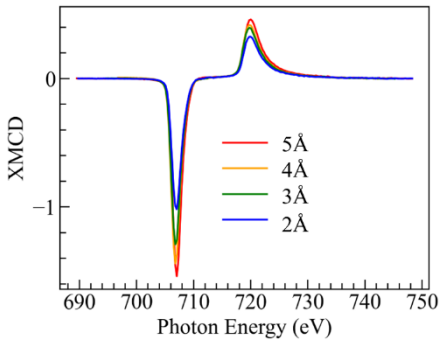

FIGURE 1. Fe L edge XMCD spectra obtained from various thickness Ni_xP/Fe_2P samples.

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