Impacts of Pentacene Spacer Layer to the Magnetic Properties of Organic Spin-Valve Studied by XPEEM

Yuet-Loy Chan (陳悅來), Ching-Yuan Chiu (邱清源), Ying-Chang Lin (林楹璋), Yu-Ling Lai (賴玉玲), Yao-Jane Hsu (許瑤真), and Der-Hsin Wei (魏德新)

National Synchrotron Radiation Research Center, Hsinchu, Taiwan

The simplest spin valve is constructed from three layers: a "soft" magnetic layer, a nonmagnetic spacing layer and a "hard" magnetic layer. The spacing layer plays an important role in the spin valve device as it governs the injection, transport and detection of spin-polarized carriers through mediating various coupling between soft-hard layers. Recently, the possibility incorporating organic of semiconductor as the spacing laye in spin-valve structures has been extensively pursuded. Within the available organic semiconductor materials, pentacene is known for its weak spin-orbit, and therefore a very long spin diffusion length is expected. In this study, we employed XPEEM and MOKE to investigate the magnetic properties and molecules orientation by constructing a pseudo organic spin-valve using pentacene as the spacing layer, $Ni_{80}Fe_{20}$ and cobalt are selected as the soft and hard magnetic layer respectively.

The substrate used in this study was a silicon (001) wafer, which had been deposited with a 500Å thick Au buffer layer before introduced into the preparation chamber. A series of Co/Pentacene/NiFe trilayers with different thickness of pentacene (Pn) were prepared at room temperature by electron beam evaporation and Knudsen cell method under ultrahigh vacuum condition.

For the MOKE measurements, square loops were observed in all samples and the coercivities decrease monotonically as a function of Pn thickness. A typical hysteresis loop measurement is shown in figure 1.

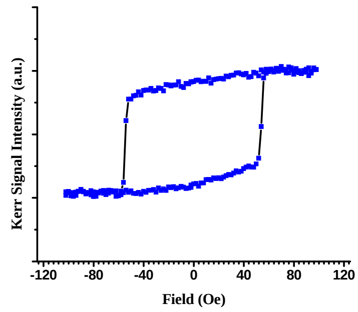

Figure 1. A typical hysteresis loop measurement from a Co/Pn(10Å)/$Ni_{80}Fe_{20}$ trilayer. Hysteresis loop shows up a strong direct coupling between the two FM layers but the two-state loops are missing in this kind of coupling.

The magnetic domain images and XMCD spectra from a Co/Pn(10Å)/$Ni_{80}Fe_{20}$ sample are shown in figure 2. These images and spectra were captured at the same sample position. The domain images display nearly the same shape and same contrast, it is an indication of strong ferromagnetic coupling between top layer (Co) and bottom layer ($Ne_{80}Fe_{20}$). This strong coupling blocks the two-state hysteresis loop often found in systems with weaker interlayer coupling. The XMCD display the results consistently with the MOKE measurements. A drastic reduction in magnetic contrast was also found from PEEM image for the thickness of Pn beyond 20Å.

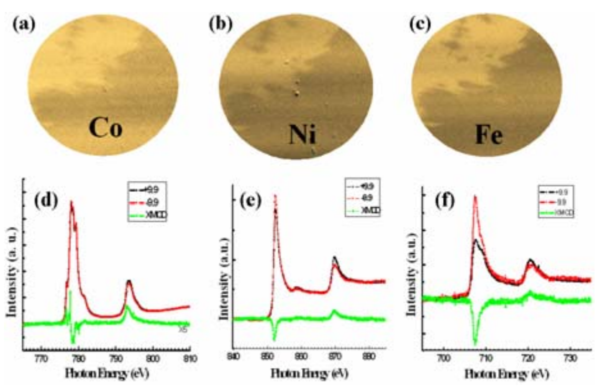

Figure 2. The domain structures and X-ray magnetic circular dichroism (XMCD) spectra of a pseudo organic spin valve in a Co/Pn(10A)/NiFe trilayer thin film were measured at the same sample position.

In addition, the orientation of Pn molecules was examined by X-ray linear dichroism (XLD) at C1s K-edge. The enhanced π^* absorption at s-polarization further implies that the long-chain of Pn molecules may orientate perpendicularly to sample surface. Further study about how to trace out the cause of one-state hysteresis loop and the reduction of domain intensity at the thickness of Pn beyond 20 Å is needed.

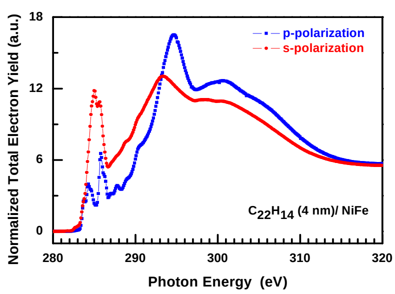

Figure 3. Pentacene deposited on $Ni_{80}Fe_{20}$ surface displays strong linear dichroism at C 1s K-edge. The enhanced π^* absorption at s-polarization further implies that the long-chain of Pn molecules may orientate perpendicularly to sample surface