Ferromagnetism of single monolayer Fe sandwiched by Pt

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Mono-atomic layer of Fe and that of Pt are stacked one after the other to form the ordered FePt. It is ferromagnetic with its magnetization easy axis perpendicular to the plane of the layers. Due to this characteristics, the layered ordered alloy FePt in the forms of ultrathin films and nanoparticles is regarded very promising as key material for high density data storage.

Molecular beam epitaxy (MBE) method has enabled the growth of well defined FePt thin film by means of alternative deposition of Fe and Pt mono-atomic layers. It is possible to make a FePt thin film sandwiched by Pt. When the thickness of the FePt is made ultimately small, one would obtain a single monolayer of Fe sandwiched by Pt. Unlike the monolayer Fe simply grown on a substrate, the sandwiched monolayer Fe is stable even in the air. It is also symmetric with respect to the Fe layer.

Core-level x-ray magnetic circular dichroism (XMCD) is a powerful tool to investigate element-specifically the magnetic state of the ferromagnetic system. When the total electron yield method is adopted, the XMCD measurement is fairly surface sensitive with the probing depth of about 10 nm. Moreover, it is applicable even if the amount of the magnetic material is less than a monolayer. In this sense, XMCD is one of the most suitable method to investigate the magnetism of the sandwiched monolayer Fe film.

Samples are prepared as follows. On the MgO substrate, Fe seed layer is grown and subsequently Pt buffer layer is grown. On this Pt layer, mono-atomic layer of Fe is evaporated. At last, Pt protective layer of 1.0 nm thickness is grown. Layer-by-layer growth through out this process was monitored by reflection high energy electron diffraction.

Fe 2p-3d XMCD was measured by modulating the helicity of the incident soft x-ray, which is realized by the kicker magnets placed before, in between, and after the two helical undulators of BL25SU. The sample was magnetized perpendicularly by means of either permanent magnet or electric magnet. XMCD was measured under several conditions; under the magnetic field of 1.4 T, under zero magnetic field after magnetized under 1.4 T, and under varying magnetic field between +1.9 T and −1.9 T.

The obtained results were as follows. XMCD under remanence decreased as the temperature of the sample was raised and reached zero at about 170 K. On the other hand, the spontaneous magnetization estimated by means of the Arrot plot became zero at about 240 K. Therefore it is suggested that the Curie temperature of the monolayer Fe sandwiched by Pt is about 240 K. The XMCD spectrum will be analyzed by means of the XMCD sum-rule to yield the ratio between the contributions of orbital angular momentum and spin to the magnetic moment of Fe 3d electrons.

Fe atomic arrangements in Fe_xNbS_2 (x=1/3, 1/4) studied by stereo atomscope

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It is known that the Para-antiferro magnetic transition occurs for Fe_xNbS_2, when x is between 1/4 and 1/3 [1]. While the spin glass transition occurs for further smaller amount doped Fe. Moreover, the electronic characteristics are strongly affected by the magnetic transition, and the Fe atomic superstructures appear for different doping amount by its self-organization. The atomic arrangement position study, especially for Fe atoms, is important for understanding the magnetic and electronic properties. Stereo atomscope [2] was used to study the Fe atomic arrangement directly, which is realized by the combination of display type spherical mirror analyzer (DIANA) and circularly polarized X-ray.

The single crystal Fe_xNbS_2 (x=1/3 or 1/4) was cleaved in ultra-high vacuum preparation chamber, respectively, and transferred into the main analyzer chamber immediately. Spectrum was taken by scanning the kinetic energy of photoelectrons. Stereoscopic atomic arrangements around Fe atoms were taken by setting the pass energy of the analyzer to the peaks of Fe 2p photoelectrons. Circularly polarized X-rays are produced by the helical Undulators in BL25SU.

Figure (a) shows the spectrum of $Fe_{1/3}NbS_2$ at photon energy 800 eV. The Fe2p photoelectron intensity is weak because of its small amount. Figure (b) and (c) are PEAD patterns taken by DIANA at clockwise (left) and counterclockwise (right) circularly polarized X-rays for x=1/3 and 1/4, respectively. The Fe 2p photoelectrons with kinetic energy 500 eV were used to take the PEAD patterns. The PEAD patterns of secondary electrons are used as backgrounds. The two PEAD patterns of cw and ccw circularly polarized X-ray show us the atomic arrangement stereo-photograph seen from specific atoms. Six strong forward-focusing peaks forming hexagonal arrangement can be observed in PEAD patterns in Fig. (b). This is reasonable for the crystal structure, which is formed by the stacking of sheets of hexagonally packed atoms. For Fig. (c), the peak positions become diffuse as decreasing Fe doped amount. The peak positions are different between the PEAD patterns of x=1/3 and 1/4. Further analysis is necessary to show the accurate atomic positions.

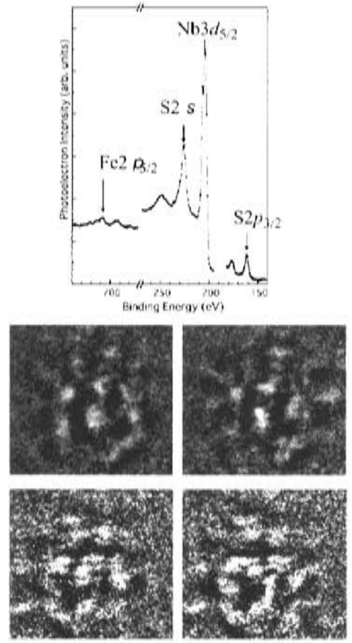

Fig. (a). Spectrum of $Fe_{1/3}NbS_2$, (b) and (c) are the PEAD patterns for Fe_xNbS_2 (x=1/3 or 1/4), respectively.

1) 斉藤裕児, 2003A0600-NS1-np.
2) H. Daimon, *Phys. Rev. Lett.* **86**, 2034 (2001).