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A novel spin-polarized photoemission spectrometer with very-low-energy electron diffraction type spin-polarimeter

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Introduction

Spin- and angle-resolved photoemission spectroscopy is sometimes called complete experiment since one can determine all the parameters of electrons inside the materials, such as binding energy, momentum and spin. However, detection of the electron spin by Mott scattering that is commonly used for the spin-resolved photoemission (SRPES) measurement is very inefficient and the experiment is very time consuming. The efficiency of the spin detection which is often defined by the figure of merit (FOM), $\varepsilon = S^2 I/I_0$ is 10^{-4} order in the Mott scattering. Here S is so-called Sherman function and I and I_0 are intensity of scattered and injected electrons in the Mott scattering process. In the Mott scattering, typical values of S and I/I_0 are 0.1 and 10^{-2}, respectively. Because of this low efficiency it is very difficult to consist high-energy and/or high-angular resolution angle-resolved photoemission spectroscopy with spin-resolution.

Development of high-efficient spin polarimeter

In order to accomplish the spin-polarized photoemission measurement with high energy- and angular resolutions, we have developed a new spin-polarized photoemission spectrometer with very-low-energy electron diffraction (VLEED) type spin-polarimeter. It has been reported that the VLEED type spin-polarimeter can realize relatively higher efficiency than that of Mott type detector and very high figure of merit of $\varepsilon = 10^{-2}$ order has been reported so far[1]. Despite the high efficiency, the VLEED spin polarimeter has not been popular because the Fe(001) target that is usually used for the VLEED can be easily contaminated and the operation of the VLEED type polarimeter is very difficult.

It is reported recently that this week point of the VLEED can be overcome by utilizing the pre-oxidized Fe(001) surface, Fe(001)p(1x1)-O surface[2]. The performance of this new target can last more than a week and recover by short annealing even when the target is deteriorated.

Here we report our recent results of development of the SRPES system combined with the VLEED spin detector utilizing Fe(001)p(1x1)-O target. In our spin polarized photoemission system, we adopted very large electron analyzer (SPECS, PHOIBOS150) which has high electron transmission. After the energy analysis, the electrons are transported to the target through simple Einzel lens that has also high transmittance and reflected at the target. The reflected electrons are measured with the channeltrons just beside the exit lens[3].

Figure 1 shows the spin resolved secondary electron spectra taken from the residually magnetized Ni(110) single crystal excited by a synchrotron radiation light at 21.2 eV. The asymmetry between the observations with the target magnetization parallel and antiparallel to the sample magnetizaion is clearly seen. Comparing the obtained asymmetry (~3.2 % at E_k=2 eV) and the previously reported polarization of the secondary electrons from the Ni(110) (~ 8 % at E_k=2 eV[4]) we have estimated the spin-resolving power, the effective Sherman function as **0.40±0.02**. From the estimated effective Sherman function and the reflectivity (I/I_0~0.12) the FOM is determined as **$1.9\pm0.2\times10^{-2}$**. This obtained FOM is about 100 times higher than that of usual Mott detector. Due to the high efficiency of the spin detector, we could achieve very high energy and angular resolutions (**ΔE~30meV, Δθ~ ±0.7°**) in the SRPES measurement[3]. This new system will provide the new quality of the spin-polarized photoemission measurement and open new insight in the magnetism of surfaces and nanostructures and their applications for the spintronics in the future.

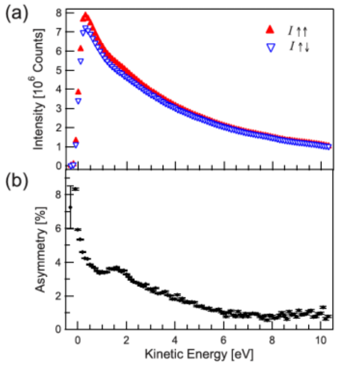

Fig. 1 Spin resolved secondary electron spectra from Ni(10) and the asymmetry between parallel and anti parallel geometry (see text)

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