Development of transmittion geometry supermirror polarizer

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Magnetic multilayer mirror consisting of ferromagnetic layers and nonmagnetic layers is useful to polarize neutron beam. Polarizing supermirror is a stack of magnetic multilayer with gradually increasing value of the d-spacing. Polarizing supermirror is stable and it is easy to handle as neutron polarizer. Recently performance of He-3 spin filter is improved and it is better than supermirror when we need analyzer covering wide scattering angle for thermal neutron. When we use cold neutron and polarizer covering narrow beam cross section, polarizing supermirror is more useful than He-3 spin filter since transmission probability of supermirror is better than that of spin filter.

Recently we succeeded in fabricating m=4.9 Fe/Ge polarizing supermirror by using ion beam sputter (IBS) machine at KURRI[1]. The magnetic property of supermirror is better than Fe/Ge and Fe/Si ones by inserting thin Si layer in which thickness 0.5 nm between Fe and Ge layer. The measurement was carried out at C3-1-2-3 port (MINE2) at JRR-3M at JAEA. The average wavelength of incident neutron is 0.88 nm and the resolution is 2.7 % in full width half maximum. The divergent angle of neutron beam was smaller than 1 mrad. The strength of external magnetic field is 45 mT. The reflectivity and polarization efficiency of reflected neutron is estimated to be above 0.7 and 0.94, respectively. The reflectivity is very high, however, the polarization efficiency of transmitted neutron is 0.5. Because polarization efficiency of transmitted neutron P_t is related reflectivity R and it is given by the following equation $P_t \simeq P_r R/(2-R)$, where P_r is the polarization efficiency of reflected neutron.

The transmission geometry supermirror polarizer does not change neutron beam line and it is more useful and it is important for development of transmission geometry supermirror polarizer (analyzer) to enlarge utility of polarized neutron beam. Thus we started to develop transmission geometry supermirror polarizer.

The supermirrors were deposited on silicon wafer (150x60x0.6mm^3) using IBS at KURRI. The measurement was carried out at C3-1-2-2 port (MINE1) at JRR-3M at JAEA. The average wavelength of incident neutron is 0.81 nm and the resolution is 17.4 % in full width half maximum. The divergent angle of neutron beam was 1.9 mrad. The strength of external magnetic field is 60 mT. As shown in Fig.1, we succeeded in fabricating m=4 transmission geometry polarizing supermirror. The flipping ratio is higher than 20 at 2*le*m*le*4.1 and it is especially higher than 70 at 1.4*le*m*le*2.6. As a next step, we will improve the flipping ratio at m*ge*2.6.

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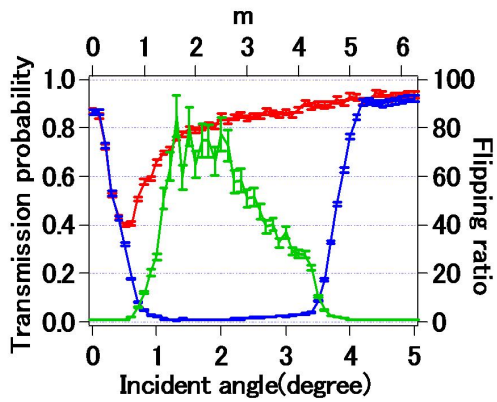

Fig. 1. Fig.1 Measured transmittion probabilities of up (blue) and down(red) spin neutron for m=4 Fe/SiGe$_3$(Si:0.5nm) magnetic supermirror. The green line indicates flipping ratio that transmittion probability of down spin neutron devided by that of up spin one.