# Possible improvement of thin magnetic film using Pd

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Multilayers consisting of alternative stack of a magnetic material and a non-magnetic material is widely used as neutron spin polarizers. Such multilayers are also a key element for consisting multilayer spin splitter, consisting of polarizing mirror, gap layer and reflection mirror, which can be used to measure precise quantity of absorbed material by the gap layer material.

One way to the improvement of polarizing efficiency of the multilayer polarizer is to make the saturated magnetic field higher. Higher field strength allows us higher potential contrast between neutron eigenstates, and higher reflectivity for neutron with field-parallel spin. Recently, Noma et al. [1] reported that saturated magnetic field of FeCo was increased by being sandwiched by Pd thin films. In the present study, we studied the effect of Pd thin layer over Fe films in polarizing multilayers.

The samples are fabricated with vacuum evaporation. Firstly combination of thickness of Pd and Fe layers is investigated. Multilayers with various combination of Pd and Fe such as (1nm, 4nm), (1nm, 5nm), (1nm, 6nm), (2nm, 6nm), (3nm, 6nm) where total Fe thickness is equal to 60nm were fabricated and their magnetization is measured with vibrating magnetometer. The thickness of the films are measured with X-ray reflectometer. Combination of 3nm-Pd and 6nm-Fe gave highest magnetization. Measured magnetic field is 1.51 T which is reasonable value comparing with bulk magnetization of 2.1 T for density reduction of 75% given by X-ray reflectivity.

Secondly, for comparison, various combination of Fe and other material was tested. Here Ge, Ti, Si were adopted other than Pd. The thickness of all non magnetic material is 2nm, and that of Fe is 6nm. The calibrated hysteresis curves are shown in the upper figure in Fig.1. Here Ge gives similar result as Pd. However, Pd gives a little higher field and smaller coercive force. These saturated magnetization was also confirmed with polarized neutron reflectivity.

The lower figure in Fig.1 shows polarized neutron reflectivity of Fe6nm-Pd2nm-Ge2nm-Pd2nm multilayer with 15 period. The rise of reflectivity in the region $Q_z > 0.06$ is due to the position dependent back ground. Other than this region, the reflectivity is well reproduced by the calculation in which saturated magnetic field is assumed as 1.51T.

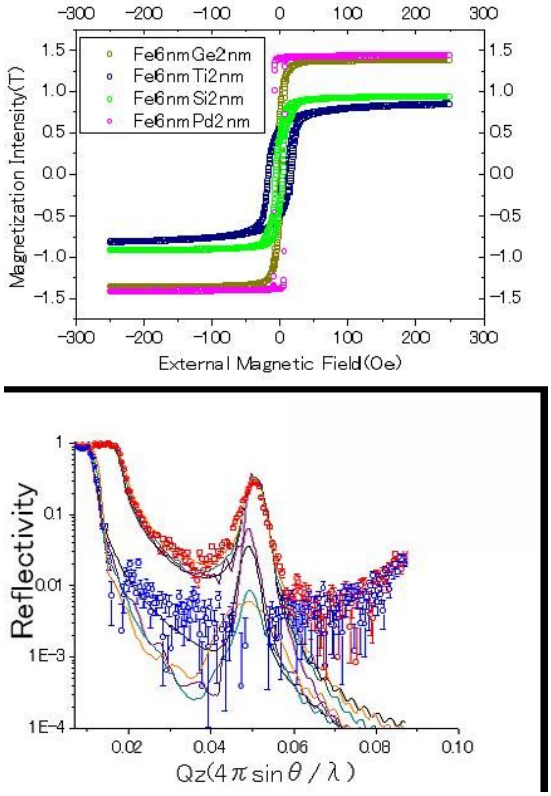


Fig. 1. The caribrated hysteresis curves of multilayers of Fe and various material (upper), and polarized neutron reflectivity of Fe6nm-Pd2nm-Ge2nm-Pd2nm multilayer with 15 period (lower).