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Thickness dependence of magnetic domain structure of Fe/NiO polycrystalline bilayers studied with SPLEEM

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Antiferromagnetic (AFM) insulators have attracted much attention as materials suitable for spintronic applications because they can realize highly efficient spin transport in the ferromagnetic (FM)/AFM/nonmagnetic (NM) structure in addition to other advantages that they are robust against external magnetic fields and produce no stray fields. Studies have done intensively by using both single crystalline and polycrystalline samples consisting of AFM insulators and FM or NM metals to reveal details of their spin-transmission properties. Magnetic domain structure of FM on a single crystalline AFM layer was also studied with spin-polarized low energy electron microscopy (SPLEEM) and it was found that magnetic domains of FM on a single crystalline AFM were unusually small as resulting from competition between AFM and FM exchange interactions at the FM/AFM interfaces [1]. However, no study with SPLEEM for polycrystalline samples had been done yet. In the present study, we observed the magnetic domain structure of Fe/NiO polycrystalline bilayers at various Fe and NiO thicknesses (d_{Fe}, d_{NiO}) with SPLEEM and clarified relation between the size of magnetic domains and the thickness of layers.

NiO polycrystalline layers with thicknesses of 2, 5, 10, and 20 nm were prepared *ex situ* on thermally oxidized Si substrates by rf magnetron sputtering at RT and introduced from the ambient environment into the SPLEEM instrument. The samples were degassed at about 200 °C followed by Ar ion sputtering to clean their surfaces, and then Fe was in-situ deposited onto the surface of the samples up to a thickness of 5 nm at RT in UHV while observing with SPLEEM. No magnetic contrast was observed with d_{Fe} below 1 nm. Magnetic domains with in-plane uniaxial anisotropy appeared at a d_{Fe} around 1 nm and grew larger with increasing d_{Fe}. We observed the magnetic domain structure clearly as shown in Fig. 1 even though the NiO layers were prepared *ex situ* and Fe was deposited at RT after the cleaning by a simple procedure. We found that the size of magnetic domains depended strongly upon d_{NiO}. The sizes of magnetic domains for d_{NiO} = 10 and 20 nm were much smaller than those for d_{NiO} = 2 and 5 nm, which were in the same order as those observed in FM/non-AFM bilayers because polycrystalline NiO was paramagnetic at RT for $d_{NiO} \leq 5$ nm. We also found from the results for d_{NiO} = 10 and 20 nm that growth rate of the magnetic domains with d_{Fe} depended upon d_{NiO}. The growth rate for d_{NiO} = 20 nm was about 40% smaller than that for d_{NiO} = 10 nm. This indicates that the interlayer exchange coupling between Fe and NiO increases with d_{NiO} [2].

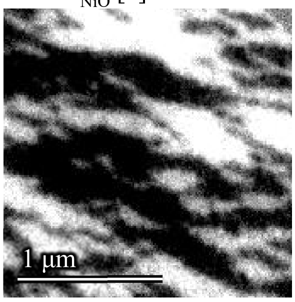

Figure 1. SPLEEM image with in-plane magnetization of a Fe/NiO polycrystalline bilayer with d_{NiO} = 20 nm at d_{Fe} = 5 nm.

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