Dependence of exchange bias field on antiferromagnetic layer thickness in NiFe/FeMn/CoFe heterostructures grown under a magnetic field

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We have investigated the antiferromagnetic layer thickness dependence of exchange bias field in NiFe (F)/FeMn(t_{AF}, AF)/CoFe(F) trilayered heterostructures with t_{AF} up to 30 nm. It was found that exchange bias field at both F/AF interfaces exhibit anomaly around t_{AF} = 20, 25 nm after saturation at t_{AF}=10 nm. Considering that the theoretical and experimental results studied so far[1-4], it has been found to be very unusal behavior. Well-known factors such as FeMn(111) texture, FeMn grain size, and F/AF interface roughness are unlikely to explain the observed anomaly. We measured and compared polarized neutron reflectivity of NiFe (F)/FeMn(t_{AF} =25nm)/CoFe(F) at positive (300 Oe, R^+) and negative (-300 Oe, R^-) saturations using Magnetism Reflectometer @BL4A, Spallation Neutron Source (SNS) at Oak Ridge National Laboratory. By comparison, we found that there exists very small, but non-zero spin asymmetry. Spin asymmetry is defined as $(R^+-R^-)/(R^++R^-)$. This is unexpected results because spin asymmetry at both saturations should be the same with each other. We attempt to understand our results as follows. In case of $t_{AF}\leq$ 20 nm less than AF domain wall length, the intra-layer AF exchange coupling tends to make FeMn(111) fully compensated spin structures. This may be ascribed to the fact that the uncompensated magnetic moments within FeMn(111) layer have seldom been seen in previous reports regarding (NiFe or Co)/FeMn(111) bilayered heterostructures. Meanwhile, partially uncompensated, rotatable AF spins or partial domain wall is likely to be accommodated within FeMn(111) layer in case of t_{AF}= 25 nm, close to a AF domain wall length for FeMn(111) texture. We believe that partially uncompensated rotatable spins or partial domain walls possibly lead to the anomaly observed even after saturation of exchange bias field around t_{AF}=10 nm in NiFe/FeMn/CoFe heterostructures.

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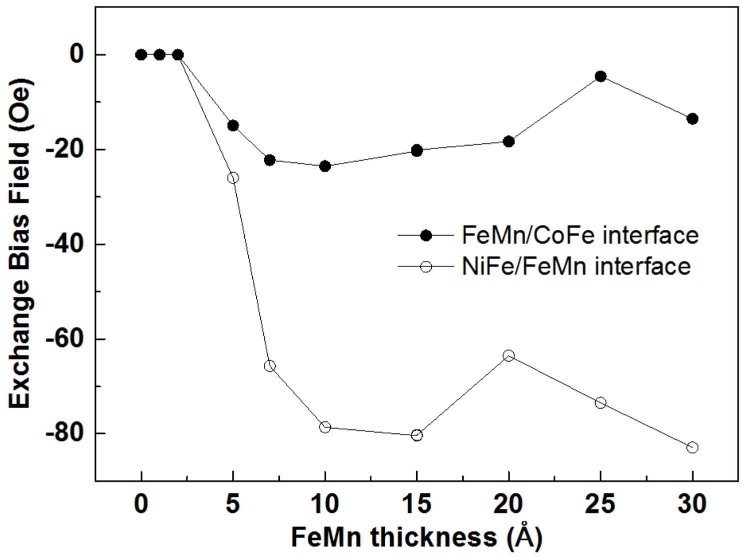

Fig. 1. Antiferromagnetic layer thickness dependence of the exchange bias field at NiFe/FeMn(open circle) and FeMn/CoFe(solid circle) interfaces in NiFe/FeMn/CoFe heterostructures.

References

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