Magnetic Properties of Ir/Co/Pt Films Tuned by Ga^{+} Ion Bombardment

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Magnetic properties of layered films are determined not only by the materials of the particular layers and their thicknesses but also by the structure of their interfaces. In particular, this applies to magnetic anisotropy and Dzyaloshinskii-Moriya interaction. The morphology of interfaces can be modified as a post-deposition treatment. One of the most frequently used methods of modification is ion bombardment (IB).

The study aimed to investigate the effect of Ga^{+} IB on the magnetic properties of Ti(4nm)/Au(30nm)/Ir(30nm)/Co(0.8nm)/Pt(5nm) films. The changes of magnetic properties were determined from hysteresis loops measured using the magneto-optical Kerr effect in polar geometry (P-MOKE) in an as-deposited state and after each step of IB. The evolution of hysteresis loops caused by the IB process indicates that with increasing ion energy ($5 \leq E_{\mathrm{ion}} \leq 30$ keV) and ion dose ($10^{12} \leq D \leq 10^{15}$ Ga^{+}/cm^{2}) a gradual transformation from loops characteristic for perpendicular magnetic anisotropy to loops characteristic for easy-plane anisotropy take place. These changes are well described by the dependence of the coercive field (H_{C}) on E_{ion} and D.

A previous study performed by C.T. Rettner [1] for Co/Pt multilayers modified by IB with He^{+} and Ar^{+} ions indicates that the value of D should be greater to obtain the same changes in H_{C} for E_{ion}=2 MV as for E_{ion}=20 keV. In our case, the same changes of H_{C} for the higher value of E_{ion} are obtained for a smaller value of D.

To explain this difference, we performed Monte-Carlo simulations using the SRIM code to investigate the so-called stopping power of Ar^{+}, He^{+}, and Ga^{+} ions in a Co layer. This parameter can be separated into the ion-atom nucleus (S_{n}) and ion-electron (S_{e}) interactions. The simulations revealed that Ga^{+} ions with E_{ion} of 5, 8, and 30 keV have $S_{\mathrm{n}} > S_{\mathrm{e}}$, which leads to elastic collisions and requires a higher D to observe the same effect with decreasing E_{ion}. On the other hand, E_{ion}=2 MeV for He^{+} and Ar^{+} ions have $S_{\mathrm{n}} < S_{\mathrm{e}}$, resulting in less efficient atom displacement and requiring a higher D than E_{ion}=20 keV to observe the same effect.

This study emphasizes that careful parameter selection during IB is crucial for precise modification of the magnetic properties and structure of thin-film systems.

References:

[1] C. T. Rettner et al., App. Phys. Lett. 80 (2002) 279-281

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