Sign reversals of magnetoresistance in Co/Cu multilayers in ion-matter collision

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Co/Cu multilayers have been irradiated with 1 MeV Si^+ ions in the fluence range $1x10^{14}$ – $1x10^{17}$ ions/cm^2 and the evolution of magnetoresistance (MR) has been investigated. At 2K MR is negative (-42%) for the pristine sample. Upon irradiation at a fluence of $1x10^{14}$ ions/cm^2 the magnitude of MR decreases, but remains negative (-31%). MR switches from negative to positive at a fluence of $5x10^{14}$ ions/cm^2 and remains positive up to the irradiation fluence of $5x10^{16}$ ions/cm^2. A second sign reversal of MR from positive to negative occurs at the fluence of $1x10^{17}$ ions/cm^2. No sign reversal of MR in ion irradiation of magnetic multilayers was reported earlier. Here we observe double sign reversals as a function of ion fluence

Ion-atom collision in materials, including magnetic multilayers, can modify their properties. Energetic ions cause atomic displacements across the interface. Ion irradiation has been found to trigger a spin orientation transition in Co/Pt multilayers. Such modifications are suited for patterned ultra-high-density recording media [1]. Ion irradiation also displaces atoms from any layer into the adjacent layers in a multilayer system [2,3]. A nonmagnetic to ferromagnetic transformation has been observed in ion irradiation [3]. In a magnetic multilayer, atoms from the magnetic layers can be displaced and incorporated into the nonmagnetic layers. Even a small (~a few percent) magnetic impurity concentration in the nonmagnetic spacer layer can drastically change magnetic coupling and magnetoresistance (MR) [4]. Thus, ion irradiation can modify magnetic multilayers in many different ways.

Giant magnetoresistance (GMR) effect has been observed in antiferromagnetic Co/Cu multilayers. The MR in this case is negative. We report a novel phenomenon of sign reversals of MR in an ion-irradiated antiferromagnetically coupled [Co(1.1 nm)/Cu(0.9 nm)]x50 multilayer, grown on a Si substrate. The multilayer samples have been irradiated with 1 MeV Si^+ ions at room temperature. At 2K MR is negative for the pristine sample (- 42%). Upon irradiation at a fluence of $1x10^{14}$ ions/cm^2 the magnitude of MR decreases, but remains negative (- 31%). MR switches from negative to positive at a fluence of $5x10^{14}$ ions/cm^2 and remains positive up to the irradiation fluence of $5x10^{16}$ ions/cm^2. A second sign reversal of MR from positive to negative occurs at the fluence of $1x10^{17}$ ions/cm^2. Although MR in ion-irradiated magnetic multilayers has been investigated earlier and a reduction in the magnitude of MR was observed, no sign reversal of MR was reported. This is apparently the inadequate fluence range used in earlier investigation. We observe double sign reversal as a function of ion fluence. These effects are attributed to ion-irradiation-induced interface disorder and defects and change in their concentration as a function of ion fluence. Interface disorder and the structural evolution as a function of fluence has been investigated by X-ray reflectometry and X-ray diffraction. The correlation between the observed phenomenon and the structural evolution will be discussed.

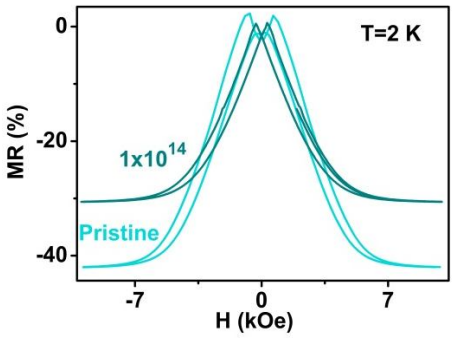

Figure 1. The magnetoresistance of the pristine Co/Cu multilayer and the sample irradiated at a fluence of $1x10^{14}$ ions/cm^2.

References

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