Magnetic Properties of Metallic Multilayered Systems

TERUYA SHINJO* and KO MIBU**
Institute for Chemical Research, Kyoto University, Uji, Kyoto-fu 611-0011, Japan

Abstract. The giant magnetoresistance (GMR) effect was an epoch-making discovery in the field of magnetic materials research. In this article, studies on magnetic multilayered systems relating to GMR are briefly surveyed and the role of interlayer coupling in GMR phenomena is argued. The usefulness of Mössbauer spectroscopy as a tool to investigate GMR systems is introduced. Although the GMR effect was observed for the first time in Fe/Cr multilayers, magnetic properties of ultrathin Cr layers were not well known until quite recently. Magnetic behaviors of multilayers including ultrathin Cr layers have been investigated from $^{119}$Sn Mössbauer spectroscopy and neutron diffraction. In Cr/Sn multilayers, it was found that the spin-density-wave structure of Cr layer is systematically modified by the insertion of monatomic Sn layers.

Key words: GMR, interlayer coupling, Mössbauer spectroscopy, hyperfine field, ultrathin Cr layers.

1. Introduction for the GMR effect

Grünberg et al. have investigated magnetic behaviors of Fe/Cr/Fe trilayer system and found that an interlayer exchange coupling exists between Fe layers across an intervening Cr layer [1]. The coupling strength becomes rather strong when the Cr thickness is around 10 Å. In order to study the features of interlayer coupling in more details, Baibich et al. prepared Fe/Cr multilayers with various artificial periodicities. Each Fe layer is an independent ferromagnet but, because of the antiferromagnetic interlayer coupling, magnetizations in adjacent layers are oriented antiparallel. By applying strong external fields, Fe layer magnetizations are oriented parallel and, associating with the magnetic reorientation, the electric resistance was found to be reduced drastically. That is the giant magnetoresistance (GMR) effect discovered in 1988 [2] (Figures 1(a) and 2(a)). The decrease of resistance at low temperature by applying an external field, 2 T, has reached to be almost 50% in [Fe(30 Å)/Cr(9 Å)]×60. Even at room temperature, the decrease of magnetoresistance (MR) was about 17%, which is much larger than the con-
Figure 1. Examples of the GMR effect. Magnetization and magnetoresistance curves are shown for (a) Fe/Cr multilayers at 4.2 K [2], and (b) non-coupled Co/Cu/NiFe/Cu multilayers at 300 K [3].