6-1 Electronic Origin of Giant Magnetoresistance Effect in C_{60}-Co Films

— Spectroscopic Examination of Spin States in Organic-Transition Metal Materials —

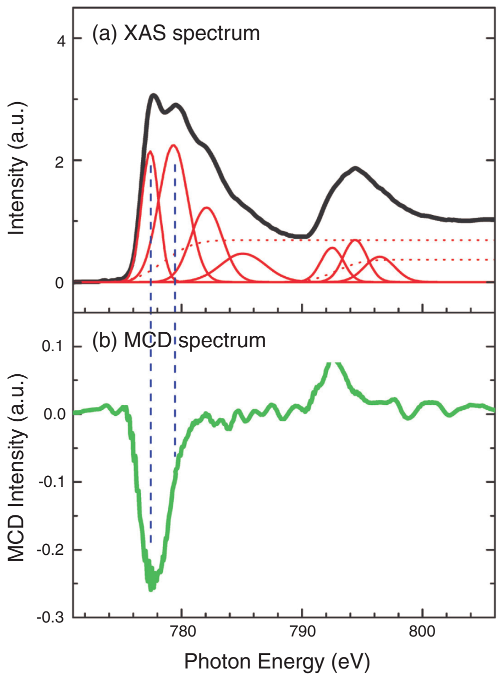

Fig.6-2 X-ray absorption and magnetic circular dichroism spectra of the C_{60}-Co compound
(a) X-ray absorption spectrum of the C_{60}-Co compound in the Co 2p→3d excitation region.
(b) Magnetic circular dichroism spectrum of the C_{60}-Co compound measured under a high magnetic field (H=50kOe) and low temperature (T=6K).

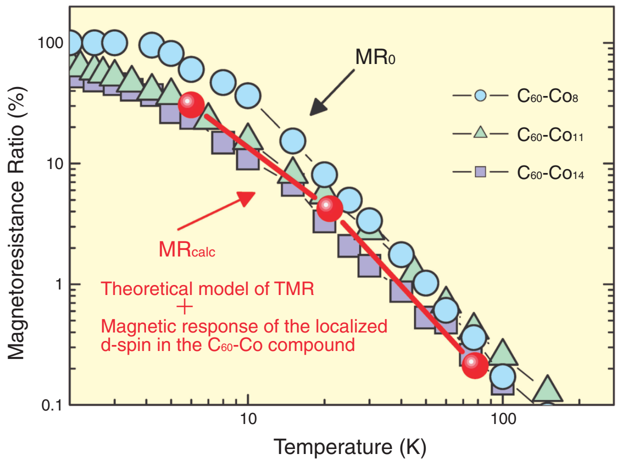

Fig.6-3 Temperature-dependence of the magnetoresistance ratios
Magnetoresistance ratios measured under the high magnetic field of H=50kOe (MR_0), and calculated magnetoresistance ratio with the theoretical model of the TMR effect and the magnetic response of the localized spins in the C_{60}-Co compound. The symbols (○, △, □) are correspond to MR_0 of the C_{60}-Co films with the different Co content, respectively.

A technology in which both electronic charges and spins are employed as information carriers has emerged recently. This technology is called "spintronics", and has been investigated actively in order to realize spintronics devices with a variety of new features. One of the important principles in the spintronics devices is the influence of magnetic field on electronic resistivity in these devices, i.e. magnetoresistance. Such phenomenon is caused by the different conductance of the electron carriers depending on the direction of the spin (up / down). Recently, we have found the C_{60}-Co films exhibit a much larger tunnel magnetoresistance (TMR) effect than previously used inorganic materials. In the present study, we investigated the electronic and spin states of the C_{60}-Co films by X-ray absorption (XAS) and magnetic circular dichroism (MCD) spectroscopy, and found that the magnetic response of the localized spins in the C_{60}-Co compound is an important factor in its giant TMR effect.

Fig.6-2(a) is a typical XAS spectrum of the C_{60}-Co compound in the C_{60}-Co films. Several multiplet structures (red curves) can be distinguished in the absorption spectrum. These structures are attributed to the different electronic states of the Co atoms due to their bonding in the C_{60}-Co compound. Moreover, a clear MCD signal (green curve) which indicates the presence of the spin-polarization can be distinguished clearly in the C_{60}-Co compound (Fig.6-2(b)). The observed MCD signal can be assigned to two major peak positions in the XAS spectrum of Fig.6-2(a). This indicates the presence of the spin-polarized states of electrons localized in the C_{60}-Co compound.

Fig.6-3 shows the temperature-dependence of the magnetoresistance ratio (MR_0) measured in the C_{60}-Co films, together with magnetoresistance ratio calculated with the theoretical model of the TMR effect (MR_{calc}). In the present study, we assumed that the localized spins in the C_{60}-Co compound affect the spin states of the electrons tunneling in the C_{60}-Co films so that their spin-polarizations (P) are enhanced to nearly P = 100%, in other words, completely spin-polarized states. It was found that in this case, the temperature-dependence of MR_{calc} agrees well with that of MR_0. This suggests the direct influence of the localized spins in the C_{60}-Co compound on the observed giant TMR effect.

Reference

Matsumoto, Y. et al., X-ray Absorption Spectroscopy and Magnetic Circular Dichroism in Codeposited C_{60}-Co Films with Giant Tunnel Magnetoresistance, Chemical Physics Letters, vol.470, issues 4-6, 2009, p.244-248.