GA03

Colossal Anisotropic Magnetoresistance in Pseudo-cubic Manganite Single Crystals

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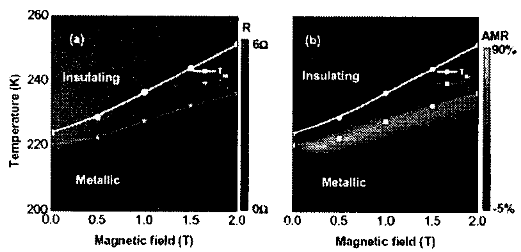
Anisotropic magnetoresistance (*AMR*) is one of the fundamental effects of magnetic materials, where the electrical resistance depends on the angle between the current and magnetization direction. *AMR* is very important not only for the fundamental research, i.e. the spin-orbital coupling and magnetocrystalline anisotropy, but also for practical applications such as magnetic read heads and sensors. The conventional *AMR* found in ferromagnetic metals or alloys, which have been used extensively in magnetic read heads and recording devices, is small, i.e. 1-2% in Ni-Fe films, and decreases monotonously with increasing the temperature and saturates under a high magnetic field. In pseudo-cubic perovskite manganite single crystals, which are well known due do the discovery of colossal magnetoresistive effect thereof[1,2], we observed colossal *AMR* effects though the magnetocrystalline anisotropy is very weak. The extraordinary *AMR* shows a very large value, for example in $La_{0.69}Ca_{0.31}MnO_3$ single crystals, an *AMR* over ~90% ($AMR = \frac{R(0)-R(90)}{R(0)} \times 100\%$, where *R(0)* and *R(90)* represent the resistivity with a magnetic field parallel and perpendicular to the a-axis, respectively.) at 220K under a magnetic field of 0.2T was achieved, which is around two orders of magnitude larger than that of conventional ferromagnetic materials. Furthermore, the colossal *AMR* indicates a nonmonotonic magnetic field and temperature dependences. The extraordinary *AMR* effect is probably a unique, however, universal feature of double-exchange systems.



$La_{0.69}Ca_{0.31}MnO_3$

Fig. 1. phase diagram of resistance and AMR in the magnetic field and temperature plane

From the viewpoint of application, the extraordinary large *AMR* near room temperature under a low magnetic field is of potential application for magnetic sensors and read heads. More details on experimental and theoretical results will be presented in this talk.

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GA04

Magnetic Inhomogeneities in Crystalline Bulk and Nanometer Sized $La_{0.7}Ca_{0.3}MnO_3$: Electron Spin Resonance Study

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One of the central problems in physics of mixed-valence manganites is the extent to which unavoidable structural imperfections are crucial for electron/magnetic phase separation and phase coexistence in these materials. To address this question, we studied Electron Spin Resonance (ESR) in single crystal and ceramic (both of bulk origin), as well as in nanometer-sized samples of $La_{0.7}Ca_{0.3}MnO_3$ (LCMO) manganites, having the *same* Ca content, but a different degree of structural imperfections due to strongly different methods of its synthesis.

The powder of LCMO nano-crystals with the average size of 15 ± 2 nm was prepared by sonication assisted coprecipitation. The ceramic and single-crystalline LCMO samples were sintered/grown by the conventional solid state reaction and by floating zone with radiative heating methods, respectively. The crystallinity and single-phase nature of all samples were checked by room temperature x-ray diffraction, the Curie points (T_C) were determined using low field magnetic measurements. ESR spectra were recorded with Bruker EMX-220 (ν = 9.4 GHz) spectrometer in the temperature range 120 (± 0.5) K ≤ T ≤ 600 (± 0.5) K on loose packed crushed bulk and on as fabricated nanometer sized LCMO samples.

It was found that in the bulk specimens the coexistence of ferromagnetic and paramagnetic phases (coexistence of two ESR signals) occurs in about 70 K and 10 K width temperature intervals in the vicinity of the T_C for ceramic and single crystal, respectively. In a marked contrast, nanometer sized crystalline powder demonstrates a single resonance line (single magnetic phase) within the whole temperature interval 120 - 600 K. It appearsthat the bulk samples, independently on its origin (single- or polycrystalline ones), are less magnetically homogeneous than nanometer-sized powder. Except of higher homogeneity, nanometer-sized $La_{0.7}Ca_{0.3}MnO_3$ is characterized by a weaker magnetic anisotropy. The results obtained are discussed in a frame of different synthesis conditions. E.g., the temperatures of synthesis, being of 700 C, 1300 C and 1600 C for nano-crystals, ceramic and single crystal of LCMO, respectively, may lead to strongly different levels of structural imperfections. This level is high enough for bulk samples, while the nanometer-sized counterpart seems to be practically free from bulk-like imperfections. Note that the results obtained agree pretty well with those reported previously for $La-Sr-MnO_3$ nano-sized and bulk samples [1]. This, in turn, may mean that high quality crystalline structure and high magnetic homogeneity are generic properties of nanometer-sized doped manganites prepared by sonication assisted coprecipitation.

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