11A, 13C/2001G005

Surface magnetic domain of $La_{2-2x}Mn_{1+2x}SrO_7$ (x=0.3) observed by low temperature photoemission microscopy (LT-PEEM)

T. Okuda[1]*, T. Wakita[1], A. Harasawa[1], T. Kinoshita[1], F.U. Hillebrecht[2], T. Kimura[3] and Y. Tokura[3]
[1] Institute for Solid State Physics, University of Tokyo, Tokyo, Japan.
[2] Institut für Festkörperphysik, FZ Karlsruhe, P.O. Box 3640, 76021 Karlsruhe, Germany.
[3] Department of Applied Physics, University of Tokyo, Tokyo 113, Japan.

Introduction

Transition metal oxides are presently at the focus of widespread research activities. Among them Mn containing perovskite materials show a very large magneto resistance[1], which makes them attractive for device applications based on spin dependent carrier transport. The record for the magneto resistance was probably observed for Mn double perovskites $La_{2-2x}Sr_{1+2x}Mn_2O_7$ with x=0.3 (LSMO). The magnetic properties of the LSMO with x=0.3 are also very interesting[2]. At low temperatures, ferromagnetic regions are immersed in an antiferromagnetic (AF) surrounding and the ferromagnetic regions appear with the shape of bubble domains[3]. The magnetic moments are thought to be parallel to the *c*-axis both for the ferro- and antiferromagnetic portions of the sample. With increasing temperature, fraction of ferromagnetic domains increases, while the magnetization rotates towards the *ab*-plane. At higher temperature, an in-plane ferromagnetic phase is realized, in which the local magnetization lies in the *ab*-plane, however with random orientation within the domains. This magnetic behaviour was deduced from Kerr microscopy[4,5] and magnetic force microscopy(MFM)[2]. In this study, we have investigated the magnetic domain structure of LSMO (x=0.3) by photoemission microscopy, using magnetic dichroism. With this method, we can observe both ferro- and anti-ferromagnetic domains with different orientations of the AF vectors[6] by use of magnetic circular dichroism and magnetic linear dichroism, respectively.

Experimental

The experiments were carried out at the BL11A for MCD and BL13C for MLD. The observations were performed in the photoemission microscopy apparatus which is equipped with a comprehensive sample preparation facility, housed in a special UHV chamber. An attractive feature of the apparatus is that it allows to perform microscopy also at temperatures reaching down to 50 K. The used LSMO sample was cleaved in the UHV chamber.

Results and discussion

Fig. 1(a) shows images of the LSMO surface obtained with circularly polarized light at room temperature which was acquired with the photon energy tuned to the Mn 2p 3/2 and 2p 1/2 edges. To reveal magnetic contrast, each pixel shows the ratio of intensities obtained with the two photon energies. A contrast can be recognized which suggests the presence of ferromagnetic domains. The contrast disappears when the sample is cooled to 100 K as shown in Fig. 1(b). This is consistent with the phase diagram described above, since at this temperature the material is in the out-of-plane ferromagnetic state, so that the projection of the magnetic moments of the light polarization is very small, and the contrast becomes very weak. When the temperature is raised to 340 K, the contrast decreases, indicating a transition to a paramagnetic state near to this temperature. The apparent observation of magnetic contrast at room temperature, suggests a significant deviation of the surface magnetic properties from those of the bulk. Additional experiments will be carried out in order to better characterize the surface behavior, and to identify the antiferromagnetic phase in the low temperature regime in future.

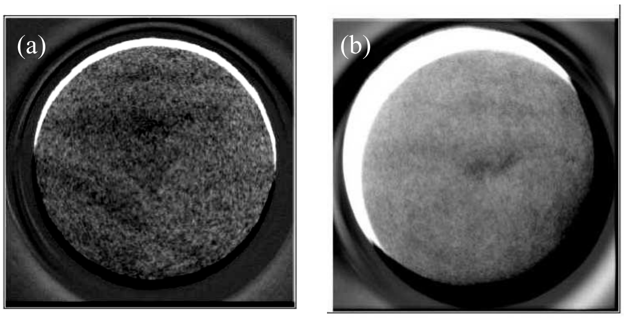

Fig. 1 (a) PEEM image of doped LSMO taken at the Mn 2p edge with circularly polarized light at R.T.. The images show the ratio of intensities taken at the 2p 3/2 and 2p 1/2 edges. The field of view is about 80 µm. (b) the same as (a) but at 100 K.

References

[1]T. Kimura, Y. Tomioka, A. Asamitsu *et al.* , Science **274**, 1698 (1997).
[2]T. Fukumura, H. Sugawara, T. Hasegawa *et al.*, Science **284**, 1969 (1999).
[3]T. Fukumura, T. Hasegawa, H. Sugawara et al., Appl. Phys. Lett. **78**, 2023 (2001).
[4]U. Welp, A. Berger, D.J. Miller *et al.*, Phys. Rev. Lett. **83**, 4180 (1999).
[5]U. Welp, A. Berger, V.K. Vlasko-Vlasov *et al.*, Phys. Rev. B **62**, 8615 (2000).
[6]F.U. Hillebrecht, H. Ohldag, N. Weber *et al.*, Phys. Rev. Lett. **86**, 3419 (2001).
[7]T. Kinoshita, J. Electron Spec. Relat. Phenom. **124**, 175 (2002).

*okudat@issp.u-tokyo.ac.jp