

**PR10.05.26 THE SUPERCONDUCTING STRUCTURE FRAGMENTS WITH  $T_C$  180K.** G.M. Kuz'micheva, S.I. Mukhina, Academy of Fine, Chemical Technology, Moscow, Russia; A.V. Mitin, Institute for Physical Problems, RAS, Moscow, Russia; E.P. Khlybov, Institute for High Pressure, Physics RAS, Troitzk, Russia

The study of the temperature variation of the electrical resistivity and the current-voltage characteristics of phases in the La-Sr-Ti-O, Ln-Sr-Nb-O, La-Mn-O, Ba-Sr-Pb-O, La-Pb-Re-O, Mg-Ti-O systems suggests that some compositions contain superconducting inclusions. The structure of superconducting inclusions (structure fragments) is coherently connected with structure of the non-superconducting phase and has different composition from one. A similar phenomena was observed in samples of the well-known system  $YBa_2Cu_3O_{6+x}$  when increased from 0.2 to 0.5. The phases of compositions  $(Ln,Sr)_xNbO_{3-x}$ ,  $(La,Sr)_xTiO_{3-x}$ ,  $(La,Pb)_xReO_{3-x}$ , which belong to cubic bronzes of perovskite structure, contain superconducting structure fragments with  $T_C$  160 K,  $T_C$  50K and  $T_C$  60K, respectively. The phases  $(Ba,Sr)PbO_3$  (perovskite structure) with  $T_C$  70K and  $Mg(Mg,Ti)_2O_4$  (spinel structure) with  $T_C$  130K have the cubic symmetry. There are indications of the possible presence of superconducting fragments with  $T_C$  180K in the phase  $LaMnO_{3+x}$  with rhomboedral perovskite structure. The dependence of the critical temperatures of the phases,  $T_C$ , and inclusions,  $T_C$ , on formal charge of Ti, Nb, Pb, Re, Mn, Bi, Cu cations is found.

## Materials VI

### Giant Magnetoresistive Materials

**MS10.06.01 STRUCTURAL "TUNING" OF MAGNETISM IN  $A_{1-x}A'_xMnO_3$  ( $A = La, Pr$ ;  $A' = Ca, Sr, Ba$ ).** P.G. Radaelli<sup>a</sup>, D.E. Cox<sup>b</sup>, M. Marezio<sup>c,d</sup>, S.-W. Cheong<sup>d</sup>, P. E. Schiffer<sup>d</sup>, A.P. Ramirez<sup>e</sup>, D.N. Agryiou<sup>e</sup> and J.D. Jorgensen<sup>e</sup>, <sup>a</sup>Institut Max Von Laue-Paul Langevin, BP156, 38042 Grenoble Cedex FRANCE, <sup>b</sup>Physics Dept., Brookhaven National Lab, Upton, NY, <sup>c</sup>Lab de Cristallographie, CNRS/UJF, BP166, 38042 Grenoble Cedex FRANCE, <sup>d</sup>AT&T Bell Labs, Murray Hill, NJ, <sup>e</sup>Materials Science Div., Argonne National Lab, Argonne, IL 60439

Manganese oxide perovskites with general formula  $A_{1-x}A'_xMnO_3$  ( $A = La, Pr, Y, \dots$ ;  $A' = Ca, Sr, Ba, \dots$ ) have been the subject of renewed interest, due to the giant magnetoresistance (GMR) exhibited near the ferromagnetic (FM) spin ordering temperature  $T_C$ . In fact, for values of the electronic doping  $x \sim 0.30$ , the high-temperature paramagnetic state is electrically insulating, whereas the low-temperature FM state is metallic. The Curie temperature can be raised upon application of an external magnetic field, thereby producing the GMR effect. At higher doping levels ( $x > 0.50$ ) the system is antiferromagnetic at low temperatures, and, in a narrow region of composition around  $x=0.50$ , both types of magnetic order occur. The presence of structural anomalies associated with the magnetic transitions in  $A_{1-x}A'_xMnO_3$  ( $x=0.25$ ,  $x=0.30$  and  $x=0.50$ ) has been evidenced by high-resolution synchrotron x-ray and neutron powder diffraction. In all cases, the lattice parameter anomalies are associated with a significant rearrangement of the Mn-O bond lengths, so that the  $MnO_6$  octahedra are Jahn-Teller-distorted in the insulating state, and almost undistorted in the metallic state. These results provide strong experimental evidence for the importance of static/dynamic Jahn-Teller distortions as a charge carrier localization mechanism. Very recently, it has been shown that, at a constant value of the electronic doping level  $x$ , the Curie temperature can be "tuned" by changing the average radius  $\langle r_A \rangle$  of the A-site ion or by applying external pressure ( $dT_C/dP$  is always *positive*, although its value changes significantly as a function of  $\langle r_A \rangle$ ). To study this effect, the structural phase diagram of the  $A_{0.7}A'_{0.3}MnO_3$  system ( $A = La, Pr$ ;  $A' = Ca, Sr, Ba$ ) was determined by neutron powder diffraction as a function of temperature, pressure and  $\langle r_A \rangle$ .

In addition to confirming that the overall increase of  $T_C$  as a function of  $\langle r_A \rangle$  is associated with a reduction of the structural distortion from the cubic symmetry, this study has evidenced the extreme sensitivity of  $T_C$  to the average Mn-O distance. In fact, as a function of  $\langle r_A \rangle$ ,  $\langle Mn-O \rangle$  has a *minimum* that coincides with the *maximum* of the Curie temperature. Furthermore, the structure responds to external pressure by a compression of the Mn-O bond lengths, while the Mn-O-Mn bond angles are only slightly pressure-dependent.

**MS10.06.02 MAGNETOSTRUCTURAL PHASE TRANSITIONS IN  $La_{1-x}Sr_xMnO_3$  WITH CONTROLLED CARRIER DENSITY.** Atsushi Asamitsu<sup>1</sup> and Yoshinori Tokura<sup>1,2</sup> <sup>1</sup>Joint Research Center for Atom Technology, Tsukuba 305, Japan <sup>2</sup>University of Tokyo, Tokyo 113, Japan

Magnetic field-induced structural phase transitions as well as thermally induced ones between the orthorhombic (O) and rhombohedral (R) structures have been investigated for perovskite-type manganese oxides,  $La_{1-x}Sr_xMnO_3$ , with finely controlled carrier density ( $x=0.160, 0.170$  and  $0.180$ ). In  $x=0.170$  crystal, the composition of which is tuned so that the structural transition temperature  $T_S$  ( $\approx 285K$ ) is located close to the ferromagnetic transition temperature  $T_C$  ( $\approx 264K$ ). As a result, novel magnetostructural effects have been observed: the  $T_S$  is lowered by more than 50K with application of an external magnetic field of 7T. We determined the structural phase diagram in the field-temperature plane from measurements of the lattice striction. Utilizing the structural phase diagram, we can switch the crystal structure, reversibly or irreversibly, between the O- and R-phases by applying magnetic field at a fixed temperature. Such a large magnetostructural effect arises from the mutual coupling among the transfer interaction of doped  $e_g$  carriers, the local spin moment of  $t_{2g}$  electrons, and the lattice distortion. In the case of  $La_{1-x}Sr_xMnO_3$  crystal, the transfer interaction of  $e_g$  carriers that is responsible for the ferromagnetic double-exchange interaction and hence the induced magnetization  $M$  is larger in the R-phase than in the O-phase in a magnetic field. Therefore the gain of the free energy by Zeeman term,  $-M \cdot H$ , can drive the field-induced structural transition from the O- to R-phase. Thermodynamical aspects of these phenomena are understood semi-quantitatively in terms of the Landau free energy with coupled order parameters, the magnetization  $M$  and the lattice distortion  $Q$ .

In  $x=0.160$  or  $0.180$ , on the other hand, the  $T_S$ 's are not changed conspicuously up to 7T, since their  $T_S$  and  $T_C$  differ considerably, either  $T_S \gg T_C$  or  $T_S \ll T_C$ , and hence the effective coupling between  $M$  and  $Q$  is reduced.