Influence of annealing temperature on structural and magnetic properties of $LaMnO_3$ nanoparticles

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It is known that stoichiometric $LaMnO_3$ is an A-type antiferromagnet with the Néel temperature T_N = 135~140 K. Recently, the thin films and nanoparticles based this material have attracted intensive interest because its magnetic and electrical properties can be controlled in a large temperature range from 60 to 300 K upon tuning the deficiency or excess of oxygen in non-stoichiometric compounds of $LaMnO_{3\pm\delta}$, leading the mixed valence of Mn^{2+}, Mn^{3+} and/or Mn^{4+} ions. Particularly, with non-stoichiometric compounds, one can easily fabricate transparent ferromagnetic conducting thin films. To get more insight into this problem, we fabricated $LaMnO_3$ nanoparticles (NPs), and then studied the influence of annealing temperature on structural and magnetic properties of NPs. Here, $LaMnO_3$ NPs were synthesized from precursors of lanthanum (III) acetate sesquihydrate, and manganese (II) acetate tetrahydrate by using a sol-gel method. As-prepared NPs were then annealed at different temperatures (T_{an}) of 600-1550 ^oC for 4 h in air. Crystal-structural analyses based on X-ray diffraction patterns revealed the samples crystallized in a rhombohedral structure, with the ratio of the lattice parameters c/a varying from ~2.3 for T_{an} = 600 ^oC to 2.6 for T_{an} = 1550 ^oC. By changing T_{an}, we fabricated $LaMnO_3$ particles with average sizes of 16-3000 nm, which were estimated by using the Scherrer equation and scanning electron microscope. Magnetization measurements indicated their ferromagnetic-paramagnetic phase transition temperature (T_C) can be tuned in the range between 43 and 260 K. At 15 K, the saturation magnetization (M_s) and coercivity (H_c) values are tunable in the ranges of 4~84 emu/g and 25~1300 Oe, respectively. We think that these changes in magnetism of NPs versus T_{an} are due to the changes in the concentration of Mn^{3+} and Mn^{4+} ions, lattice parameters, local geometrical structures, and grain sizes.