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Effect of Dy doping on the properties of La-Ca-Mn-O ceramics

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The influences of Dy doping in La site of $(La_{1-x}Dy_x)_{7/8}Ca_{1/8}MnO_3$, $(La_{1-x}Dy_x)_{2/3}Ca_{1/3}MnO_3$ and $(La_{1-x}Dy_x)_{1/2}Ca_{1/2}MnO_3$ systems have been studied. The doping concentration were varied in a full range from x=0.00 to x=1.00 for each system. XRD data show that the samples of each system are in orthorhombic distorted perovskite structures, which resulted from the JT distortion. This lattice distortion weakens the DE coupling among the Mn ions and breaks the path of the electron hopping. From the susceptibility measurement as a function of $(La\text{-}Dy)_{7/8}Ca_{1/8}MnO_3$ compound undergoes the typical transition from the paramagnetic to ferromagnetic insulator. The second transition is to an antiferromagnetic phase with a possible charge-ordering process. For the $(La\text{-}Dy)_{2/3}Ca_{1/3}MnO_3$ system, all samples with Dy content show a clear deviation from the well behaved ferromagnetic behaviour seen for the undoped sample. The $(La\text{-}Dy)_{1/2}Ca_{1/2}MnO_3$ system shows both ferromagnetic and antiferromagnetic. The presence of Dy in the system, disturbed the antiferromagnetic and another phase appears at a much lower temperature. From the resistance measurement, all the samples of three systems exhibit maximum resistance at T_P which indicate the transition from metallic-like behaviour to insulator behaviour upon warming the samples to room temperature. The semiconductor model $\ln(R) \alpha (-E_a/k_BT)$ was used to explain the transport mechanism of the perovskite manganites above T_P. The values of activation energy are in the order of 0.2 eV or lower for all samples of $(La\text{-}Dy)_{7/8}Ca_{1/8}MnO_3$, $(La\text{-}Dy)_{2/3}Ca_{1/3}MnO_3$ and $(La\text{-}Dy)_{1/2}Ca_{1/2}MnO_3$ systems, indicating that these samples exhibit narrow band-gap semiconducting compounds. Phase diagram deduced from T_C and T_P correlate a close interplay between magnetism and transport properties, via a DE mechanism of Mn^{3+}-O-Mn^{4+}. However, the substitution of Dy in these three systems favour the DE interaction up to x=0.3. Beyond this composition, T_C and T_P deviates indicating the decrease in the long-range ferromagnetism and metallic conductivity. By totally replacing La with Dy in the systems, CMR values was also observed at temperature approaching their T_P. This observation requires further investigation.