

UNIVERSITI TEKNOLOGI MARA

EFFECT OF Cr^{3+} SUBSTITUTION IN
 $\text{Bi}_0.3\text{Pr}_0.3\text{Ca}_0.4\text{Mn}_x\text{Cr}^0.3$
AND
 La^{3+} SUBSTITUTION IN
 $\text{Bi}_0.3-x\text{La}_x\text{Pr}_0.3\text{Ca}_0.4\text{Mn}_0.9\text{Cr}_0.1\text{O}_3$
ON ELECTRICAL AND MAGNETIC
PROPERTIES OF BISMUTH-BASED
MANGANITE

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ABSTRACT

Sample of $\text{Bi}_{0.3}\text{Pr}_{0.3}\text{Ca}_{0.4}\text{Mn}_{1-x}\text{Cr}_x\text{O}_3$ ($0 < x < 0.14$) and $\text{Bi}_{0.3-x}\text{La}_x\text{Pr}_{0.3}\text{Ca}_{0.4}\text{Mn}_{0.9}\text{Cr}_{0.1}\text{O}_3$ ($0 < x < 0.2$) were prepared by solid-state synthesis method to elucidate the structural, magnetic properties and electrical transport in bismuth based-manganite. For $\text{Bi}_{0.3}\text{Pr}_{0.3}\text{Ca}_{0.4}\text{Mn}_{1-x}\text{Cr}_x\text{O}_3$, R versus T curve shows that $x=0$ sample exhibited a strong insulating behaviour, and Cr^{3+} substitution at $x=0.08$ induced metal-insulator (MI) transition at MI temperature (T_{MI}) of 56 K. For $x=0.08$ sample can successfully weaken the hybridisation effect through the strong ferromagnetic (FM) interaction. Further substitution of Cr^{3+} for $x=0.1$ increased the T_{MI} to 58 K but decreased to 36 K for $x=0.12$. Susceptibility versus temperature measurements presented an increase in FM-paramagnetic transition from 66 K ($x=0.04$) to 125 K ($x=0.14$) which suggested that Cr^{3+} substitution enhanced the growth of FM phase. Fitting of the experimental data in the metallic region to scattering models suggested that scattering involving a combination of electron-electron, electron-magnon, Kondo-like spin-dependent scattering and electron-phonon interactions are responsible for the observed resistivity behaviour. Fitting in the insulating region indicated that resistivity behaviour followed the variable-range hopping (VRH) model below the charged ordered temperature for ($x=0$) and $T_{MI} < T < T_{OD}/2$ for $x=0.04-0.14$. High temperatures involved small polaron hopping mechanism (SPH). Therefore, the enhanced double exchange mechanism increased the delocalisation of charge carrier and destabilisation of the charged ordering-AFM state. Besides that, R versus T curve of the $\text{Bi}_{0.3-x}\text{La}_x\text{Pr}_{0.3}\text{Ca}_{0.4}\text{Mn}_{0.9}\text{Cr}_{0.1}\text{O}_3$ ($0 < x < 0.2$) samples in zero field showed the same trend in increasing of MI transition from 58 K ($x=0$) to 88 K ($x=0.2$). The increase in both T_c and T_{MI} indicates the enhancement of double exchange interaction involving Mn^{3+} and Mn^{4+} as a result of weakened of hybridization effect between Bi^{3+} $6s^2$ lone pair with O orbital due to La^{3+} substitution. Magnetic susceptibility versus temperature measurements showed all samples exhibits ferromagnetic to paramagnetic transition with Curie temperature, T_c . Fitting of the experimental resistivity data below T_{MI} ($T < T_{MI}$) in the metallic region to scattering models suggested the observed resistivity behaviour of all samples are due to combined effect of electron-electron, electron-magnon, Kondo-like-spin-dependent scattering and electron-phonon interaction. Fitting in the insulating region above T_{MI} ($T > T_{MI}$) suggested that resistivity behaviour obeys two different model which are VRH model and SPH model. La substitution in the weak-hybridization Bi-based compound is suggested reduced some types of blocking mechanism effect which may related to reduction of MnO₆ octahedral distortion hence increase the movement of charge carrier.

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