

UNIVERSITI TEKNOLOGI MARA

**EFFECTS OF Li^+ AND Bi^{3+}
SUBSTITUTION ON STRUCTURAL,
MAGNETIC PROPERTIES
AND
ELECTRORESISTANCE
BEHAVIOURS OF $\text{La}_{0.8}\text{Na}_{0.2}\text{MnO}_3$
MANGANITES**

NUR AMIRAH BINTI ZAHRIN

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ABSTRACT

Recent studies in manganites suggested that the changes in resistivity upon the application of higher current, known as the electroresistance (ER) effect is highly influenced by the lattice distortion and the presence of inhomogeneities. However, such effects are not fully understood and require further investigation. Hence, both effects which can be induced by A-site disorder (σ^2) and hybridization effect is further investigated in $\text{La}_{0.8}\text{Na}_{0.2-x}\text{Li}_x\text{Na}_{0.2}\text{MnO}_3$ ($x = 0 - 0.15$) and $\text{La}_{0.8-x}\text{Bi}_x\text{Na}_{0.2}\text{MnO}_3$ ($x = 0 - 0.20$) manganites, respectively which was prepared via solid-state method and the structural, magnetic properties and the ER behaviour is determined. For Li-substituted series, the ρ vs T curve revealed that all samples exhibited a metal-insulator transition behavior and the metal-insulator transition temperature, T_{MI} decreased from 270 K ($x=0$) to 255 K ($x=0.15$) with the increase of σ^2 from $2.074 \times 10^{-4} \text{ \AA}^2$ ($x=0$) to $1.107 \times 10^{-2} \text{ \AA}^2$ ($x=0.15$). Both samples of $x=0.10$ and $x=0.15$ exhibited ferromagnetic – paramagnetic transition behaviour and a decrease of Curie temperature, T_C . The observed behaviour indicates that increasing σ^2 weakened the double-exchange (DE) interaction between Mn ions which may be related to the enhancement of MnO_6 distortion and magnetic disordering. All samples exhibited a reduction in resistivity in the temperature range of 30 K – 300 K under a higher applied current of 5 mA compared to 1 mA, thereby showing ER effects. The ER (%) values at 300 K showed an increasing trend from -34% ($x = 0$) to -59% ($x = 0.15$) The observed large ER effect for the $x=0.15$ sample implies that an increase of σ^2 favours larger magnetic inhomogeneities and contributes to the formation of more conducting filaments (CF) with higher applied current. In addition, the existence of Griffiths Phase (GP) due to the additional FM clusters above T_C in the PM region may also facilitate CF growth, which connects the boundaries of these FM clusters and forms additional conduction paths across the insulating region with stronger current. On the other hand, substitution of Bi^{3+} in $\text{La}_{0.8-x}\text{Bi}_x\text{Na}_{0.2}\text{MnO}_3$ ($x = 0 - 0.20$) series increased the Mn-O bond length and unit cell volume, as well as reducing the Mn–O–Mn bond angle. Additionally, Bi^{3+} substitution also displayed a similar trend of reduction in T_C and T_{MI} . This behaviour is suggested due to the suppression of DE interaction resulting from a stronger hybridization effect between Bi 6s and O-2p orbitals with further Bi^{3+} substitution. All samples exhibited ER effect when a higher current of 5 mA was applied. The reduction of resistivity below T_{MI} was due to the enhancement of DE itinerant hopping and the decrease in the scattering effect of conduction electrons. Meanwhile, a large current above T_{MI} leads to the weakening of the electron–lattice attraction, as indicated by the reduction in activation energy (E_a) of charge carriers. Both $x = 0.15$ and $x = 0.20$ samples respectively exhibited large ER effects of -61% and -64% at 300 K. The enhancement of ER with Bi substitution is attributed to the presence of magnetic inhomogeneities induced by MnO_6 distortion which favours the formation of CF. A large value of ER effect observed in $x = 0.15$ sample is suggested due to the GP formation, whereas for sample $x = 0.20$, the large ER effect may be dominantly contributed by the weakening of electron–lattice attraction under higher current. The enhancement of ER effect in both Li- and Bi-substituted sample at $x = 0.15$ is attributed to the presence of GP which indicates the significance of GP phase as an important contributor factor for the improvement of ER effect. The large ER (%) observed for both Li- and Bi-substituted samples are found to be interesting for spintronics application at room temperature.

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