UNIVERSITI TEKNOLOGI MARA

EFFECT OF Fe AND Cr SUBSTITUTION AT Mn-SITE ON STRUCTURE, MAGNETIC, MAGNETOTESISTANCE BEHAVIOUR AND DIELECTRIC PROPERTIES IN Pr-BASED MANGANITES

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ABSTRACT

The substitution of Fe or Cr at the Mn site was suggested to directly impact the interaction between Mn ions in manganites and have different effects on the compound properties which required detailed investigations. Thus, $Pr_{0.75}Na_{0.05}K_{0.20}Mn_{1-x}Fe_xO_3$ and $Pr_{0.75}Na_{0.05}K_{0.20}Mn_{1-x}Cr_xO_3$ (x =0.00-0.05) manganites were prepared using solid-state synthesis to elucidate their structural, magnetic, electrical, and dielectric properties as well as magnetoresistance (MR) effect. For $Pr_{0.75}Na_{0.05}K_{0.20}Mn_{1-x}Fe_xO_3$ series, all samples (x = 0-0.05) exhibited ferromagnetic (FM)-paramagnetic (PM) transition behaviour and a decrease of Curie temperature (T_C). The reduction in T_C indicates the weakening of the FM interaction involving Mn^{3+} and Mn^{4+} ions as Fe^{3+} replaces Mn^{3+} site. The observed large increased in resistivity with Fe substitution with the decreased in the metal-insulator transition temperature (T_{MI}) from 122 K (x = 0) to 80 K (x = 0.02). Under a 0.8 T applied field, all samples showed a decrease in resistivity between 30 K - 300 K, indicating the presence of MR effects. The intrinsic MR effect increase from 22% (x = 0.0) to 40% (x = 0.02) near T_{MI} indicates Fe^{3+} substitution enhanced intrinsic MR effect, which may be related to the reduction of spin disordering. The extrinsic MR effect increased to 42% (x = 0.04), due to enhancement of the spin polarised tunnelling process. While for $Pr_{0.75}Na_{0.05}K_{0.20}Mn_{1-x}Cr_xO_3$ series, Cr^{3+} substitution increased the unit cell volume and distorted the MnO_6 octahedra. The T_C value slightly decreased from 140.7 K (x = 0.00) to 139.3 K (x = 0.02) and increased with higher concentration of Cr^{3+} to 143.4 K (x = 0.05). The observed large increased in resistivity with Cr^{3+} substitution and the decrease in T_{MI} from 122 K (x = 0) to 90 K (x = 0.05) samples. The observed absence of GP in all Fe and Cr-substituted samples, on the other hand, may be related to variations in magnetic interaction in the studied compounds. The dielectric constant, dielectric loss, and tangent loss all drop with frequency, owing to the dominant contributions of Maxwell-Wagner interfacial polarisation and grain boundary resistance. The observed change in the metal-insulator transition temperature and resistivity due to Fe and Cr substitution, implies a potential approach for precisely enhancing the electrical characteristics of these materials, which is essential in spintronic applications. Thus, Fe and Cr substitutions at Mn-sites in $Pr_{0.75}Na_{0.05}K_{0.20}MnO_3$ play an important role in structure, magnetic, electrical, magnetoresistance behaviour and dielectric properties but not in GP.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Manganite materials have recently emerged as one of the most intriguing research topics due to their physical properties and colossal magnetoresistance (CMR) [1]–[3]. Furthermore, manganite have unique properties which can be considered for a new class of electronic devices based on the MR effect [4] which predicted an increase in wide applications area such in consumer, automotive, medical, industrial, and other applications [5]. With the rapid development of electronic devices towards integration and miniaturisation, the feature sizes of microelectronic devices based on rare-earth-doped perovskite manganite are now down-scaled to nanoscale dimensions [6]. Based on the need and demand from society for effective technologies and communication , more research should be focused on next generation nanoelectronics devices [7]. A wide range of study has been conducted, focusing on various methods and chemicals [8] for improving the magnetic, electrical, and dielectric properties of these compounds, which may be potential candidates for industrial applications such as spintronic-based devices [1], [2], [9], magnetic sensors [1], non-volatile memory elements [9], and supercapacitor electrodes [8]. Furthermore, manganite exhibit tuneable electrical and magnetic properties that are switchable in an external applied field, implying a wide range of applications. In addition to the stated above properties, some manganite have high dielectric permittivity values, which improve their multiferroic properties and industrial applications due to spontaneous polarisation [10]. Belmabrouk et al. reported that the substitution of Mn by a transition metal such as Aluminium (Al) caused structural disorder, which was responsible for high dielectric properties of material, making the study sample a potential candidate for a wide range of applications such as microelectronic devices, energy industry applications, multilayer ceramic capacitors, and high density energy storage [8].