جـــامعة الفـــيوم
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Degree: Ph.D. in Science (Experimental Solid State Physics)

Title of Thesis: Fundamental Studies on Li-Ion Batteries

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ABSTRACT

Lithium-ion batteries (LIBs) are regarded as reliable energy storage technology for portable electronic technologies. The disordered rocksalt Li-excess cathode materials are considered promising materials for their significant properties. Despite most studies are directed to the electrochemistry of Li-ion batteries electrode materials, adequately few fundamental studies were presented.

The thesis contains four chapters: chapter one, a survey of Li-ion batteries with a review of the literature about its components, electrolytes, anode, and cathode materials were presented. In addition, the disordered rocksalt Li-excess (DRX) transition metal (TM) oxide cathode materials were discussed. The fundamental and theoretical background of optical, magnetic, thermodynamic, and dielectric properties were presented. Chapter two presents the experimental techniques of the synthesis and characterization procedures of $Li_{1.3}Nb_{0.3}Mn_{0.4}O_2$ (LNMO) and $Li_{1.3}Nb_{0.3}Fe_{0.4}O_2$ (LNFO) in detail.

Chapter three presents the results of fundamental properties investigation for the synthesized LNMO and LNFO cathode materials and a discussion of these output results. Chapter four presents the outcome results.

Since the electrochemical properties of the disordered rocksalt Li-excess (DRX) $Li_{1.3}Nb_{0.3}Me_{0.4}O_2$ (*Me* = Mn, Fe), LNMO, and LNFO only published, this work throw light on the fundamental properties such as structural, optical, magnetic, thermodynamic, and dielectric properties. Both LNMO and LNFO were prepared by using the molten-salt method. The characterization of the as-prepared samples was performed by different techniques: Powder X-ray Diffraction (XRD), Field-Emission Scanning Electron Microscope (FE-SEM), and Fourier Transform Infrared (FTIR) spectroscopy.

The transient absorption spectroscopy (TAS) used the ultra-fast laser to study the dynamics of charge carriers and electron-phonon coupling in LNMO and LNFO systems. Magnetic DC and AC susceptibility as well as the magnetization as a function of the applied magnetic field revealed the magnetic ordering at low temperatures that LNMO and LNFO have an antiferromagnetic (AFM) transition at Néel temperatures (T_N) of 6.5 K and 4.94 K, respectively, with the coexistence of other canted AFM or weak ferromagnetic (FM) phases as observed from the hysteresis loop. The specific heat measurements at the different applied magnetic fields are consistent with the observed magnetic behavior at low temperatures. The thermal stability of LNMO and LNFO is examined by thermogravimetry analysis (TGA) and differential scanning calorimetry (DSC).

The dielectric properties of LNMO and LNFO show high permittivity with losses in the low-frequency region. Furthermore, the electrical modulus, as well as the AC conductivity as a function of the frequency and temperature, were presented.

The summary not more than 500 words