Microstructural and Electrochemical Characterization of Nanosized Mn-Ni Oxide Thin Films for Supercapacitors

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In the class of materials of pseudocapacitive oxides for supercapacitors [1], manganese oxide has received great attention in recent years, because of its low cost, environmentally friendly nature, and high theoretical specific capacitance. Notoriously, however, the high resistance and low cycle life of this oxide have been repeatedly pointed out as a serious concern. Different strategies are being attempted to overcome these intrinsic limitations. In particular, doping or mixing with other transition metal oxides is a possible solution which has not yet been explored in much detail[2-4].

In the present study, Mn-Ni oxide thin films were deposited potentiodynamically on a stainless steel substrate. The effects of the deposition scan rate (50-800 mVs^{-1}), electrolyte Ni to Mn molar ratio and annealing on microstructure and capacitance behavior of Mn-Ni oxide thin films were investigated. The mixed oxide deposits were characterized by X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), field emission scanning electron microscopy (FESEM) and transmission electron microscope (TEM). The electrochemical behavior of the Mn-Ni oxide electrodes was studied by cyclic voltammetry (CV) at different scan rates (5- 100 mVs^{-1}), charge discharge at different specific currents (0.1-10 Ag^{-1}) and electrochemical impedance spectroscopy (EIS) in 1 M Na_2SO_4 electrolyte. Results showed that the specific capacitance increases with the increase in deposition scan rate of Mn-Ni oxide and reached 202 Fg^{-1} (measured at CV scan rate of 20 mVs^{-1}) at deposition scan rate of 600 mVs^{-1} and decreases at higher deposition scan rate. The specific capacitance increased with increasing the Ni to Mn molar ratio in solution (from 0 to 10), and correspondingly the Ni content in the oxide film up to a point. Precisely, the specific capacitance change goes through a maximum of 249 Fg^{-1} at approximately 12 at% Ni fraction and a specific current of of 0.1 Ag^{-1}. Further increasing the Ni content to about 19 at% causes the specific capacitance value to decrease. Finally, specific capacitance of 384 Fg^{-1} (Fig. 1) was obtained at a specific current of 0.1 Ag^{-1} for the annealed (200 ^{o}C, 6 hr) Mn-Ni oxide film deposited potentiodynamically (48 cycles, 600 mVs^{-1}, pH=6 and RT, mass load per unit area of 0.1 $mg.cm^{-2}$) from an electrolyte with Ni to Mn molar ratio of 2. As illustrated in Fig. 1, the decrease in the specific capacitance of electrode when subjected to specific current of 10 Ag^{-1} was 39% (233 Fg^{-1}), revealing a good rate capability of the Mn-Ni oxide thin film electrodes.

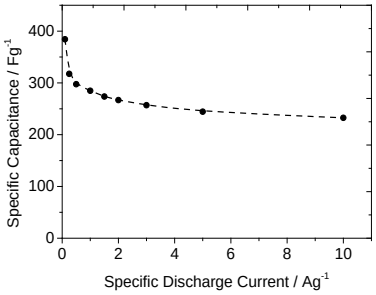

Figure 1: *Specific Capacitance vs. specific discharge current for annealed Mn-Ni oxide electrode with mass load per unit area of 0.1 $mgcm^{-2}$.*

References

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