Modification of Sol-Gel Manganese Oxide Films by Adding Active Carbon Powders for Supercapacitor Application

Yueh-Han Tien (田岳翰), Chin-Hua Cheng (鄭錦華), Chin-Yi Chen (陳錦毅), and Chung-Kwei Lin (林中魁)

Department of Materials Science and Engineering, Feng Chia University, Taichung, Taiwan

Manganese oxide electrodes with promising pseudo-capacitive behavior were successfully prepared by sol-gel process using manganese acetate as the precursor. Modification by adding active carbon powders into the sol-gel process was also attempted. Effects of post heat treatment and adding active carbon powders on material characteristics and electrochemical properties were investigated. After supercapacitance evaluation by cyclic voltammetry (CV) tests, significant improvements can be noticed by adding active carbon powders into the sol gel process. The active carbon-added manganese oxide electrodes heat treated at 350°C exhibited the best electrochemical performance.

Synchrotron X-ray absorption spectroscopy studies was used to evaluate further the electrochemical behavior of manganese oxide films before and after CV tests. As shown in Fig. 1, the main peaks of curves (a) and (b) are 6559.3 eV and 6560.6 eV, repectively, that indicated a slight increase in manganese valence after adding active carbon. After CV tests, curves (c) and (d) in Fig 1, not only the edge shifted to 6561.7 eV, but the peak at ~6575 eV increased. This suggests that the manganese valence increased further after CV test.

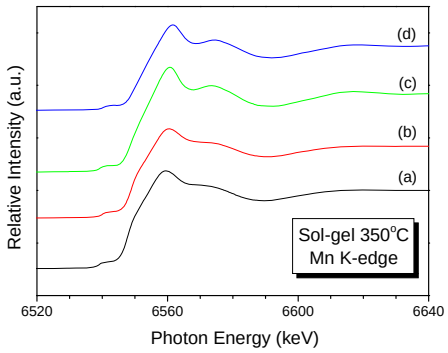

Figure 1. XANES spectra of (a) pure manganese oxide film before CV test, (b) active carbon-added manganese oxide film before CV test, (c) pure manganese oxide film after CV test, and (d) active carbon-added manganese oxide film after CV test.

Though the EXAFS spectra were not shown, after Fourier transformation the EXAFS spectra, the radial distributions of Mn revealed further the local atomic environments at various stages of pure and modified manganese oxide films. Figure 2 shows the corresponding RDFs for the samples examined in Fig. 1, no significant differences can be noticed for curves (a) and (b), while significant differences can be noticed after CV tests (curves (c) and (d)). Similar trend can be noticed by the XANES spectra taken at the Mn L edges. As shown in Fig. 3, no significant differences can be noticed within the pure and modified manganese oxide thin films, i.e., curves(a) and (b), while observable differences were visible after CV tests. Detailed investigations at carbon edge and by other techniques are still in progress.

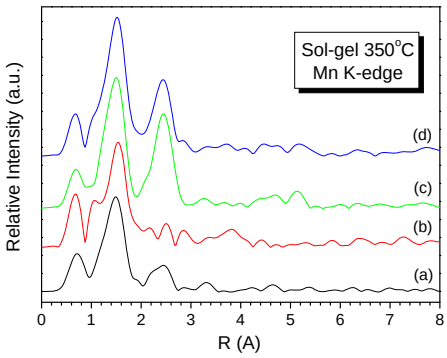

Figure 2. Radial distribution functions of (a) pure manganese oxide film before CV test, (b) active carbon-added manganese oxide film before CV test, (c) pure manganese oxide film after CV test, and (d) active carbon-added manganese oxide film after CV test.

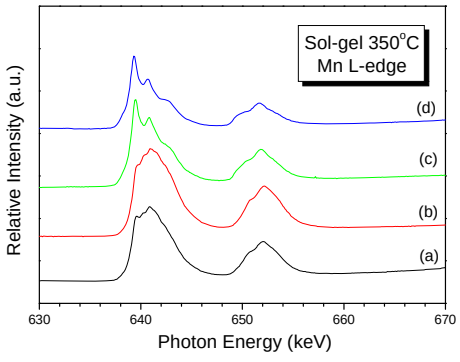

Figure 3. XANES spectra of (a) pure manganese oxide film before CV test, (b) active carbon-added manganese oxide film before CV test, (c) pure manganese oxide film after CV test, and (d) active carbon-added manganese oxide film after CV test.