Process and properties of the carbon nanotube assisted $LiCoO_2$ thin film battery electrode by the pulsed laser deposition method

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Abstract

In this work, the feasibility to use the pulsed laser deposition (PLD) method to co-deposit carbon nanotubess (CNTs) and the $LiCoO_x$ electrodes to improve their electrochemical properties was investigated. The CO_2 pulsed laser ablation system (λ= 10.6 μm) was adopted, where the sputtering target is made of 90 wt% $LiCoO_2$, 9.3 wt% graphite, and 0.7 wt% In powders, through mixing, milling, compressing and sintering processes. The electrodes were deposited on Pt-coated Si substrates with Ar and O_2 as sputtering gases under different deposition sequences with various pressures, gas ratios, substrate temperature and time. The structures and properties of the deposited electrodes were characterized by AFM, SEM, TEM, HRTEM, Raman spectroscopy, ICP-MS, XPS and 3-electrodes CV (cyclic voltammetry) measurements.

The results indicate that the electrode compositions are depending on pressure in PLD system, where the significant multi-walled carbon nanotubes (MWNTs, 10 ~ 15 nm in diameter) in the electrodes can be observed for pressure > 100 Torr, and the Li/Co ratios of the electrode can vary from 1.4 to 241 by changing pressure from 0.1 to 100 Torr. In other words, to deposit the CNTs-assisted $LiCoO_x$ electrodes with Li/Co ratio of 1.4, multiple-steps process is required to alternately deposit CNTs and $LiCoO_x$ under different conditions. The results also show that a higher heating temperature can cause compositions and crystallinity of the deposited electrode to approach $LiCoO_2$ crystals at 600^{o}C. The power density for the CNTs-assisted composite electrode can be improved 1.7 times greater then the corresponding electrode without CNTs at 600^{o}C.