The Electrochemical properties of metal oxide by ESD(electrostatic spray deposition) for lithium and sodium battery

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Introduction

Thin film micro-batteries have attracted considerable interest and are being developed as power sources for implantable microelectronic devices, including smart cards, microelectronic mechanical systems (MEMs), and portable electronic devices.

The need for low-cost, dependable, high-energy density rechargeable batteries continues to escalate with the demands of the electronics and automobile industries. Metallic lithium and sodium presents serious problems as an anode material in lithium and sodium rechargeable batteries. The formation of lithium and sodium dendrites during deposition has required the use of a separator and lowered the coulombic efficiency ~stripping/plating. A wide separation of these electrodes results in high resistance and low current density. Sodium-anode batteries, in contrast, can be constructed with a minimum of free electrolyte between electrodes because sodium deposits evenly on the surface of the electrode. Furthermore, sodium is inexpensive because of its abundant supply. These two factors may make sodium an attractive anode alternative

The use of lithium and sodium metal as the negative electrode in rechargeable batteries introduces some problems regarding dendrite deposition upon charging. Also, carbons in various forms are currently the first choices in commercial lithium ion batteries. However, their theoretical capacity is relatively low. In recent years, nanosized transition-metal oxides have become promising candidates for the negative electrode materials for lithium batteries[1-3].

The specific capacity of these materials can be as high as 1000 mAh/g [1], which is about few times higher than for carbons. Thin films of transition metal oxides have been fabricated as anodes for lithium microbatteries by various methods, such as electron beam evaporation [4], pulsed laser ablation [5], sputtering [6], and electrostatic spray deposition [7, 8]. J. Sarradin et al. used a sputtering technique to prepare Fe_2O_3 based thin films and investigated their electrochemical characteristics [9]. The electrical conductivity of the thin films was dramatically higher than that of the reference bulk sample. Since the electrostatic spray deposition (ESD) method offers many advantages for thin-film deposition, such as a low cost set-up, high deposition efficiency, and easy control of the composition of the deposited films, many conventional thin films for lithium rechargeable batteries, e.g. $LiCoO_2$ [10], $LiMn_2O_4$ [11], and $Li_4Ti_5O_{12}$ [8], have been successfully prepared by this method. In this paper, we have investigated the electrochemical properties of metal oxide thin-films for the lithium and sodium battery that were made by the electrostatic spray deposition (ESD) technique.

Experiment

The precursor solution was colorless or light brown with good stability; it can maintain its clear solution state for at least several days without precipitation. The morphology of the films deposited by ESD can be controlled through a few parameters, such as the metal nozzle size, the flow rate of precursor solutions, the distance between the substrate and the nozzle, the applied voltage, the temperature of the substrate, the deposition time, etc. The surface morphology of the thin films was characterized using a scanning electron microscope (SEM). Chemical analysis of the thin films was conducted using an energy dispersive X-ray (EDX) analyzer. The crystal structure of the films was determined by a X-ray diffractometer (XRD).

The electrochemical behavior of the samples was examined via CR2025 coin cells. The Lithium and electrode used was lithium metal foil. The anode used was sodium electrode, which was prepared by cutting from a bulk sample. Each battery was assembled by stacking in turn thin film, the porous polypropylene separator (Celgard 2200) soaked with each electrolyte, and the metal (lithium and sodium) anode. Preparation of the electrode and electrolyte and assembly of the cells were performed in an argon-filled glove box. The charge–discharge measurements were carried out at ambient temperature on a multi-channel battery cycler at different current densities and voltage cut-offs of 0.01 and 2.8 V.

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