β-FeOOH Positive Active Material Prepared by Liquid Phase Deposition Method for Lithium Secondary Cells

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Introduction

Lithium-transition-metal oxides such as $LiCoO_2$, $LiNiO_2$, and $LiMn_2O_4$ were applied as positive active materials for lithium-ion cells. β-FeOOH positive active material has been recently proposed to be one of promising candidates for the low-cost and environmentally-friendly alternatives to these materials. [1] This material was prepared by the complicated hydrolysis process resulting in the contamination of remained impurity of chlorine ion. [1]

The liquid phase deposition (LPD) method is one of simple process for preparing metal oxide or hydroxide thin films from an aqueous solution in the electrical and optical field. [2-4] Pure β-FeOOH positive active material for lithium secondary cells has been successfully prepared by this new method. In this report, the basic electrochemical performance of β-FeOOH positive electrode was investigated.

Experimental

β-FeOOH positive electrode was prepared as described below. First, α-FeOOH precipitate was dissolved in 1.0 mol dm^{-3} $NH_4F \cdot HF$ to give the parent solution. The concentration of iron ion in the parent solution measured by ICP was 0.073 mol dm^{-3}. The H_3BO_3 solution was then prepared in distilled water at the concentration of 0.7 mol dm^{-3}. Finally, the parent solution and H_3BO_3 one were mixed at various concentrations. A foamed Ni substrate was immersed into this mixture solution at 30 °C followed by drying in vacuum for 5 h at 60 °C.

Electrochemical performance was investigated by using three-terminal test cells with metallic Li foil as counter and reference electrodes in 1.0 mol dm^{-3} $LiClO_4$ of ethylene carbonate (EC) and diethyl carbonate (DEC) mixed solution. The positive electrode was discharged to 1.8 V and charged to 4.3 V vs. Li / Li^+ at the constant current density of 0.01 mA cm^{-2}.

Results and discussion

XRD pattern of positive electrode prepared by LPD method is shown in Fig. 1. The sharp diffraction peaks were assigned to high-crystalline tetragonal β-FeOOH with the lattice constant of a = 10.46 Å and c = 3.02 Å.

Initial discharge characteristic of β-FeOOH positive electrode is shown in Fig. 2. The delivered discharge capacity of the electrode shows the high utilization of 260 mAh g^{-1}. This value is 86% of the theoretical capacity of this material with one electron change reaction (1).

$$\beta\text{-FeOOH} + Li^+ + e^- \rightarrow FeOOHLi \qquad (1)$$

Namely, The β-FeOOH prepared by LPD method was verified to be high-efficiency positive active material without binder even at the high discharge current density of 50 mA g^{-1} on the mass basis of active material. Furthermore, the cycle performance of this electrode is shown in Fig. 3. This electrode is found out to show good cycleability at this high current density.

References

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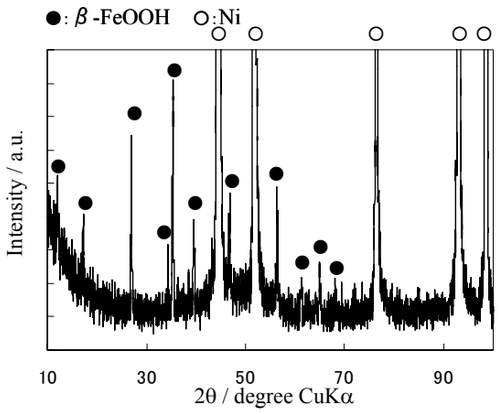

Fig. 1 XRD pattern of β-FeOOH electrode prepared by LPD method with iron ion of 0.0073 mol dm^{-3} in the parent solution and H_3BO_3 of 0.3 mol dm^{-3} at the immersion time for 15 h.

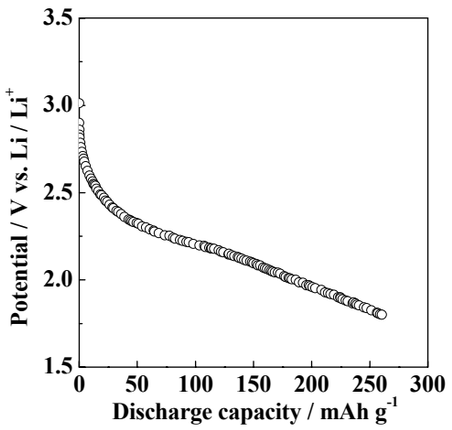

Fig. 2 Discharge characteristic of β-FeOOH electrode prepared by LPD method with iron ion of 0.0073 mol dm^{-3} in the parent solution and H_3BO_3 of 0.55 mol dm^{-3} at the immersion time for 2 h.

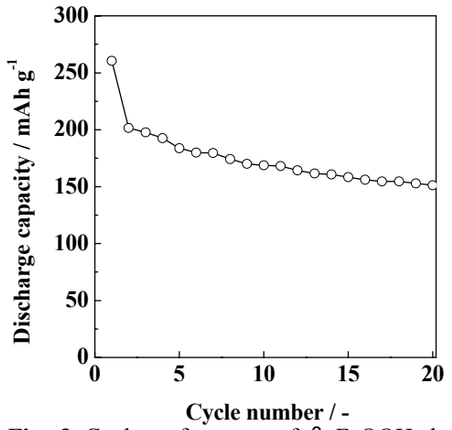

Fig. 3 Cycle performance of β-FeOOH electrode prepared by LPD method with iron ion of 0.0073 mol dm^{-3} in the parent solution and H_3BO_3 of 0.55 mol dm^{-3} at the immersion time for 2 h.