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The Development of a Lithium-type Advanced Energy Storage Device

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1. Introduction

We have developed the new device using a novel composite material as the negative electrode and ordinary activated carbon as the positive electrode. The composite material was obtained by the heat treatment of activated carbon with pitch. The structure of this composite was shown to be amorphous based on the X-ray diffraction pattern. This device can discharge at an extremely high current density of 10,000mA/g based on the composite weight. The power density of around 2.2kW/L was two times higher than EDLC's and the energy density of around 20Wh/L was three times higher.

2. Experimental

The negative electrode active material was modified an activated carbon composite, prepared by the heat treatment of activated carbon with pitch under an inert atmosphere[1]. An X-ray diffraction measurement of the composite was performed. The interlayer spacing was estimated by the Bragg method and the crystallite size was estimated by a Scherrer-type formula. The active material, acetylene black as the conductive filler and NMP solution of PVDF were mixed, and coated on copper foil current collectors.

The positive electrode active material was ordinary activated carbon and its BET surface area was 2200m^2/g. The active material, acetylene black as the conductive filler and NMP solution of PVDF were mixed, and coated on aluminum foil current collectors.

Test devices were fabricated as follows. The positive electrode and the negative electrode were stacked by insertion of a microporous polyethylene membrane, and soaked with nonaqueous electrolyte containing Li salt. These devices were investigated for evaluation of their electrochemical characteristics under various conditions.

3. Results and Discussion

The X-ray diffraction patterns of the composite and activated carbon are shown in Figure 1. We consider that the appearance of the new peak is caused by attached carbonaceous material. The crystallite size (in the c axis direction for graphite) and space distance (d002) of the composite is 12.1 Å and 3.66 Å, respectively. This pattern shows that the attached carbonaceous material has an amorphous structure.

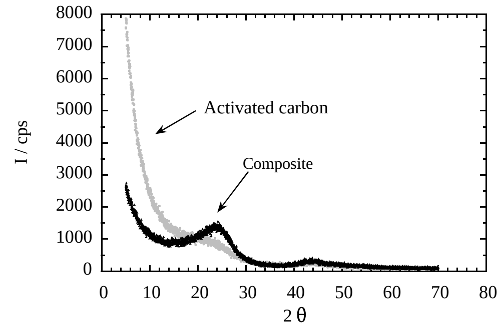

Figure 1. The X-ray diffraction patterns of the composite and base activated carbon

We evaluated the potential profile of the positive and negative electrodes using a test device with a Li reference electrode. Figure 2 shows the potential profile of this device during constant current/constant voltage charging.

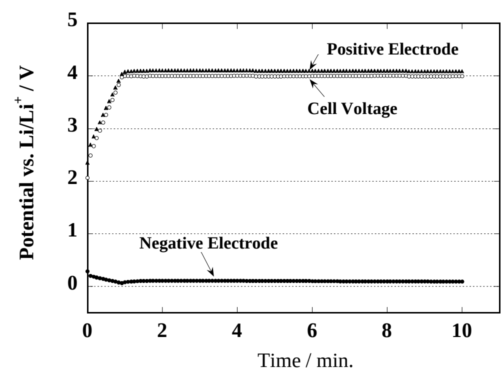

Figure 2. Potential profiles during charging at a constant current/constant voltage (4.0V max)

Figure 3 shows the high rate charging and discharging profiles. This testing was performed with a 1 minute constant current charging and 1 minute discharging. The charging cutoff voltage was 4.0V, and the discharging cutoff voltage was 2.0V. The energy density of around 20Wh/L is obtained during cycling.

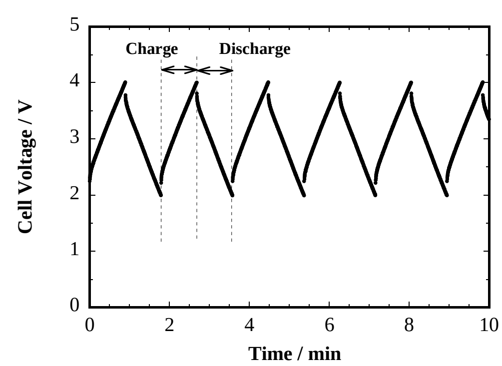

Figure 3. High rate charge and discharge profiles

Reference

1. T. Tsubata, M. Shimoyamada, A. Yoshino, H. Satake, Y. Okano, S. Yata, Abstract 3C08, the 43rd Battery Symposium in Japan, Fukuoka, October 12-14 (2002).
2. A. Yoshino, T. Tsubata, M. Shimoyamada, H. Satake, Y. Okano, S. Mori, S. Yata, J. Electrochem. Soc., in press (2004)