Importance of Thermal Management of Lithium Ion Cell

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INTRODUCTION

Proper thermal management of a lithium ion cell is a unavoidable issue for the scale up of the cell. We have been studying the thermal behavior of the $LiCoO_2$ / graphite cell using a precise isothermal calorimeter and have assigned the thermal characteristics of the cell components[1]. However, the temperature change of the cell under practical operation conditions is the most important indicator of thermal management. The center temperature of the cell had been supposed to increase higher than the surface temperature, but has been estimated only by simulation of the cell. In this work, the actual center temperature of a commercially available lithium ion cell was measured by the insertion of a thermocouple into the cell without critical damage to the cell components, and was compared to the surface temperature.

EXPERIMENT

The CGR-18650 (Panasonic) lithium ion cell was used in the analysis. A sheath thermocouple (type K, 1/16 inch ϕ) was inserted from the bottom of the can (negative electrode). The schematic of the cell is shown in figure 1. The interface between the can and the thermocouple was sufficiently sealed by a viton rubber. The entire process was carried out in an Ar-filled glove box (<0.1 ppm H_2O and <0.4 ppm O_2). The capacity of the cell was not decreased by the modification. The cell temperatures during charge and discharge were measured in a homo-isothermal room in which the temperature was controlled at 298 K. The operation voltage range was between 4.2 V and 3.0 V, which was the limit recommended by the manufacturer.

RESULTS AND DISCUSSION

Figure 2 shows the charge-discharge profiles and corresponding temperature changes at the cell center and at the cell surface. The applied current was 400 mA, which corresponded to C/4. The thermal profile showed good agreement with the result obtained by isothermal calorimetry measurement. The maximum temperature during charge was recorded at the end of charge. The increase of the temperature was due to the phase transition of $LiCoO_2$. Likewise, the maximum value during discharge was also recorded at the end of discharge. Both electrode reactions are exothermic at the end of discharge. Furthermore, the heat of resistance due to the polarization also reached the maximum. Therefore, the most thermally critical condition of the lithium ion cell is at the end of discharge. The temperature increase (ΔT) of the cell center and of the cell surface against room temperature for various operation rates are shown in figure 3. Under the 1C discharge condition, the center temperature increased to 311.5 K, and the difference between the center temperature and the surface temperature was 5.5 K. The internal resistance and the open circuit voltage (OCV) of the cell show lower values when the cell temperature increases. Therefore the imbalance of the temperature inside the cell leads to the concentration of the current at the center of the cell. The results will provide a fundamental database for cell design from the viewpoint of proper thermal management.

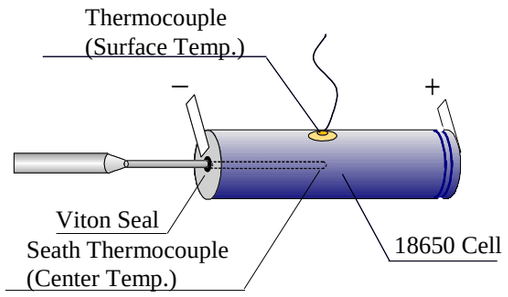

Figure 1. Schematic of modified cell with thermocouple.

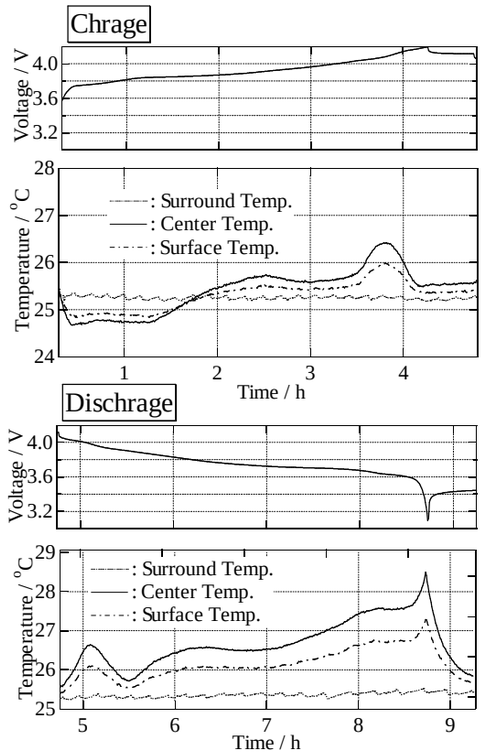

Figure 2. Charge-discharge profiles and temperature changes of lithium ion cell.

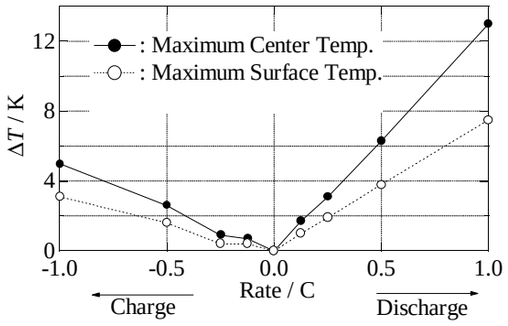

Figure 3. Temperatures increase during charge and discharge for various operation rates.

REFERENCE

1. Y. Kobayashi, H. Miyashiro and T. Iwahori, No. 167, Extended Abstracts, **Vol. 00-2,** ECS Fall Meeting, Phoenix, 2000