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In Situ Measurement of Li-ion Battery Internal Temperature

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Driven by booming applications and remaining grand challenges of Li-ion batteries in electric vehicles[1-3], the need for their better performance, durability and safety is increasing.

Many studies show that temperature has significant effects on the performance, durability and safety of Li-ion battery[4-6]. While too low temperature reduces battery performance and durability, too high temperature can jeopardize battery durability and safety.

In laboratory research and practical applications, the surface temperature of Li-ion battery or battery cell is commonly monitored for proper thermal management. Because heat is generated inside Li-ion battery during operation due to Joule heating, irreversible reaction heat, and entropic heat[1], it is expected that the internal temperature of a Li-ion battery cell would be higher than the outer surface temperature. Measuring internal temperature can thus provide more accurate information and it is a better indicator of the health and safety state of a Li-ion battery. In addition, the internal temperature data will provide a critical source of validation for the latest electrochemical-thermal coupled models for low-temperature performance as well as battery safety[7-9].

Therefore, it is very important to measure internal temperature of Li-ion battery under various conditions, including extreme conditions. The efforts will promote the development of Li-ion battery with better performance, durability and safety.

In this study, experimental 18650 cells with embedded micro thermocouples are manufactured in the Battery Manufacturing Lab at Penn State University. Internal temperature of the experimental cell is measured experimentally and compared with the surface temperature under various conditions, including different C rates, ambient temperatures, cooling conditions, etc.

Representative results are shown in Figure 1 and Figure 2. Figure 1 shows discharge performance of the experimental battery cell at various C rates. Figure 2 shows the rise of internal temperature and outer surface temperature during the discharge processes. It can be seen that both internal and surface temperature increase faster and reach higher values by the end of discharge during higher C rate discharge. The difference between internal temperature and surface temperature is also larger during higher C rate discharge. The results can be attributed to more and faster heat generation at higher C rate discharge.

The results of this work can be very helpful in validating electrochemical-thermal coupled (ECT) battery models and shedding insight into thermal behaviors of battery cells, which can then help improve the performance, durability and safety of Li-ion batteries.

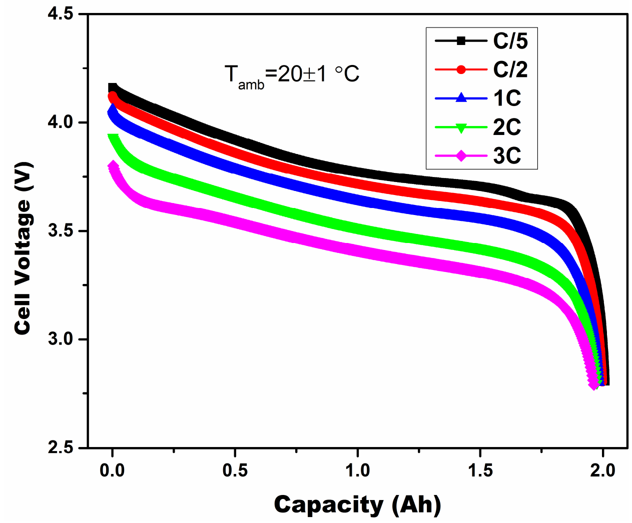

Figure 1. Discharge performance of experimental battery cell at various C rates

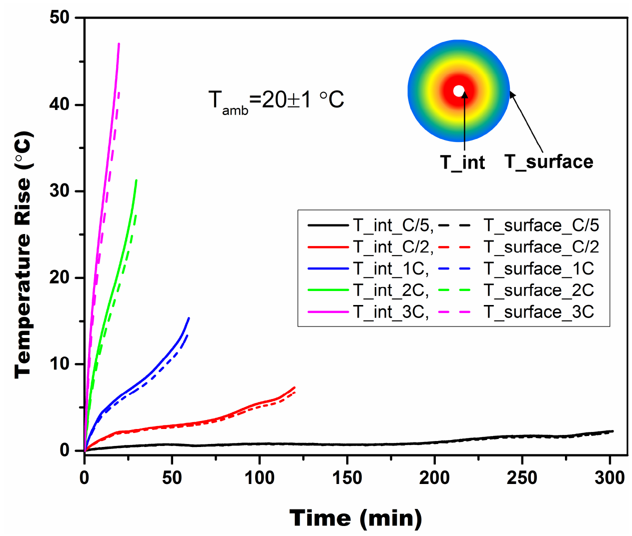

Figure 2. Rise of internal temperature and outer surface temperature during discharge at various C rates

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