

Internal temperature distribution in lithium-ion battery cell and module based on a 3D electrothermal model: An investigation of real geometry, entropy change and thermal process

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In recent years, lithium-ion batteries (LIBs) have been massively developed in many applications, especially for the transportation associated with the rapid growth of electric vehicles (EVs). They provide high energy and power densities, high efficiency and long lifespan compared to other battery technologies. Despite remarkable improvements, Li-ion batteries still face thermal issues, which cause performance drop, limited calendar life, safety concerns and degradation [1]. Therefore, proper thermal management for a LIB is necessary to control its temperature and to extend its lifetime. In particular, internal temperature needs to be known for improving the safety and limiting premature ageing of LIBs as a remarkable difference between the external and internal temperatures can be observed [2].

In the present work, the internal temperature distribution of a large commercial prismatic NMC-type lithium-ion battery (Table 1) is investigated using a 3D electrothermal model developed with the COMSOL Multiphysics[®] software. The internal geometry is modeled from a large number of tomograms performed on the corresponding cell. The study is extended to a module of 12 cells in series (12S) to evaluate the heterogeneities of internal temperatures considering the real geometry of each cell. In addition, the cell and module are experimentally charged and discharged at several currents at 25°C in a climatic chamber to determine the temperature changes. Finally, the numerical results are compared to the experimental data at both cell and module scales to validate the model.

Nominal capacity/Ah	25
Maximum capacity measured/Ah	22.8
State of health/%	91.2
Maximum charge voltage/V	4.2
Minimum charge voltage/V	2.7
Type	Prismatic
Chemistry	Graphite/NMC
Dimension/mm × mm × mm	148 × 91 × 26.5
Mass/g	698

The results show a cooling process due to entropy change at low C-rate while at higher C-rate the Joule effect is predominant. Therefore, entropy change can act as an active cooling process at low C-rate. In addition, the anisotropic properties considerably influence the internal temperature distribution as well as the inert gas which insulates the inner part of the cell by acting as thermal resistance. Finally, higher internal temperatures are observed in the module because of its architecture (Figure 1).

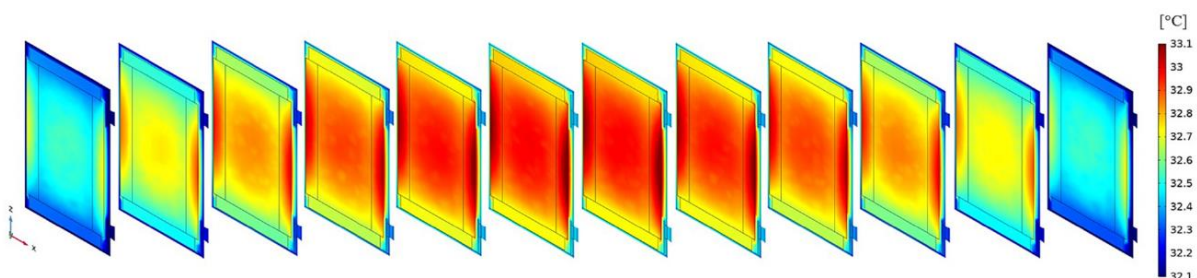


Figure 1. Temperature distribution in a module 12S at the end of 1C discharge at 25°C considering the real geometry of each cell.

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