Three-dimensional modeling the thermal behavior of a lithium-ion battery for electric vehicle applications

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The lithium-ion battery (LIB) is a preferred power source for the electric and hybrid electric vehicle applications due to its high energy density, high voltage and low self-discharge rate. Previous studies reveal that the battery cell does not generate heat evenly throughout its volume and thus the temperature distribution within the cell is not uniform. Because both of the battery performance and life are the strong functions of battery temperature, it is important to calculate accurately the uneven temperature distribution of the battery cell in battery modeling.

In this work, a three-dimensional modeling is performed to study the thermal behavior of a LIB cell comprising a $LiMn_2O_4$ cathode, a graphite anode, and a plasticized electrolyte. The combined effects of the thermal and electrical contact resistances between the current collecting tab of an LIB cell and the lead wire connecting the cell with an external cycler are considered explicitly as well as the heat generation due to the electrochemical reactions and the ohmic heating in the electrode region of the battery cell. The effect of electrical contact resistance are taken the into account in the calculation of heating of the current collecting tabs and the effect of thermal contact resistance is included in the heat flux boundary condition at the contact area between the current collecting tab and the lead wire. The three-dimensional thermal modeling is validated by the comparison of the experimental temperature distributions from IR images during discharge in an LIB cell with the modeling results.

Fig.1 shows the comparison between the temperature distributions based on the experimental IR image and the modeling after the discharge of 11 minutes 10sec with a rate of 5C at room temperature. The experimental and modeling temperature distributions are in good agreement with a minimum around at 33℃ and a maximum around at 44℃.

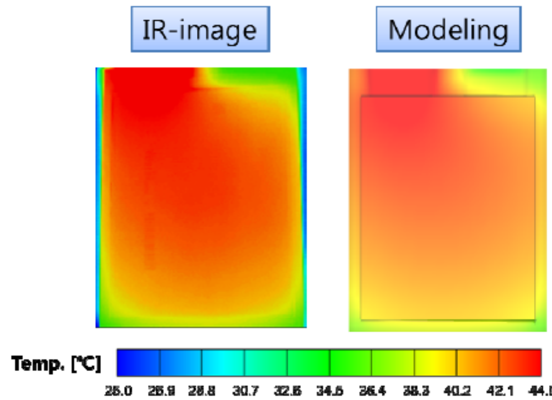

Fig. 1. Comparison between the temperature distributions based on the experimental IR image and the modeling after the constant current discharge of 11 minutes 10 seconds with a rate of 5C.