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EXTERNAL SHORT CIRCUITS APPLIED TO LITHIUM-ION CELLS: MODELING AND VALIDATION

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Besides increasing the overall energy density and reducing the cost of lithium-ion batteries, guaranteeing a high level of safety is one of the key concerns to meet the requirements of consumer electronics, the automotive industry and stationary energy storage systems. Even though there is a vast amount of electrical, thermal and mechanical testing procedures available in regulations and standards allowing for a thorough evaluation of the safety level of a lithium-ion cell, module and battery system, there is still a vivid discussion in the community, how to interpret such test data in the best possible way. In order to allow for a closer look into the processes and mechanisms occurring during destructive abusive scenarios, validated modeling and simulation can be a powerful tool in terms of interpreting this test data.
In the work presented here, external short circuits applied to lithium-ion batteries comprising a graphite anode and a $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ cathode are investigated by means of a modified physical-chemical model [1]. This model allows to distinguish between various stages of a short circuit event based on limitations in charge and mass transport throughout the solid and liquid components of the electrode stack as well as overpotentials related to charge transfer kinetics [2]. With the aid of the presented model, external short circuit test data is evaluated in order to explain the observed characteristics during the applied short circuit events [3]. It can be shown that the step-like characteristics in cell potential and evolving current rate can be directly correlated to limitations in charge and mass transport as well as charge transfer kinetics resulting in lithium-ion depletion and saturation effects within the solid and liquid phases of both anode and cathode. The presented validated model is further used to derive design guidelines for lithium-ion batteries in order to increase its tolerance towards short circuit events as well as to discuss possibilities to improve short circuit tests.

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