Thermophysical properties of electrode materials for lithium-ion batteries

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Lithium-ion batteries are presently used as power sources in energy storage applications due to the adapted functionality and chemistry for a long cycle life-time, high energy density, high power density and relatively simple reaction mechanisms. The main challenge not only for electric vehicles but also for smaller portable devices as well as high capacity stationary storage facilities is related to safety behaviour under normal and abusive operation conditions. Understanding the heat generation and propagation in lithium-ion batteries and avoiding thermal runaway at high temperature is a critical issue. In an attempt to improve the battery safety, battery management systems (BMS) were introduced for thermal controlling batteries of high power and energy density. Therefore the thermal properties such as thermal conductivity, heat capacity and thermal diffusivity are required for a well optimisation of the BMS.

The goal of this work is to investigate the high temperature thermophysical properties of individual lithium-ion cell components. The focus is set on composite thick film (thickness about 0.1 mm) electrode materials containing binder, conductive agents and active material, such as (1) layered intercalation lithium cobalt oxide ($LiCoO_2$), which is the main cathode material used nowadays in many commercial lithium-ion cells, and (2) graphite as the anode. In addition, the influence of the additives on the active material properties was studied. Thus, samples containing mixtures of (3) $LiCoO_2$ and binder, (4) $LiCoO_2$ and carbon black and (5) bare $LiCoO_2$ were measured. Thermal conductivity data up to 400 °C was determined from thermal diffusivity measured by laser flash analysis method and heat capacity by calorimetric methods. Scanning electron microscopy (Figure 1a) and metallographic methods (light microscopy, Figure 1b) were also used for structural investigations.

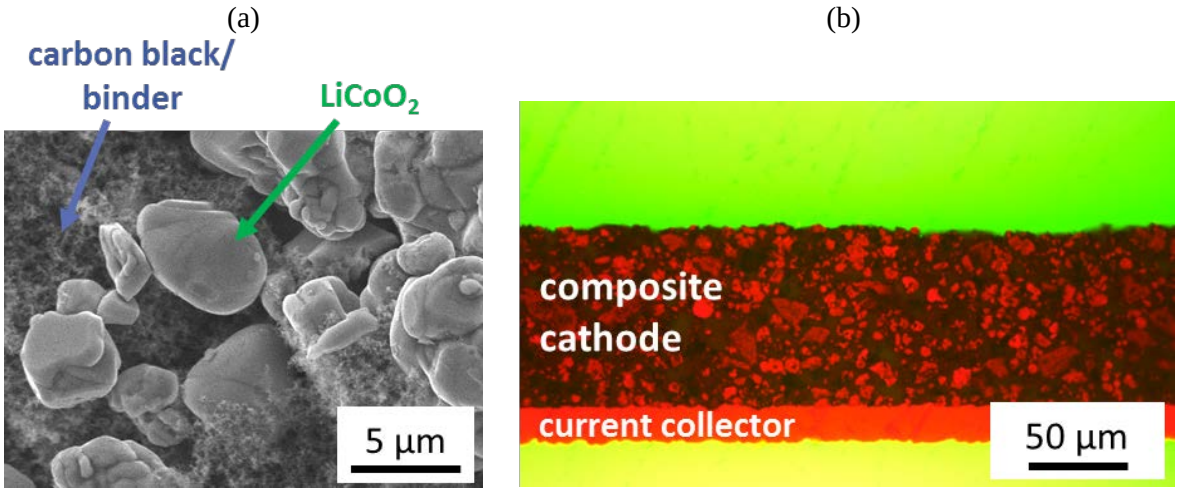

Figure 1: Composite $LiCoO_2$ cathode: a) Scanning electron microscopy image (top view), b) Light microscopy image (cross section view).