Graphene-enabled printed, flat-flex reference electrodes for in operando monitoring Li-ion battery parameters

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Abstract

To reach climate neutrality, a total installed battery storage capacity worldwide of TWh-scale is foreseen for end of this decade.[1] In this context, Li-ion batteries (LiBs) are playing a major role in several markets, including battery electric vehicles, plug-in hybrid electric vehicles and portable/mobile electronics.[2] Beyond the need for high energy density, high power density and cost effectiveness, the quality-reliability-lifetime (QRL) and safety are crucial requirements for specific end-use applications of current battery systems and cells.[3] Research and development efforts are therefore considering the integration of sensing components into battery cells, so that their output data can be used by advanced Battery Management Systems (BMSs) to monitor, through *in operando* and real-time modes, the key parameters of a battery cell, providing accurate estimates for states of charge, health, power, energy and safety cell indicators, along with other early-failure indicators.[3] This, in turn, should enable the BMS to implement corrective actions to protect the cell and battery systems from degradation phenomena and undesired electrochemical side-reactions, preventing dangerous effects, like thermal runaway events and consequent battery fire, and even guaranteeing possibly battery reuse in second-life applications.[4] In this talk, we will report the recent progress on the development of reference electrodes to monitor separately the anode and cathode potentials, avoiding the latter to reach critical thresholds that initiate irreversible cell failures. Meanwhile, reference electrodes can be used to monitor the electrochemical behaviour of each half-cell through non-invasive electrochemical impedance spectroscopy measurements. A special focus will be dedicated to the graphene-enabled printed, flat, and flexible reference electrodes, directly deposited onto the cell separator in form of thin film (without using any metallic current collector).

References

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