Optimization of electrochemical performance of NMC cathode via adjacent synthesis and test protocols

Svitlana Krüger[1], Bilge Saruhan[1], Emre Guney[2] and Neslihan Yuca[2]

[1] Institute of Materials Research, German Aerospace Center (DLR), 51147 Cologne, Germany
[2]ENWAIR Energy Technologies Corporation, Maslak, 34469 Istanbul, Turkey

$LiNi_xMn_yCo_{1-x-y}O_2$ (so-called NMC) has demonstrated the most effective combination of nickel, manganese, and cobalt for the cathode materials to yield better performance in terms of specific energy and power density, life span, costs and safety at Li-ion Batteries-LiB [1]. Nickel is responsible for high energy density and good storage capacity of LiBs, but suffers from low thermal stability and insufficient cycle life [2]. Considering these deficiencies, the NMC compositions are designed to include Manganese which acts not only as a stabilizer, but also prevents Nickel oxidation and thus, reduces the risk of capacity fading. Moreover, a new generation of cathode microparticles have been emerged aiming in a clever integration of Manganese in NMC morphologies by their core/shell structured designed synthesis. This special morphology provides surface stabilization of Ni-rich NMC by Manganese rich shell, to keep the energy storage capabilities at a higher level and thus, preventing the early cathode degradation. The strong dependence of the NMC cathode's functional properties on the relative ratios of the involved transition metals as well as the insufficient understanding of the synergistic effect of core and shell during the electrochemical tests, forced the researches to explore new synthesis approaches to enhance the overall performance of cathodes with this new structural design.

In this work, the cathode powders having Ni-rich Core/Mn-rich Shell have been synthesized via a cost efficient and easy controlled process that is built on a two-step co-precipitation method by optimization of process parameters under steady performance tests. These include variation of synthesis steps, co-precipitation agents, Li-infiltration approaches, heat treatment conditions as well as establishment of the proper synthesis protocols to fabricate NMC cathodes with a good electrochemical performance for Li-ion batteries. In order to identify the morphological, dimensional, structural and compositional relations within the core/shell particles SEM, EDX and XRD techniques have been employed. It has been shown that thermal treatment (temperature, duration, heating rate) slightly effect the morphology of the obtained particles, however relying on to the generated XRD analysis, plays a significant role in the achievement of the best NMC crystalline phase composition by avoiding undesirable for batter performance compounds. In turn, it is observed that a likely non-efficient Li-infiltration results in poor electrochemical performances. Electrochemical characterization by means of EIS spectroscopy and CV tests indicated that the combination of crystalline phase composition, the presence of the residual Li-based compounds, as well as Li incorporation approach has a high impact on the electrochemical properties of the obtained core/shell structured NMC cathode powder.

References

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Dr. Svitlana Krüger is a material scientist with PhD-degree on specialty Inorganic Substances Technology. Her research interests include synthesis of metal-oxide nanostructures of various morphology and its composites for their application as cathode materials, as well as sensitive layers of semiconductor gas sensors.

Presentating author: Svitlana Krüger, e-mail: Svitlana.Nahirniak@dlr.de

Dr.-Ing. habil Bilge Saruhan-Brings is a material scientist with PhD-degree on high-performance functional ceramic and the lecturing qualification (habilitation) on nanomaterials and nano-/micro-technologies. She is leading the Research Activities of the Functional Coatings Group at the Institute of Materials Research of DLR. Her research fields cover energy storage systems, development of catalysts and functional nano-structured coatings for energy applications and thin film gas sensor devices.

Presentating author: Bilge Saruhan, e-mail: Bilge.Saruhan@dlr.de