Development of 3D architectures in $LiFePO_4$ cathode material using ultrafast laser ablation

M. Mangang[a], H. J. Seifert[a], W. Pfleging[a,b]
[a]*Institute for Applied Materials - Applied Materials Physics, Karlsruhe Institute of Technology, P.O. Box 3640, 76021 Karlsruhe, Germany*
[b]*Karlsruhe Nano Micro Facility, H.-von-Helmholtz-Platz 1, 76344 Egg.-Leopoldshafen, Germany*
melanie.mangang@kit.edu

Abstract

The growing demand of lithium-ion batteries with high energy and power density as well as an increased cycle life-time set the focus on three dimensional (3D) architectures in advanced electrode materials. $LiFePO_4$ is a promising positive electrode active material to be used in cost-efficient lithium-ion batteries. Nevertheless, a reduced electric and ionic conductivity is the main drawback of this cathode material. A common technical approach to overcome the limitation given by a low electric conductivity is to use thin carbon coatings on $LiFePO_4$ particles. In order to ensure charge balancing even for high charging/discharging currents, the lithium-ion diffusion kinetic has also to be improved. Short lithium-ion diffusion paths can be realized by using small particles and 3D surface architectures. However, small particles lead due to an enhanced agglomeration to an increased tap density and thus to a reduced energy density.

Ultrashort laser ablation was applied in order to generate different 3D surface structures. It was shown that the ultrashort laser pulses lead to a reduced thermal impact and increased ablation efficiency in comparison to nanosecond laser radiation. To investigate the structure shape and the thermal influence, white light profilometry and scanning electron microscopy were applied. Electrochemical properties (specific capacity, cycle stability) were determined in order to compare cells with unstructured cathodes and cells with structured cathodes. It was shown that due to the structuring an improved lithium-ion kinetic can be achieved which might be induced by a reduced cell polarization. Finally, an improved cycle stability and an increased cell life-time for high C-rates were obtained.