Tailored electrode morphologies for insertion electrodes

M. Wagemaker[1], D.P. Singh[1], A. George[2], J.E. ten Elshof[2] and F.M. Mulder[2]

[1]Delft University of Technology, Faculty of Applied Physics, Mekelweg 15, 2629JB Delft, The Netherlands
[2]University of Twente, Faculty of Science & Technology, P.O. Box 217, Enschede, The Netherlands

To realize electric mobility research activities are focused on developing high power and high energy density electrodes for rechargeable lithium-ion batteries. Although nano-sizing electrode materials is the most frequently applied strategy the disadvantage is the low tap density of these electrodes leading to lower energy densities. High power densities in combination with high tap densities require optimization of the ionic and electronic wiring by tailoring the complete electrode microstructure. Generally this is possible with relatively complicated and costly templating methods. Here we present 2 low cost templating methods (1) using carbonate salts creating a 3D interconnected ionic pathway that significantly improves the charge transport without compromising the tap density significantly. This method was demonstrated for carbon coated olivine $LiFePO_4$ and spinel $Li_4Ti_5O_{12}$ electrode materials resulting in excellent capacity retention, as shown in Figure 1.

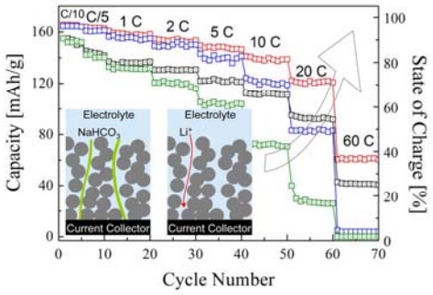

Figure 1. Impact of carbonate salt templating on the rate performance of carbon coated $LiFePO_4$ (140 nm)

(2) The second method is based on soft lithography using PDMS (a polymeric organosilicon) molds to create a pattern in the electrodes aiming at better electrolyte access. Any pattern can be imposed, for example see Figure 2. However, the aspect ratio's between the vertical and lateral features is currently limited to 10. Nevertheless, the method shows large potential to control electrode morphology.

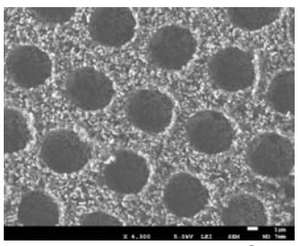

Figure 2. Micropatterend $LiFePO_4$ electrode. The holes have a diameter of approximately 5 micron.

The prepared electrodes were characterized with in-situ XRD up to 5C (dis)charing, giving interesting insight in the phase front movement through the electrode depending on the conditions and on the single phase versus two phase reaction in the storage particles.

(1) D.P.Singh, F.M. Mulder and M. Wagemaker, submitted.
(2) D.P.Singh, J.E. ten Elshof and M. Wagemaker, submitted.