

Carbon and Oxide Materials with Designed Pore Architectures for Li Ion Diffusion and Battery Applications

Michael Wark

Institute for Chemistry, Technical Chemistry, Faculty for Mathematics and Natural Sciences,
Carl von Ossietzky University Oldenburg, D-26111 Oldenburg, Germany

Corresponding author: Michael Wark, E-Mail: michael.wark@uni-oldenburg.de

In recent years it has been realized that improved battery performance can be achieved by reconfiguring the electrode materials currently employed in 2-D batteries into 3-D architectures.

Starting from TiO_2 , which was studied intensively for structuring into nanosheets and 3-D architectures [1,2], the synthesis strategies for oxides with 3-D ordered pore systems were first extended to other single oxides like SnO_2 [3], Co_3O_4 or some manganese oxides. Most often the nanocasting approach starting from a SiO_2 network with ordered mesoporosity is used for the fabrication. Recently, even well-ordered mesoporous crystalline mixed metal oxides have been synthesized; in case of CuCo_2O_4 the nanocasting strategy using mesoporous silica KIT-6 as the hard template has been employed [4], MgMoO_4 was even synthesized via a soft-templating route with the block-co-polymer KLE [5]. All the materials exhibit promising charge storage characteristics. It is concluded that the combination of open mesopore cavities with thin, sub 15 nm inorganic walls provides a beneficial microstructure for lithium-ion battery applications.

Moreover, also carbon materials have been in the focus for quite some time, due to their ability to intercalate lithium ions. Recently, carbons with organized porosity have gained more and more interest as anode materials [6]. Even without further functionalization, carbons with 3-D mesopore architecture can have capacities larger than those of, e.g., carbon nanotube systems. However, because of their high surface areas as well as the mesoporous oxides they exhibit large capacity losses in the first cycle, due to electrolyte decomposition at the inner surface. But the high surface areas and porous structures also enhance the lithium-ion transfer. Thus, the ordered mesoporous carbon CMK-3 exhibited a very high reversible capacity (up to 1100 mAh/g) and good cycle performance. Hence, these materials appear, although possessing some drawbacks, to be useful for situations where quick charge and discharge are desired. One of the advantages is that the porous carbon networks can easily be used for encapsulation of further active material, e.g. Co_3O_4 nanoparticles [7].

The talk will discuss recent synthesis strategies to oxides and carbons with 3-D architecture and will try to evaluate the advantages, challenges and perspectives of such materials for Li ion insertion and diffusion in view of improved performance in battery systems.

References

- [1] D. Fattakhova-Rohlfing, M. Wark, T. Brezesinski, B. Smarsly, J. Rathouský, *Adv. Funct. Mater.* **17** (2007), 123.
- [2] J.M. Szeifert, J.M. Feckl, D. Fattakhova-Rohlfing, Y. Liu, V. Kalousek, J. Rathousky, T. Bein, *J. Am. Chem. Soc.* **132** (2010), 12605.
- [3] H.B. Wu, J.S. Chen, X.W. Lou, H.H. Hng, *J. Phys. Chem. C* **115** (2011), 24605.
- [4] S.J. Sun, Z.Y. Wen, J. Jin, Y.M. Cui, Y. Lu, *Microporous Mesoporous Mater.* **169** (2013), 242.
- [5] J. Haetge, Chr. Suchomski, T. Brezesinski, *Small* **15** (2013), 2541.
- [6] A. Stein, Z. Wang, M.A. Fierke, *Adv. Mater.* **21** (2009), 265.
- [7] J. Park, G.-P. Kim, H.N. Umh, I. Nam, S. Park, Y. Kim, J. Yi, *J. Nanopart. Res.* **15** (2013) 1943.

