Hierarchically Structured Materials for Supercapacitors and Batteries

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Amphiphilic block-copolymers are known to form well-ordered structures on the 10nm length-scale. Such nanostructures have been utilized to enhance the performances of solar cells[1] and supercapacitors[2] among other applications. By confining sol-gel chemistry to one of the blocks of the copolymer these structures can be transferred to various functional inorganic materials.

We synthesize and study nanostructured electrodes with different morphologies. The materials under investigation are either already used in lithium-ion batteries or supercapacitors, or considered as promising candidates for the next generation of energy materials. The obtained well-defined morphologies (cf. figure 1) provide large internal surface areas coated with carbon facilitating ionic and electronic conductivities.

We further aim to incorporate this synthesis approach into the fabrication of hierarchically structured materials. By blending the sol-gel precursor/block-copolymer mixture with a sacrificial homopolymer, macroporosity can be introduced into the electrode structure. Using this method, morphologies such as mesoporous microspheres, bicontinuous frameworks, and graded films can be obtained, which contain hierarchical pore networks. This particular structure is believed to be important to reduce the diffusion limitation of ion transport in the electrolyte to the intercalation sites of the material. In addition, a better understanding of the interplay between pore-volume and -interconnectivity will enable us to define an optimal ionic diffusivity for the electrodes, crucial for applications in consumer electronics, electromobility and large-scale energy storage.

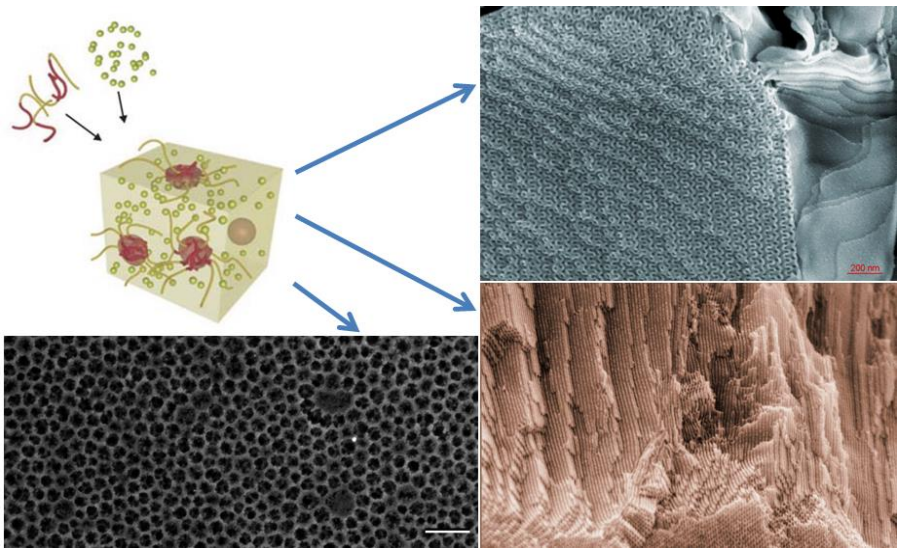

Fig. 1: Different ordered nanostructures of TiO2, obtained by combining sol-gel chemistry with block-copolymer self-assembly.

[1] E. Crossland et. al., Nano Letters 9 (2009) 2807–2812.
[2] D. Wei et. al., Nano Letters 12 (2012) 1857–1862.