Abstract #607, 224th ECS Meeting, © 2013 The Electrochemical Society

CDCs from silicon carbide with tunable ordered meso and macroporosity for high-power supercapacitor

Peng-Cheng Gao [a, b], Wan-Yu Tsai [b, c], Barbara Daffos [b, c] Pierre-Louis Taberna [b, c], Carlos R. Perez [d], Yury Gogotsi [d], Patrice Simon [b, c], Frederic Favier [a, b, z]

[a] Institut Charles Gerhardt Montpellier UMR 5235 CNRS, Université Montpellier 2, cc1 502, 34095 Montpellier cedex 05, France
[b] Réseau sur le Stockage Electrochimique de l'Energie (RS2E), FR CNRS 3459, France
[c] Université Paul Sabatier, CIRIMAT UMR CNRS 5085, 118 route de Narbonne, 31062 Toulouse, France
[d] Department of Materials Science and Engineering & A.J. Drexel Nanotechnology Institute, Drexel University, 3141 Chestnut St., Philadelphia, PA 19104, United States
[z] Corresponding author : Email: fredf@univ-montp2.fr (F. Favier), +33 4 67 14 33 32

Carbide-derived carbons, thanks to a mono-disperse size distribution of ultra-micropores, afford one of the highest volumetric and gravimetric capacitances in supercapacitor. [1] However, ion transport is rather limited in such ultra-microporous materials and they suffers from a dramatic decrease of capacitance at extreme high scan rates. To address this issue, larger channels inheriting from meso or macro porous carbides could serve as ion-highways for fast transport though the bulk of the resulting CDC particles. [2] Thanks to the use of magnesium as efficient reductive agent, we synthesized at a relatively low temperature, silicon carbide with an open meso- or macro- porosity structure deriving from templated silica/carbon composites. [3] Two Pluronic triblock copolymers, P123 and F123, were chosen as soft-template structuring agents leading to SiO2/C composites showing a hexagonal mesoporous pattern with constant unit parameter of 4 or 9 nm, respectively. By altering the carbon/silica molar ratio in the pristine composite, we generated through magnesio-thermal reduction, mesoporous silicon carbides with tuned single pore distributions ranging from 2.5 nm to 6 nm. Restricted to the unique unit parameter, the wall thickness of the silicon carbide decreased while increasing the pore size. By coupling this soft template approach with a hard template route using assembled latex spheres, we succeeded in the synthesis of an ordered 3D hierarchical SiC with two pore size distributions in the macro and mesoporous ranges. The CDCs deriving from prepared silicon carbides showed improved power and energy densities thanks to the efficient macro and meso pathways for electrolyte ions to the electrode micropores. An attractive gain is also anticipated for low temperature operation.

[1] J. Chmiola, G. Yushin, Y. Gogotsi, C. Porter, P. Simon, P. L. Taberna "Anomalous Increase in Carbon Capacitance at Pore Sizes Less Than 1 Nanometer", Science, 2006, 313, 1760-1763
[2] J. Chmiola, C. Largeot, P. L. Taberna, P. Simon, Y. Gogotsi "Desolvation of Ions in Subnanometer Pores and Its Effect on Capacitance and Double-Layer Theory", Angew. Chem. Int. Ed, 2008, 47, 18, 3392-3395

[3] P. C. Gao, Y. Lei, A. Cardoso, K. Rajoua, D. Zitoun, F. Favier "New topotacitc synthetic route to mesoporous silicon carbide", J. Materials Chem., 2011, 21, 15798-15805