



of a bottom mirror to reflect downward emitted photons back to the nanowire tip. The researchers integrated a gold mirror at the nanowire base by transferring the

nanowires into a flexible and fully transparent polymer film and coating it with the metal by evaporation. Through this novel approach the researchers were able

to achieve a 20-fold enhanced single-photon emission flux.

Joan J. Carvajal

Nano Focus

Nanoporous carbon electrode supercapacitors store more charge by efficiently adsorbing electrolyte ions

The recent discovery that microporous carbide-derived carbon electrodes have higher capacitances than their mesoporous counterparts, and thus that they can act as supercapacitors able to store high amounts of electrical energy, has inspired an international team of researchers to investigate the origin of this phenomenon. Together with their collaborators in France, the United Kingdom, and the United States, C. Merlet, B. Rotenberg, and M. Salanne from the Université Pierre et Marie Curie in Paris sought to answer whether the increased capacitance derives from the additional surface area in the micropores, or whether the pore structure also contributes to this effect. Their findings are published in the April issue of *Nature Materials* (DOI: 10.1038/NMAT3260; p. 306).

The researchers used molecular dynamics (MD) simulations of microporous carbon and a 1-butyl-3-methylimidazolium hexafluorophosphate (BMI-PF₆) ionic liquid to develop a picture of an ionic liquid adsorbed in microporous carbon. Merlet's MD study found that the ion coordination in nanoporous electrodes was significantly different from the layered arrangement which had previously been accepted, and that the number of BMI⁺ cations coordinated around a PF₆⁻ anion was reduced inside the electrode as compared with the bulk liquid, and decreased further again on application of a positive potential to the electrode. An analogous result occurred

for the opposite coordination under applied negative potentials (see Figure). Commenting on their findings the researchers said, "The volume occupied by the liquid in the [nanoporous] electrode remains almost constant, but the ratio of numbers of ions of different charges deviates substantially from unity. . . . The charging mechanism involves the exchange of ions between the electrodes and the bulk electrolyte, and not the filling of the pores by the liquid."

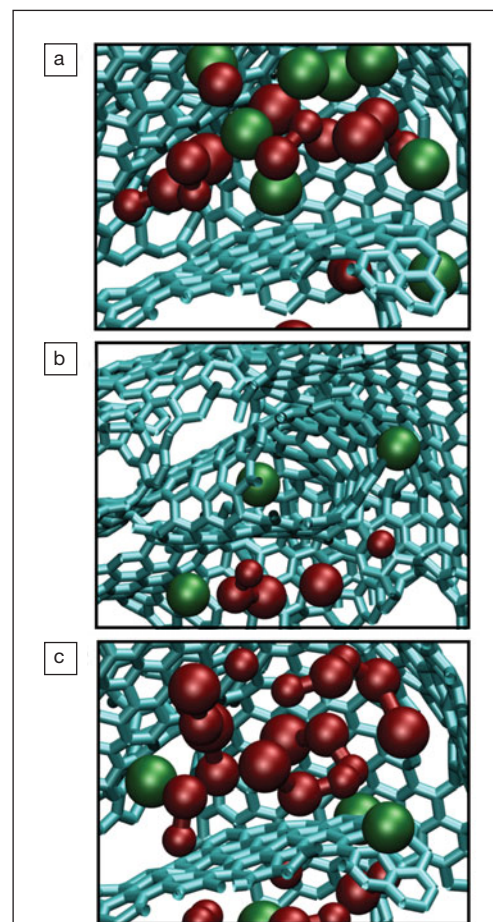
Building on this insight, comparison of simulations of nanoporous carbon with those of planar graphite revealed that the ions in the porous electrode were on average located closer to the accessible surfaces than in graphite. As capacitance is inversely proportional to the distance between opposite charges, the shorter distance would result in increased capacitance. The researchers also found that far fewer ions adsorbed onto the surface in nanoporous carbon, but that the surface of the electrode exactly balanced the charge of those adsorbed ions. The charge storage in the nanoporous electrode was therefore much more efficient, where the pores enhanced the capacitance by confining ions and preventing overscreening.

According to the researchers, further developments in electrical energy storage may also be possible, where control over pore geometries and ion size may enable the capacitance to be tailored.

Co-authors on the article are P.A. Madden of the University of Oxford; P.-L. Taberna of RS2E and Université Paul Sabatier; P. Simon of RS2E, Saba-

tier, and Institut Universitaire de France; and Y. Gogotsi of Drexel University.

Ashley Predith



The figure shows typical structures of BMI-PF₆ ionic liquid inside a realistic, nanoporous carbide-derived carbon in a molecular dynamics simulation (C-C bonds in blue, BMI⁺ cations in red, and PF₆⁻ anions in green) where (a) depicts the enhanced anion density at a +0.5 V positively polarized surface, (b) shows a PF₆⁻ anion in a +0.5V polarized cylindrical pore, and (c) shows enhanced BMI⁺ cation density at a -0.5V negatively polarized surface. Reproduced with permission from *Nature Materials* **11** (2012), DOI: 10.1038/NMAT3260; p. 306. ©2012 Macmillan Publishers Ltd.

Correction

In the March 2012 issue of *MRS Bulletin*, the following reference was omitted from the Rondinelli et al. article: E. Bousquet, M. Dawber, N. Stucki, C. Lichtensteiger, P. Hermet, S. Gariglio, J.M. Triscone, P. Ghosez, *Nature* **452**, 732 (2008). This should have been cited in place of Reference 47 on pages 263 (second citation), 268, and 269.