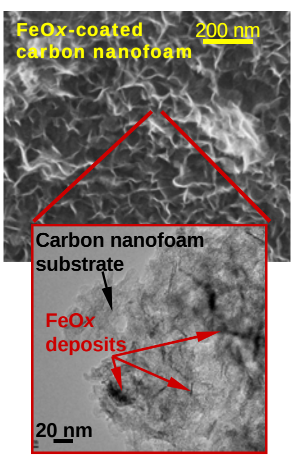
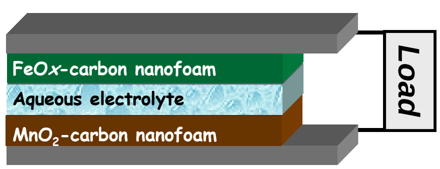
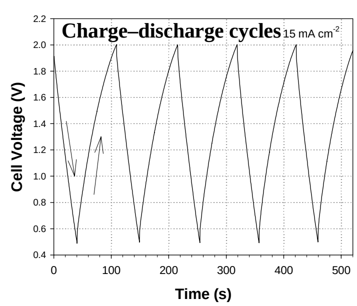
Multifunctional Electrode Nanoarchitectures for Electrochemical Capacitors

Electrochemical capacitors are a class of energy-storage devices that bridge the critical performance gap between conventional capacitors and batteries. Electrochemical capacitors are distinguished by their ability to fully charge and discharge over short time scales (on the order of seconds), and by their exceptional cycle life (tens to hundreds of thousands of cycles). In order for electrochemical capacitors to have an impact in the fields of hybrid-electric power systems, mission-fielded electronics, and sensors, the nanoscale structure and architectural design of their electrode components must be redesigned to increase energy and power density and to meet the ever decreasing dimensions of the platforms that they support. Recently, we have developed ultraporous carbon nanofoam papers whose interior structures can be decorated with ultrathin (<50 nm) coatings of a metal oxide (MnO_2 or FeO_x), using low-cost, scalable electroless deposition methods. In the resulting hybrid electrode structure, the carbon nanofoam scaffold serves as a high surface area, massively parallel 3-D current collector, facilitating long-range electron transport to the poorly conductive metal oxide coatings. The porous nature of the underlying carbon nanofoam is maintained after coating with the metal oxide, thereby allowing effective electrolyte infiltration and transport within the electrode interior, which is essential to achieve high charge–discharge rates. The nanoscale metal oxide coating serves as a charge-storage bank, facilitated by ion–electron insertion reactions involving cations from the electrolyte and electrons from the supporting carbon nanofoam structure. Such hybrid electrode structures are currently being evaluated in prototype two-volt aqueous asymmetric capacitors that deliver energy densities >10Whkg-1 and exhibit charge-discharge response times of <20s. Combining such performance metrics in a capacitor design that utilizes aqueous electrolytes will yield a class of safe, low-cost energy-storage devices with superior combinations of energy and power density that will enable emerging civilian and military applications.







A.E. Fischer, K.A Pettigrew, D.R. Rolison, R.M. Stroud, and J.W. Long, *Nano Lett.* **7**, 281–286 (2007).

Patents or other steps toward commercialization: The transition of technology resulting from this program is already underway, with a patent application and corresponding licensing agreement to develop and commercialize electrochemical capacitors based on NRL-developed materials.

Contributing Agency: DoD / NRL