Abstract: Electrochemical power sources typically use electrode constructions that blend discrete, powdered components (charge-storing phase, conductive additive, polymer binder) into ad-hoc composite structures that often limit power and energy output. We use fiber-paper-supported carbon nanofoams as a base platform for redesigning electrode architectures, where the nanofoams serve as conductive, ultraporous scaffoldings for subsequent incorporation of electroactive functionalities that store charge and/or promote electrocatalytic activity. Transition metal oxides are particularly attractive architectural additions for such purposes, and we have developed self-limiting electroless deposition protocols to generate conformal, nanoscopic coatings of manganese, iron, or ruthenium oxides on the exterior and interior surfaces of carbon nanofoams. The faradaic pseudocapacitance exhibited by these particular metal oxides amplifies the charge-storage capacity of the nanofoam by factors of 2–10, while the conformal and nanoscopic nature of the metal-oxide coating ensures rapid electrochemical turnover for high-rate capability. When MnOx–carbon and FeOx–carbon nanofoam structures are paired together as complementary electrodes (positive and negative, respectively) in asymmetric aqueous electrochemical capacitors, the device exhibits operating voltages approaching 2 V while delivering technologically relevant power and energy densities within a 1–100 s charge–discharge timeframe. We are also adapting manganese oxide-functionalized carbon nanofoam as air-breathing cathodes for alkaline Zn–air batteries, in which the nanoscopic MnOx provides not only enhanced oxygen-reduction activity but also supports intermittent pulse-power demands, via the MnOx pseudocapacitance and can provide power at rates where oxygen reduction alone is not sufficient to satisfy the demand. En route to practical power source applications, these multifunctional nanoarchitectures are also used as platforms to investigate the fundamental electrochemical processes that are critical to ultimate device performance.

Speaker: Jeffrey Long joined the U.S. Naval Research Laboratory in Washington, DC in 2000 as a staff scientist after receiving a Ph.D. from the University of North Carolina, Chapel Hill in 1997 and finishing a National Research Council postdoctoral fellowship at the NRL (1997–2000). His research focuses on the design, synthesis, and evaluation of nanostructured materials (metals, metal oxides, and carbons) and advanced electrode architectures, with the primary goal of improving the performance of electrochemical power sources (Li-ion batteries, metal–air batteries, electrochemical capacitors). During his tenure at the NRL, Jeffrey has been recognized with three Young Investigator awards (International Symposium on Aerogels, 2000; Society for Electroanalytical Chemistry, 2004; NRL-Edison Chapter of Sigma Xi, 2004), the R.A. Glenn Award from the American Chemical Society (ACS) Division of Energy & Fuels (2007), and the A.K. Doolittle Award from the ACS Division of Polymeric Materials: Science & Engineering (2009). Jeffrey is recognized as one of the leaders in the field of “electrochemical capacitor” research, serving as invited guest editor for the Spring 2008 issue of Interface, and as lead or co-organizer for several ECS symposia (past and pending) on that topic.