Nano-structured Materials for Electrical Energy and Power Storage

Summary

Battery or capacitor charged electric vehicles offer attractive alternatives for fossil fuel based transportation. Supercapacitors are energy and power storage and delivery devices with a number of desirable properties including the ability to deliver significantly more power than batteries. The UCLA group is developing new materials and materials architectures that have already demonstrated increased performance when compared with that of devices available to date.

Powering Electric Vehicles

Electric vehicles represent the next generation of power sources that will enable a transition from fossil fuels to environmental friendly alternative. Both batteries and supercapacitors are currently proposed as effective alternatives.

Supercapacitors are energy and power storage devices. While batteries and fuel cells offer large energy storage, supercapacitors are the choice when large power density is required. Capacitive storage offers a number of desirable properties: fast charging, reliability, long-term cycling and the ability to deliver significantly more power than batteries. Increased performance, expressed as the storage capacity per unit weight is the key element that has to be enhanced in order to offer effective alternative to fossil fuels.

The UCLA Supercapacitor Project: Nano-scale Materials for Enhanced Performance

The UCLA group is developing new, nano-scale materials and materials architectures that have already demonstrated increased energy and power density performance when compared to that of devices available to date.

Classes of Materials

The extremely large capacitance of supercapacitors is due to the capacitive interface between the liquid (electrolyte) and solid (electrode) parts of the devices. Supercapacitors use high surface area and electrically conducting materials as electrodes and charge collectors, and in some variants where electrochemical reactions contribute to the capacitance also employ active ingredients - again in nano-scale form. The devices make use of three main classes of materials: (1) carbon, (2) conducting polymers and (3) metal oxides.

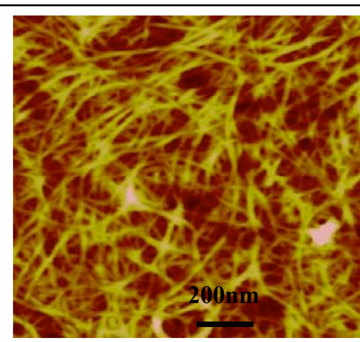

Fig.1. Nanowire network architecture. Such networks provide high surface area and high electrical conductivity, the pre-requisites for high power density.

Research and development focus

The UCLA supercapacitor group is involved in a range of research projects with the fundamental objective of ***increasing the energy and power density,*** through a combination of novel, high surface area electro-active and electrically conducting materials. Novel forms of carbon, called carbon nanotubes (CNTs) and graphene are experimented with together with various polymer, such as polyaniline, fibers and oxide materials such as TiO_2 in nano-scale form. Research to date has demonstrated that by a combination of such materials performance figures significantly exceeding that of devices currently available are feasible. Fig. 2 displays the energy and power density of conventional, commercially available devices, together with the performance figures achieved by the UCLA group.

Intellectual Property

Several patent applications that include the use of carbonaceous and oxide materials have been submitted by the group.

The UCLA Team

The team represents a cross-section of multidisciplinary R/D that is required to attack the complex problem of increased performance. It brings expertise in materials science, chemistry, physics and engineering towards a single goal. Several materials synthesis and fabrication laboratories together with a central device fabrication and testing laboratory support the overall goal of the project.

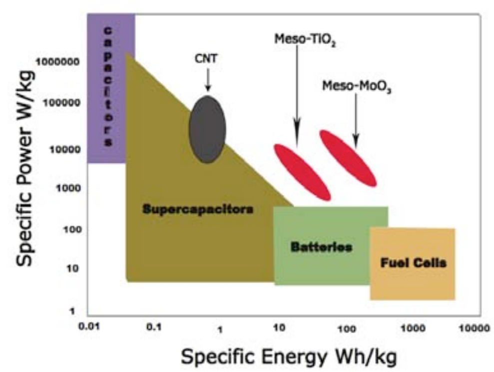

Fig.2. Supercapacitors are intermediate between batteries and capacitors in both energy and power density. The regions indicated by arrows identify the performances achieved by the UCLA group.

Team members:

Professor **Bruce Dunn** is the Nippon Sheet Glass Professor of Materials Science and Engineering. His research interests concern the synthesis of inorganic materials and characterization of their electrical, optical, and electrochemical properties. He has published some 250 papers in scientific and technical journals and has been awarded 13 patents.

Professor **George Gruner** is Distinguished Professor of Physics. His group develops novel solutions for alternative energy applications. He has published over 400 papers, and is the inventor of 30 Patents. He is one of the most highly cited physicists in the Word.

Professor **Richard Kaner** is an expert on the synthesis and investigation of solid-state materials including conducting polymer nanofibers and graphene. He has published over 180 papers and has been awarded 10 patents. He holds a joint appointment in Materials Science and Engineering and currently serves as an Associate Director of the California NanoSystems Institute.

Professor **Sarah Tolbert** is a member of the Department of Chemistry and Biochemistry. Her research focuses on the synthesis, characterization, and study of the physical properties of self-organized nanoscale materials. Professor Tolbert is the recipient of many awards, including a Sloan Foundation Research Fellowship, a Beckman Young Investigator Award, and an Office of Naval Research Young Investigator Award. Professor Tolbert has published more than 65 papers; she holds several patents and patent applications.

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