



## Electrochemical Ultracapacitors Using Graphitic Nanostacks

**Applications include cell phones and other portable consumer electronic devices, hybrid electric vehicles, automatic electronic defibrillators, and uninterruptable power supplies.**

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Electrochemical ultracapacitors (ECs) have been developed using graphitic nanostacks as the electrode material. The advantages of this technology will be the reduction of device size due to superior power densities and relative powers compared to traditional activated carbon electrodes. External testing showed that these materials display reduced discharge response times compared to state-of-the-art materials. Such applications are advantageous for pulsed power applications such as burst communications (satellites, cell phones), electromechanical actuators, and battery load leveling in electric vehicles. These carbon nanostructures are highly conductive and offer an ordered mesopore network. These attributes will provide more complete electrolyte wetting, and faster release of stored charge compared to activated carbon.

Electrochemical capacitor (EC) electrode materials were developed using commercially available nanomaterials and modifying them to exploit their energy storage properties. These materials would be an improvement over current ECs that employ activated carbon as the electrode material. Commercially avail-

able graphite nanofibers (GNFs) are used as precursor materials for the synthesis of graphitic nanostacks (GNSs). These materials offer much greater surface area than graphite flakes. Additionally, these materials offer a superior electrical conductivity and a greater average pore size compared to activated carbon electrodes.

The state of the art in EC development uses activated carbon (AC) as the electrode material. AC has a high surface area, but its small average pore size inhibits electrolyte ingress/egress. Additionally, AC has a higher resistivity, which generates parasitic heating in high-power applications. This work focuses on fabricating EC from carbon that has a very different structure by increasing the surface area of the GNF by intercalation or exfoliation of the graphitic basal planes. Additionally, various functionalities to the GNS surface will be added that can exhibit pseudocapacitance. This pseudocapacitance exhibits faradaic (charge transfer) properties that can further increase the overall relative and volumetric capacitance of the material.

A process is also proposed to use GNF as a precursor material to fabricate GNS

that will be used as EC electrodes. This results in much better electrical conductivity than activated carbon. This is advantageous for high-pulsed-power applications to reduce parasitic heating. Larger average pore size allows more complete electrolyte wetting (faster charge transfer kinetics). These properties contribute to a lowered equivalent series resistance (ESR), increased specific power, shorter charging times, and decreased parasitic heating. The high density of basal plane edges provides nucleation sites for activation (addition of hydrophilic functional groups) that facilitate electrolyte wetting, and will contribute to pseudocapacitance.

*This work was done by Christopher Marotta of Eltron Research & Development, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18787-1.*