Carbon Nanomaterials for Energy Related Applications

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This lecture will provide an overview of research activities in the area of nanostructured carbon materials with focus on nanoporous carbons for supercapacitors and other energy-related applications. Supercapacitors are devices that store electrical energy electrostatically and are used in applications where batteries cannot provide sufficient power or charge-discharge rates. Until now, their higher cost, compared to batteries with similar performance, has been limiting the use of supercapacitors in many household, automotive and other cost-sensitive applications. This presentation describes the material aspects of supercapacitor development, addresses unresolved issues and outlines future research directions.

High surface area carbon materials are widely used as supercapacitor electrodes. Extraction of metals from carbides can generate a broad range of potentially important carbon nanostructures, which range from porous carbon networks to onions and nanotubes. They are known as Carbide-Derived Carbons (CDC). The CDC structure depends on the crystal structure of the carbide precursor as well as process parameters including temperature, time and environment. Extraction of silicon, boron, aluminum, zirconium or titanium from their respective carbides by chlorine at 200-1200°C results in the formation of micro- and mesoporous carbons with the specific surface area up to 3000 m^2/g. CDC technology allows the control of carbon growth on the atomic level, monolayer by monolayer, with a high accuracy. It will be shown that the pore size to ion size ratio determines the efficiency of electrochemical energy storage systems. Design of nanoporous carbons for supercapacitor electrodes, hydrogen and methane storage, fuel cells and other applications will be addressed in this presentation.