CARBON MATERIALS MANUFACTURING

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

OVERVIEW

Carbon is a unique material that can exist in several different forms that range from the graphite used in pencil leads to the diamonds used in jewelry. The primary difference between these materials is the arrangement of individual carbon atoms and the specific types of chemical bonds that exist between these atoms. It is this arrangement of atoms and chemical bonds that gives graphite its black color and potential for use as a lubricant. The atomic arrangements and chemical bonds in diamond give rise to the material's beautiful optical luster and unsurpassed hardness. Controlling the arrangement of atoms and their chemical bonds in carbons offers unique opportunities to engineer these materials for exciting, new, high-tech applications.

MANUFACTURING HIGH-TECH CARBON PRODUCTS

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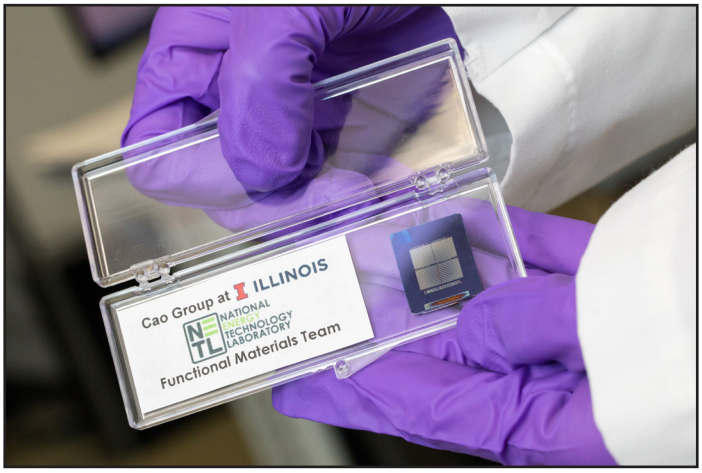
The National Energy Technology Laboratory's (NETL) Carbon Materials Manufacturing (CaMM) program is developing new methods for processing carbon and controlling the arrangement of atoms and chemical bonds that exist in these materials. NETL is using this approach to convert carbon waste from mining, industrial, and consumer activities into high-value, high-tech, carbon materials. This approach diverts coal fines, coal refuse, spent graphite, plastic waste, and other forms of carbon waste from impoundments and landfills, where they are a costly, long-term, environmental risk. They can then be inserted back into the manufacturing supply chain where they are used to make computer microelectronics, water purification membranes, batteries, supercapacitors, and many other products that are beneficial to society and our economy. Since this research approach utilizes unconventional manufacturing feedstocks and processing methods, it has resulted in new inventions and technologies that could not be realized using traditional feedstocks and processing approaches.

Current areas of research include:

- ENERGY STORAGE MATERIALS: This research effort develops high-surface area porous carbon materials with controlled morphologies and pore-size distributions in the nanometer to micron size range. These carbons are then evaluated as electrode materials for electrochemical energy storage (EES) devices, such as conventional supercapacitors, zinc-ion hybrid capacitors or next-generation metal-air and metal-sulfur batteries.
- CARBON MICROELECTRONICS: This area of research is conducted in collaboration with the University of Illinois at Urbana-Champaign (UIUC) and focuses on developing novel carbon materials that will improve the energy efficiency, miniaturization, performance, and cost of microelectronic devices in a manner that cannot be achieved with conventional semiconductor materials and manufacturing methods. Through this effort the research team has used coal fine waste to fabricate atomically thin 2D amorphous carbon films for use as the dielectric components in memristor resistive random access memory (RRAM) devices and field-effect transistors.
- GRAPHITE MANUFACTURING: This area of research utilizes coal, coal waste, waste plastics, biomass, and their blends to produce battery-grade graphite with a low-temperature, catalytic, technology that decreases processing temperatures from ~3,000 °C to ~1,500 °C and reduces processing times from several days to less than one hour. The technology produced from this effort will decrease the supply chain disruptions and price volatility associated with the offshore production of graphite and reduce the environmental footprint of producing graphite. The graphite produced from these unconventional feedstocks will be characterized and tested in a Li-ion battery so direct comparisons can be made with the current industrial practice for manufacturing battery-grade graphite.



A functional memristor computer memory device fabricated in a collaborative project between NETL and the University of Illinois at Urbana-Champaign. The atomically thin dielectric carbon film used as the switching media in this device is made from domestically sourced coal and outperforms the metal oxide films typically used for this application.

NETL is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. By leveraging its world-class talent and research facilities, NETL is ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans.

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