2019 JMR Paper of the Year: High-performance wire-shaped supercapacitor

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Video Abstract

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Abstract

The Journal of Materials Research is proud to announce the 2019 Gordon E. Pike JMR Paper of the Year Award. This award recognizes excellence in advancing materials knowledge through written scholarship. This year's honors go to a team of researchers from China and the US for their report on a new form of flexible and rechargeable supercapacitor wire, which was published in the September 14, 2019 issue of Journal of Materials Research. With the rapid growth of portable and wearable electronics, researchers face many important challenges. They're tasked with fabricating devices that are smaller, lighter, and more flexible than ever—all while delivering the same or higher levels of performance. Wire-shaped supercapacitors are among the most promising technologies developed to address these challenges. These flexible devices store and deliver energy in the form of tightly wound fibers of electrochemically active materials, such as carbon nanotubes. These flexible devices possess highly attractive properties that include low resistance, high capacitance, and long-term stability. But they also suffer from many drawbacks. One of the most prominent is their low energy density. Because most devices of this type use aqueous electrolytes, their energy density reaches only as high as water allows before it splits into oxygen and hydrogen gas. To address that limitation, this year's JMR award recipients incorporated a more robust ingredient to support their wire-shaped supercapacitor based on an ionic liquid electrolyte. Ionic liquids, or molten salts, support operating voltages more than twice that of water. Because energy density scales with the square of the operating voltage, that translates to quadruple the energy density. In their design, the team used an ionic liquid gel as a matrix for a composite yarn made of thin carbon fibers. The fibers themselves were decorated with iron-based nanosheets designed to maximize the surface available for holding and shuttling electrical charge. All of these components were wrapped within a protective aluminum sheath embedded with faceted carbon particles. Experiments showed that this coaxial wire-shaped supercapacitor possessed energy and power densities well beyond those measured for similar devices made from composite materials. Even when bent, the flexible devices retained a high specific capacitance over an operating voltage window of up to 3 V. To demonstrate the device's potential for application, the team integrated it with a mini-wind-power conversion unit. That allowed them to store natural wind energy within the wire-shaped supercapacitor and use it to power a small LED lamp. Light, flexible, and sustainable, the team's novel wire-shaped supercapacitor marks an important step forward in the design of wearable power electronics. And for that reason, the work behind its design is deserving of this year's JMR Paper of the Year Award.