Electronics/Computers

Nanocomposite Photoelectrochemical Cells

Efficiencies greater than those of state-of-the-art cells are predicted.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved, solid-state photoelectrochemical cells for converting solar radiation to electricity have been proposed. (In general, photoelectrochemical cells convert incident light to electricity through electrochemical reactions.) It is predicted that in comparison with state-of-the-art photoelectrochemical cells, these cells will be found to operate with greater solar-to-electric energy-conversion efficiencies.

The proposed cells could be fabricated by layering nanocomposites of active particles with organic binders on flexible polymer substrates. Each cell would contain a dye-sensitized semiconductor electrode, a proton-conducting solid electrolyte, and a solid-state proton-intercalation counter electrode. By designing the cells to rely on protons as the charge carriers, it should be possible to enable the cells to sustain rates of transport and concentrations of charge carriers greater than those of state-of-the-art photoelectrochemical cells designed to rely on hole conduction and organic semiconductors. The proposed cell configuration is expected to minimize the incidence of recombination of holes and electrons, thereby minimizing the energy losses associated with them and thereby, further, contributing to greater energy-conversion efficiencies.

This work was done by Sri R. Narayan, Andrew Kindler, and Jay F. Whitacre of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Ultracapacitor-Powered Cordless Drill

Whereas charging of batteries usually take hours, ultracapacitors can be charged in seconds.

John H. Glenn Research Center, Cleveland, Ohio

The figure depicts a portable, handheld power drill with its attached power-supply unit, in which ultracapacitors, rather than batteries, are used to store energy. This ultracapacitor-powered drill is a product of continuing efforts to develop the technological discipline known as hybrid power management (HPM), which is oriented toward integration of diverse electric energy-generating, energy-storing, and energy-consuming devices in optimal configurations.

Instances of HPM were reported in several prior *NASA Tech Briefs* articles, though not explicitly labeled as HPM except in the most recent such article, which was "Hybrid Power Management" (LEW-17520-1), Vol. 29, No. 12 (December 2005), page 35. To recapitulate from that article: The use of ultracapacitors as energy-storage devices lies at the heart of HPM. An ultracapacitor is an electrochemical energy-storage device, but unlike in a conventional rechargeable electrochemical cell or battery, chemical reactions do not take place during operation. Instead, energy is stored electrostatically at an electrode/electrolyte interface. The capacitance per unit volume of an ultracapacitor is much greater than that of a conventional capacitor because its electrodes have much greater surface area per unit volume and the separation between the electrodes is much smaller.

HPM offers many advantages over the conventional power-management approach in which batteries are used to store energy. To place the present development in context, it is necessary to reiterate these advantages from the cited previous article:

- Power-control circuits for ultracapacitors can be simpler than those for batteries for two reasons: (1) Because of the absence of chemical reactions, charge and discharge currents can be greater than those in batteries, limited only by the electrical resistances of conductors; and (2) Whereas the charge level of a battery depends on voltage, temperature, age, and load condition, the charge level of an ultracapacitor, like that of a conventional capacitor, depends only on voltage.
- Whereas a typical battery can be charged and discharged about 300 times, an ultracapacitor can be charged and discharged more than a million times. The longer lifetimes of ultracapacitors contribute to reliability.
- The longer lifetimes of ultracapacitors greatly reduce life-of-system costs, including the indirect costs of maintenance and downtime.
- The longer lifetimes of ultracapacitors reduce adverse environmental effects, inasmuch as it will probably never be necessary to replace and dispose of ultracapacitors in most applications, whereas batteries must be replaced frequently.
- Disposal problems and the associated contributions to life-of-system costs can be reduced because the chemical constituents of ultracapacitors are less toxic and less environmentally harmful than are those of batteries. Indeed, ultracapacitors are somewhat recyclable.