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Engineering three-dimensional hybrid supercapacitors and microsupercapacitors for high-performance integrated energy storage

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Significance

Batteries run just about everything portable in our lives such as smartphones, tablets, computers, etc. Although we have become accustomed to the rapid improvement of portable electronics, the slow development of batteries is holding back technological progress. Thus, it is imperative to develop new energy storage devices that are compact, reliable, and energy dense, charge quickly, and possess both long cycle life and calendar life. Here, we developed hybrid supercapacitors that can store as much charge as a lead acid battery, yet they can be recharged in seconds compared with hours for conventional batteries.

Abstract

Supercapacitors now play an important role in the progress of hybrid and electric vehicles, consumer electronics, and military and space applications. There is a growing demand in developing hybrid supercapacitor systems to overcome the energy density limitations of the current generation of carbon-based supercapacitors. Here, we demonstrate 3D high-performance hybrid supercapacitors and microsupercapacitors based on graphene and MnO_2 by rationally designing the electrode microstructure and combining active materials with electrolytes that operate at high voltages. This results in hybrid electrodes with ultrahigh volumetric capacitance of over 1,100 F/cm^3. This corresponds to a specific capacitance of the constituent MnO_2 of 1,145 F/g, which is close to the theoretical value of 1,380 F/g. The energy density of the full device varies between 22 and 42 Wh/l depending on the device configuration, which is superior to those of commercially available double-layer supercapacitors, pseudocapacitors, lithium-ion capacitors, and hybrid supercapacitors tested under the same conditions and is comparable to that of lead acid batteries. These hybrid supercapacitors use aqueous electrolytes and are assembled in air without the need for expensive "dry rooms" required for building today's supercapacitors. Furthermore, we demonstrate a simple technique for the fabrication of supercapacitor arrays for high-voltage applications. These arrays can be integrated with solar cells for efficient energy harvesting and storage systems.

supercapacitor | microsupercapacitor | graphene | metal oxide

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Footnotes

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