

What are supercapacitors made of

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Supercapacitors are categorized into three distinct types:

What is a supercapacitor and how does it work?

Figure 1: Illustration of double layer formation and electric potential distribution in one electrode of a charged supercapacitor. (Image is in the public domain)

The double-layer mechanism implies that the amount of charge stored per unit voltage (i.e., the capacitance) is proportional to the interfacial area of the electrodes. Thus, supercapacitor electrodes tend to be made from extremely porous materials whose surface areas can be in excess of 1000 m² (about one-fifth the size of a football field) per gram of material.

*Some specially designed supercapacitors, called pseudocapacitors, may also store charge via rapid redox reactions that do not result in any phase transition of the electrode material. (See page on pseudocapacitance.) Pseudocapacitors offer energy densities around 30 Wh/kg, better than supercapacitors based only on double-layer capacitance but still much less than lithium-ion batteries.[3]Figure 2: Plot of gravimetric (mass-based) power density versus energy density for various capacitor and battery technologies. Source: Wikimedia Commons, user Shaddim (CC by-SA 3.0)

Because of their robustness and fast mechanism for storing and releasing charge, supercapacitors are ideally suited for applications that require high power (a large current delivered in a short time) over many cycles. As one example, they can recover energy from the repetitive braking of automobiles or trains, which would normally be wasted as heat.[4,5] Other examples are cold startup of large diesel engines, radar pulses, and energy storage for solar-powered LED streetlights.[6–8]

Supercapacitors can also act as a power buffer, mitigating the effects of high peaks and brief interruptions of current. They have been used as backup power supplies for computer memory modules and pitch control system in wind turbine actuators.[9,10] In addition, they have been proposed as buffers for the high pulse power that is drawn by some electric vehicles while charging, which would otherwise reduce the efficiency of the grid.[11]

[1] J. Bird, Electrical Circuit Theory and Technology, Routledge, 2014.

[2] A.K. Singh, D. Sarkar, G.G. Khan, K. Mandal, Unique hydrogenated Ni/NiO core/shell 1D nano-heterostructures with superior electrochemical performance as supercapacitors, Journal of Materials Chemistry A. 1 (2013) 12759. doi:10.1039/c3ta12736b.

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[3] H.D. Abruna, Y. Kiya, J.C. Henderson, Batteries and electrochemical capacitors, *Physics Today*. 61 (2008) 43–47. doi:10.1063/1.3047681.

[4] P. Weissler, Mazda introduces supercapacitor-type regenerative braking – SAE International, (2013). (accessed June 15, 2016).

[6] H. Liu, Z. Wang, S. Qiao, Y. Liu, Improvement of engine cold start capability using supercapacitor and lead-acid battery hybrid, in: *Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition*, 2008. APEC 2008, 2008: pp. 668–675. doi:10.1109/APEC.2008.4522793.

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