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Communication

# Flexible asymmetric supercapacitor based on $MnO_2$ honeycomb structure

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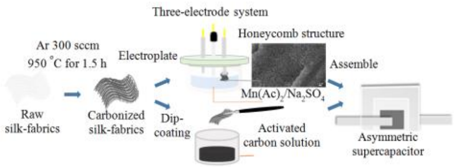
## Graphical Abstract




By controlling the electroplating time of solution containing $Mn(Ac)_2$, the $MnO_2$ nanosheets were self-assembled to the honeycomb structure and showed an excellent electrochemical performance in 1 mol/L $Na_2SO_4$ electrolyte. *Via* pairing with activated carbon as negative electrode, the capacitor could deliver a maximum energy density of 43.84 Wh/kg and a maximum power density of 6.62 kW/kg.

*ABSTRACT*
A flexible asymmetric supercapacitor with high energy density was constructed by using a flexible substrate of carbonized silk-fabrics decorated with carbon nanotube, electroplating $MnO_2$ nanosheets and dip-coating activated carbon powders as the positive and the negative electrodes, respectively. By controlling the electroplating time, the $MnO_2$ nanosheets can be self-assembled to honeycomb structure and showed excellent electrochemical performance in 1 mol/L $Na_2SO_4$ electrolyte with SC950-EP30 performing the best. It exhibited a high specific capacitance (1110.85 F/g at a current density of 1 A/g based on the mass of $MnO_2$) and superior rate capability (77.44% capacity retention from 1 A/g to 10 A/g). Thus, the optimal asymmetric device assembled with this material as positive electrode can deliver a maximum energy density of 43.84 Wh/kg and a maximum power density of 6.62 kW/kg.

*Keywords:Electroplating Self-assembling nanosheets Honeycomb structure $MnO_2$ Asymmetric supercapacitors High energy density*

With the accelerating consumption of fossil fuel and the rapid growth of the global population, energy storage and energy transformation have become an urgent topic in the modern society [1]. Supercapacitors appear as potential candidates for energy storage system since they exhibit many desirable properties such as rapid charge/discharge rate, high power density and superior cyclic stability [2,3]. Besides that, due to the rapid development of portable and wearable electronic industries in recent years, the demands for flexible storage devices have greatly increased [4-6]. Therefore, the research needs of flexible supercapacitors devices have also been created [7].

According to the energy storage mechanisms, supercapacitors can be mainly categorized into two types: Electric double-layer capacitors (EDLCs) and pseudocapacitors [8]. EDLCs store energy through the electrostatic charge adsorbing at the interface between electrode and electrolyte, while pseudocapacitors store energy through fast faradaic redox reaction [9]. Due to only electrostatic reaction concerned in the EDLCs, EDLCs usually exhibit excellent power density [10-12]. On the other hand, pseudocapacitors usually exhibit higher energy density [6,13,14].

How to further increase energy density is a core issue of developing supercapacitors since the energy density of supercapacitors is generally less than 10 Wh/kg [1,15,16]. Based on the equation of energy density ($E$) for supercapacitors: $E = CV^2/2$ [17,18], which indicates that the energy density can be improved by widening the potential window ($V$). One way to increase the potential window is