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Three-Dimensional Carbon Foam Based Asymmetric Assembly of Metal Oxides Electrodes for High-Performance Solid-State Micro-Supercapacitor

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Abstract : Micro-supercapacitors hold great attention as one of the promising energy storage devices satisfying the increasing quest for miniaturized and portable devices. Despite having impressive power density, superior cyclic lifetime, and high charge-discharge rates, micro-supercapacitors still suffer from low energy density, which limits their practical application. The energy density ($E=1/2CV^2$) can be increased either by increasing specific capacitance (C) or voltage range (V). Asymmetric micro-supercapacitors have attracted great attention by using two different electrode materials to expand the voltage window and thus increase the energy density. Currently, versatile fabrication technologies such as inkjet printing, lithography, laser scribing, etc., are used to directly or indirectly pattern the electrode material; these techniques still suffer from scalable production and cost inefficiency. Here, we demonstrate the scalable production of a three-dimensional (3D) carbon foam (CF) based asymmetric micro-supercapacitor by spray printing technique on an array of interdigital electrodes. The solid-state asymmetric micro-supercapacitor comprised of CF-MnO positive electrode and CF-Fe_2O_3 negative electrode achieves a high areal capacitance of 18.4 mF/cm² (2326.8 mF/cm³) at 5 mV/s and a wider potential window of 1.4 V. Consequently, a superior energy density of 5 µWh/cm² is obtained, and high cyclic stability is confirmed with retention of the initial capacitance by 86.1% after 10000 electrochemical cycles. The optimized decoration of pseudocapacitive metal oxides in the 3D carbon network helps in high electrochemical utilization of materials where the 3D interconnected network of carbon provides overall electrical conductivity and structural integrity. The research provides a simple and scalable spray printing method to fabricate an asymmetric micro-supercapacitor using a custom-made mask that can be integrated on a large scale.

Keywords : asymmetric micro-supercapacitors, high energy-density, hybrid materials, three-dimensional carbon-foam
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