Self-standing MoS2/CNT and MnO2/CNT one dimensional core shell heterostructures for asymmetric supercapacitors application

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Recently, two-dimensional layered nanostructures, specially MoS_2 (molybdenum disulfide) has come out as the most investigated electrode material for batteries and supercapacitors, possessing well preserved in-plane covalent bonding, leading to extraordinary mechanical elasticity within the layers as well as outstanding firmness along the c-axis. We have synthesized vertically aligned edge exposed molybdenum disulfide nanoflakes onto free standing carbon nanotubes sheet as an efficient negative electrode material. Functionalization of carbon nanotubes with metal oxides or chalcogenides is rather a complicated practice due to the superhydrophobic nature of these films. The inherit hydrophilicity and controlled chirality of carbon nanotubes makes them an ideal candidate for heterostructured electrode material synthesis. Moreover, their self-standing nature allows them to function both as the active material, as well as highly conductive current collector. For positive electrode, MnO_2 (manganese oxide) nanoparticles loaded CNTs have been fabricated, owing to the work function contrast between MoS_2 and MnO_2, in order to utilize the maximum potential window in our asymmetric design. Both the electrodes, developed using a unique combination of chemical and physical deposition techniques, form hierarchical core-shell heterostructure consisting of large number of edge-exposed catalytic sites available for electrode-electrolyte interaction. The electrodes were first tested in a three-electrode configuration, found to have very high areal capacitance of 0.41 and 0.6 F/cm^2 and at a scan rate of 10 mV/sec in 1M Na_2SO_4 system for MoS_2-CNT and MnO_2-CNT, respectively. MoS_2-CNT electrode depicted purely electrostatic polarization in the voltage range of -0.6 to 0.2 V, whereas MnO_2-CNT electrode also displayed non-faradaic charge storage in the range of 0 to 1 V. Next, the device was fabricated and tested in a wide potential range of 0.8 to 1 V, with the calculated areal capacitance and volumetric capacitance of 820 mF/cm^2 and 4.2 F/cm^2, respectively, at the scan rate of 10 mV/s. Moreover, the device showed a capacitance retention of ~97.2 % in 2000 cycles, displaying extremely robust nature, with high coulombic efficiency of 92%..

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