Doctoral Dissertation Defense Announcement

HYBRID SUPERCAPACITOR ELECTRODES BASED ON TRANSITION METAL OXIDE/GRAPHENE/3D-POROUS NICKEL ARCHITECTURE

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December 7, 2021; 1.00 PM – 3.00 PM (CST)

Zoom: https://uh-edu-cougarnet.zoom.us/j/92444398347

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ABSTRACT

The research on reliable and high-performance electrode materials for hybrid supercapacitor applications have been evolving ever since the demand for fast and portable energy storage solutions began. Even though, transition metal oxides like Manganese Oxide, Iron Oxide and Cobalt Oxide have a very high theoretical specific capacitance value, they fail to perform well if used by themselves as active material in the electrodes because of their poor electron transport properties and low active surface area per unit volume of the electrode. Electrodes made of carbon-based composites of these transition metal oxides on a highly porous materials are believed to be a viable candidate to overcome those limitations. In our work, we developed a nanoporous 3D architecture of Nickel as a substrate and combined it with graphene-based composites of transition metal oxides. The developed structure allows us to have a humongous active surface area per unit volume, and the involvement of graphene in the process improves the electronic transport properties of the electrode. Electrodeposition is used to deposit transition metal oxides like MnO_2, Co_3O_4, and Fe_2O_3 on the developed substrates as active material for the supercapacitors. Our electrode-making process is very simple and environmentally friendly as we do not use any biding materials in the process. The device assembled using the electrodes made of the developed hybrid structure exhibits a very good specific capacitance taking us a step closer to their theoretical capacity and a very high durability with capacity retention. The device based on MnO_2 electrodes with graphene exhibited a specific capacitance of 341 F/g, whereas the electrodes without graphene had a specific capacitance of 242 F/g. The supercapacitor retained more than 98% of its original capacity even after 5000 cycles of charging and discharging. The device assembled with Co_3O_4 as the active material exhibited a specific capacitance of 1237 F/g and good capacity retention. The Fe_2O_3 based devices had a specific capacity of 297 F/g when assembled as a symmetrical supercapacitor and individual specific capacitance of 435 F/g. The assembled devices are very thin and also flexible making them an excellent candidate for energy storage in portable and flexible electronics applications.