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Sulfur-Doped Graphene as a Rational Anode for an Ionic Liquid Based Hybrid Capacitor with a 3.5 V Working Window

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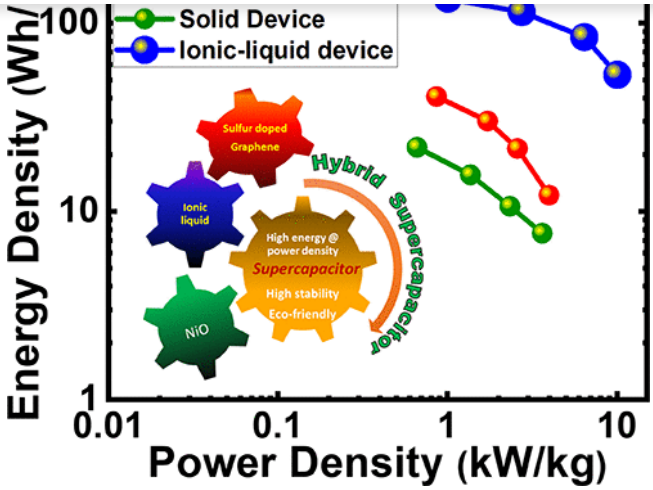

In this work, the facile thermal annealing of graphene oxide in a H_2S atmosphere was used to obtain sulfur-doped graphene (SG) for anode materials for supercapacitors. The high electrical conductivity and the interconnected micro-pore structure of the SG electrode assisted in the fast transportation of electrons and ions at the electrode–electrolyte interface in the developed hybrid supercapacitors. The SG-based electrode resulted in an excellent specific capacitance of 460 F/g at 1 A/g. The nickel oxide could be obtained by a simple hydrothermal method, exhibiting a specific capacitance of 1236 F/g in 1 M KOH. The fabricated solid-state hybrid devices (Ss-HSCs) showed a high energy density of 21.8 Wh/kg at 661.7 W/kg power density with substantial cycling stability up to 89.0% over 1000 cycles in the PVA-KOH solid electrolyte. Considering pragmatic usages in heavy-duty appliances and hybrid vehicles, we fabricated quasi-solid-state ionic liquid BMIM-PF_6/DMF based hybrid supercapacitors (Iq-HSCs) that were operated at 3.5 V. The Iq-HSC devices were capable of delivering 134.6 Wh/kg of the energy density at 1005.7 W/kg and the high power density with 69.3% capacitance retention over 1000 cycles.