Vertically Aligned 1D Boron Doped Diamond Nanostructures for Electrochemical Supercapacitors

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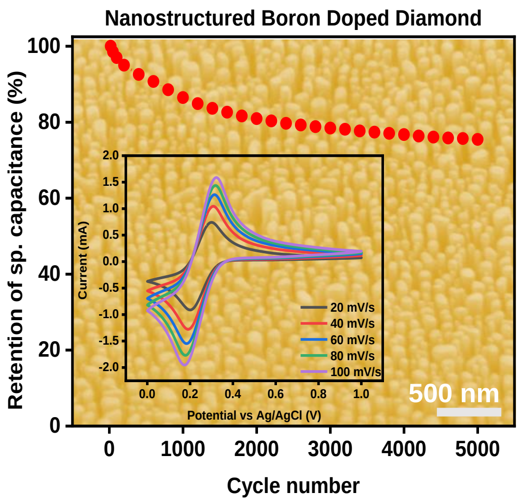
The escalating demand for high-performance compact energy storage (ES) systems has increased the need to design an efficient electrode material with high energy density and long cycle life. Electrodes with high electrical conductivity, large ion-accessible area, large specific capacitance and good mechanical robustness are suitable for electrochemically stable ES devices, especially electrical double-layer capacitors (EDLC). In recent years, extensive studies have been done on boron-doped diamond (BDD) supercapacitors as they possess mechanical and chemical stability even in harsh environments and a wide electrochemical potential window.



In the present work, BDD films of microcrystalline diamond films ($BMCD_F$) have been studied along with their corresponding 1D nanostructures ($BMCD_{NS}$). The nanostructures were fabricated using Au nanodots as a mask using the reactive ion etching technique. The influence of the nanostructures is directly reflected in the electrochemical properties of BDD. The $BMCD_{NS}$ sample shows a specific capacitance (C_s) value of 14.49 mF/cm^2 at a current density of 0.33 mA/cm^2 in 0.05M $K_3[Fe(CN)_6]$ contained in 1M Na_2SO_4 aqueous solution (AS) with a loss of only 19% in C_s after 5000 charge-discharge cycles. Such robust nature of the material can be attributed to the 1D nanostructures, boron doping and induction of sp^2-graphitic grain boundaries, which enhance the electron conduction and the interaction area, in turn enhancing the EDLC value and lifetime stability of the ES system. These results indicate that the nanostructured boron-doped diamond materials will pave the future for next-generation electrochemical supercapacitors.