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Diamond Nanowires Decorated with Metal Layers for Supercapacitors

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Supercapacitors have attracted intensive attention because of the increasing global demand for alternative energy sources. In order to enhance the energy storage of a capacitor, pseudocapacitive materials such as metal oxide/hydroxide and polymers are often used [1]. However, to find a highly stable and conductive electrode with high surface area is still challenging for the super-capacitors applications.

Boron-doped diamond has been well acknowledged to be an excellent electrode material due to its metallic conductivity, high overpotential for hydrogen/oxygen evolution and long-term stability. Moreover, diamond nanowires (NWs) array fabricated through a top-down method have proved to be capable of providing a surface enhancement of 10-80 times compared with planar electrodes[2]. Therefore, diamond NWs array is a potential electrode material for supercapacitor applications.

In this presentation, we introduce for the first time to use Pt particles coated diamond nanowires (NWs) as pseudocapacitive material. Diamond NWs array was fabricated by inductance coupled plasma (ICP) etching with metal nanoparticles as etching mask. Then a thin layer Pt (<5 nm) was deposited on the nanowires by sputtering. The morphology of these Pt-diamond core-shell wires were characterized by high resolution SEM. Electrochemical measurements disclosed that a working potential window of 1.4 V was obtained for these wires even in aqueous solution. A capacitance of 627.7 F/g and an energy density of 170.8 Wh/kg were realized at a charging current 2.33 A/g with a Pt film thickness less than 1 nm. Also, for large charging current as high as 233 A/g, the capacitance still maintains a high value at 324 F/g with a power density of 163.2 kW/kg (NOTE: only the mass of Pt was taken into account). This is because for Pt not only the surface oxidation/reduction contributes to the pseudocapacitance, but also the chemisorption of hydrogen atoms stores extra charge. Moreover, unlike traditional pseudocapacitors with bulk material for energy storage, the redox reaction on Pt only happens at the surface which enables fast charging/discharging of the device. The relation between film thickness and device performance was studied in detail. Ni film was fabricated in the same way as an alternative material for this technique. The capacitance of the Ni metal layer coated diamond NWs in electrolyte systems will be studied and compared with those from Pt metal layer coated diamond NWs. The capacitance of these systems in ionic liquid will be investigated as well.

[1] H.L. Wang, H.S. Casalongue, Y.Y. Liang, H.J. Dai, $Ni(OH)_2$ Nanoplates grown on graphene as advanced electrochemical pseudocapacitor materials, *Journal of the American Chemical Society*, **2010**, *132* , 7472-7477.
[2] W. Smirnov, A. Kriele, N. Yang, C.E. Nebel, Aligned diamond nano-wires: Fabrication and characterisation for advanced applications in bio- and electrochemistry, *Diamond and Related Materials*, **2010**, *19*, 186-189.