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Growth and plasma functionalization of carbon nanotubes for supercapacitor applications

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Owing to their high performance in supercapacitive and other devices, carbon nanotube-based electrodes are being extensively studied. In order to improve current energy and power density values, as well as enhance cycling stability, surface functionalization and growth process of carbon nanotubes need to be optimized.

Vertically aligned carbon nanotubes (VACNTs) have been grown by plasma enhanced chemical vapor deposition (PECVD) on different substrates. Usually, VACNTs are grown on non-metallic substrates, which are disadvantageous to reduce the equivalent series resistance (ESR) and increase the power density. Growth of VACNTs on metallic substrates is possible by pre-treating the substrate surface and using intermediate layers between substrate and nanotubes. In this way, adhesion of the VACNTs is improved and the growth is more homogeneous.

Modification of VACNTs by surface specific treatments as well as by MnO_2 electrodeposition, allows tailoring of CNTs physico-chemical properties and the enhancement of the electrochemical performance. Oxygen, nitrogen and water plasma treatments are used to decorate the CNTs with desired functional groups such as hydroxyl, carboxyl, pyridinic or pyrrolic. As a consequence of the treatment, the surface area increases and the electrodes become hydrophilic, which is suitable for electrochemical, biological, and environmental applications.

Both plasma treatments and manganese dioxide electrodeposition improves the specific capacitance of the CNTs. CNTs/MnO_2 nanocomposite show high specific capacitance values of up to 750 Fg^{-1} at 10 mVs^{-1} scan rate. Charge-discharge cycling of the VACNTs electrodes show a higher stability for the plasma treated CNTs (up to 8000 cycles) than for the CNTs/MnO_2 nanocomposite electrodes (about 1000 cycles).

Keywords: vertically aligned carbon nanotubes; plasma treatment; plasma CVD; adhesion; manganese dioxide