Multifunctional electrodes based on MWNTs sheets and yarns

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ABSTRACT

Nanostructured multiwalled carbon nanotube (MWNTs)–polymer based electrodes exhibiting high electrical conductivity and high surface area shown to be ideal candidates for use as electrodes in electronically driven applications as actuators and supercapacitors.

Keywords: carbon nanotube, actuator, supercapacitor.

1 INTRODUCTION

Solid-state fabricated carbon MWNTs sheets[1] and yarns[2] exhibit very high electrochemically accessible surface area, which combined with their high electronic conductivity and useful mechanical properties make these materials attractive candidates for supercapacitor and artificial muscle applications. In this study we demonstrate the capacity of MWNTs yarns and sheets to store and release energy. MWNTs sheet electrodes were fabricated and assembled into solid-state devices, by employing a phosphoric acid/polyvinyl alcohol mixture as the polyelectrolyte. Using various device configurations, various sheet densities and polyelectrolyte/polymer/water concentration ratios were tested to determine the principal parameters affecting the formation of the electrochemical double−layer between the surface of the MWNTs and the polyelectrolyte. Electrode capacitances of between 50 and 200 F/g were obtained for these solid-state supercapacitors.

2 MATERIALS AND METHODS

Transparent nanotube sheets were drawn from a side of multiwalled nanotube (MWNT) forest that were synthesized by catalytic chemical vapor deposition, using acetylene gas as the carbon source[1]. The MWNTs were ~ 10 nm in diameter, and the range of investigated forest heights and areal densities were 70–300 µm and 0.7–1.6 µg/cm^2, respectively. MWNT yarns are formed by twisting the sheets during the spinning process. The direction of drawing was orthogonal to the vertical MWNTs on the forest.

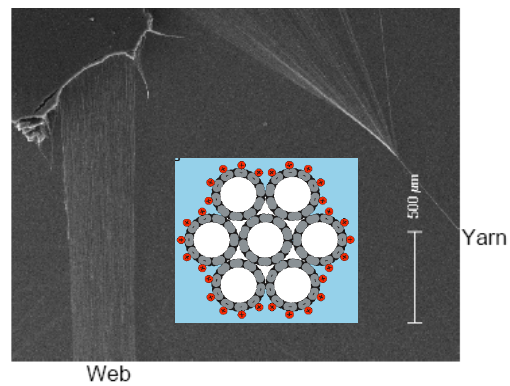

Fig. 1. MWNTs sheets and yarns being draw from a forest. The inset illustrates charge injection at the surface of MWNTs bundle, which is balanced by the pictures surface layer of electrolyte cations.

The MWNTs and polyvinyl alcohol−based electrodes were prepared by solution casting from an aqueous suspension of polymer and phosphoric acid. Electrodes made of yarns or sheets were mounted on top of two metal−pins (current collectors) and then on a polytetrafluoethylene (PTFE) mold in which the polyelectrolyte was poured and dried overnight at room temperature. Cyclic−Voltametry curves, electrical impedance and galvanostatic charge/discharge testing were carried out. CV curves were scanned at voltage ramp rates between 1 and 500 mV per second. Capacitance values were calculated from the CV curves by dividing the current by the voltage scan rate. Specific capacitance values reported are the capacitance for the carbon material based electrode (sheet or yarn) per gram of MWNTs on the electrode.

3 RESULTS AND DISCUSSION.

Figure 2 shows the CV curves that were obtained for a MWNTs sheet electrode. As it can be observed the CV curves are nearly rectangular evidencing optimum charge propagation within the carbon nanotubes electrodes. Another indication of the good charge propagation was the low variation of specific capacitance for increasing voltage scan rates.

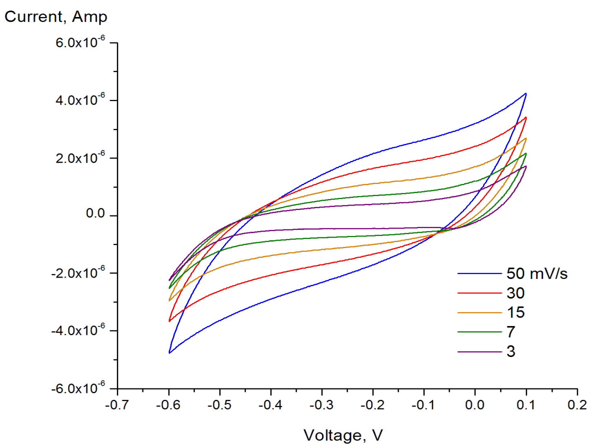

Fig. 2. Cyclic voltammograms showing the performance of a MWNTs sheet solid–state supercapacitor as a function of scan rate.

The specific capacitance of the MWNTs solid state–based electrodes was between 50 and 220 F/g in the voltage range from -0.8 to 0.2 V. The results confirm that MWNTs electrodes have good electrical conductivity and very promising charge storage. These properties besides with the already evidenced mechanical properties[1,2] suggest that these new materials could be used as multifunctional electrodes in electromecanical devices (actuators) and supercapacitors.

References

1. Mei Zhang *et al*. *Science*, 309, 2005.

2. Mei Zhang *et al*. *Science*, 306, 2004.