Carbon Nanotube Anodes for Lithium Ion Batteries

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Highly purified single-wall carbon nanotubes (SWCNT's) were investigated as anode materials for thin film lithium ion batteries. High purity SWCNT's were obtained through chemical refinement of soot generated by pulsed laser ablation. The purity of the nanotubes was determined using Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), and UV/Vis Spectrophotometry. Anodes were prepared by casting thin films of SWCNT's dispersed in polyvinylidiene (PVDF) and polyacrylonitrile (PAN) onto copper and stainless steel, respectively. Cyclic voltammetry and lithium capacity measurements were made using a standard 3-electrode cell.

Figure 1 shows an SEM of SWCNT bundles produced by laser vaporization of a graphite target. Purified SWCNT's showed a single sharp TGA transition that began at approximately 600°C. The surface area of SWCNT's is exceptionally high compared to that of other conventional anode materials (i.e., carbon black, graphite, and multi-walled carbon nanotubes). Nitrogen adsorption with Brunauer, Emmett, and Teller (BET) analysis was used to determine surface area of various anode materials (see Table 1).[1] SWCNT's exhibited a surface area that was greater than 915 m^2/g, which is approximately 400 times that of graphite. Accordingly, it may be reasoned that SWCNT's will offer a more accessible structure for Li intercalation.

Initial cyclic voltammetry results from the SWCNT-doped thin films showed well-defined lithium deposition and stripping peaks. There was also evidence of "staging" similar to other carbonaceous materials.

Figure 2 shows the voltage change verses time for a SWCNT/PVDF anode when both charged and discharged at 20μA between 0.02 and 2.0 V. This sample showed a large initial charge, indicative of the creation of a lithium electrolyte interface which is commonly seen in lithium ion batteries. The calculated capacity based on the charge and discharge times showed excellent reversibility after the initial cycle (see Figure 3). Tested SWCNT/polymer thin film anodes had a Li capacity over 1300 mAh/g after 30 charge-discharge cycles. The factors that optimize Li capacity will be presented and discussed, as will SWCNT concentration effects on the electrochemical and physical properties of the anode.

[1] Personal communication, J. Maranchi, P. Kumta, Carnegie-Mellon University, 4309 Wean Hall, Pittsburgh, PA, 15213.

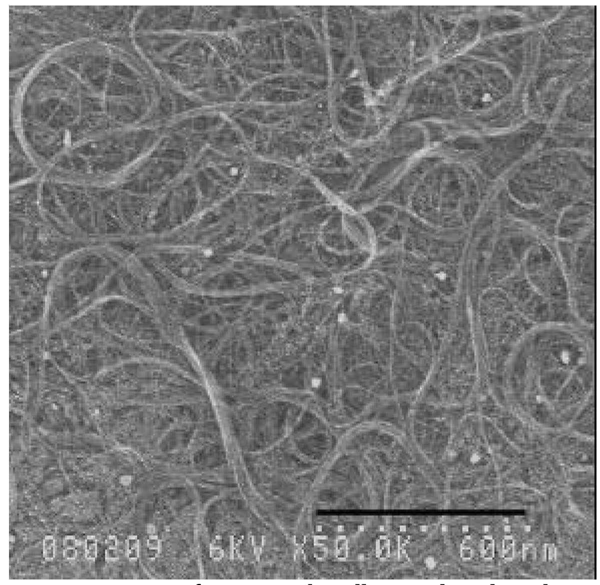

Figure 1: SEM of SWCNT bundles produced via laser vaporization.

Sample	Specific Surface Area (m^2/g)
Superior Graphite	2.76
Commercial Nanotubes	4.30
Alpha/Aesar Carbon Black	84.31
Un-purified Laser Vaporization Soot	225.26
High Purity SWCNT's	915.75

Table 1: BET surface area measurement results.

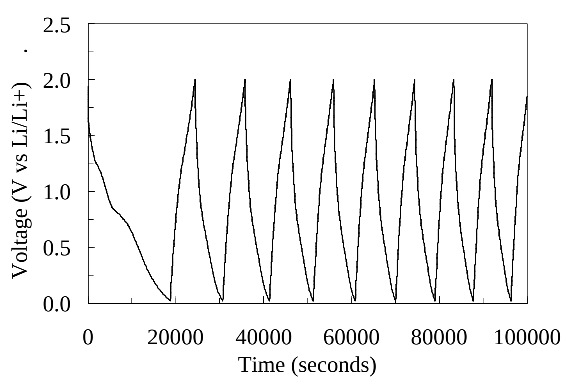

Figure 2: Galvanostatic cycling of high purity SWCNT/ polymer films on copper.

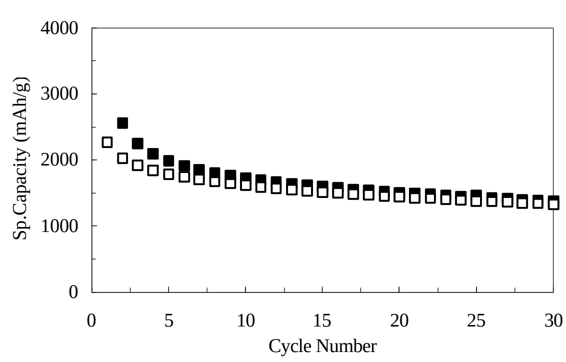

Figure 3: High purity SWCNT anode capacity versus cycling number.