Structural Characterization of Carbon Nanotubes and Their Anode Performance

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Lithium ion batteries (LIBs) are being used in many electronic devices from cell phones to laptop computers. In present, high power LIBs with an upgraded high performance (e.g., a large capacity, good rate capability and long cycle life) are critically needed for their widespread uses in light electronic portable devices and hybrid electric vehicles. Within this background, nanostructured materials including carbon nanotubes have been examined as a potential electrode material in LIBs because of their low dimensionality and excellent physicochemical properties. In this study, I have carried out systematic structural characterizations on various types of nanocarbons (e.g., HiPco-based single walled carbon nanotubes, carbon black and thick multi-walled carbon nanotubes), and then evaluated their electrochemical performance in related with their microtexture.

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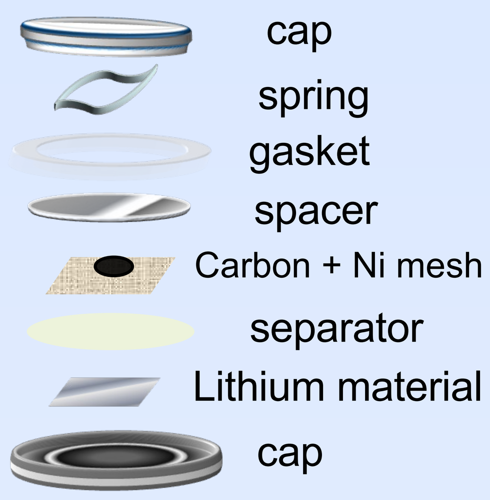
Introduction

Lithium ion batteries (LIBs) are being used in many electronic devices from cell phones to laptop computers. In present, high power LIBs with an upgraded high performance (e.g., a large capacity, good rate capability and long cycle life) are critically needed for their widespread uses in light electronic portable devices and hybrid electric vehicles.

Purpose

To evaluate the electrochemical performance of carbon nanotubes in relation with their microtexture

LIB component



Materials used

HiPco SWNT - High Pressure Carbon monoxide Single Walled Nanotube (dia. = 1 nm)
Thin MWNT – Multi-walled Carbon Nanotubes (dia. = 50 nm)
Thick MWNT – Vapor grown Carbon Fiber (dia = 100nm)

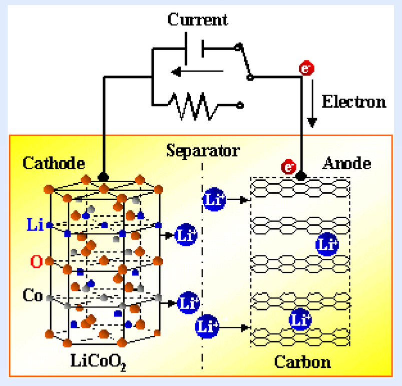
Setup

Make electrodes → Dry electrodes for 24 hours → Make batteries → Run 5 cycles

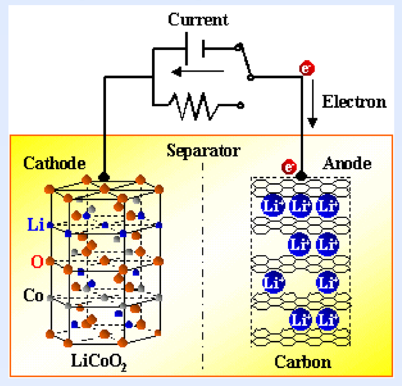
Current Rate: 30 mA/g
Electrolyte: $LiClO_4$ dissolved in mixed EL/EC

1 cycle = charge and discharge of LIB battery

How it Works

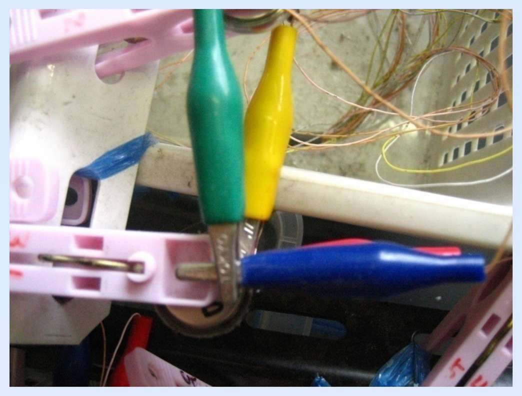


charge



discharge

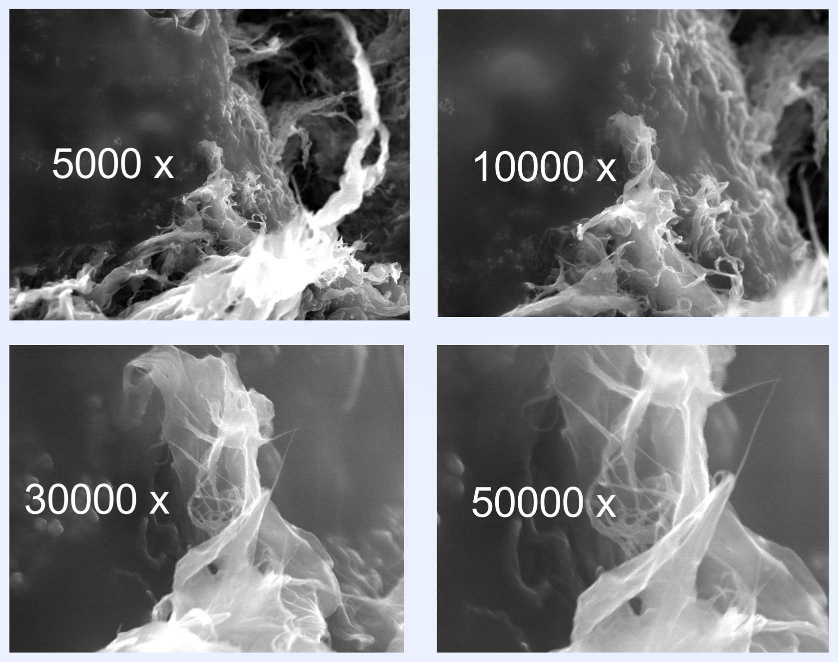
Setup



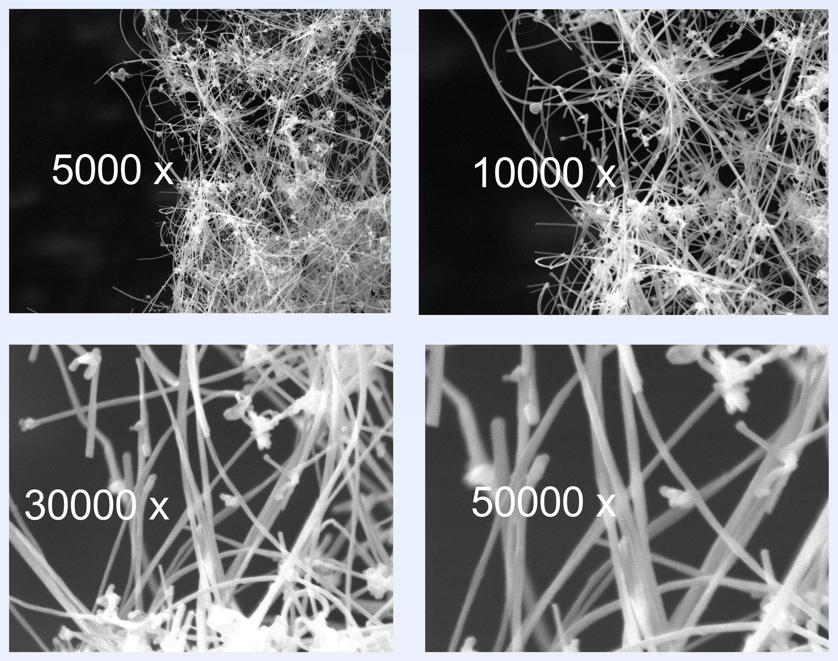
The setup to run discharge cycles

The glove box used to make the batteries

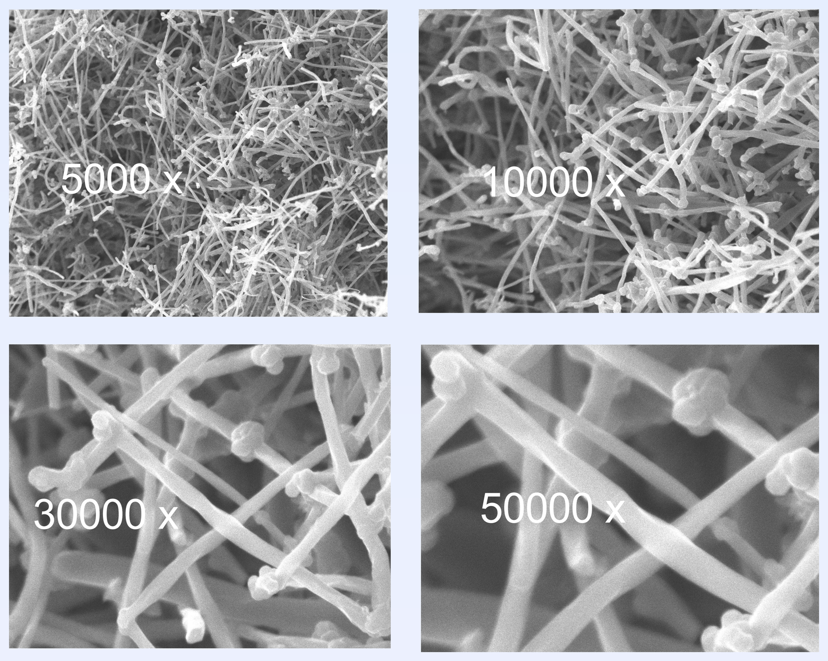
HiPco SWNT



Thin MWNT

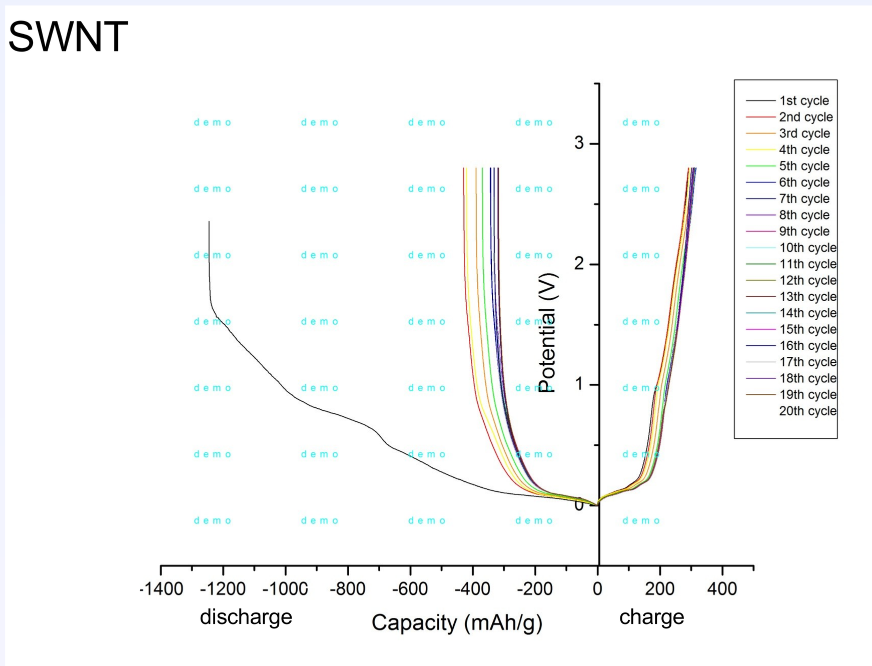


Thick MWNT

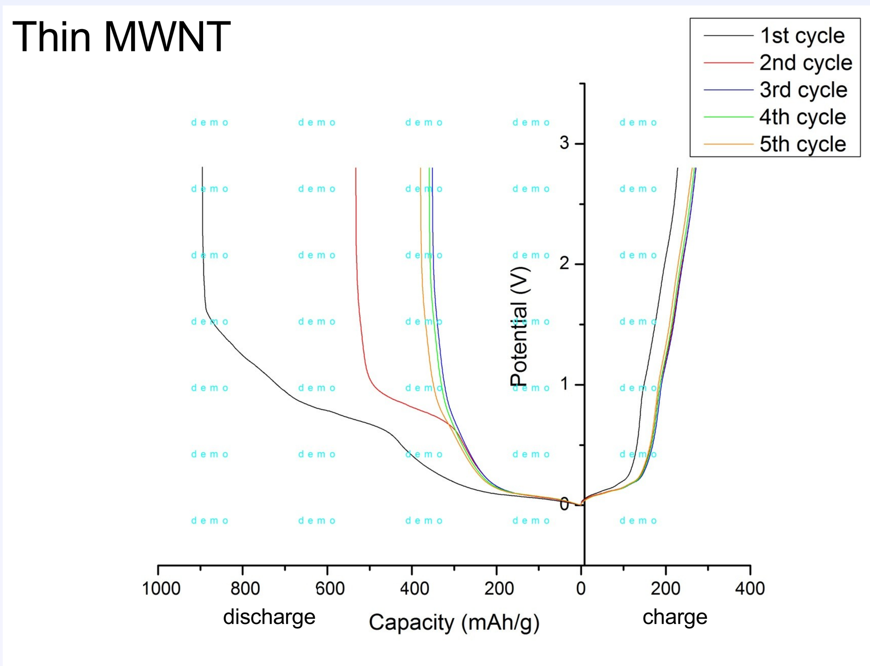


Results

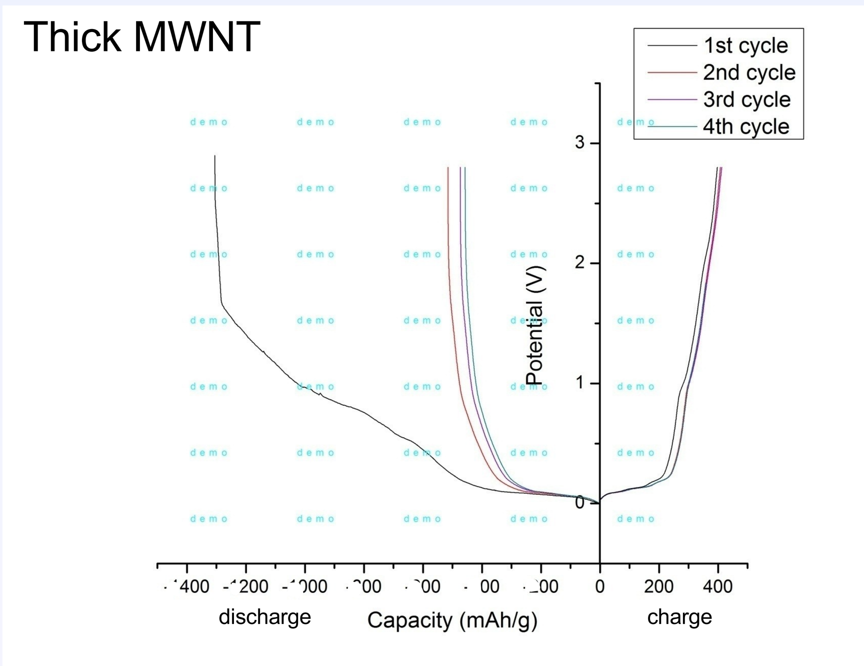
SWNT



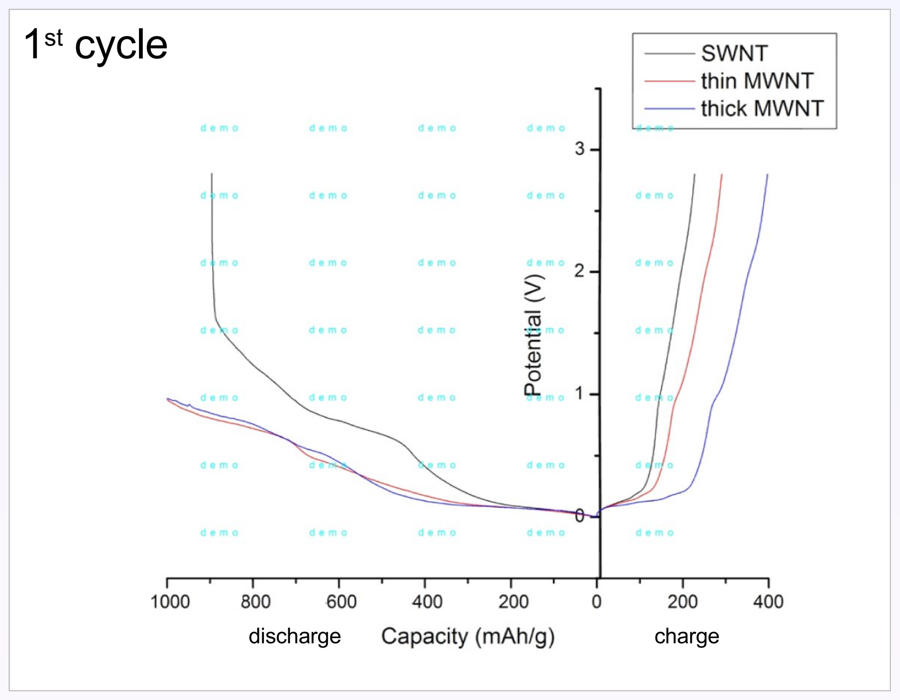
Thin MWNT



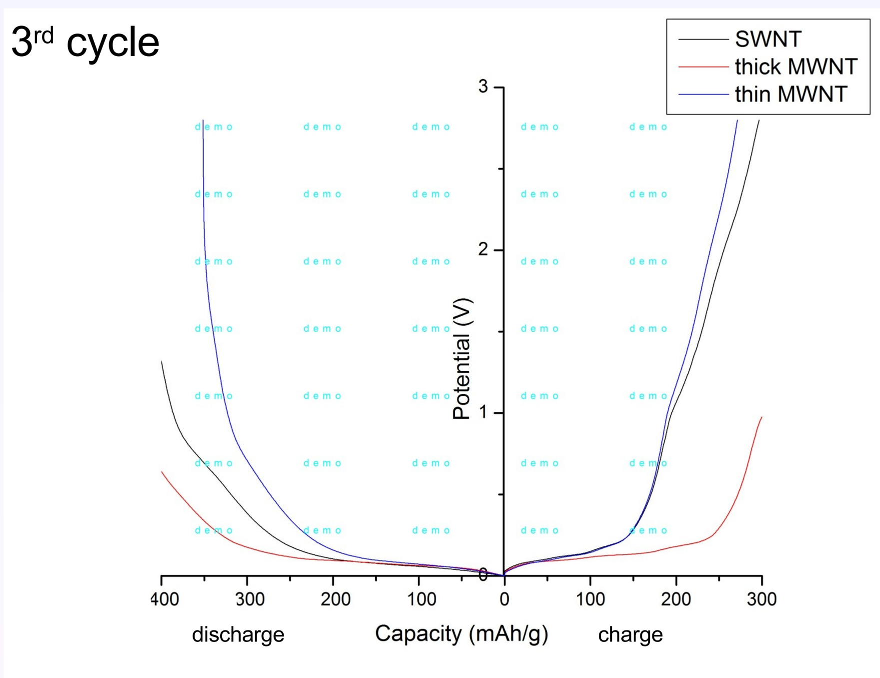
Thick MWNT



1st cycle



3rd cycle



Summary and Discussion

We have studied the dependence of electrochemical behaviors for three different types of carbon nanotubes, single walled carbon nanotubes (SWNTs) (diameter = 1nm), thin (diameter = 50 nm) and thick (diameter = 100nm) multi-walled carbon nanotubes (MWNTs).

As shown in charge and discharge profiles, SWNTs exhibited quite different electrochemical behaviors compared to those of thin and thick MWNTs.

It is noteworthy that thin and thick MWNTs, prepared by the catalytic chemical vapor deposition and the subsequent high-temperature thermal treatment in argon, are chemically inert and highly crystalline. However, as-purified SWNTs are expected to have high chemical activity due to their large surface area.

These structural differences is directly reflected to the solid electrolyte interphase (SEI) formation.

It is expected that the controlled surface of carbon nanotubes will be key factor to use as potential anode material or conductive filler in lithium ion batteries.

Conclusion

We have found that electrochemical behaviors of carbon nanotubes are strongly depending on their microtexture. In order to use them as anode material or conductive filler in lithium ion batteries, the surface properties of carbon nanotubes should be controlled via post-treatment such as high-temperature thermal treatment.

Acknowledgments

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