University of Nevada, Reno

Nanotube Li-ion Battery Technology

Titanium Manganese (TiMn) fluoro-oxide Nanotube, Lithium-ion (Li-ion) Battery

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Background:
UNR's Lithium-ion (Li-ion) battery uses advanced titanium-manganese (TiMn) fluror-oxide nanotube technology to produce a more stable, higher capacity battery as compared with conventional Li-ion solutions. Li-ion batteries have become the worldwide battery of choice leading to rapid growth in the Li-ion battery market. These batteries can be formed into custom shapes and sizes, have no memory effect, possess an extremely low self-discharge rate, and are able to operate at more extreme temperatures. The application of nanotechnology to Li-ion development is providing the economies of scale to make Li-ion technology even more viable in the marketplace, especially for larger scale projects.

In the past, the Li-ion market was dominated by the portable electronics market. Newer developing markets include applications for the electric car, storage capacity for renewable energy, military and aerospace applications. The total U.S. market for Li-ion batteries in 2008 was $911 million and is estimated to reach $9.1 billion by 2015.[1] In addition, a public-private alliance in the U.S., dubbed the National Alliance for Advanced Transportation Battery Cell Manufacture, has been created to help stimulate U.S. solutions for the worldwide battery market. UNR seeks a development partner to help commercialize this technology.

[1] Power Electronics Market Research, Jan 2009

Benefits & Advantages Include:

- Solves the problem associated with limited Lithium flow due to deposit build-up, a characteristic of carbon-based batteries which inhibits or impedes Li flow and reduces battery performance.
- Nanotube structure leads to greatly enhanced surface reaction area and a more efficient and productive battery.
- Significantly more stable than those made with conventional technologies that are prone to overheating.
- Initial capacity tests using TiMn reveal specific capacity ranges from 1200-1500 mAh/g.
- Long-term capacity after stabilization has shown to be 1,000 mAh/g, more than tripling the industry standard of 300 mAh/g.

Intellectual Property:
Self-Ordered Nanotubes of Titanium Oxides and Titanium Alloy Oxides for Energy Storage and Battery Applications
Technology Transfer ID:
UNR07-011

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Li-ion Battery Technology Overview

The high energy and high power Li-ion battery technology developed by the University of Nevada, Reno is based on a patent pending self-ordered nanotubular materials technology. The vertically oriented, thin-walled, and self-organized Ti-Mn fluoro-oxide nanotubes offer several advantages over conventional graphite anode materials.

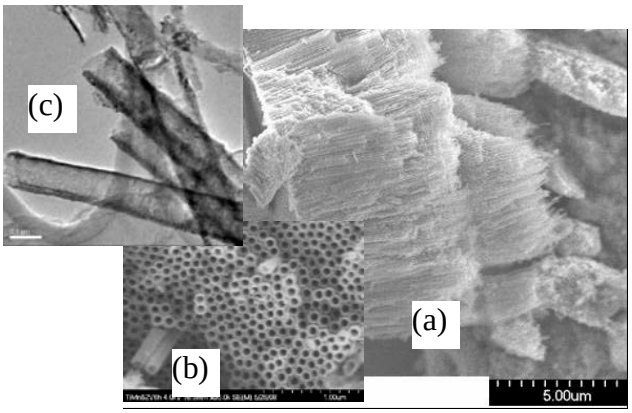


Fig. 1 Electron microscopic images of the nanotubes. (a) side view showing length of the nanotubes,; (b) top view of the nanotubes; and (c) HRTEM image of the nanotubes.

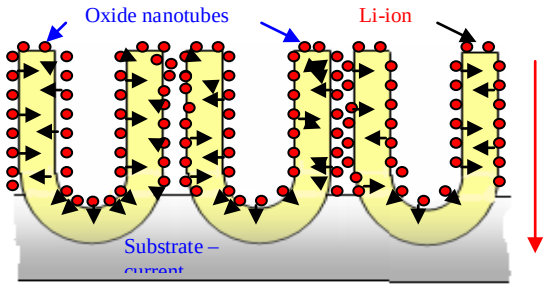
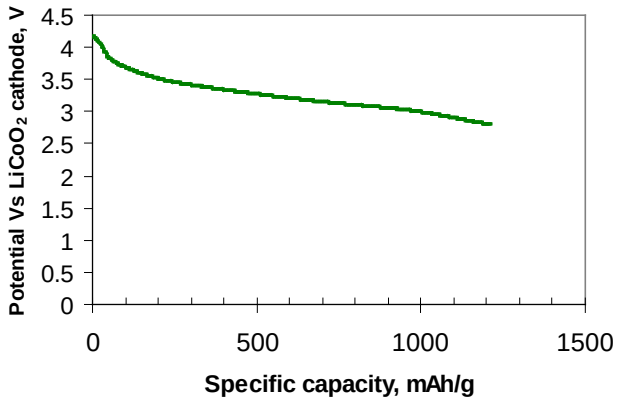
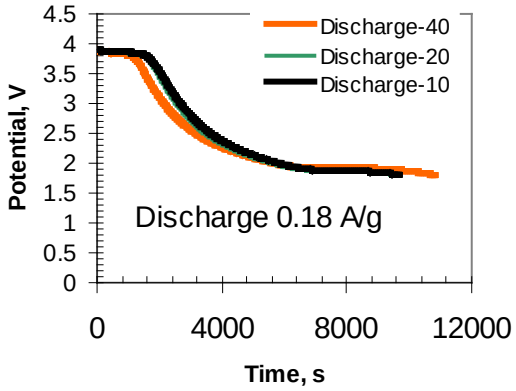


Fig. 2 Schematic illustration of intercalation of the Li-ions in the walls of the nanotubes. Vertical orientation and thinner nanotube walls ensure faster and more complete intercalation than that occur in the conventional materials

The UNR's technology is capable of providing high power in continuous discharge modes. Individual cells can be integrated as a module to provide high energy and high power.





Company	Anode Material	Reversible specific capacity, mAh/g	Diffusivity, cm^2/s	Specific energy, Wh/kg	Maximum Power, W/kg
.	Graphite	230 (1 C)*		160	**1800**
EnerDel	$Li_4Ti_5O_{12}$	< 200	#10^{-14} – 10^{-12}	NA	**NA**
Altair Nano	Nano TiO_2	# 140-170 (2 C)	#10^{-14} – 10^{-12}	NA	**NA**
UNR	Ordered arrays of Ti-Mn oxide nanotubes	> 600 (1 C)* > 280 (17 C)*	5 x 10^{-11}*	> 1200* (1C) > 500 (17 C)	7000 -9000

* laboratory measured values

Benefits: High specific energy and power, Fast re-charge, Light weight, No memory effect, Long cycle life, and Safe and Reliable.

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