Lithium Ion Battery Anodes

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Uses of Li-Ion Batteries

Li-Ion batteries – with sales at over $3 billion / yr and growing at nearly 10% / yr– are the battery of choice for many consumer applications.

The next big market to 'go lithium' is transportation. With the advent of HEV's and PHEV's the need for Li-Ion batteries will go up significantly. Toyota has already announced the Gen3 Prius (2009 Model) will be Li-ion powered with a projected mileage of 95-113 mpg.

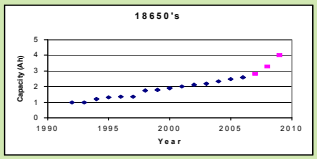
Lithium Ion Batteries have three basic components – an (1) anode, (2)cathode, and (3) electrolyte

<u>State of the Art</u> – Graphite anode, Li(Ni,Co,Mn)O_2 cathode, 1M LiPF6 in organic carbonates electrolyte

What's WRONG with Graphite?

Not much…for now.

As portable power energy demands increase – manufacturers are looking for new ways to squeeze more 'stuff' into a standard size battery case. Most increases over the past decade have come from engineering and design improvements – most use the same cell chemistry.



Increase in 18650 capacity over time. (Data points after 2006 are Samsung projections.)

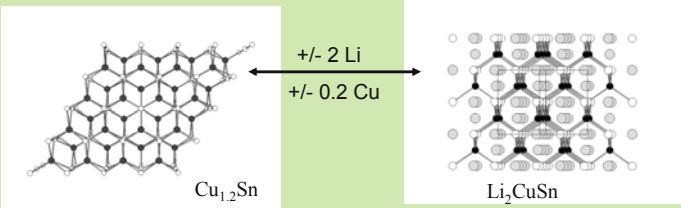
Graphitic anodes have several drawbacks that open up the window for alternative materials

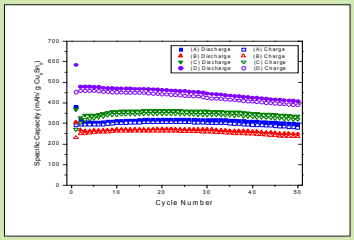
- Insertion voltage is close to lithium potential – abuse tolerance issues from Li-plating
- Density is lower than competing technologies = lower volumetric capacity
- Capacity is lower than some up and coming materials.
- Some applications require better power capability

Alternative Anodes to Graphite

The Cu_6Sn_5 / Li system

The NiAs-type Cu_6Sn_5 ($Cu_{1.2}Sn$) has 0.8 interstitial holes/formula unit. As lithium is inserted but before it reaches this limit, the structure re-arranges to form a 'stuffed diamond' type structure.



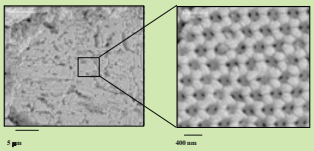


Electrochemical evaluation of several Cu_6Sn_5-type materials

The $Li_4Ti_5O_{12}$ / Li system

Flat working potential of ~1.5 V vs. Li+/Li°, ~175 mAh/g. Higher insertion voltage puts it outside the normal range of electrolyte decomposition (~ 0.9 V) – however low intrinsic electrical conductivity hinders power capability.

In collaboration with Northwestern University , we made and evaluated $Li_4Ti_5O_{12}$ using an opal-templating process. The resulting material was very porous while maintaining strength and electrical contacts. The short diffusion lengths increased rate capability compared to the bulk material by a significant amount.



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