Lithium iron phosphate battery

From Wikipedia, the free encyclopedia

The **lithium iron phosphate ($LiFePO_4$) battery** (also designated "LFP") is a type of rechargeable battery, specifically a lithium ion battery, which uses $LiFePO_4$ as a cathode material.

Battery specifications	
Energy/weight	90-110 Wh/kg
Energy/size	220 Wh/L
Power/weight	>3000 W/Kg
Energy/consumer-price	$1.50 US$/Wh
Time durability	>10 years
Cycle durability	2000 cycles
Nominal Cell Voltage	3.3 V

Contents

History

$LiFePO_4$ was discovered by John Goodenough's research group at the University of Texas in 1996[1],[2] as a cathode material for rechargeable lithium batteries. Because of its low cost, non-toxicity, the high abundance of iron, its excellent thermal stability, safety characteristics, good electrochemical performance, and high specific capacity (170 mA·h/g) it gained some market acceptance.[3][4]

The key barrier to commercialization was its intrinsically low electrical conductivity. This problem, however, was then overcome partly by reducing the particle size and effectively coating the $LiFePO_4$ particles with conductive materials such as carbon, and partly by employing the doping[3] approaches developed by Yet-Ming Chiang and his coworkers at MIT using cations of materials such as aluminum, niobium, and zirconium. It was later shown that most of the conductivity improvement was due to the presence of nanoscopic carbon originating from organic precursors.[5] Products using the carbonized and doped nanophosphate materials developed by Chiang are now in high volume mass production by A123Systems and other companies, and are used in industrial products by major corporations including Black and Decker's DeWalt brand, General Motors' Chevrolet Volt, Daimler, Cessna and BAE Systems.

Most lithium-ion batteries (Li-ion) used in consumer electronics products are lithium cobalt oxide batteries ($LiCoO_2$). Other varieties of lithium-ion batteries include lithium-manganese oxide ($LiMn_2O_4$) and lithium-nickel oxide ($LiNiO_2$). The batteries are named after the material used for their cathodes; the anodes are generally made of carbon and a wide variety of electrolytes are used.

Advantages and disadvantages

The $LiFePO_4$ battery uses a lithium-ion-derived chemistry and shares many of its advantages and disadvantages with other lithium ion battery chemistries. The key advantages for $LiFePO_4$ are the safety (resistance to thermal runaway) and the high current or peak-power rating. Cost is claimed to be a major difference as well, but, that cannot be verified until the cells are more widely used in the marketplace.

LFP batteries have some drawbacks:

1. The specific energy (energy/volume) of a new LFP battery is somewhat lower than that of a new $LiCoO_2$ battery. Battery manufacturers across the world are currently working to find ways to maximize the energy storage performance and reduce size & weight.[6]
2. Brand new LFP's have been found to fail prematurely if they are "deep cycled" (discharged below 33% level) too early. A break-in period of 20 charging cycles is currently recommended by some distributors.
3. Rapid charging will shorten lithium-ion battery (including LFP) life-span when compared to traditional trickle charging.
4. The lithium reserves are estimated at 30,000 tonnes in 2015[7].

While $LiFePO_4$ cells have lower voltage and energy density than normal, $LiCoO_2$ Li-ion cells, this disadvantage is offset over time by the slower rate of capacity loss (aka greater calendar-life) of $LiFePO_4$ when compared with other lithium-ion battery chemistries (such as $LiCoO_2$ "cobalt" or $LiMn_2O_4$ "manganese spinel" based Lithium-ion polymer batteries or Lithium-ion batteries).[8][9] For example:

- After one year of use, a $LiFePO_4$ cell typically has approximately the same energy density as a normal, $LiCoO_2$ Li-ion cell.
- Beyond one year of use, a $LiFePO_4$ cell is likely to have *higher* energy density than a normal, $LiCoO_2$ Li-ion cell due to the differences in their respective calendar-lives.

Specifications

- Cell voltage = Min. discharge voltage = 2.8V. Working voltage = 3.0V to 3.3V. Max. charge voltage = 3.6V.
- Volumetric Energy density = 220 Wh/L
- Gravimetric Energy Density = 90 Wh/kg [1] (http://jcwinnie.biz/wordpress/?p=2823)
- Deep cycle life = ? (Number of Deep cycles to 66% of capacity)
- 80% Cycle life = 2000 (Number of cycles using 80% of rated capacity)
- Cathode Composition (weight)
  - 90% C-LiFePO4, grade Phos-Dev-12
  - 5% Carbon EBN-10-10 (Superior Graphite)
  - 5% PVDF
- Cell Configuration
  - Carbon-Coated Aluminum current collector 15
  - 1.54 cm^2 cathode
  - Electrolyte: EC-DMC 1-1 LiClO4 1M
  - Anode: Metallic lithium
- Experimental conditions:
  - Room temperature
  - Voltage limits: 2.5 – 4.2V
  - Charge: C/4 up to 4.2V, then potentiostatic at 4.2V until I <C/24

Safety

$LiFePO_4$ is an intrinsically safer cathode material than $LiCoO_2$ and manganese spinel. The Fe-P-O bond is stronger than the Co-O bond, so that when abused, (short-circuited, overheated, etc.) the oxygen atoms are much harder to remove. This stabilization of the redox energies also helps fast ion migration. Only under extreme heating (generally over 800 °C) does breakdown occur and this bond stability greatly reduces the risk of thermal runaway when compared with $LiCoO_2$.

As lithium migrates out of the cathode in a $LiCoO_2$ cell, the CoO_2 undergoes non-linear expansion that affects the structural integrity of the cell. The fully lithiated and unlithiated states of $LiFePO_4$ are structurally similar which means that $LiFePO_4$ cells are more structurally stable than $LiCoO_2$ cells.

No lithium remains in the cathode of a fully charged $LiFePO_4$ cell — in a $LiCoO_2$ cell, approximately 50% remains in the cathode. $LiFePO_4$ is highly resilient during oxygen loss, which typically results in an exothermic reaction in other lithium cells.[4]

Usage

LFP batteries were featured on the November 5, 2008 episode of *Prototype This!*. They were used as the power source for a hexapod (walking) vehicle. Lithium Technology Corp. announced in May 2007, that they had developed a new Lithium Iron Phosphate battery with cells large enough for use in hybrid cars, claiming they are "the largest cells of their kind in the world."[10]. While they may be large enough for such uses, there remain limitations to the use of this particular Lithium battery technology which may make their use contraindicated. See Advantage and Disadvantages above for details.

Thundersky LiFePO4 batteries have become the most popular lithium-ion batteries used in hobbyist electric vehicle (EV) conversions since they are relatively inexpensive and easily obtainable from retail sources.

This battery is used in the electric car made by Aptera http://www.engadget.com/2009/02/03/aptera-unveils-full-specs-for-its-flagship-2e/#comments

This type of battery technology is used on the One Laptop per Child (OLPC) project [11].

Segway Personal Transporters advanced from a 10 mile range to a 24 mile range with Valence Lithium Phosphate technology.

OLPC batteries are manufactured by BYD Company of Shenzhen, China, the world's largest producer of Li-ion batteries. BYD, also a car manufacturer, plans to use its Lithium Iron Phosphate batteries to power its PHEV, the F3DM and F6DM (Dual Mode), which will be the first commercial dual-mode electric car in the world. It plans to mass produce the cars in 2009.[12]

Manufacturers

- A123Systems
- BYD Company[12]
- LifeBATT, Inc. Nevada, USA (http://www.lifebatt.com)
- Valence Technology - makes lithium phosphate battery modules
- Video example of Valence Batteries in an electric delivery van (http://www.relevantminded.com /relevant_mindedcom/2008/10/video-of-smith.html)
- Tradwin Hongkong International(Distributor) (http://www.tradwinhk.com)
- Lithium Technology Corporation

- FalconEV (http://www.falconev.com)

References

1. ^ "$LiFePO_4$: A Novel Cathode Material for Rechargeable Batteries", A.K. Padhi, K.S. Nanjundaswamy, J.B. Goodenough, Electrochimical Society Meeting Abstracts, **96-1**, May, 1996, pp 73
2. ^ *Phospho-olivines as positive-electrode materials for rechargeable lithium batteries", A.K. Padhi, K.S. Nanjundaswamy and J.B. Goodenough, J. Electrochem. Soc., 144, 1188-1194 (1997).*. http://scitation.aip.org /getabs/servlet/GetabsServlet?prog=normal&id=JESOAN000144000004001188000001&idtype=cvips&gifs=yes.
3. ^ [a] [b] "Bigger, Cheaper, Safer Batteries: New material charges up lithium-ion battery work" (html). http://www.sciencenews.org/articles/20020928/fob4.asp. sciencenews.org
4. ^ [a] [b] (html)*Building safer Li ion batteries*. http://www.houseofbatteries.com/librarydetail.asp?articleid=11. houseofbatteries.com
5. ^ *N. Ravet, A. Abouimrane, and M. Armand, Nat. Mater., 2, 702 ~2003*.
6. ^ Guo, Y.; Hu, J.; Wan, L. Nanostructured Materials for Electrochemical Energy Conversion and Storage Devices. Adv Mater 2008, 20, 2878-2887
7. ^ Pag4.- The trouble with lithium (http://www.meridian-int-res.com/Projects/Lithium_Microscope.pdf)
8. ^ A123Systems (http://www.rc-netbutik.dk/getdoc.asp?id=100& md5hash=9810C237586CF6B4325753101E37DAE1) "...Current test projecting excellent calendar life: 17% impedance growth and 23% capacity loss in 15 [fifteen!] years at 100% SOC, 60 deg. C..."
9. ^ How to prolong lithium-based batteries (http://www.batteryuniversity.com/parttwo-34.htm) "...The speed by which lithium-ion ages is governed by temperature and state-of-charge. Figure 1 illustrates the capacity loss as a function of these two parameters...
   25°C...[100% State of charge]...80% after 1 year
   40°C...[100% State of charge]...65% after 1 year ..."
10. ^ "Next Generation Battery Technology Makes Hybrid and Electric Vehicles a Reality" (html). http://www.lithiumtech.com/pr51407.htm. lithiumtech.com
11. ^ "Laptop With a Mission Widens Its Audience". New York Times. http://www.nytimes.com/2007/10 /04/technology/circuits/04pogue.html. Retrieved on 2007-10-04. $LiFePO_4$ used in OLPC nytimes.com
12. ^ [a] [b] China Daily 2008-12-16 08:13 "BYD zooms past Toyota, GM in electric car race" (http://www.chinadaily.com.cn/bizchina/2008-12/16/content_7308809.htm)

Retrieved from "http://en.wikipedia.org/wiki/Lithium_iron_phosphate_battery"
Categories: Lithium-ion batteries
Hidden categories: All articles with unsourced statements | Articles with unsourced statements | Articles with unsourced statements since March 2009 | Articles with unsourced statements since September 2008