# Seek Production Expertise During Li-ion Cells Selection

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From a modest start in 1990, lithium-ion cell production has mushroomed into a multibillion-units-per-year industry with manufacturing facilities spread all over the world. Because of the potential for dangerous thermal-related incidents during the manufacture and use of Li-ion cells, extreme care must be taken during the manufacturing processes to produce high-quality cells that are as safe as possible.

All Li-ion cells are not the same. They vary widely depending on technology, form factors, cell manufacturer and, most important, how they are manufactured. (To illustrate the differences between Li-ion batteries and other chemistries, Nexergy has created the accompanying chart to help customers visualize how different battery chemistries apply. Refer to the accompanying chart.) The process controls that are implemented in a factory have a profound effect on the quality, safety and reliability of Li-ion cells. The cell qualification process must include an audit of the cell-manufacturing lines as well as electrical and mechanical testing of multiple production lots.

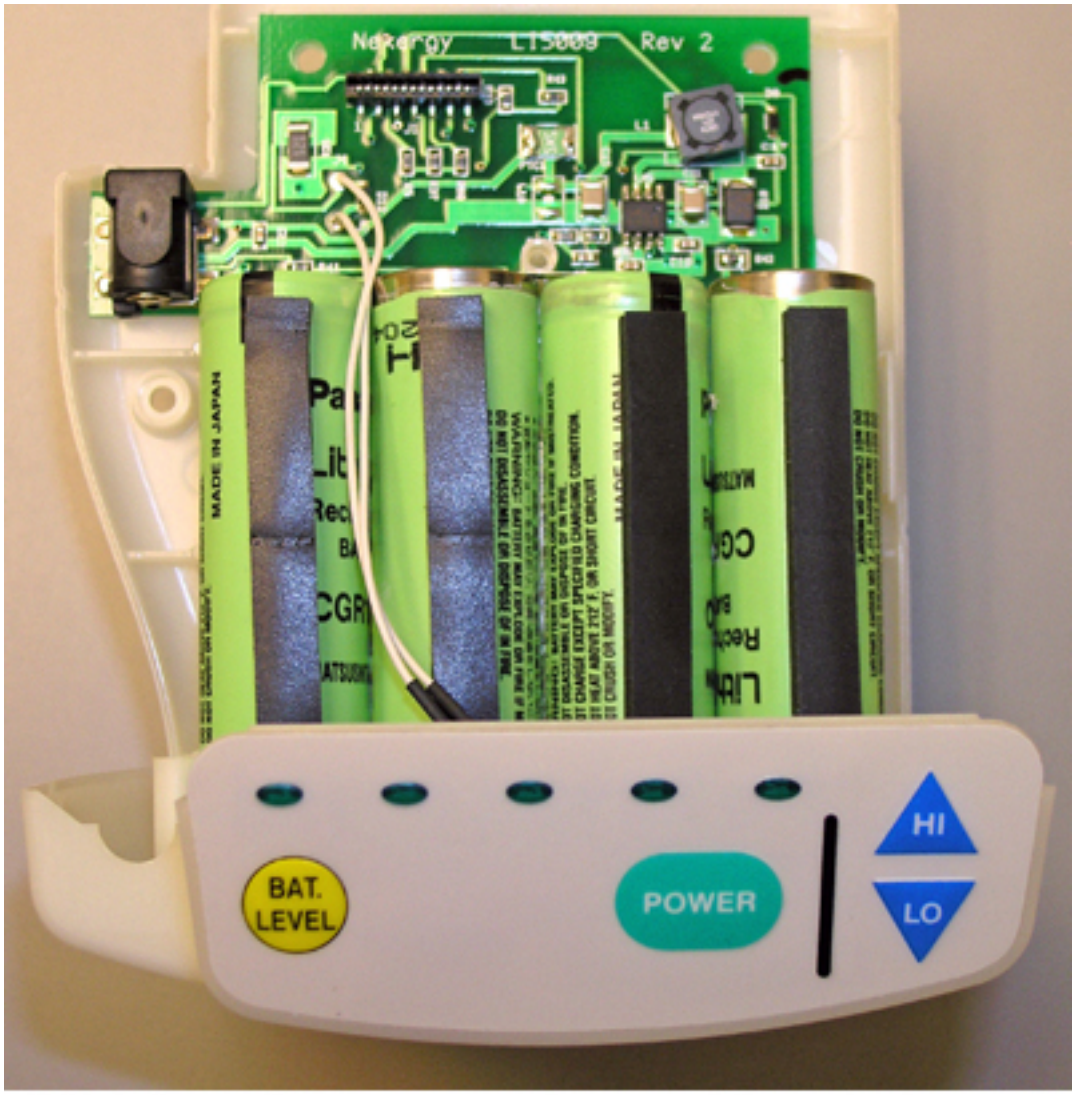
**Production Processes**
Li-ion production processes were first developed in Japan. The Japanese process typically used heavy machinery and automated equipment to perform certain steps while using robots to transfer partially assembled materials from one step to another. About 10 years later, Chinese companies developed more manual production processes for Li-ion cells, taking advantage of the availability of abundant, inexpensive labor in China. These production processes are markedly different from those that were employed in Japan or by some of the South Korean companies.

Japanese and South Korean manufacturers had considerable experience with the highly technical, high-volume production of semiconductors, magnetic tapes and compact disks, as well as expertise in quality control and production processes. That experience and knowledge helped them to adopt a highly automated production processes for Li-ion cells with high yields and six-sigma quality.

Less expensive, simplified machinery is used by second-tier manufacturers in the semiautomatic production process of Li-ion cells. To manufacture safe and reliable cells, automated equipment should be used in the most critical areas such as mixing of powder, coating and winding. In any operation, the use of large number of operators in the production increases the variability both between production lots and within production lots.

Some companies have even simplified the production process further by using

simple in-house equipment for the coating and mixing processes. Part of this process includes the significant involvement of operators.




**Li-ion battery packs represent a complex system of chemicals and components. When the cells are not properly designed and manufactured, significant quality and safety problems can result. But these defects are often not found until the product is in use in the field and has been cycled many times, resulting in costly recalls for the device OEM.**

## Critical Production Steps

There are many critical processes involved in the manufacture of lithium-ion cells. These include:

* Powder mixing
* Slurry preparation
* Electrode coating
* Slitting of electrodes
* Winding
* Jelly roll Insertion
* Laser welding or sealing (polymer cells)

* Electrolyte injection
* Formation and aging
* Labeling and traceability

The greater the amount of manual labor or human intervention in any one of these processes, the greater variability in the finished product or cell. This variability translates into performance and or safety anomalies.

**Cell Evaluation**
Cells should be evaluated electrically and mechanically, not only against common industry standards but also ideally per specific application requirements whenever possible.

Many of these industry tests such as UL 1642 or UN transportation testing should be considered minimum basic requirements — but should not be taken as evidence alone that the cell manufacturer is capable of producing consistently high-quality battery cells. It should be stressed that these certifications, while important, show only that a certain set of samples passed a particular set of tests at a particular point in time. Nexergy also works closely with customers to evaluate and qualify cell manufacturers for use in their specific application.

1) Mechanical evaluation: This category of tests includes shock, vibration and impact to determine the robustness of the cells. These tests will give valuable data on the robustness of cells and can be used to determine weak design or manufacturing processes.

2) Electrical Tests: In this category a number of tests can be used to evaluate the cell performance. Tests included here are cycle life, charging and discharging at a range of temperatures, measuring impedance changes, etc. The focus of the tests are not only to quantify the performance in terms of capacity delivered but, perhaps more important, to determine the consistency of a cell manufacturer over multiple samples and multiple production lots.

3) Safety Tests: Typical safety tests are described in documents published by UL and other agencies. At a minimum all cells should be UL1642 and UN Transportation tested and approved. Some of the tests are overcharge, overdischarge, crush test, short circuit, etc.

4) Forced Internal Short Circuit Test: It has been recognized that internal shorts in Li-ion cells cause field failures and that no production processes can completely eliminate the possibility of internal shorts. Therefore, the emphasis is on the design and manufacture of cells that are tolerant to internal shorts. Various types of Forced Internal Short Circuit tests have been developed.

**Quality Maintenance**
It is possible that the controls established in a Li-ion factory for a particular cell model can deteriorate over time. This requires customers to evaluate the cells and factory production processes periodically. This can be done on an incoming inspection basis as well as evaluating the cells and factory processes periodically.

**Partner with Experts**

A device OEM may be expert in the various disciplines needed to design their specific product. However, a detailed knowledge of lithium-ion batteries and cells is often one of the disciplines found lacking at even the largest device OEMs. This lack of detailed knowledge is typically accompanied by a lack of appreciation for the complexity of lithium-ion batteries.

As the engineers in the new Nexergy design center can attest, Li-ion cells in particular are a very complex system of chemicals and components. When the cells are not properly designed and manufactured, significant quality and safety problems can result. Unfortunately, these defects are often not found until the product is in use in the field and has been cycled many times, resulting in costly recalls for the device OEM.

Device OEMs are strongly encouraged to work with reputable battery pack manufacturing partners such as Nexergy. They have experience in evaluating Li-ion cell manufacturers and that can independently qualify cell manufacturers to ensure a safe and reliable battery for the OEM.

*Chris Turner is director of batter technology at Nexergy, Inc., a leading designer, integrator and manufacturer of battery packs and chargers for electronic products. Turner, who has written extensively on battery pack design, addressed lithium ion cell evaluation and performance at Battery Power 2008, an international conference highlighting the latest developments and technologies in the battery industry. Based in Columbus, Ohio, Nexergy operates additional design and assembly centers in Centennial, Colo., Canon City, Colo., and Escondido, Calif. Dr. George Thomas is vice president of Shiningstar Technology Corp., a Lawrenceville, Ga., consulting firm with expertise in Li-ion technology and production processes. The holder of more than a dozen U.S. patents, Dr. Thomas has worked at Motorola Corp. and, most recently, was senior vice president of Tianjin Lishen Battery Joint-Stock Co. in Tianjin, China.*