



# Demystifying the Lithium Battery Industry

## Introduction

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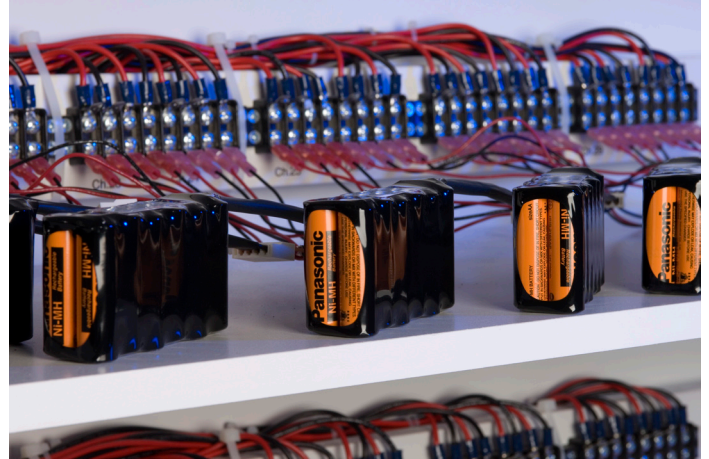
The rechargeable battery industry can be confusing to companies that engage this industry on an infrequent basis. There are many idiosyncrasies affiliated with the battery industry today, including tight regulation by the cell suppliers, migration of all cell production to Asia, and concern over tarnishing global brands due to customer misuse. A battery pack supplier has the responsibility to navigate these issues for their original equipment manufacturer (OEM) customers, and Micro Power Electronics takes the initiative to make our products integrate seamlessly with our customers' supply chain as well as their portable product designs. It is useful for the OEM to familiarize themselves with the peculiarities of the battery industry in order to facilitate communication, and the information found in this primer is an introduction and reference for some common battery industry issues.

## Incomplete Data Sheets

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Often, designers simply refer to the product specification sheets published by cell manufacturers in the design, development, and cell selection process. However, these data sheets rarely tell the real story: the performance data is often collected under so-called 'perfect world' conditions — room temperature and a low continuous discharge rate.

But the 'real world' isn't a perfect one, and battery systems must handle extreme variations in temperature and high discharge rates. Also, the cell impedance is often collected only at high frequency, which gives little indication of the cell's performance in a continuous discharge mode. These factors can combine to reduce battery system performance, capacity, and reliability. And matching the wrong battery to the wrong device — and using it in the wrong conditions — can lead to field failures, which can sometimes be dangerous. In summary, the performance data on the cells data sheet is probably not totally relevant to your specific application, and additional testing in a lab, such as Micro Power's 'advanced systems lab', equipped with cell and pack cycling channels and environmental chambers, will be required to fully qualify any cell and assembled pack for your product's individual performance and environmental requirements.



Cells should be and packs should be cycled with an exact usage profile.



Micro Power's Advanced Systems Lab has extensive cell cycling capability and numerous environmental chambers.

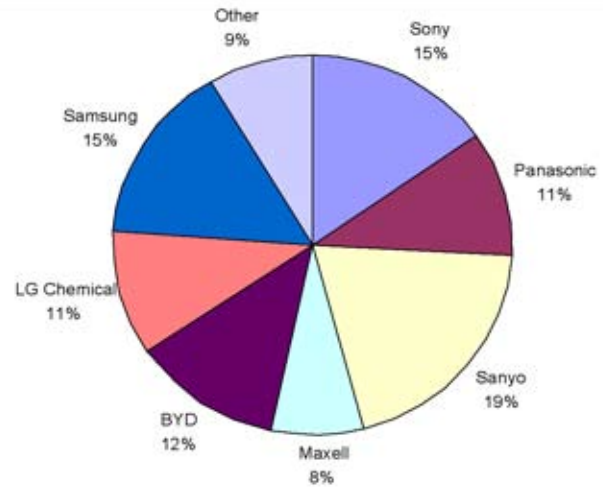
## Tightly Regulated Distribution Network

Batteries, or raw lithium ion (Li-ion) cells, are manufactured primarily by Asian cell suppliers such as Sanyo, Panasonic, Sony, LG, Samsung, Lishen, BAK and BYD. They distribute their cells to certified OEMs and battery pack manufacturers, typically called pack assemblers, who assemble their cells and mandatory protection circuitry into plastic enclosures – typically called battery packs.



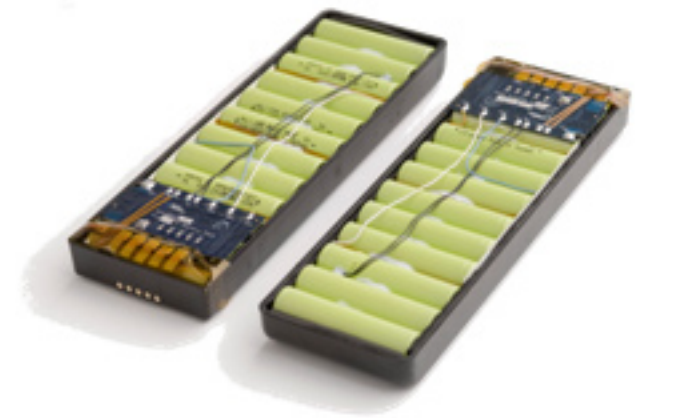
A Variety of Lithium Cells Provided by Cell Manufacturers.

Presented below is an analysis of the market shares for the major cell suppliers. This data is forecasted for calendar year 2008 when the cell industry is forecasted to produce 3,300 million cells. Note that the over 90 % of the market is controlled by seven larger international conglomerates. This data is sourced from the Institute of Information Technology Ltd, Worldwide Market Update on NiMH, Li ion and Polymer Batteries for Portable Applications and HEVs, 2008.



Market Share of Lithium Cell Manufacturers

## Certification for Pack Assembly



Battery Pack with Lithium Cells and Protection Circuit Board in Plastic Enclosure.

Li-ion cell manufacturers require pack assemblers and OEM customers to earn a certificate of competence with this technology before they will allow these companies to purchase cells. If an OEM consumes a high volume of cells over the long term (i.e. typically \$ 5 M annually), it may make sense to undergo the lengthy and expensive certification process. If not, you will want to work with a pre-certified battery pack assembler. In the rare instance that the OEM buys cells directly from the cell supplier, the challenge for an OEM is that they are typically locked in with that single cell manufacturer, and the selection of available cells is quite limited with just one source of cells. Most OEMs choose to work with battery pack assemblers, thus receiving a wider selection of cells from multiple cell manufacturers, as well as dual sources and competitive bidding among cells manufacturers.

The Li-ion cells are tightly regulated by cell manufacturers for two reasons. First, the cells can be highly explosive if mistreated or mishandled, so raw cells (loose cells that are

not assembled into packs) are only transported from the cell manufacturer to the pack assemblers according to specific UN and DoT shipment guidelines.

Second, due to the volatility of the Li-ion chemistry when subjected to conditions outside the recommended operating range, protection circuits are embedded within packs to ensure that the cells do not undergo “rapid disassembly” due to external conditions. For each brand of cells that the pack assembler wishes to utilize, pack assemblers must get qualified by the cell manufacturer to use their cell in the packs. This qualification is to ensure that the pack assembler can design and manufacture an adequate protection circuit for the pack. Cell manufacturers tightly manage their distribution network of pack assemblers, as they want only competent pack assemblers using their cells.

The tight regulation of the supply of cells stems from the fact that most of the major cell suppliers are some of the world’s largest companies with phenomenal brand recognition. These cell manufacturers do not want their brand name affiliated with any dangerous incidents. Additionally, in the event of an incident, the affected parties are inclined to take legal action against direct and indirect suppliers with the deepest pockets – usually the cell manufacturer. Hence, the cell manufacturers’ motivation for tight distribution is both quality control of assembled packs, as well as avoidance of brand name deterioration and unwanted lawsuits.

## **Class A and Class B Certification**

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For qualified pack assemblers, there is two degrees of certification. The first class of certification, Class A, is the pack assembler is self-certified to complete protection circuit design without any supervision by the cell manufacturer. With the second class of certification, Class B, the pack assembler can design the protection circuit, but the circuit design must be approved by the cell manufacturer to ensure it provides adequate degrees of protection. This review/approval step by the cell manufacturer can add an additional month to the development schedule of a battery pack.

In addition, pack assemblers with only Class B certification need prior approval by the cell manufacturer to address medical life-saving (i.e. defibrillators), medical life-sustaining (i.e. ventilators), and military life-taking (i.e. weapons) applications on a case-by-base basis. Pack assemblers with Class A certification have more freedom to select their addressable applications, as cell manufacturers have a higher sense of confidence in these assemblers.

## **Legal Indemnification from Cell Manufacturer**

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Cell manufacturers will only provide legal indemnification to select pack assemblers. Most cell manufacturers are very risk averse, and wish to avoid applications where failure to operate could result in personal and material damage. Therefore, cell manufacturers provide legal indemnification for their cells with a few select pack assemblers. This indemnification is provided on a case-by-case basis (customer and application specific).

As an OEM providing medical or military products, it is essential to have the legal support of both the pack assembler and the cell manufacturer in the event that the battery pack is the source of legal action. A pack failure usually involves the cells, and the documented support of the cell manufacturer provides an additional layer of financial support and legal resources in the event of legal action. Buying cells from non-approved distributors or from the gray market does not provide legal indemnification from the cell manufacturer.

Additionally, the OEM should insure that the pack assembler has several million dollars of liability insurance. In the unexpected event that a consumer takes legal action due to battery pack failure, the OEM can rely on the financial and legal resources of the OEM themselves, the pack assembler, and the cell manufacturer.

## Shipping Regulations

The shipment of lithium batteries is highly regulated by U.S. Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) and the United Nations (UN). Understanding the shipment regulations and qualification process is complex. Micro Power manages this process for our OEM customers.

The DOT's Lithium battery final rule was published on August 9th, 2007 in the Federal Register. This long awaited rule will harmonize the U.S. lithium battery hazardous materials regulations (HMR) with those that have been in effect internationally since 2003. This rule designates which batteries must be shipped as Class 9 hazardous material.

The publication of the final rule incorporates many of the dictates from the Agency's previous proposed rule as well as changes from the 2004 interim final rule on lithium metal (primary) batteries. Substantial regulatory and formatting changes to the lithium metal (and lithium ion) battery provisions in U.S. HMR have been unveiled. The effective date of the rule is January 1, 2008; however, some of the special provisions will go into effect later.

These regulation changes are overwhelming to understand and apply to your specific product or shipping patterns. Look to Micro Power to provide continual updates to changes in shipping policies.

## Industry Allocation of Lithium Cells

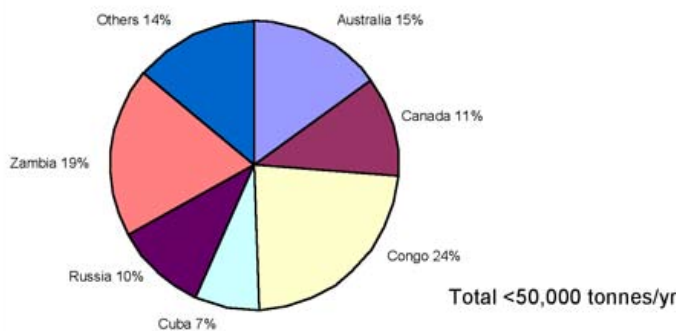
There is a global shortage of lithium cells. The lithium cell market is constricted by allocation and long lead-times. Several factors have contributed to the tight allocation of cells currently implemented by the cell manufacturers.

- Demand for lithium cells for the power tool market and electric vehicles is increasing faster than expected.
- For Li-ion cells, a 10+ % CAGR will be maintained through 2013.
- Li-ion cell recalls and factory fires have had a negative impact on supply.
- Price increases have been driven by spiraling raw material costs, fuel costs, and high demand.

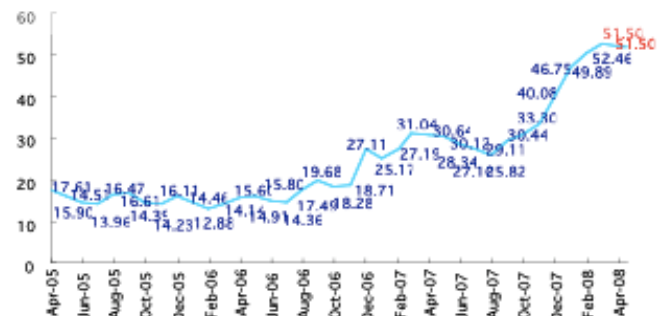
Like many commodities, cobalt and nickel raw material costs have reached historic highs. Cobalt is a primary material for lithium cells. 64% of known deposits are in political unstable countries such as Congo and Zambia. Recent price fluctuation range from \$5.50 to \$25 per pound, with spot prices at \$50 per pound (2006).

Additionally, transportation costs have increased due to rising fuel cost. For North American OEMs, the exchange rate for the U.S. dollar has not been favorable for American based companies.

### Cobalt - Mine production 2004



Global Sources of Cobalt



Raw Material Cost of Cobalt from 2005 to 2008

In addition to these other factors, the cell manufacturers have experienced an unusually large number of factory shutdowns or product recalls. Listed below are the larger industry events which contribute to the global shortage of lithium cells:

- In August 2006, Sony recalled all battery packs sold to Dell over a multi-year period. This recall was expanded to include other laptop manufacturers.
- In September 2007, E-One Moli announced end-of life of their 2.4 Ah Li-ion cell that was manufactured in Canada, as they are refocusing efforts on the more profitable power tool market. Moli recently announced all Li-ion cell manufacturing will be transferred to Taiwan, however, subsequent capacity will be severely limited.
- In October 2007, Panasonic had a fire in one of their factories which impacted all Panasonic Li-ion models and severely impacted worldwide cell supply. Panasonic has announced plans to increase capacity, with production capacity increases scheduled to be available in Q1 2009.
- In March 2008, LG Chemical experienced a factory fire which impacted all LG Chemical models and further impacted the global shortage of batteries. LG Chemical plans to restart their assembly lines in the second half of 2008.

## Conclusion

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The Li-ion cell industry has long term ongoing idiosyncrasies which make the specification and design of a battery pack and cells less than straight forward. These issues include the lack of sufficient data sheets and the need for certification of reputable assemblers from the cell suppliers. In addition shipping regulations are confusing and constantly in flux. Finally, recent industry events, such as product recalls, have resulted in cell allocations and global markets have resulted in price increases for raw materials and shipping. In combination, these factors put a strain on supply that makes the ability to dual source and contract with a stable assembler more important than ever.

## About Micro Power Electronics Incorporated

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Micro Power Electronics supplies custom battery systems to the portable medical, automatic data collection, and commercial military markets. As a pioneer in the development of lithium battery systems, smart battery packs, chargers, docking stations, and power supplies, Micro Power has more than 20 years of experience developing battery solutions. Micro Power has domestic and Asian production facilities. Micro Power is registered with the Food & Drug Administration (FDA) for design and manufacturing services, registered with the U.S. State Department for International Traffic in Arms Regulations (ITAR) programs, ISO 13485 and 9001:2000 certified.

With a proven track record of technical excellence, quality solutions and award-winning service, Micro Power is the global leader in portable power systems.