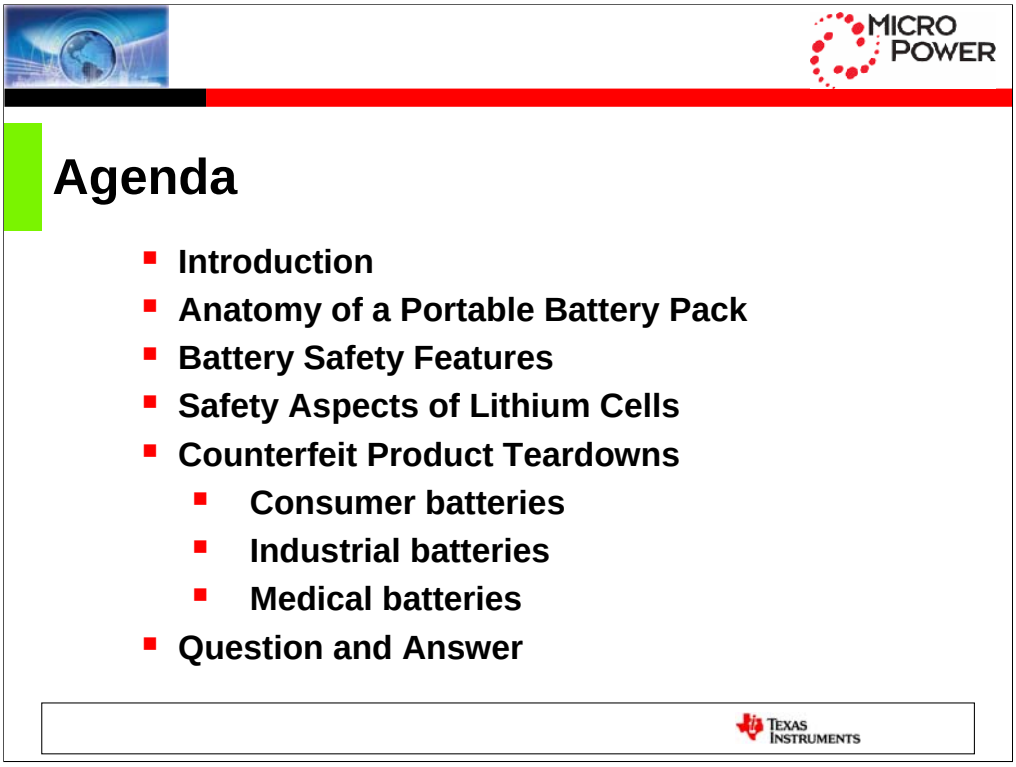
MICRO POWER

Safe Battery Design

The Dangers of Aftermarket Products

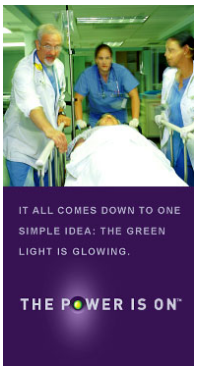
Texas Instruments



Here is a brief outline of the topics for today's webcast. First, I will provide an introduction to the problem of battery safety and an overview of all the components that make up a battery system so that you'll have a frame of reference for the rest of the presentation. Then, I will present the features of battery cells, circuitry and manufacture that can affect the stability and safety of lithium ion battery packs. We'll use the IEEE standards as a starting point. After learning what makes up a safe battery of high quality, we'll look at what not to do. Micro Power has found examples of aftermarket or counterfeit batteries widely available on the internet. We'll look at the disassembly and analysis of those battery packs and I'll point out the flaws that cause concern in the examples from a cross section of industries- consumer Industrial and Medical. The last third of the presentation will be presented by Michael Vega from Texas Instruments. He'll talk about TI's solution for the problem of counterfeits- battery authentication.

About Micro Power Electronics

- Battery packs and chargers
- Exclusive OEM customers
  - **Medical**
  - **Military**
  - **Industrial**
- Twenty years experience
- FDA Registered and ISO certified

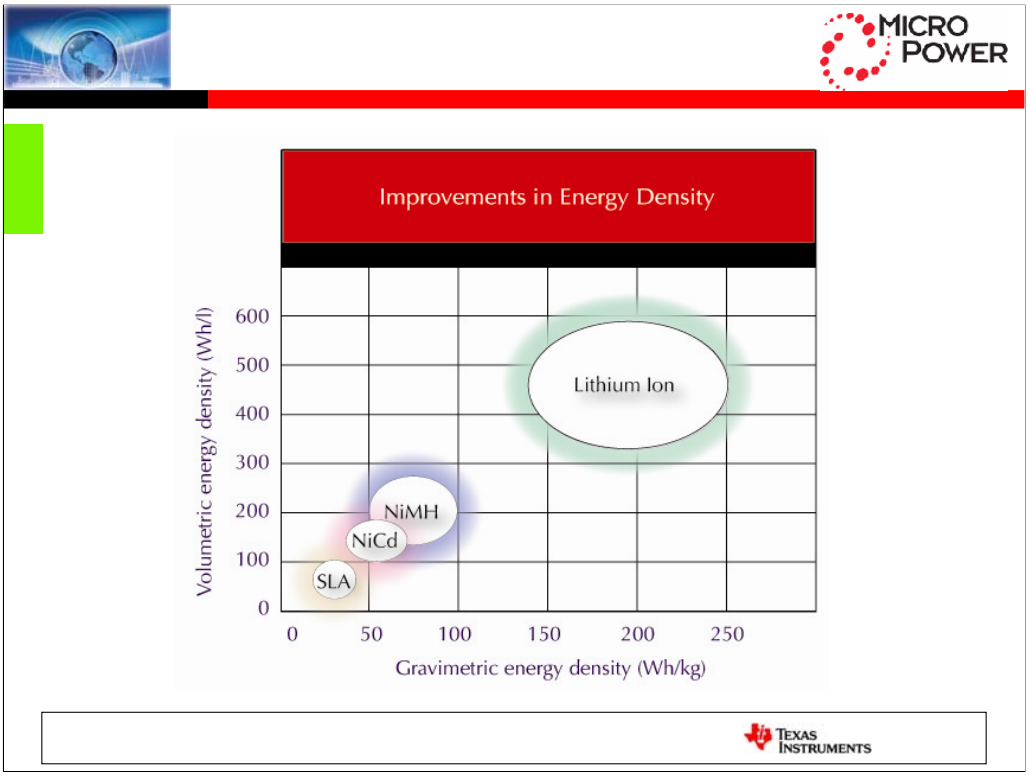


Before the main presentation, I would like to provide a quick summary of today's sponsor. Micro Power Electronics is a developer and manufacturer of lithium battery packs and chargers for mission-critical applications. Our OEM customers include leading medical, data collection, and military manufacturers of portable devices. We have over twenty years experience in designing and manufacturing battery packs, and we have completed over 1000 different battery system designs. Micro Power is FDA Registered and ISO 9001 certified.

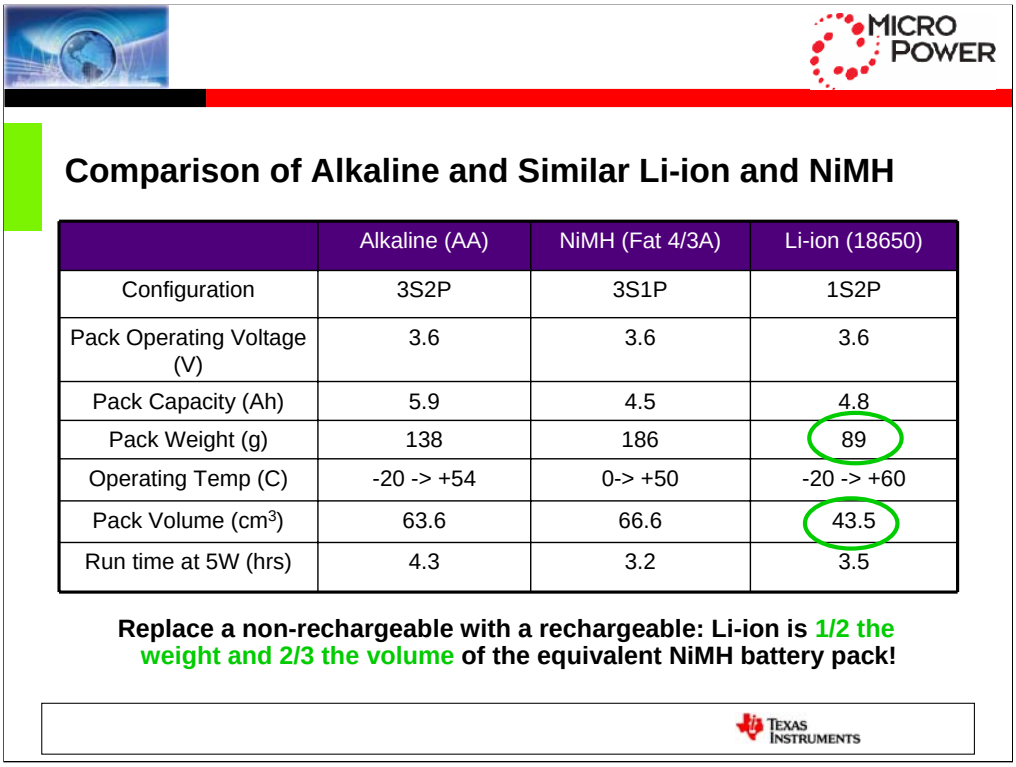
Battery performance critical in our core markets

Creating strong demand for mission-critical battery systems

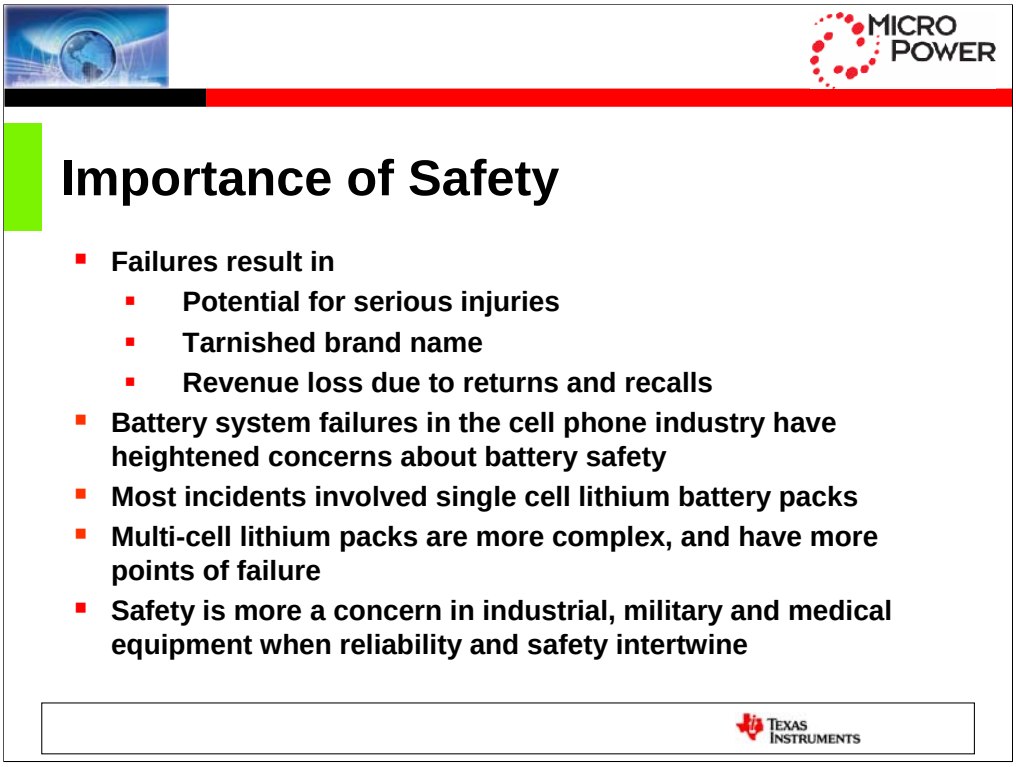
Portable Medical Equipment & Devices	Handheld AIDC & Rugged Computing	Commercial Military & Industrial GPS
		
▪ Defibrillators ▪ Patient Monitors ▪ Infusion Pumps ▪ Endoscopy	▪ Barcode Scanners ▪ RFID Readers ▪ Portable Printers ▪ Handheld Computing	▪ Ruggedized Radios ▪ Troop Location Devices ▪ Asset Management ▪ Survey & Mapping Devices
"Portable Patients"	*"Portable Data Collection"*	*"Portable Soldiers"*



Li-ion battery systems are a good option when requirements specify lower weight, higher energy density or aggregate voltage, or a greater number of duty cycles For their size and weight Li-ion cells store and deliver more energy than other rechargeable batteries. Energy density is measured both volumetrically and gravimetrically. Li-ion technology is now up to almost 500 watt-hours per liter, and 200 watt-hours per gram. Li-ion is able to deliver more power with a smaller footprint and less weight. The higher the energy density of the batteries used in designing portable devices, the more size is decreased and convenience is increased for portable products. Shrinking the battery pack compartment will allow the design of additional device capabilities in the same product.



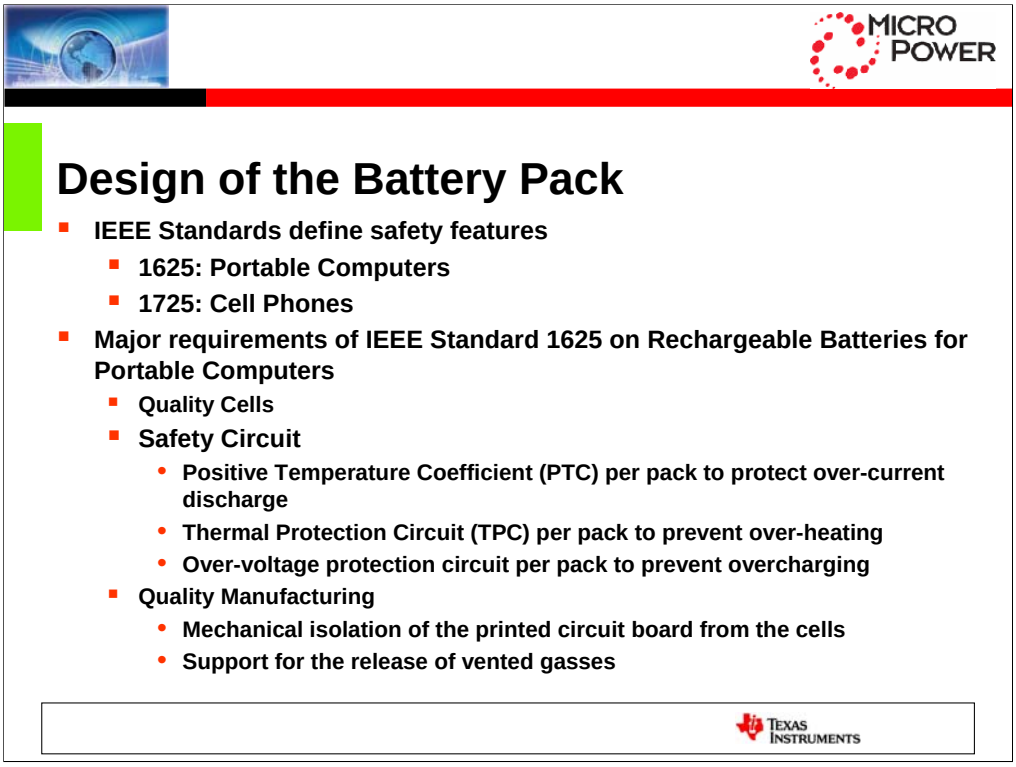
Let's imagine that you have an device that is currently using AA alkaline nonrechargable cells and would like to replace them with rechargeable batteries without changing much of the products overall design. If the alkaline pack is 3 in series 2 in parallel then the voltage will be 3.6 and the pack capacity will be 5.9 Ah which might yield a runtime of 4.3 hours at 5w. You would need to use 3 NiMH 4/3A cells or 2 Li-ion 18650s to get the same voltage and a similar runtime. In this case the Li-ion pack would be ½ the weight and 2/3 the volume of the NiMH pack. Of course price will be a factor in the choice of chemistries. The Li-ion and NiMH packs will have higher up front costs. However one might save 200 times that over the lifetime of the product. The Li-ion pack is likely to be about 20% more than the NiMH pack, but this could be waranted if the temperature tolerance, size or weight will give the design a competitive advantage.



In recent years, the news of individual battery incidents, such as cell phone and lap-top fires, has been eclipsed by factory fires and large recalls of Li-ion cells. Several of the large, well-known Li-ion cell suppliers have been affected; the most notable occurrence was the recall of Sony batteries in 2005. Panasonic and, more recently, LG chemical have had fires that affect their Li-ion manufacturing volume. While these issues present challenges for the Li-ion supply chain, it is the field failures of individual batteries that result in the potential for serious injuries. Counterfeit batteries of low quality have become increasingly common and popular with consumers. Globally, more than 5 million counterfeit cell phone batteries have been confiscated and destroyed by law enforcement officials.

Failures in the batteries result in the potential for serious injuries, a tarnished brand name for an OEM and revenue loss due to returns and recalls. Single-cell lithium battery packs for cell phones have received most of the media scrutiny, but multi-cell lithium packs are more complex and actually have many more points of failure.

Today, our emphasis will be on precluding failures in the more complex, multi-cell lithium battery packs that are common in other applications, such as portable medical, military and industrial equipment.



The safety features of a battery pack are outlined in great detail in standards from several sources. The most notable are the IEEE 1625 and 1725 standards for lap-top and cell phone batteries,

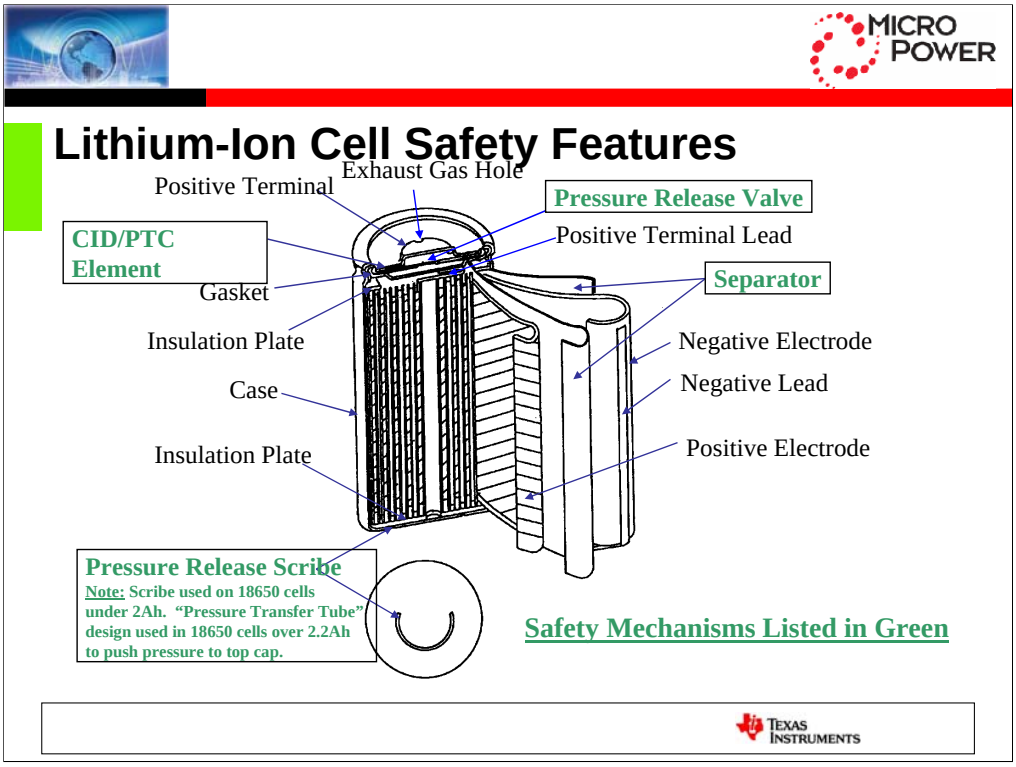
Some of the more test guidelines for battery systems include :

- Quality cells from a top tier cell manufacturer are the first line of defense against dangerous pack failure. I'll talk about the safety features resident inside the cell on the next slide.
- The protection or safety circuit provides safe electrical operation. I'll describe how it works in more detail, but first we should note that the IEEE guidelines require these features in the circuitry:
- over-current protection
- a Thermal Protection Circuit per pack to prevent over-heating.
- AN over-voltage protection circuit per pack to prevent overcharging.

- Quality manufacturing and good mechanical design are also important and IEEE requires
- Mechanical isolation of the Printed Circuit Assembly from the cells and
- Support for the release of vented gasses.

- Also, Electrical tests should be applied to every pack design including continuous charge, over-discharge, overcharge, and short-circuit tests.
- and Mechanical tests should be applied to every pack design include shock, vibration, thermal shock, altitude, thermal exposure, and mould stress.

- We'll find violations of all of these guidelines in the counterfeit packs, but first a few more details about the safety features to look for.



At the cell level, these safety mechanisms include;

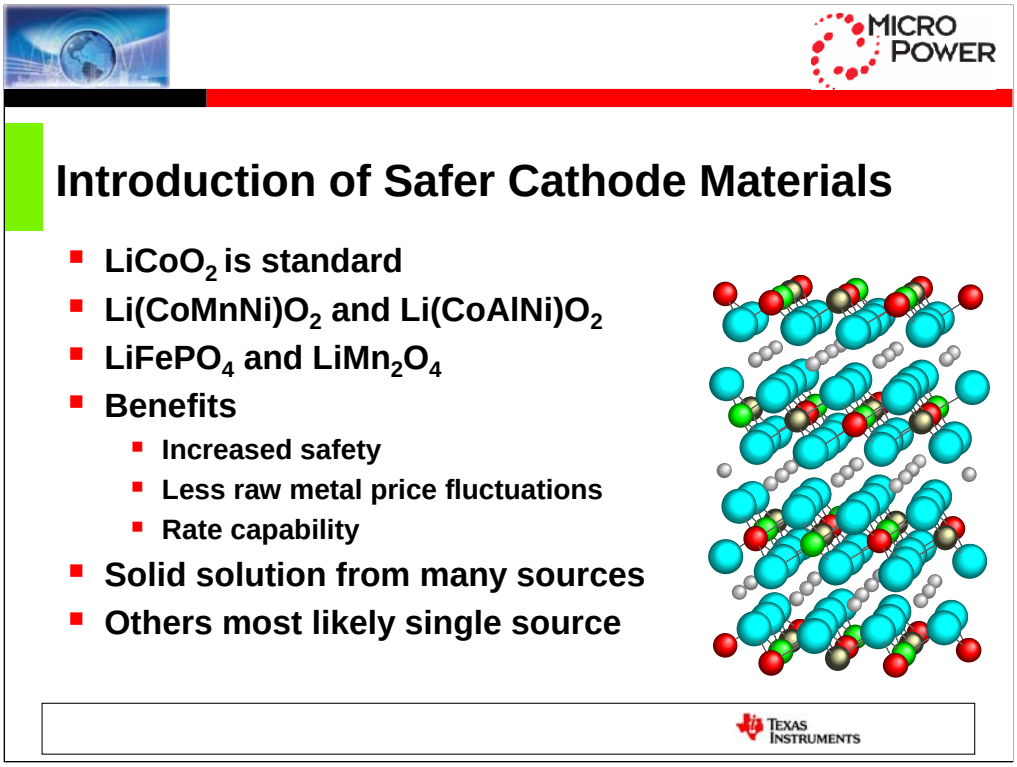
- the PTC, which provides the function of both a current fuse and a thermal fuse. When over-current flows through the PTC, self-heating increases the resistance and breaks the circuit.

- the Current Interrupt Device which works with the pressure release valve to release or vent excess gas if internal pressure reaches a unsafe level during charging.

-A Pressure release scribe and center vent tube to guide any pressure build-up at the bottom of the cell up to the pressure release valve located at the top of the cell. These eliminate ruptures in the can due to excess pressure that could be trapped in the lower portion of the can.

- And the separator, which is perhaps the most fundamental safety feature- protecting against shorts between the anode and cathode material. Multi-layer separators provide and extra level of security and safety.

-Material choices for the anode and cathode are other fundamental safety factors. The Li metal phosphate cathode material, commercialized by Valence and A123 is one example of a safe choice also the mixed metal oxide sold as panasonic's solid solution has a high thermal runaway temperature.



There are two basic types of lithium-ion chemistries: a layered cobalt compund, a related Ni based compound and manganesespinel- a three dimensional compound. To achieve maximum runtime, cell phones, digital cameras and laptops use cobalt-based lithium-ion because the drawback of spinel is lower energy density. Typically, a cell made of a pure manganese cathode provides only about half the capacity of cobalt. To find a workable compromise between high energy density, operational safety and good current delivery, manufacturers of lithium-ion batteries use different cathode metals. Typical mixes are cobalt, nickel, manganese. The benefits of the new chemistries include

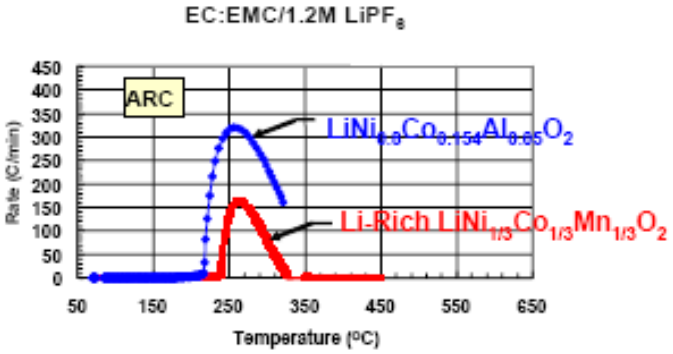
Increased safety

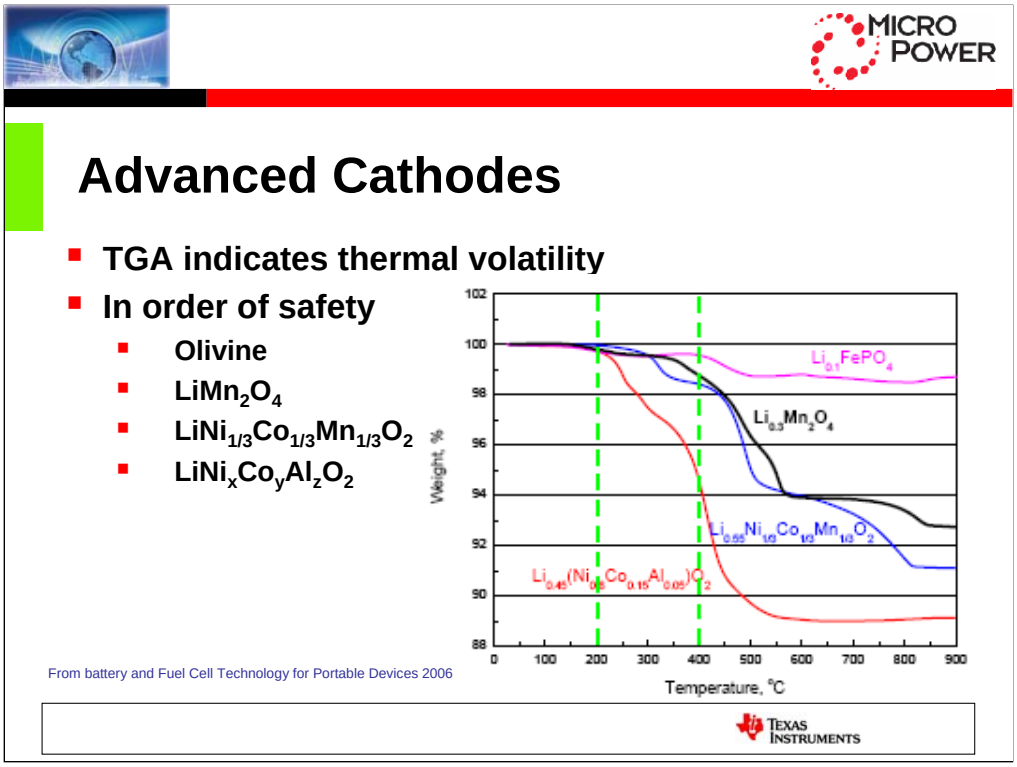
Less raw metal price fluctuations

Rate capability

ARC Test of 18650s

- ARC test shows that although all cells have the same graphite anode and same electrolyte, their thermal behaviors are different.
- Cathode impact on overall cell thermal behavior is dominant.



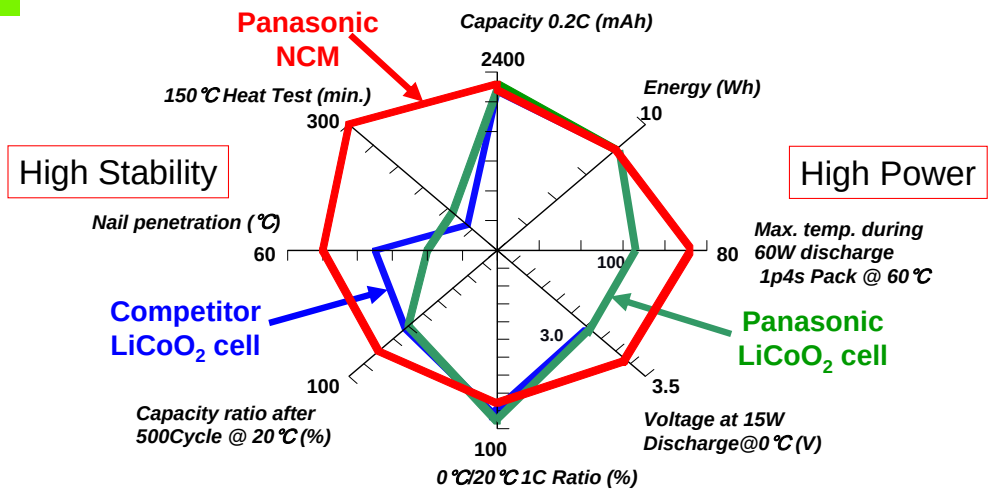


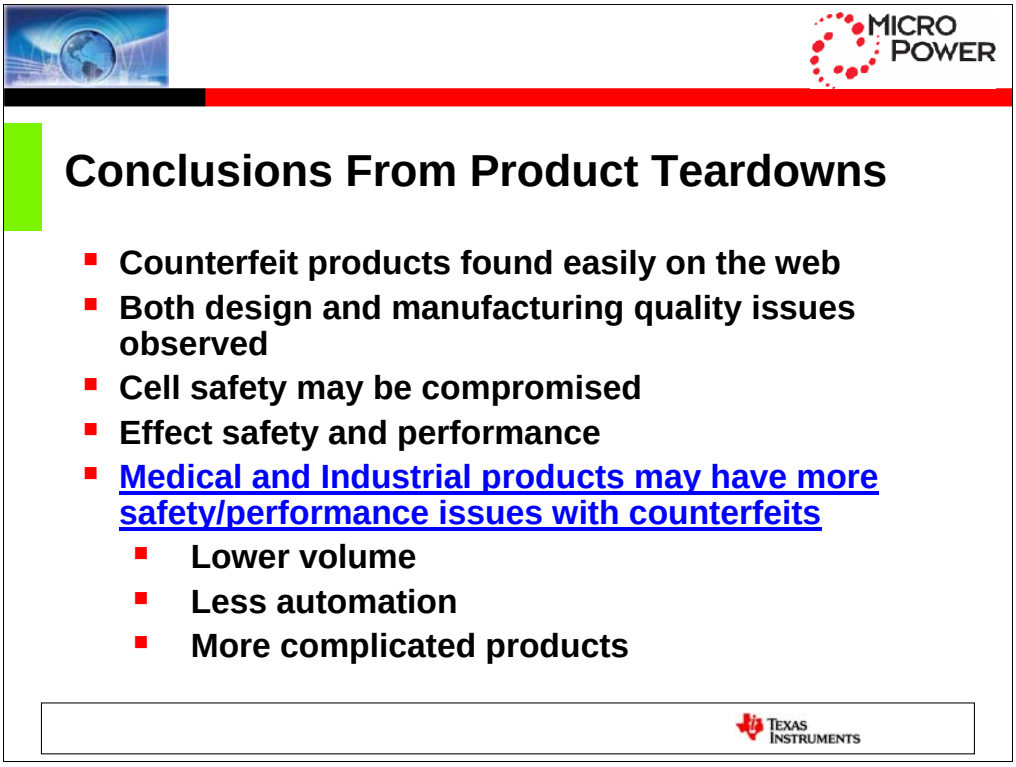
This graph shows a comparison of the thermal volatility of various new cathode materials. It is a graph of percent weight loss vs temperature. We can see that the nicoal (which is most closely related to the traditional co formulation)has the greatest weight loss then there is the ni comn and then the manganese spinel and then the iron phosphate.

This indicates that the iron phosphate/olivine cathode material is the safest while traditional materials are less safe at elevated temperatures.

We should note that weight loss begins at about 200 degrees C. A temperature that these cells would not be exposed to if the battery pack and its host device are designed well. So other battery thermal management and safety systems should be designed to prevent the cells from high temperature exposure.

Comparison of Panasonic Cell Characteristics





Counterfeit products found easily on the web for most portable products including medical and industrial equipment. No one is immune from this problem. Both design and manufacturing quality issues were observed in virtually all of the counterfeit packs. And in summary, there is a large potential for safety hazards due to manufacturing and design issues. And in some cases performance parameters such as pack runtime may be effected severely. The most surprising, and troubling observation we made is that Medical and Industrial products may have more safety and performance issues with counterfeits than consumer products. This goes against intution, but it is easily explained because these products are produced in lower volume, there is less automation and the products are more complicated.

Need for Battery Authentication

- After-market and counterfeit batteries present a host of problems:
  - Discharge rate – cell mismatch
  - Charger – Chemistry mismatch
  - Short circuit, over voltage, under voltage protection
  - Unknown cell quality

Battery Authentication: Methods

- Mechanical fit
  - Easily duplicated
- Resistor ID
  - Measure voltage drop across resistor internal to the battery on extra pin
  - Also easily duplicated
- EEPROM ID number
- Encrypted Handshake with secret key

Many innovations have occurred in the battery industry, but the increase in stored energy and number of aftermarket suppliers make a dangerous combination. Pack manufacturers and OEMs can work together to achieve a safe and reliable result. If you have any questions about the topics presented, do not hesitate to contact us.

Thank you very much for your attention.