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Battery power trade-offs: lower voltage or higher capacity?

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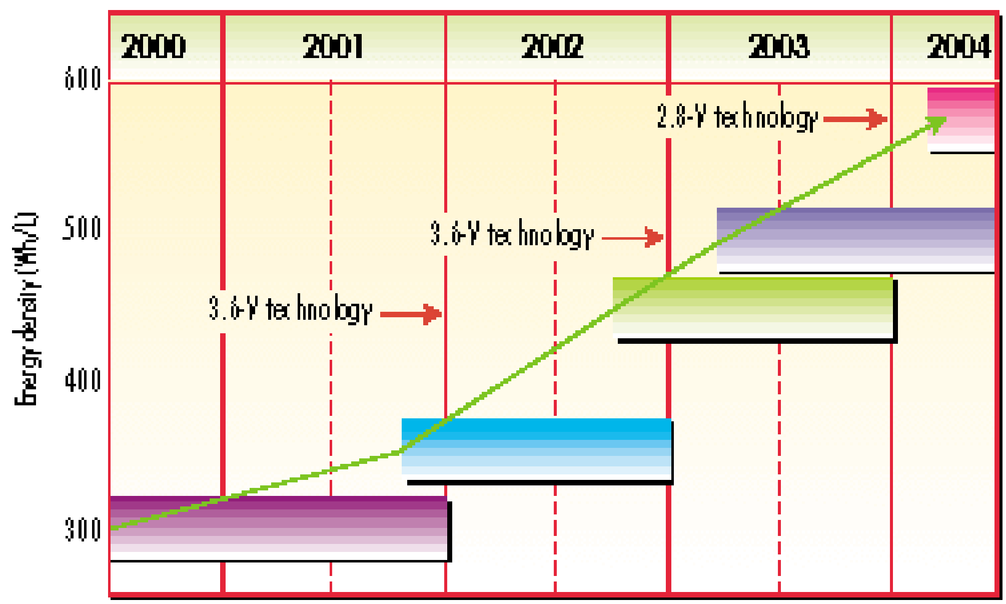
Manufactures are constantly striving for ways to increase the energy density of batteries in order to meet the increasing demands of the portable electronics applications. However, there are a few trade-offs on the road to higher density battery technologies.

Battery manufacturers are limited by the periodic table of elements when it comes to the development of new battery technologies. As a result, manufacturers have traditionally equated changes in battery chemistries, designed to improve energy density, to a slightly reduced cycle life or short-term price increases. As lithium-ion (Li-ion) technology reaches maturity, cell manufacturers are running out of periodic table options, driving the need for more radical solutions, and the main trade-off could be voltage.

As important as battery voltage may be, to further increase Li-ion capacities, it many be something designers need to sacrifice. Nominal voltage for today's Li-ion cell is 3.7 volts (V) with a maximum energy density of 470 Watt hours per liter (Wh/l). Getting to 600Wh/l and beyond will require both cell engineers and application engineers to think outside the box. In the future, cell voltages for the new battery technologies may be reduced to as low as 2.8V, opening up an array of options for cell manufacturers to develop even higher capacity batteries, while creating a number of new challenges for system engineers.

The timing of battery technology advancements is uncertain. It will be a couple of years before 2.8V technology is available In order for the new technology to succeed, there must first be a strong demand. Both system engineers and project managers typically resist the idea of lower voltages, and have yet to accept the reality that the only option for achieving increased energy density may be to sacrifice voltage.



Future 2.8-volt (Li-ion) cells will have energy densities achieving 600 watt hours per liter (Wh/l). Nominal voltage for today's Li-ion cell is 3.7 V with a maximum energy density of 470 Wh/l. However, getting to 600 Wh/l will require cell engineers and application engineers to think outside the box.

Source: Toshiba

In the future, it is possible that Li-ion capacities may plateau, if OEMs are unable to accept battery technology advancements. To prevent capacity stagnation, cell development has begun on a new nickel manganese oxide mix, which will deliver high energy density in a true safe cell technology. With limited engineering resources and products being allocated based on the voice of the customer who is demanding higher densities, reduced costs and safer battery technologies, today's battery manufacturers find themselves stretched in many different directions.

Manufacturers are also faced with the development of lithium polymer (PLB) and advanced lithium (ALB) chemistries, capacity enhancements and cell robustness of thin prismatic (Li-ion) cells, enhancement of nickel metal hydride (Ni-MH) for high drain applications, and the development of cutting-edge technologies such as fuel cells. Resistance to lowered Li-ion voltages by designers could lower the development priority causing delays in the introduction of newer technologies.

One example where new battery technology advancements, such as the nickel manganese oxide mix, could be useful, is in cellular applications where a single cell is used and the cut-off voltage is typically 3V. Cellular phones can be manufactured with a lower cut-off voltage to accommodate newer technologies. However, chip-set, power amplifier and other component manufacturers will need to allocate additional time and engineering resources to accomplish this.

Beyond energy density, there are several benefits of the new nickel manganese oxide mix Li-ion cell. The 3.7V cell technology incorporates cobalt, a costly precious metal, which provides the base for the positive electrode current. By using manganese for the positive electrode current, the cost of the battery is reduced. Although that fact alone may not excite system engineers, procurement managers and executive management in search of elusive profits are anxious to hear about ways to further reduce component costs. The other significant benefit is more universal safety. With a safe cell manganese oxide mix, the safety circuitry that is currently required in Li-ion will no longer be needed. The new technology would be a safe (Li-ion) cell and would enable the elimination of the protection circuit module in the battery pack. That would further reduce total system cost as well as the mechanical volume of the battery.

More choices

There are several battery technologies emerging today that could offer system engineers alternative choices. Today's ALB and PLB technologies provide a safer alternative to current (Li-ion) technology in an ultra-thin form factor. The major benefits to these newer ALB and PLB technologies is the thin form factor and flexibility of design. These cells are currently being manufactured in form factors of 2 to 5 mm thick and can be sized to maximize the available space in the application. They also enable product manufacturers to become slightly more creative in mechanical design, embedding cells behind LCD panels or designing "slice" type battery packs which attach to the top or bottom of the application to enable extended run times.

However, designers should keep in mind that these ALB and PLB technologies do not currently meet the energy densities of cylindrical (Li-ion) cell designs and will not reach the 600Wh/l level in the near future. Due to the form factor of the cell design, most designers compare these technologies to prismatic Li-ion cells in terms of cell capacity. Today, the energy densities of prismatic Li-ion and ALB/PLB are nearly equal when comparing similar form factors. However, they remain less than larger cylindrical (Li-ion) cells.

The fuel cell is another up-and-coming battery technology looking to displace Li-ion as the primary power supply for portable electronic devices. Although not a traditional battery solution, battery manufacturers have taken the lead in the development of the fuel cell technology. Fuel cells have the potential to give a huge boost to energy densities in portable devices and provide end users with the ability to immediately "recharge" the cell with a fuel cartridge.

There is a serious debate in the industry now regarding the incorporation of both a fuel cell and a Li-ion, ALB or PLB cell in applications. For instance, a fuel cell could be used to recharge the system when the user is away from a power outlet and normal charging could occur when access to an outlet is available. Fuel cells will give end-users the level of battery life they have been demanding, however the cost of the technology could become an issue initially.

Manufacturers will need to upgrade their equipment and manufacturing lines in order to assemble fuel cells, and as a result, fuel cells could command a premium price. This would initially limit the technology to high-end equipment while manufacturing capacities ramp up. Additionally, consumers must pay to recharge their devices so the acceptance of fuel cells is still an unknown factor. Again, for even with the potential fuel cells have, most industry watchers believe it will be another 3 to 5 years before they are commercially available.

The electronics industry has reached a crucial point in the development of Li-ion battery technology, and as a result, some decisions must be made, and quickly, if the industry is to continue to see energy densities increase. Although there are several promising technologies emerging, none of them can achieve the energy densities currently available in cylindrical (Li-ion) within the next two to three years.

The introduction of a 2.8V (Li-ion) cell, which offers energy densities achieving nearly 600Wh/l, could significantly impact the potential for additional growth, if manufacturers are resistant to the technology. The cell will offer other significant advantages over the current 3.7V cell, including cost savings at both cell and pack level and a true safe cell design. With the increasing demand on batteries from power hungry processors, CD-ROMS, Bluetooth devices and DVD players, capped energy densities could create serious problems for device manufacturers. Open communications between cell manufacturers, system engineers and other component suppliers must begin if the new 2.8V technology is to be introduced without a significant gap or flattening in energy densities.