Fuel Cell Works

Fuel Cells on the Horizon

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Despite the anticipated power improvements and environmental benefits of fuel cells for mobile devices, the technology is still limited to the lab as size constraints make commercialization a longer term objective. In the meantime, some firms are looking to hybrid solutions to boost power

With existing lithium-ion battery technology expected to soon reach its limit in energy density, handset makers and battery manufacturers have been funding research into fuel cells for years to find a more powerful replacement to fuel the advanced feature phones of the future.

Most current fuel-cell research for mobile phone use has centered on direct methanol fuel cells, which uses methanol as the hydrogen fuel supply. Stuart Robinson, service director of handset component technologies at Strategy Analytics, says the major advantage of DMFC over lithium-ion batteries is energy density.

"Theoretically there could be a factor of ten improvement in volumetric energy density, although in practice we are likely to see a three times improvement," he says.

Li-ion cells produce an output voltage of around 3.6V and currently have an energy density of around 160 Wh/kg. Lithium polymer offers a small (10%) increase in this figure, Robinson says. "Over the last 10-15 years, lithium energy density has improved at the rate of approximately 7% per year. If fuel cells can provide three times more energy density now, that is equivalent to around 18 years of Li-ion development."

This boost in power is especially important for mobile operators to offer more advanced features, such as power-hungry mobile TV, with existing Li-ion battery technologies anticipated to be unable to provide the required power.

DMFC is expected to become a cost-effective and environment-friendly technology once it is in mass production, because the fuel cells are made of low-cost materials and release only water and carbon dioxide. By comparison, Li-ion batteries use cobalt and other expensive materials such as platinum, which is used as a catalyst.

Recent breakthroughs

The thinking has been that fuel cells, one day, will provide a cheap and easy means to power mobile phones, with recharging taking only a few seconds. The only question is, when.

Several recent developments indicate that fuel cells could be in commercial use within three years. NTT DoCoMo together with Fujitsu Lab in July jointly developed a DMFC prototype recharger for its 3G FOMA handsets. The DMFC prototype enables eight hours of continuous talk time, three times the capacity of the first prototype developed in September 2004. The new cell provides 5.4V at 700 mA, using an 18cc methanol cartridge. The companies claim the unit has an energy density three times higher than a lithium polymer battery of the same size.

DoCoMo plans to complete the fuel-cell development for use in an external cradle-shaped recharger by next March. Rival KDDI, partnering with Hitachi and Toshiba, has also developed prototype rechargers for its "au" handsets. Toshiba, working independently, announced in early March the launch of its world-record breaking miniature fuel cell for use in portable devices such as MP3 players and Bluetooth headsets for mobile phones.

Earlier in the year NTT, the parent company of DoCoMo, announced that it had developed a prototype hydrogen-based fuel cell, which it expects to commercialize within three years at a size small enough to fit inside a mobile phone, providing nine hours of talk-time for a power-hungry 3G phones consuming 2.5W.

Hybrid solution

Despite this progress, fuel-cell manufacturers admit that a number of issues need to be addressed before they can be launched commercially. These include further improvements in energy density, reductions in size, longer lasting battery life and improved safety.

One of the biggest obstacles is downsizing the cells so they fit into a mobile phone. Prototypes developed to date have been too big and bulky or have been incapable of producing enough power to permit commercial production.

"Fuel-cell technology still needs to be shrunk to fit in a phone," says Robinson at Strategic Analytics. "This is still five or more years away from mainstream development, but we will see some small test products on the market before then."

He says fuel-cell manufacturers have been finding it difficult to incorporate the cells inside handsets because the "active" type of DMFCs are like a miniature engine, containing pipes, pumps and manifolds. The engine cannot yet be shrunk small enough to fit into a phone. Meanwhile, "passive" DMFCs are smaller and lighter engines, but their peak power is lower and they cannot yet be used as a replacement for lithium cells because they cannot provide the 2W peak required for making a call or taking a photo with a flash, he explains.

With DMFC's limitations in size and power unlikely to be solved anytime soon, some companies are pursing a hybrid approach. This involves a fuel cell handling the normal output required to drive the mobile phone, and a lithium cell acting as an auxiliary power supply, which will kick in when power demand increases. When consumption drops back to normal, the fuel cell then recharges the lithium cell.

DoCoMo and KDDI have adopted a hybrid configuration to trickle-charge the standard lithium cell. "Our goal is to power mobile phones directly with fuel cells, but for the time being, we aim to create hybrid phones that can be powered by both fuel cells and lithium ion batteries," said an NTT DoCoMo spokesperson.

Besides the size and power obstacles, fuel-cells will also face the challenge of cracking into the portable devices sector. First of all, consumers are unfamiliar with fuel-cell technology, so many device manufacturers will likely be reluctant to adopt it. The lack of a fuel-cell refueling infrastructure will make distribution to retail outlets difficult in the beginning. There are also regulations concerning the transport of fuel cartridges.

Commercialization

All the players in the value chain are counting on this technology working for portable applications. Fuel-cells manufacturers widely anticipate that the new solutions will be in commercial use as early as 2007.

But is that is realistic or wishful thinking? Robinson at Strategic Analytics says during the next year it should become clear whether the power output of DMFCs can be developed to provide cellphones with a small, powerful and independent alternative to lithium-based batteries, or whether they will only be present in hybrid solutions to trickle-charge a lithium cell.

"At the moment, there are insufficient data points to plot a curve. By next year there will be enough points on the curve to extrapolate," he says.

Viswanathan Krishnan, a research analyst at Frost & Sullivan, is confident that the size and energy constraints will be resolved. "We have to bear in mind that the anticipated weight reduction and the flexible geometry of fuel cells will be able to drive miniaturization of the fuel-cell technology."

On the regulatory side, Robinson warns that confusion over new regulations concerning the transportation of methanol and hydrogen fuel cartridges could cast doubts on the commercialization of fuel cells.

The US Transportation Security Administration (TSA) announced in February that cigarette lighters would be added to the list of banned items on airplanes. But just days later the United Nations approved fuel-cell cartridges for air transport and plans to bring regulations into place by 2007.

Robinson says Nokia's March announcement on its temporary withdraw from fuel cell research appears to be linked to the TSA announcement, adding that this may affect Japanese companies' strategies on fuel cell if the issue remain unresolved.

Other impediments to going commercial, such as the availability of methanol and hydrogen refueling infrastructure, Krishnan predicts will be sorted out once the technology issues are addressed. "For example, the cost of the whole system should come down the moment the volumes increase while the methanol infrastructure is going to grow as there are more end-users."

With the commercialization of fuel cells still a couple of years away at best, analysts say Li-ion batteries will continue to be the dominant power source for handsets for the foreseeable future. Strategic Analytics predicts that by 2010 fuel cells will have a 5% market share at most, with the vast majority of device running on Li-ion or lithium polymer batteries.

The DMFC advantage

A fuel cell is an electronic device that combines hydrogen fuel with oxygen to produce electric power, heat and water. There are several types, which are characterized by their electrolytes and temperatures.

For use in mobile phones, direct-methanol fuel cell (DMFC) technology has attracted much of the attention over other technologies such as reformed methanol to hydrogen fuel cells (RHFCs), formic acid fuel cells, direct borohydride fuel cells and proton exchange membrane cells.

Compared to fuel cells using pure hydrogen, DMFC has a higher energy density. In addition, methanol can be more easily transported and stored than hydrogen.

While technologies such as proton exchange membrane fuel cells and RHFCs require reformers, which are considered a barrier toward miniaturization, DMFC does not require reformers to extract hydrogen from methanol, says Vijay Shankar Murthy, a research analyst at Frost & Sullivan.

Another advantage of DMFC is that the bipolar/monoplanar plates used can be made of lighter-weight and lower-cost materials than those of other fuel-cell technologies.