Ultracapacitor Technology Forecast

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Supercapacitor Technology

Electrochemical Capacitors, also known as ultracapacitors, supercapacitors or double layer capacitors, store electrical charge. In contrast to traditional capacitors, that store electrical charge on two parallel surfaces separated by a dielectric insulator, ultracapacitors store the charge in an electrical "double layer" between a carbon surface and a liquid electrolyte (Miller & Simon, 2008). The basic cell takes form of two carbonaceous electrodes that share a common electrolyte bath. In hybrid devices one of the carbon electrodes is replaced by an electrode taken from battery technology (Maletin et al, 2006)

The crucial characteristic for supercapacitors as energy storage devices is the specific energy stored. Other important aspects are the specific power, cycling life, self discharge current and efficiency (Maletin et al, 2006), but the first shall be used in this report as the main performance characteristic.

See also: topic proposal

Limiting Factors

Basic background research discovered that the following were limiting or influential factors to the specific energy.

- Specific energy is directly proportional to the capacitance (Maletín et al, 2006)
- Capacitance depends on the surface area of the electrode (Miller, 2008)

Some research points out that increasing surface area more than 1500m2/g does not increase capacitance (frost 2005)

- Effective surface area also depends on the ion size – thus on the electrolyte

Maletín & Co (2006) state the limit for carbon electrodes in organic electrolyte is 150 F/g and the specific energy limit is 5Wh/kg. Note: this is not for hybrid Ucaps.

- Voltage
- One way to optimize is to match the electrode pores to the ion size

Hybrid Ucaps operate on a slightly different principal, and can achieve much higher energy densities.

Research directions

Here it must be noted that although the specific energy has been used as the measure of supercapacitor performance, there are other important parameters that are being maximized, such as specific power and reduced, such as internal resistance.

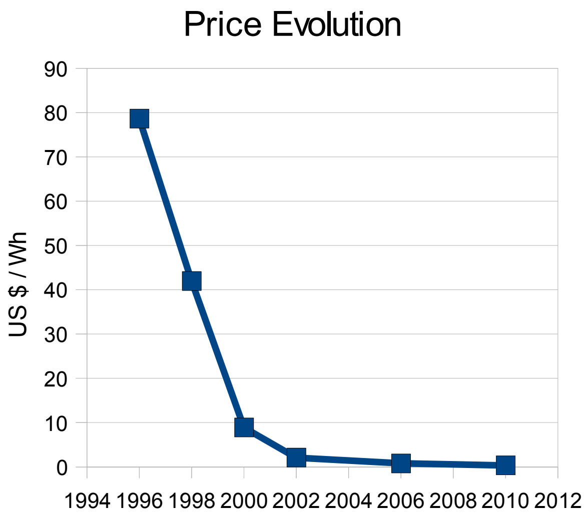
The R&D is focused on the following areas:

- New methods of fabrication are being explored, especially for nanostructured ultracapacitors and electrodes.
- Nanotechnology is a big one here, and is likely to be responsible for the improvements in “normal” Ucaps in the following years.
- As a theoretical limit for carbon electrodes in organic electrolytes has been reached and indeed exceeded research is looking at new materials. Attention should be payed to aluminum oxide use in Ucaps, as well as Titanium compounds.
- Electrode dimensions will be optimized
- Electrode structure will be optimized to the electrolyte used
- Research is pushing to develop ultra thin, and even flexible & transparent (and all of these at the same time) Ucaps.
- Woven Ucaps are being developed.
- Hybrid Ucaps are receiving a lot of attention, and still have a huge potential for improvement. There is nothing to chow that this trend would decrease.

Some companies have claimed to be able to radically up the voltage used. At the moment the maximum voltage is typically 3V, but the energy stored increases by the square of the voltage. If they were to succeed (be skeptical) the energy storage prowess of Ucaps would jump immediately in line with the very best Li-Ion prototypes; while Ucaps have other huge advantages.

Cost

- Materials are responsible for 50-65% of cost (frost 2005)



Note: not much data was found to do with cost

Current and future applications in place of batteries

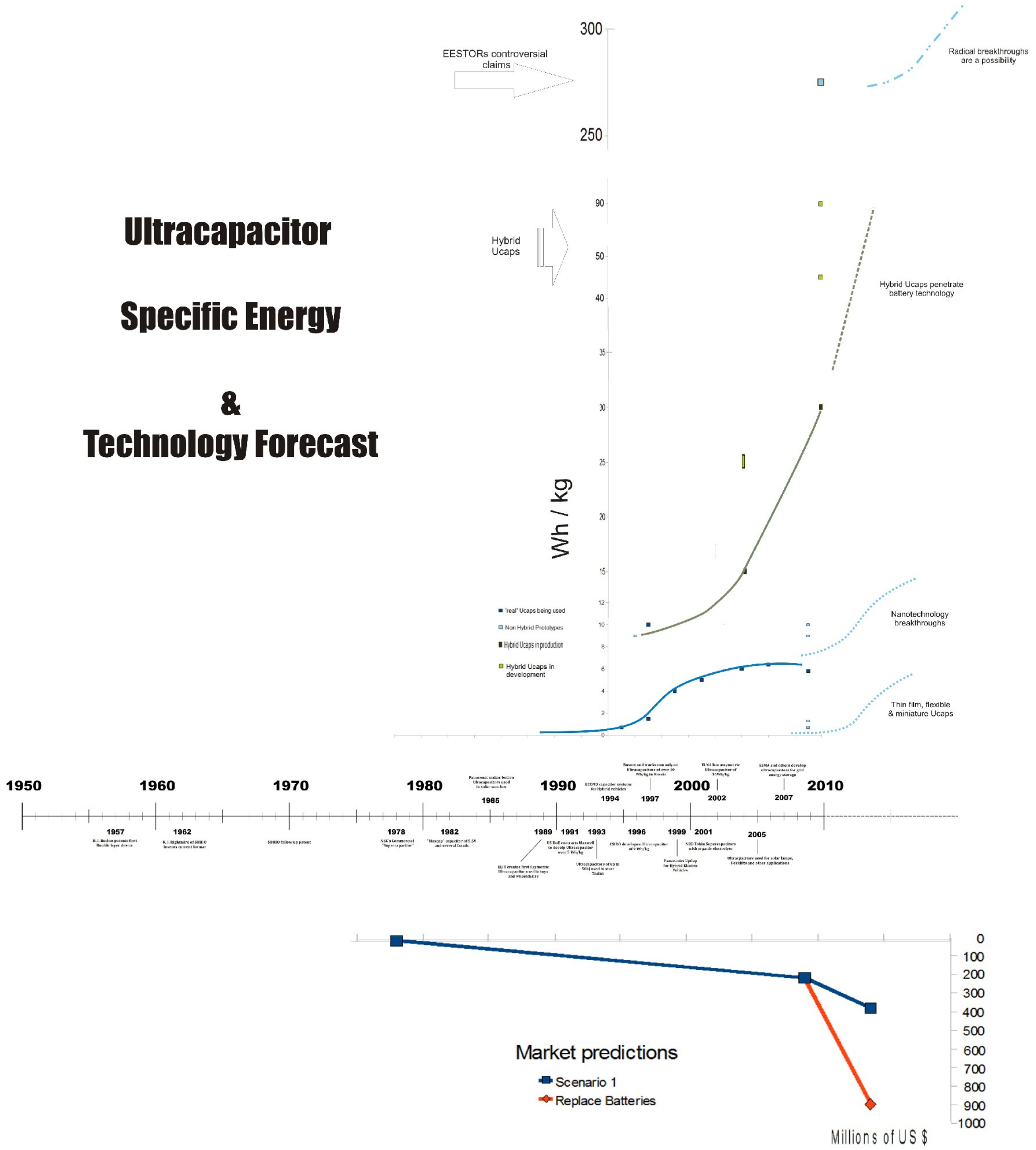
The goal of this forecast has been accomplished. Ultracapacitors have already replaced batteries in some functions. They are a viable alternative whenever high specific power is required.

They are especially suited to many applications with many short charge-discharge cyles due to the fast charging times and extremely long life cycle. Some applications can be tailored to this technology, an excellent example is the urban bus project in Shanghai.

The following is a list of applications where Ucaps have partially or fully displaced batteries as energy storage devices:

- In Hybrid-electric vehicles.
- In Diesel-electric trains (Barrade et al, 2004) a fuel reduction of 44% can be achieved, with return on investment after less than 10 years.
- In lifts and cranes as an energy buffer energy reductions of about 40% can be achieved (Burke et al, 2004)
- A very interesting case of urban buses use Ucaps and charge in 30s every 3-5 miles at stops has been implemented in Shanghai. This is technically viable in most urban settings reduces fuel costs by around 40%.
- Trolley Busses (Barrade & Rufer 2004)
- Fork lifts
- Electrical Scooters (Barrade & Rufer 2004)
- Use in uninterrupted power supplies UPS (Stepanov et al 2007) to deliver high currents before auxilary generators kick in.

Timeline and forecasts



Conclusions

Whether Ucaps do actually displace batteries in most uses is a question as to how successful various high risk projects are in the near future and how soon.

One should also be open to the remote possibility of radical disruptive innovations being achieved within the next ten years. In any case Hybrid Ucaps will continue to penetrate the market, and Ucap technology is following many different directions that will permit many novel and innovative applications.

It will be very interesting to find out just how much can be achieved with ultracapacitor technology, the next few years should be very exciting.

References

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Total 33 references. Sorry for the referencing format not being correct in many cases,