

# Bridging the gap between Li-ion and supercapacitor Technologies

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It is currently being debated what battery technology would better serve the future automotive markets, where both high specific energy and power are more and more often simultaneously required [1]. The transition to 42V systems, integrated starter-alternator, hybrid electric vehicles and purely electric vehicles, will make automobiles more battery-dependant than they currently are.

To satisfy this demand, one approach is to improve existing technologies, the other is to invent new ones. At one end of the spectrum, Li-ion batteries [2] benefit from the highest energy densities (150 to 200 Wh/kg), and can now be engineered to also deliver high power (45 Wh/kg @ 1000 W/kg). However, they suffer limited cycle-life (usually 500 to 1000 cycles @ 100% DOD). One the other end, carbon-carbon double layer capacitors [3] have virtually unlimited cycle-life, very high specific power (5000 W/kg or more), but modest energy densities (3 to 6 Wh/kg) (Fig.1).

We will present a family of hybrid devices [4] that use a nanostructured  $\text{Li}_4\text{Ti}_5\text{O}_{12}$  anode [5] and an acetonitrile- $\text{LiBF}_4$  electrolyte, combined with various types of intercalation or double-layer cathodes. Most of them demonstrate a higher cycle-life and specific power than Li-ion, and a higher specific energy than EDLCs (Fig.2). The pros and cons of each combination will be debated, taking into account specific energy, specific power and cycle-life.

## References:

- [1] Andrew Chu, Paul Braatz, Journal of Power Sources 112 (2002) 236–246
- [2] Anna M. Lackner, Elena Sherman, Paul O. Braatz, J. David Margenum, Journal of Power Sources 104 (2002) 1–6
- [3] Eugenio Faggioli, Piergeorgio Rena, Veronique Danel, X. Andrieu, Ronald Mallant, Hans Kahlen, Journal of Power Sources 84 1999 261–269
- [4] Glenn G. Amatucci, Fadwa Badway, Aurelien Du Pasquier, J. Electrochem. Soc. 148, A930 (2001)
- [5] US patent application 20020102205

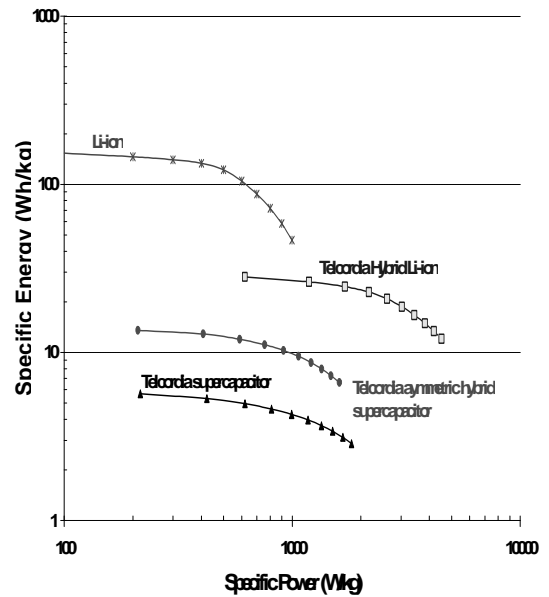


Figure 1: Ragone plots for Li-ion, supercapacitor and hybrid energy storage devices

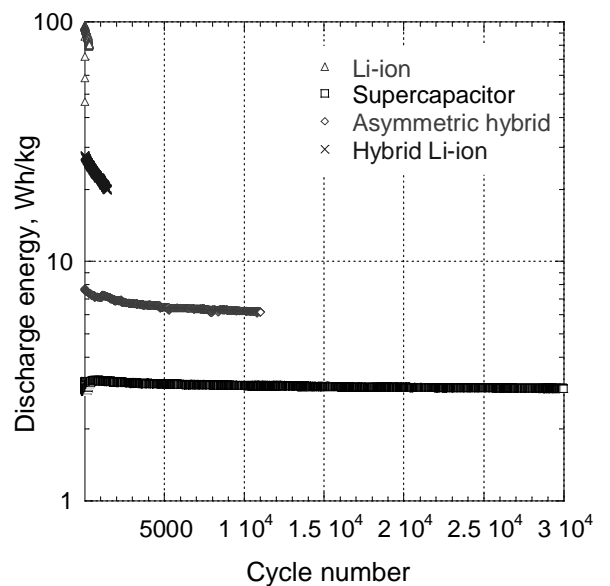


Figure 2: Cycle-life for Li-ion, supercapacitor and hybrid energy storage devices

