

# Supercapacitors

Different types				
Type	Process	Electrodes	Electrolyte	Separators
electrostatic supercapacities	Electronic and ionic charge migration	Activated carbon carbon fiber carbon aerogels metal oxides	aqueous : HCl, H <sub>2</sub> SO <sub>4</sub> , H <sub>3</sub> PO <sub>4</sub> , KOH	polyolefin membranes (polyethylene...)
			organic : Et <sub>4</sub> NBF <sub>4</sub> /Acetonitrile	microporous membranes (Celgard), or cellulose based
electrochemical supercapacities	Electronic and ionic charge migration + reversible redox reactions	IrO <sub>2</sub> , RuO <sub>2</sub> , MnO <sub>2</sub> , V <sub>2</sub> O <sub>5</sub> conductive polymers (polyaniline, polypyrrole..)	aprotic solvents plastic polymer solid (Rb <sub>4</sub> Cu <sub>16</sub> I <sub>5</sub> Cl <sub>13</sub> , RbAg <sub>4</sub> I <sub>5</sub> )	

## Principles of operation and examples

**Electrostatic supercapacities**

**Examples :** (A) Panasonic 2000F, (B) Montena 2600 F, (C) Epcos 2700 F, (D) Epcos 5000 F, (E) Maxwell 2700 F prismatic, (F) Maxwell 2700 F spiral, (G) NESS 3600 F, (H) Saft 3500 F, (I) Batscap

## Technical data

Type	Voltage /cell.	Temperature of operation	Energy	Number of deep cycles	Power at steady state/ 30s	Charge/discharge efficiency	Self discharge
<i>Aqueous electrolyte</i>	0 to 1 V	- 60 to 70 °C	0,1 to 5 Wh/kg target : 10 Wh/kg	100 000 to 500 000	0.1 to 10 kW/kg	- faradic : 100% - energy : 85 to 98%	- 50 % /month (at 25°C) - 51 % of energy loss after 250 hours at 70°C
<i>Organic electrolyte</i>	0 to 2,5 V						

Maintenance	Environmental Impact	Safety
None	Toxic compounds : biding agents PTFE, PVDF Corrosive compounds : acid electrolytes	End of charge/discharge voltages must be controlled

# Supercapacitors

Applications						Economic data
Manufacturer	Techno.	Voltage Capacity	Power	Energy	Development Status	<b>Cost Evolution:</b> <b>1997</b> : 150 € - 500 €/Wh per cell <b>2002</b> : 50 € - 150 €/Wh per cell or for a 12V (or 42V) system; ⇒ 0,03 € - 0,08 €/F. - from 200 to 1000 €/kW  <b>2005</b> : 16 €/Wh (0,01 €/F)  <b>Manufacturers :</b> France : SAFT, Batscap Denmark : Danionics Russia : Elit, Econd (Russia/USA) Israel: ECR EPCOS (Germany/Japan) Switzerland: Montana components AG, Skeleton Technologies  Japan : Hohsen Corp., Matsushita, ELNA, Panasonic Korea : Samyoung, NESS USA : IMRA, P.R.I., Cooper/PowerStor, Evans Corp, Kanthal/Cesiwid, Maxwell Technologies, Tokin/NEC (USA/Japan) Australia : CSIRO et Cap-XX PTY  <b>Research Institutes (not exhaustive) :</b> NASA, ...
EPCOS, Japan & Germany	Organic carbon	2,3 V 2700 F	3,04 kW/kg	2,74 Wh/kg	On sale	
Evans Corp, USA	H <sub>2</sub> SO <sub>4</sub> carbon	14 V 65 F	2,5 kW/kg	0,35 Wh/kg	On sale	
Montena, Switzerland	Organic carbon	2,5 V 1 400 F	3,45 kW/kg	4,34 Wh/kg	On sale	
SAFT, France	Organic carbon	2,5 V 3500 F	3 kW/kg	4,7 Wh/kg	development	
Elit, Russia	Aqueous carbon /NiO <sub>2</sub>	1,17 V 470 F	9,5 kW/kg	3,84 Wh/kg	development	
ECR, Israel	Polymer H <sup>+</sup> Carbon ?	3,6 V 1 F	0,72 kW/ dm <sup>3</sup>	0,8 Wh/dm <sup>3</sup>	development	
<p style="text-align: center;"><b>R&amp;D Perspectives</b></p> <ul style="list-style-type: none"> <li>▪ <b>Aims of technology development are:</b> <ul style="list-style-type: none"> <li>- Reduction of cost (factor 10-100 compared to 1997), &amp; self discharge (under 10% /week )</li> <li>- Increasing specific energy (&gt;5 Wh/kg), &amp; range of temperature (-30 to 60 °C)</li> <li>- Improve energy efficiency (&gt;90%), lifetime (10-15 years) &amp; recycle ability</li> </ul> </li> <li>▪ <b>Aims of system technology development are:</b> <ul style="list-style-type: none"> <li>- Increase system voltage,</li> <li>- Develop adapted energy converter,</li> <li>- demonstration of complete systems with electrical and thermal management</li> <li>- Develop multi storage systems (battery with supercap e.g.).</li> </ul> </li> <li>▪ <b>Aims of system integration development are:</b> <ul style="list-style-type: none"> <li>- energy management system,</li> <li>- standard test procedures,</li> <li>- modelling and simulation and specification of the demands on DLC's system management.</li> </ul> </li> </ul>						