

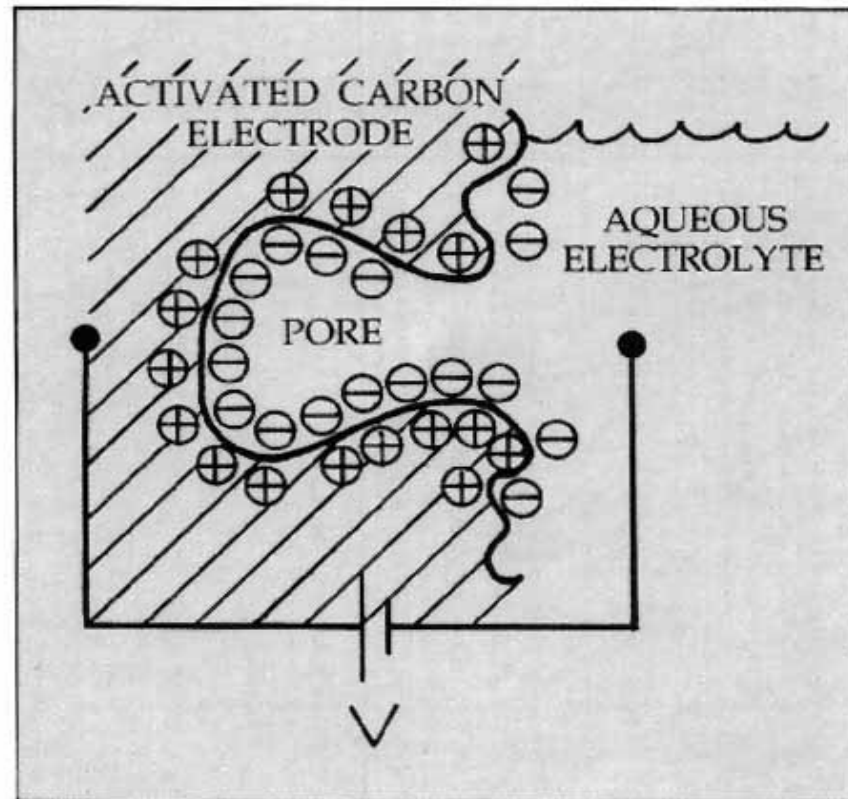
Power Density

- Conductivity of electrodes (ionic and electronic)
- Ionic conductivity of the electrolyte
- Porosity of the electrodes
- Electrochemical potential
- Presence of supercapacitor effect (good for short time pulsing)

Power Density

Supercapacitor effect

1. Good for power pulsing on the second or minute level
2. Typically detrimental for power density on the hour level
3. Can function as a built-in supercapacitor



CHARGED

Cycle, and cycle life

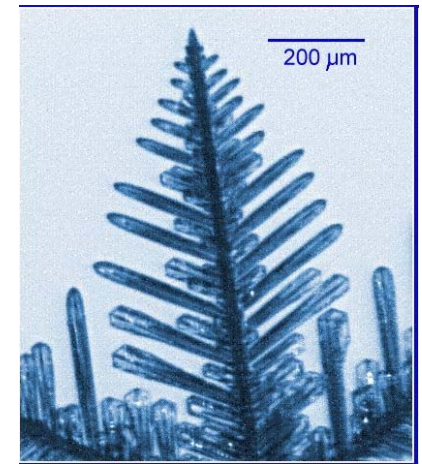
- Unique requirement on a secondary battery
- Depends on DOD (depth of discharge)
- DOD: expressed in percentage of the nominal capacity
- Cycle life varies greatly with different battery technology
- Cycle might have other unexpected effect such as the “memory effect”

Factors affecting cycle & life

- Ionic conductivity of electrolyte
- Preferably without solid state ionic diffusion
- Electrode materials of small surface tension (soft metals, etc.)
- Fuel cell type electrodes where the electrode itself is not changed before and after the reaction (catalytic electrode)

Factors affecting cycle & life

- Electrolyte is preferably aqueous (water based)
- Properly tune the surface tension of the electrolyte and electrode (avoid dendrite formation)
- Dendrite formation is a matter of wetting the surface or not (kind of)
- Solid state diffusion is to be avoided as possible. Example
LiCoO_x vs NiOOH



Comparison of some batteries

	Ag-Zn	Ni-Cd	Ni-H ₂	Ni-MH	Li-ion
Anode	Zn	Cd	H ₂	LaNi ₅	Li intercalated C
Cathode	AgO	NiOOH	NiOOH	NiOOH	LiCoO ₂
Electrolyte	KOH	KOH	KOH	KOH	Li salt in PC EC
Aquatic?	yes	yes	yes	yes	no
Active ions in electrolyte	OH ⁻	OH ⁻	OH ⁻	OH ⁻	Li ⁺
Ion diffusion rate in electrolyte	fast	fast	fast	fast	slow
Need solid-state diffusion in electrode?	no	no	no	yes	yes
Corrosive Electrolyte?	yes	yes	yes	yes	no
Catalytic Anode?	no	no	yes	no	no
Catalytic Cathode?	no	no	no	no	no
Energy density (W·Hr/kg)	90-100	40~50	50-60	60-80	100-150
Cycle life (CL)	<30	>2000	>10000	~500	~500
CL@DOD 20%	100	>10000	>130000	~3000	~4000
CL @DOD 90%	30	>1000	>20000	500	500
Charge Time	2	1	1.5	3~4	4

Cost of batteries

- Largely determined by the cost of raw materials
- Geological abundance is an important factor
- The abundance is given by nuclear chemistry – each element as synthesized in the nucleosynthesis process
- Extraction (mining) ease is given by the terrestrial geology (for now)

Cost of some raw materials (\$/ton)

- Ni ~ 30,000
- Co ~ 45,000
- ReOx 40,000
- Lithium carbonate 20,000
- Lead 2000
- Magnesium 2500
- Manganese 2500