albufera Energy Storage

From Lithium-ion to Metal-air batteries for electric vehicles

AEDIVE

Congreso europeo del vehículo eléctrico 2015

Joaquín Chacón

November 23rd 2015

Madrid

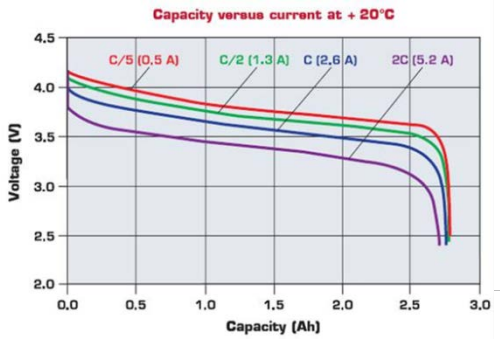
albufera Energy Storage

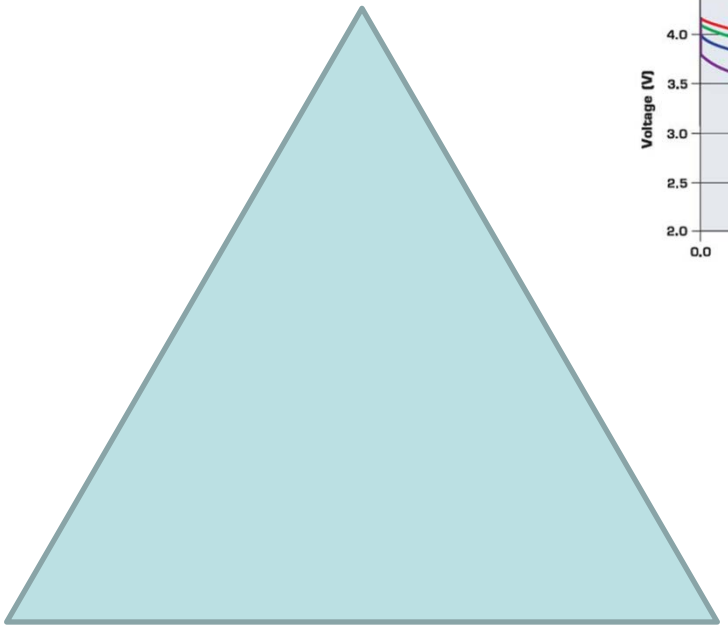
www.albufera-energystorage.com
PCM Campus de Cantoblanco, C/Faraday Nº7 , 28049, Madrid

albufera Energy Storage

>> The battery of the future

Performance





Cost

Social acceptance

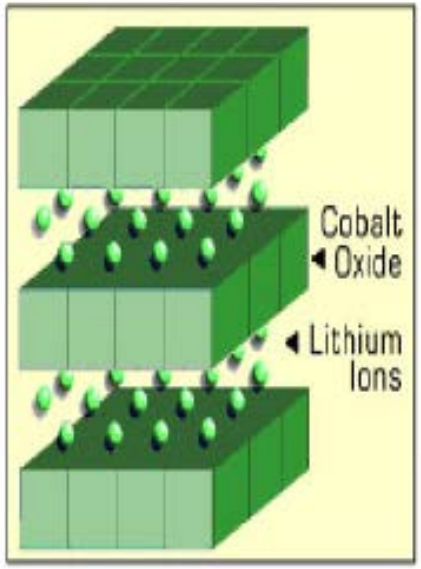
albufera Energy Storage

>> Lithium-ion technology

Lithium-ion term is referred to an electrochemical system where Lithium ions are consecutively inserted into the positive and negative electrodes

Positive electrode

- Intercalation materials (insertion) as transition metal oxides or phosphates: Co, Ni, Mn, Mg, Fe, etc.
- Atoms are oriented and organized in diverse structures: metallic oxide layers, spinels, olivines – the structure has influence in final features of the Lithium-ion cell



Negative electrode

- Intercalation materials as Carbon and $Li_4Ti_5O_{12}$
- There are also anodes based on metals which form alloys with Lithium: Si, Sn, Al, Sb, etc.

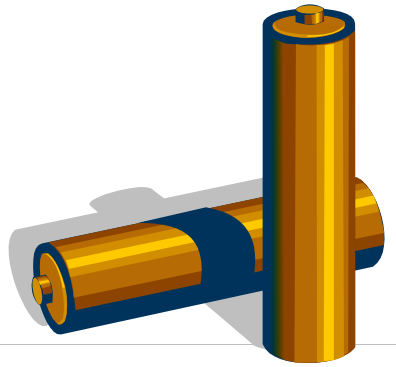
Disadvantage:

> High capacity -> Important changes of volume -> Poor cycling

> The structure can stabilize by using inactive materials

>> Lithium-ion battery market

- Doubles from 2012 to 2016.
- 22,500 MUSD in 2016.



In 2016:

- Professional and domestic electronics 52%
- Electric vehicles 25%
- Industrial 23%

And Europe is 29% of world market

albufera Energy Storage

>> Why post-Lithium-ion batteries?

Post-Lithium-ion battery technologies are not really new; however there are reasons why they have received more attention recently:

- Lithium-ion is the best battery technology we have ever seen:
  - Increases energy density by 5% per year.
  - Decreases cost at 8% per year.

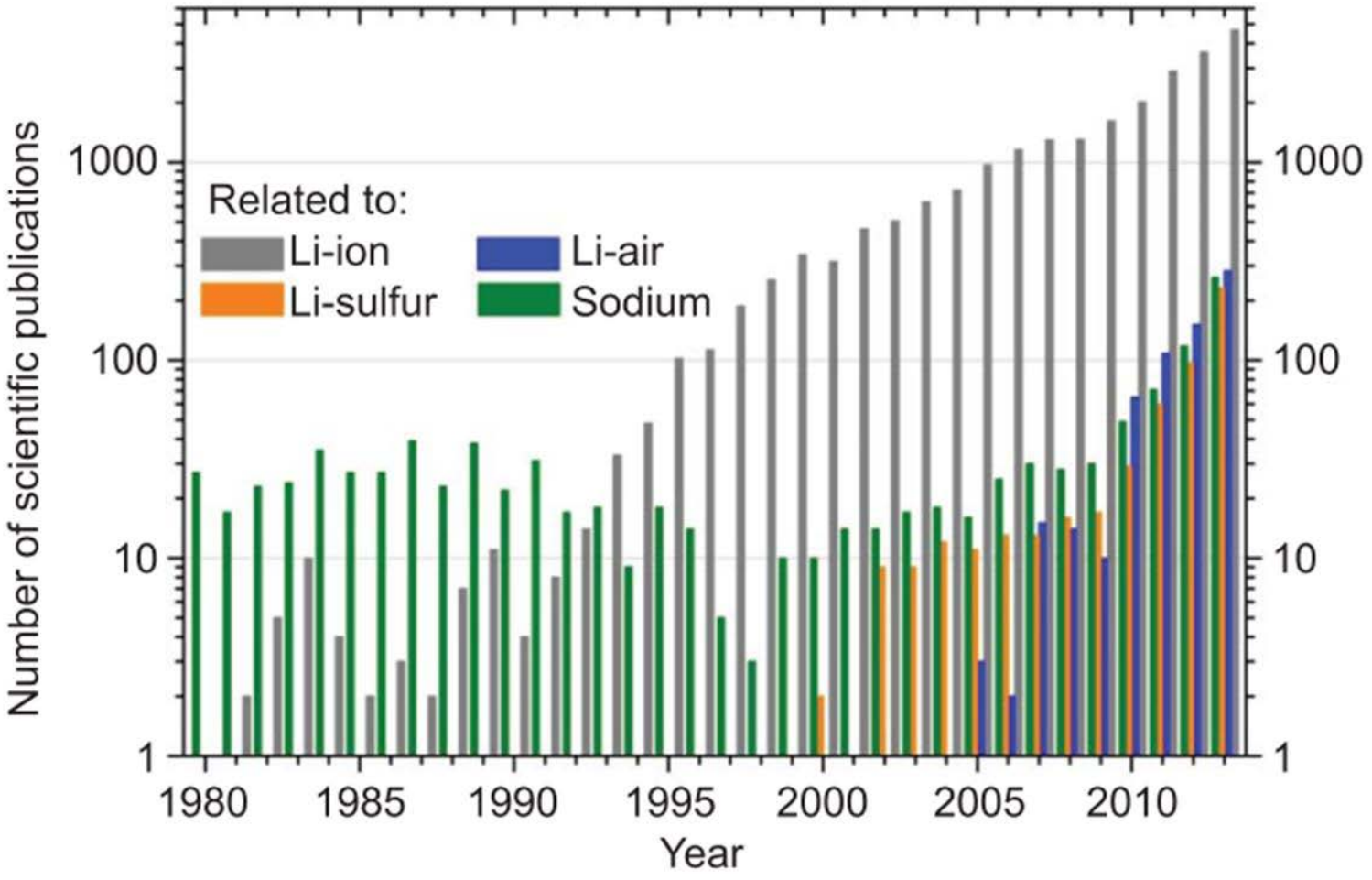
… but it cannot achieve transformative factors of five in cost and performance.

- The Lithium-ion battery manufacturing industry is already highly concentrated among five Asian producers, and further consolidation will increase margin pressures on component suppliers.

- Environmental regulation on transport is converging in many parts of the world.

albufera Energy Storage

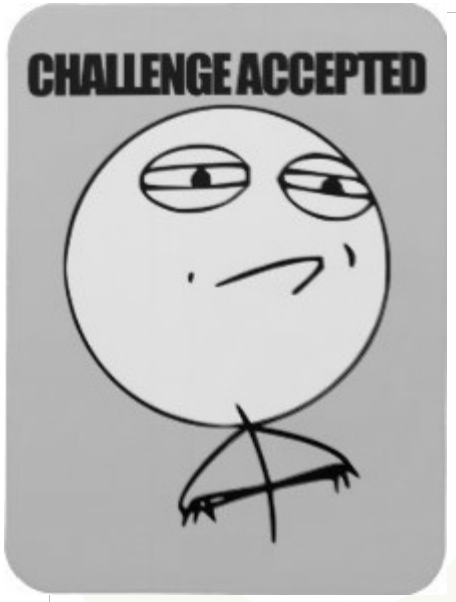
>> Growing interest in advanced technologies



albufera Energy Storage

>> Challenges: Technological

- Achieving as close as possible theoretical specific energy potential.
- Achieving that performance whilst keeping a fair number of cycles (between 500 and 1000 depending on the application).
- Safe batteries and safe manufacturing processes.
- Environmental impact of batteries.



albufera Energy Storage

>> Challenges: Engineering

- Scaling the size of the cell from laboratory coin cells to the size required in application.
- Scaling large scale manufacturing of cells whilst keeping performance and quality.
- Developing battery products for different applications.

albufera Energy Storage

>> Challenges: Commercial and financial

- Obtaining end user confidence in terms of performance, price, reliability and quality.
- Financial survival through technology development and commercialization process → Crossing the “chasm” or the “valley of the death”.
- High competition and oligopolistic practices by incumbent players.

albufera Energy Storage

>> Barriers for automotive market

- A potential barrier for entry in automotive markets is the relatively high performance, safety, and reliability requirements of customer automotive original equipment manufacturers (OEMs).OEM quality requirements, as well as their desire for financially stable suppliers, may tilt the playing field in favour of established competitors with strong production track records and proven product performance.

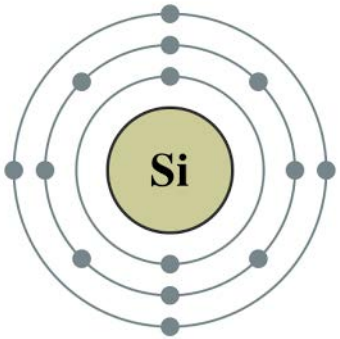
- Initial overly optimistic assumptions regarding EV demand (and BEV/PHEV demand particularly) contributed to an overbuild of large format LIB cell production capacity for automotive markets. Supply-side governmental supports have also been made available for capacity expansions in recent years.

- An additional barrier in the automotive sector is the long timeframes to implement a new technology. It usually takes 7 to 10 years for a new technology to be adopted in the automotive sector and it requires of course that the supplier to have a large manufacturing scale.

- These arguments are the reason why many of the new start-ups developing next generation technologies do not have the automotive sector as their entry point market. Usually, these companies look for high margin and less competitive niche markets.

albufera Energy Storage

>> Silicon batteries



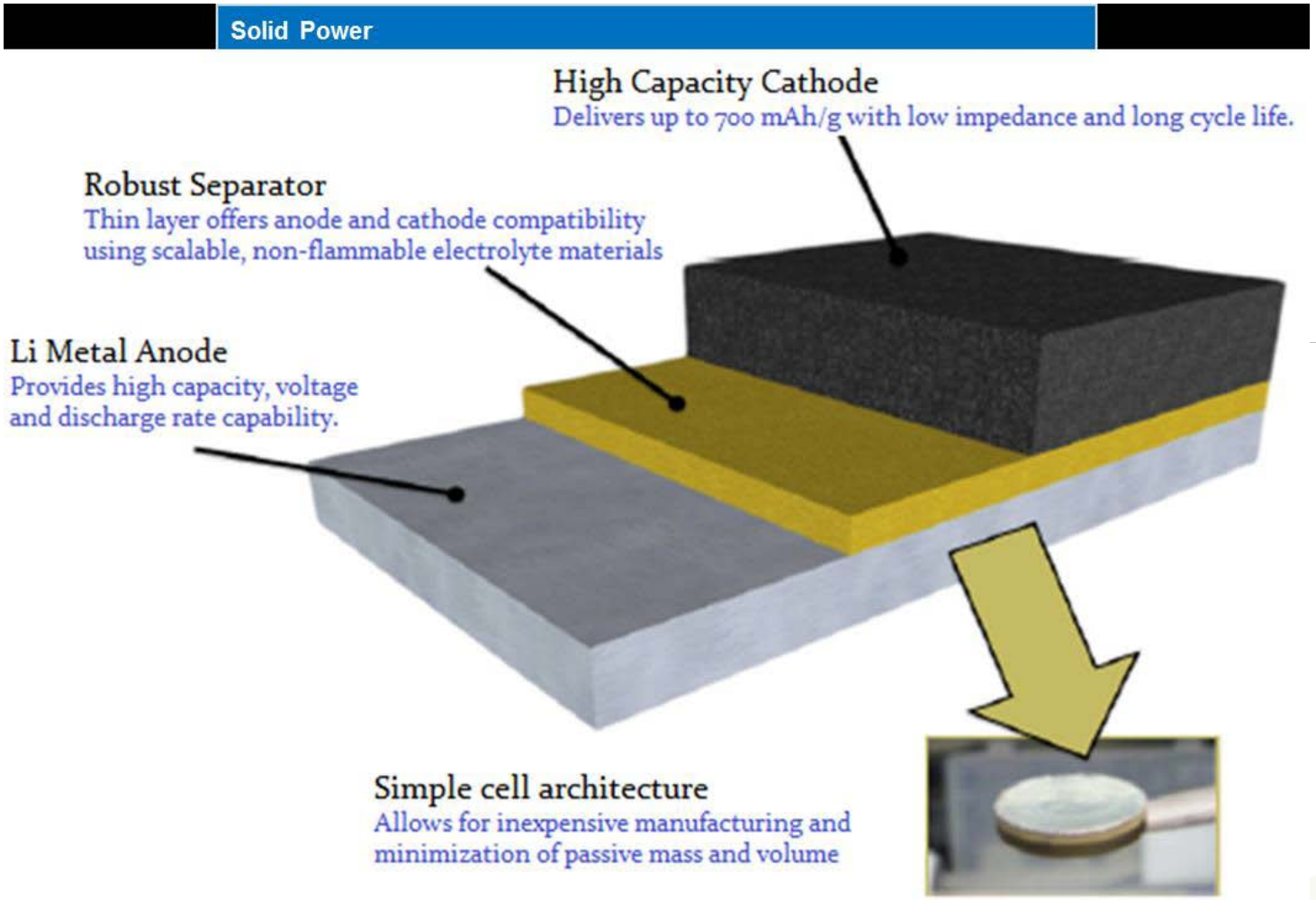
Silicon anode can provide much higher capacity than graphite anodes It can improve up to a 30% on energy density based on the same cathode.

- High specific energy: Envia Systems reported an experimental result of 400 Wh/kg, but just for 2 first cycles…
- High capacity: Silicon absorbs 10 x as many Li ions as graphite. The highest theoretical specific capacity is 4200 mAh/g.
- Abundant materials. Silicon is the 2nd most abundant element in the earth's crust.

Silicon alloys	Volume/Å^3	Volume change	Theoretical capacity/mAh/g
Si	19.6	120%	0
LiSi	31.4		954
$Li_{12}Si_7$	43.5		1635
Li_2Si	51.5		1900
$Li_{13}Si_4$	67.3	240%	3100
$Li_{15}Si_4$	76.4		3590
$Li_{22}Si_5$	82.4	320%	4198

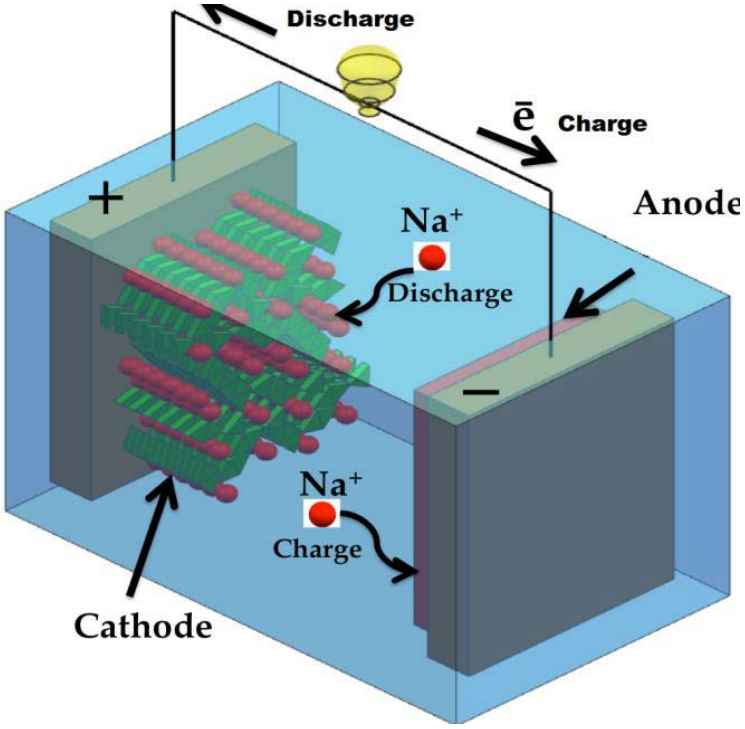
albufera Energy Storage

>> Solid state batteries



albufera Energy Storage

>> Other Metal-ion batteries



ALION

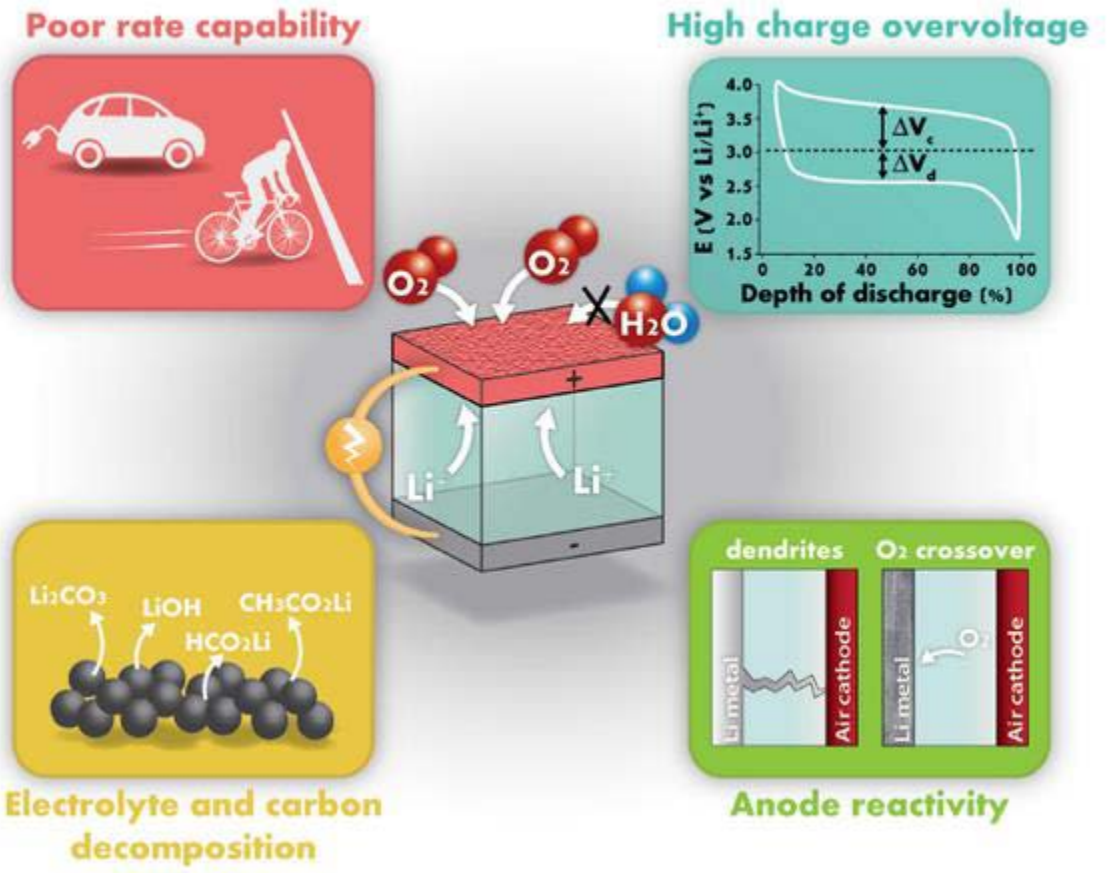
albufera Energy Storage

>> Metal-air batteries

Metal	Electrochemical equivalent Ah/g	Theoretical voltage versus O_2	Alteration of the oxidation state	Theoretical specific energy kWh/kg	Actual operative voltage V
Li	3.86	3.4	1	13	2.4-3.1
Ca	1.34	3.4	2	4.6	2
Mg	2.2	3.1	2	6.8	1.2-1.4
Al	2.98	2.7	3	8.1	1.1-1.4
Zn	0.82	1.6	2	1.3	1.0-1.2
Fe	0.96	1.3	2	1.2	1

albufera Energy Storage

>> Metal-air batteries



>> Conclusions

- Growing market and further expectations for batteries.
- Lithium-ion batteries represent the most promising technology for first steps in electric vehicle deployment worldwide.
- But new chemistries are needed:
  - Metal-air
  - Metal-ion
  - Silicon
  - Sodium
  - Aluminium
  - And more…

albufera Energy Storage

>> Contact

www.albufera-energystorage.com

joaquin.chacon@albufera-energystorage.com

MaBiC 16

Metal Air Batteries International Congress