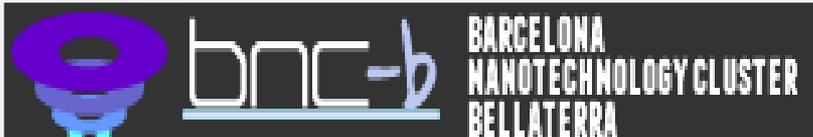


Mejora de prestaciones de baterías recargables en automoción derivadas del uso de luz sincrotrón

M.Rosa Palacín

Institut de Ciència de Materials de Barcelona (ICMAB-CSIC)

rosa.palacin@icmab.es



Barcelona Nanotechnology Cluster - Bellaterra



UAB

IMB-CNM

ICMAB

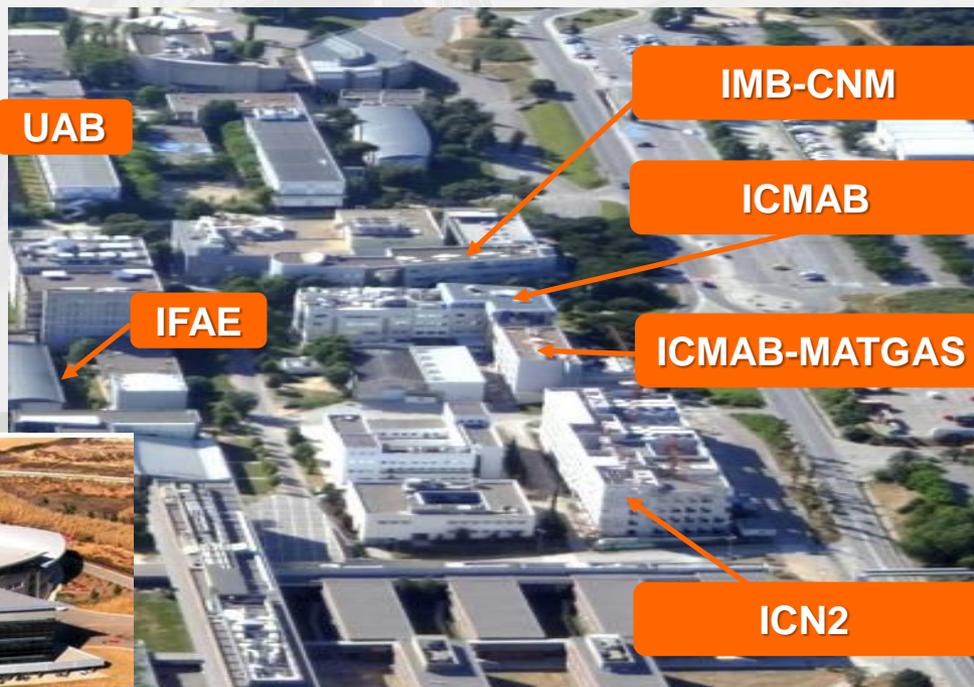
IFAE

ICMAB-MATGAS

ICN2



ALBA synchrotron



~ 700 investigadores / ~ 1000 personas

La mayor concentración en I+D N&N en España

~40-50 % producción científica Catalunya Mat&N&N



1. Introducción

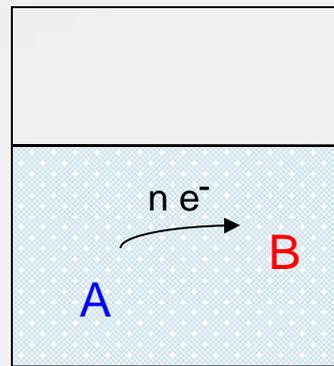
2. Aplicación en materiales comerciales

3. Aplicación en tecnologías en desarrollo

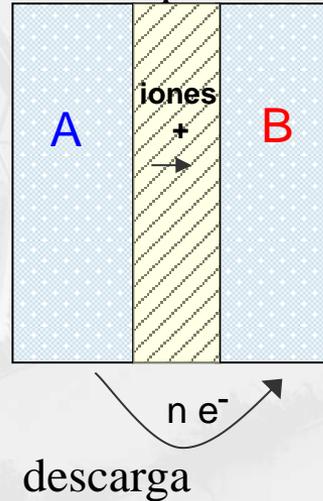
4. Aplicación en nuevas tecnologías

¿Qué es una batería?

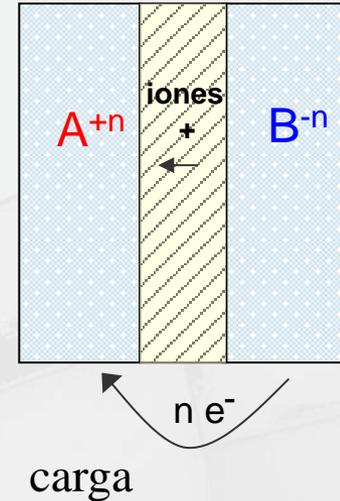
reacción redox



batería primaria



batería secundaria



Materiales ⇔ prestaciones

Bicicleta eléctrica (50-60km) ⇔ 300-360 Wh (36V, 8-10Ah)

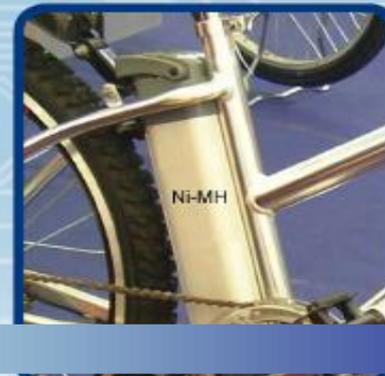
PbO-Pb
10-15 kg



Ni-Cd
7-8 kg



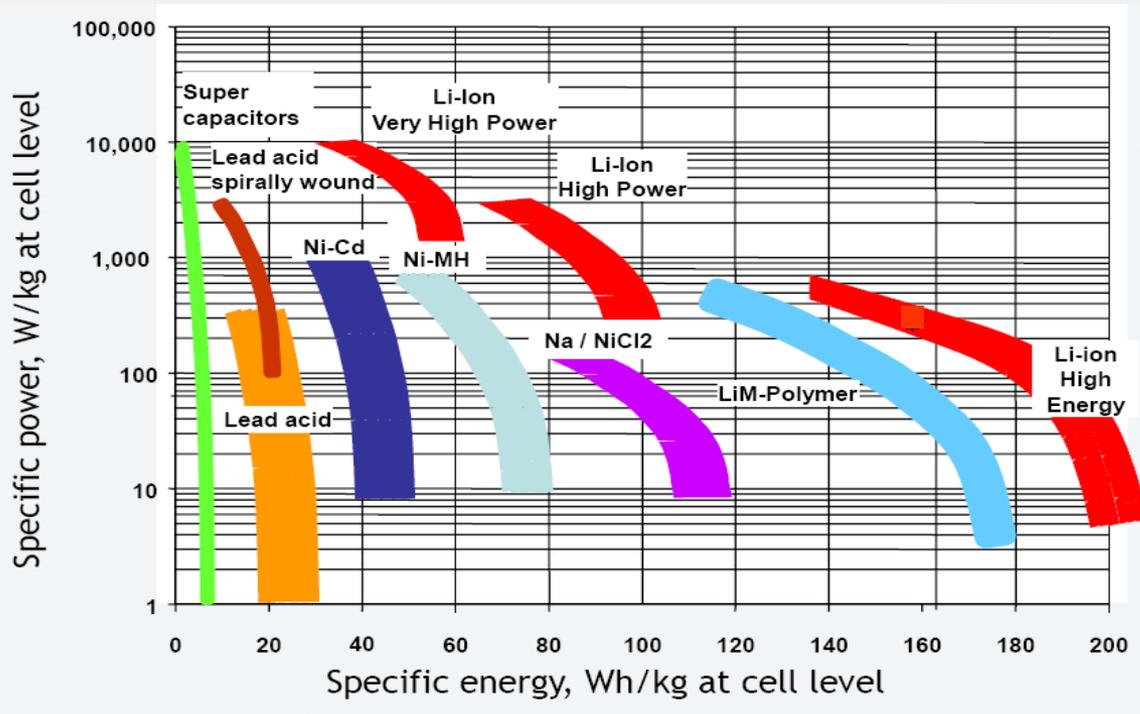
Ni-MH
6-7 kg



Li-ion
3-4 kg

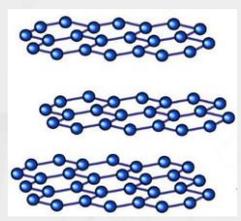


coste

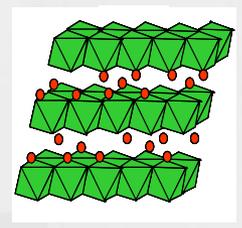
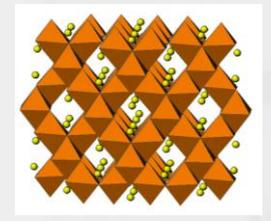
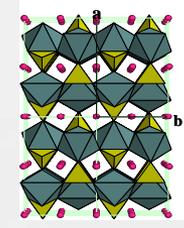


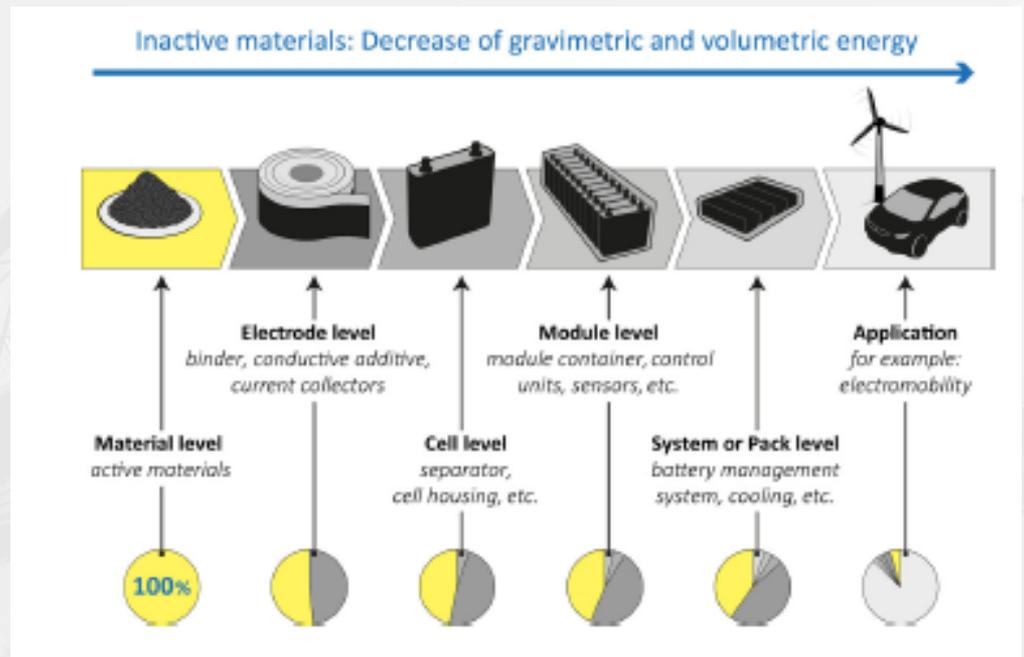
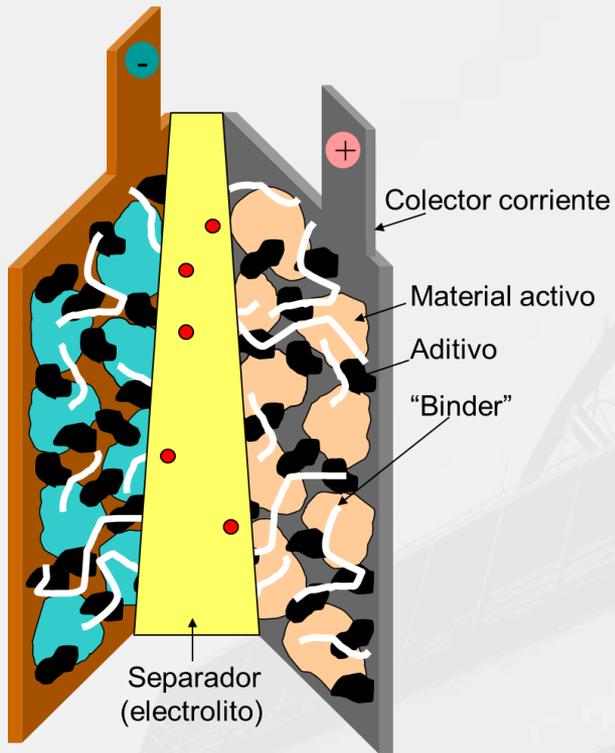
Ion-Li

MATERIALES (negativo/positivo)	Potencial
Grafito/Li(Ni,Mn,Co)O ₂	4.2 V
Grafito/LiMn ₂ O ₄	4.0 V
Grafito/Li(Ni,Co,Al)O ₂	4.2 V
Grafito/LiFePO ₄	3.6 V



Grafito





T. Placke et al. J. Solid State Electrochem. 21 (2017)1939



41000 Wh

Las prioridades dependen de la aplicación:



≠



≠



Densidad de energía

Seguridad

Vida/coste

Densidad de potencia

Seguridad

Densidad de
potencia/energía

Vida/coste

Vida/coste

Escalabilidad

Densidad de
potencia/energía

Seguridad

Mejora de las tecnologías actuales

aumentar vida media

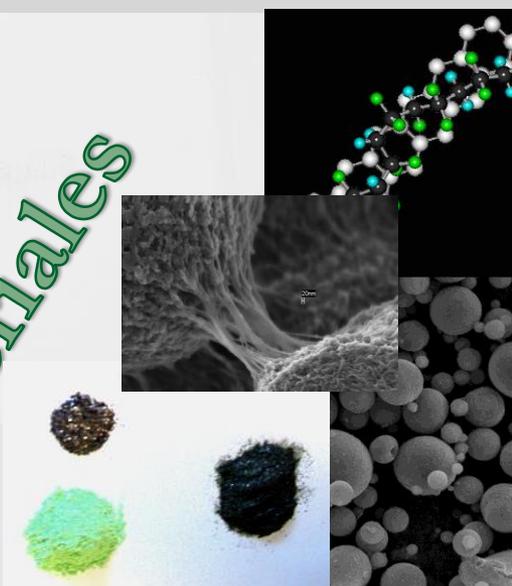
aumentar densidad de energía

reducir coste

Nuevas tecnologías



Materiales



La luz sincrotrón es una herramienta de caracterización clave en ciencia de materiales....

y los materiales para baterías no son una excepción

**CHEMICAL
REVIEWS**

29.09.2017

Review

Cite This: *Chem. Rev.* 2017, 117, 13123-13188

pubs.acs.org/CR

Synchrotron X-ray Analytical Techniques for Studying Materials Electrochemistry in Rechargeable Batteries

Feng Lin,^{*,†} Yijin Liu,[‡] Xiqian Yu,^{§,||} Lei Cheng,[⊥] Andrej Singer,^{#,Δ} Oleg G. Shpyrko,[#] Huolin L. Xin,[@] Nobumichi Tamura,[∇] Chixia Tian,[⊥] Tsu-Chien Weng,[□] Xiao-Qing Yang,[§] Ying Shirley Meng,[○] Dennis Nordlund,[‡] Wanli Yang,[∇] and Marca M. Doeff^{*,⊥}

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[‡]Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratory, Menlo Park, California 94035, United States

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^{||}Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

[⊥]Energy Storage and Distributed Resources Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States

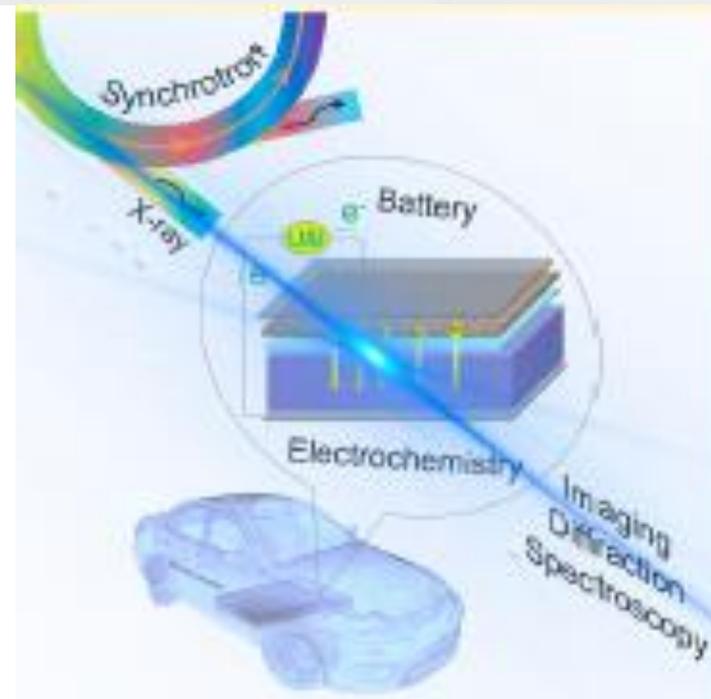
[#]Department of Physics, University of California San Diego, La Jolla, California 92093, United States

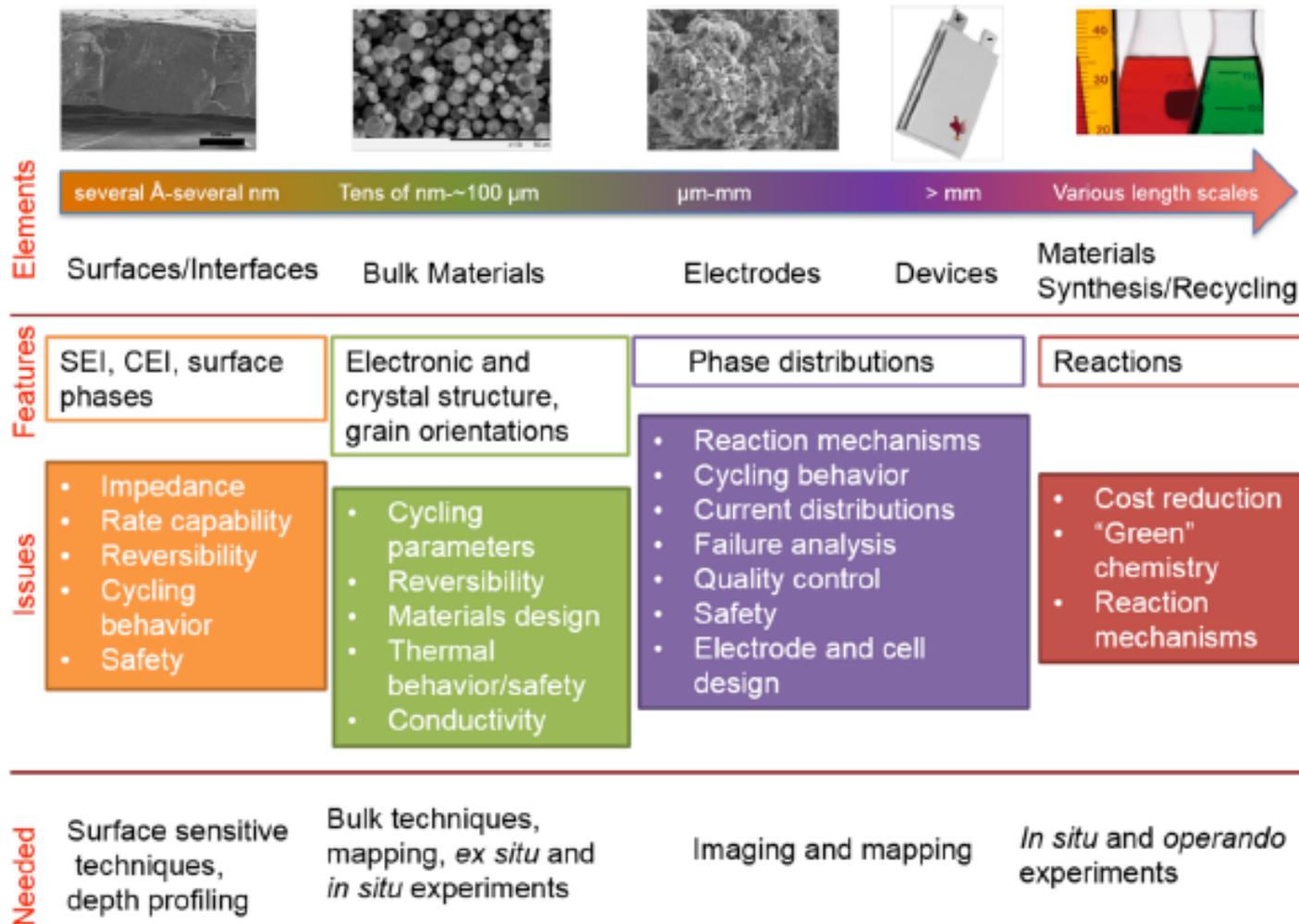
[@]Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973, United States

[∇]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States

[□]Center for High Pressure Science & Technology Advanced Research, Shanghai 201203, China

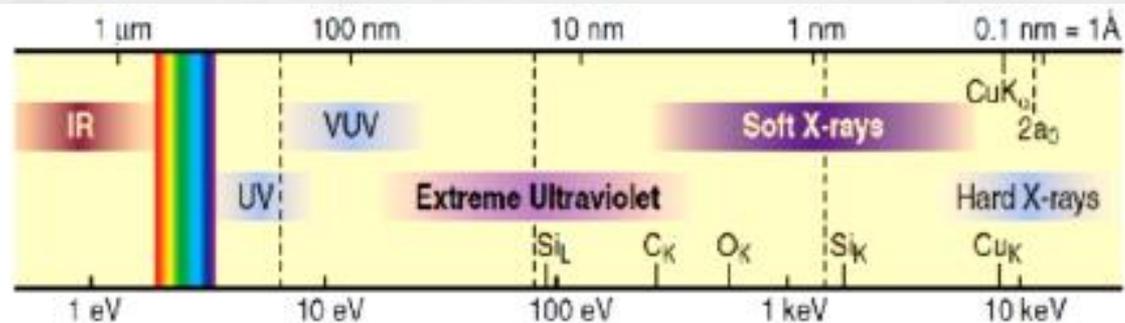
[○]Department of NanoEngineering, University of California San Diego, La Jolla, California 92093, United States





Luz sincrotrón

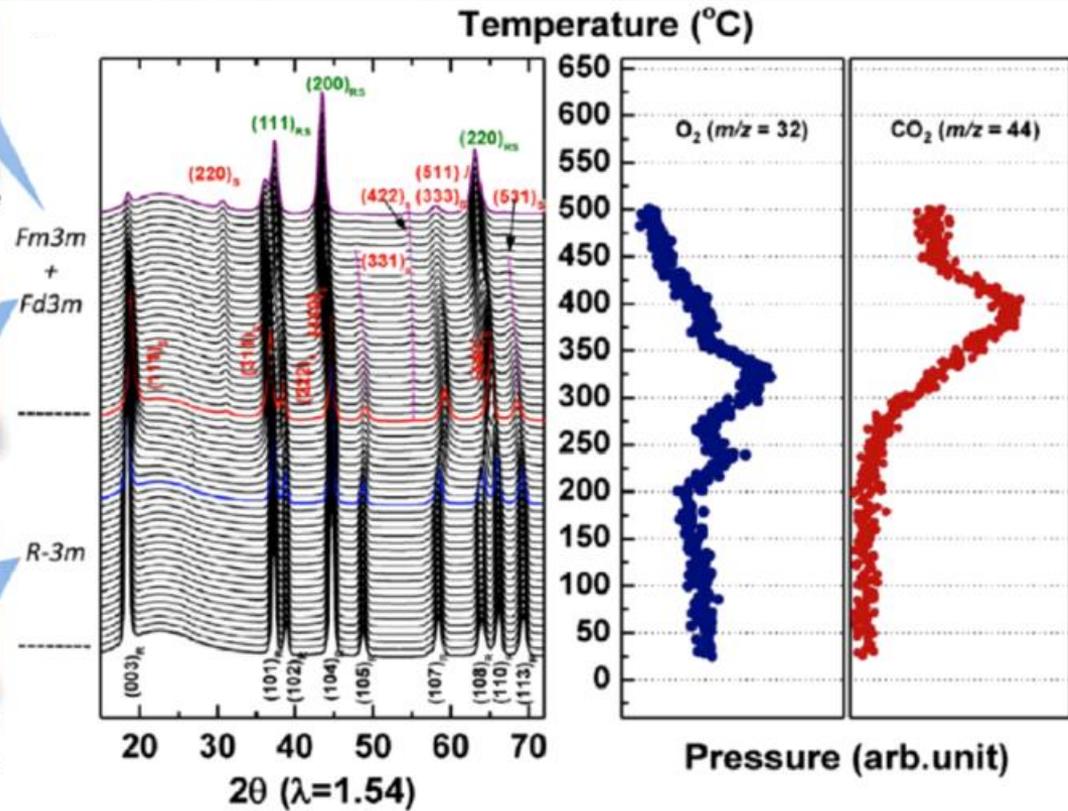
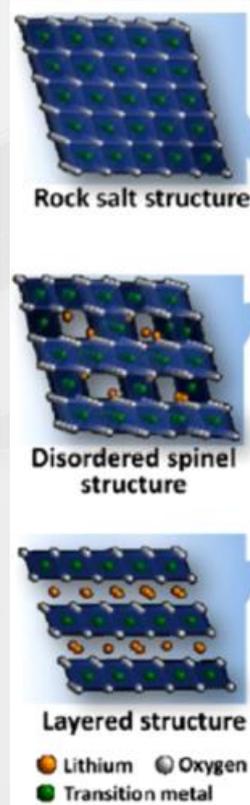
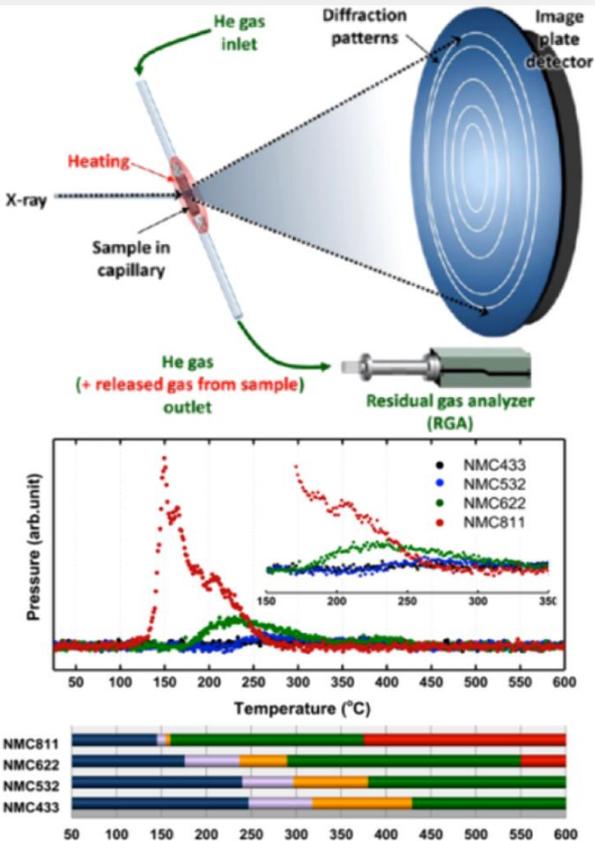
(Longitud de onda y energía)



Ejemplo 1: materiales comerciales (NMC)

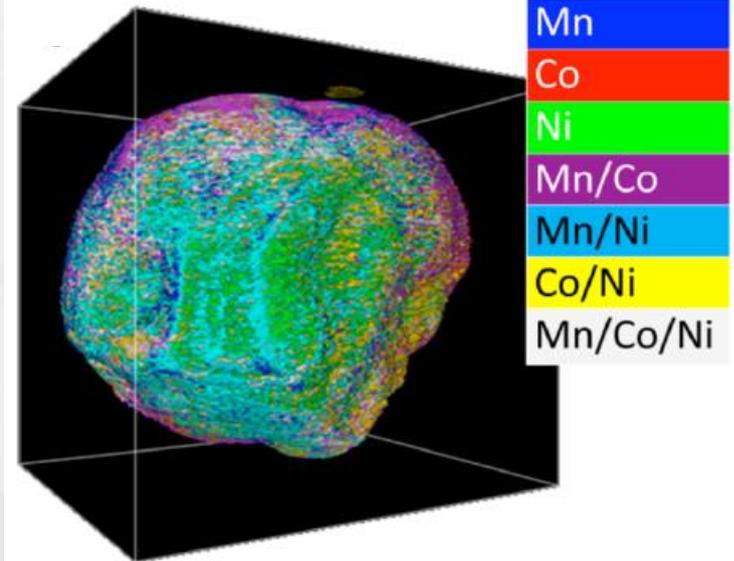
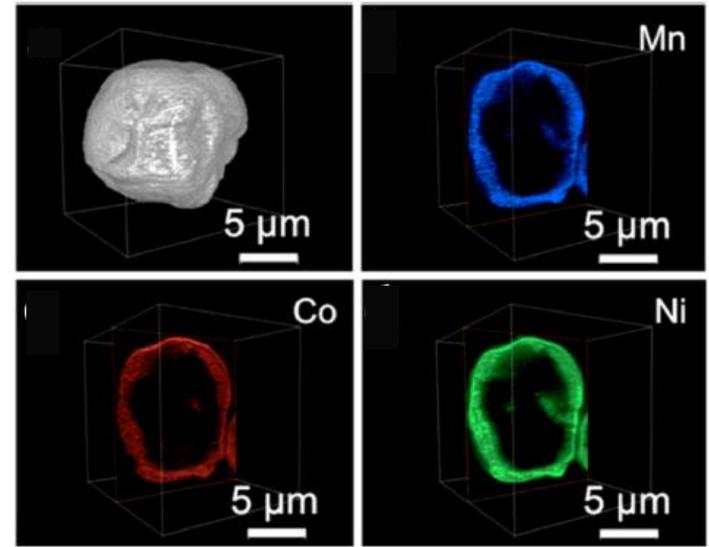
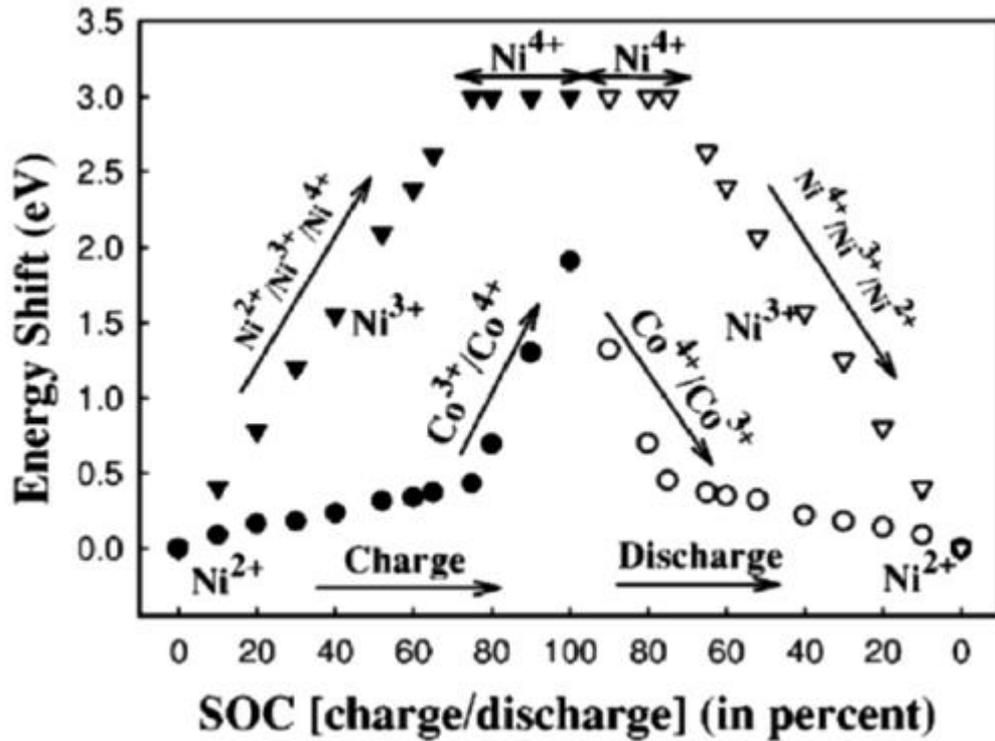


Aumentando el contenido de níquel aumenta la capacidad y disminuye el precio del material

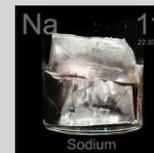
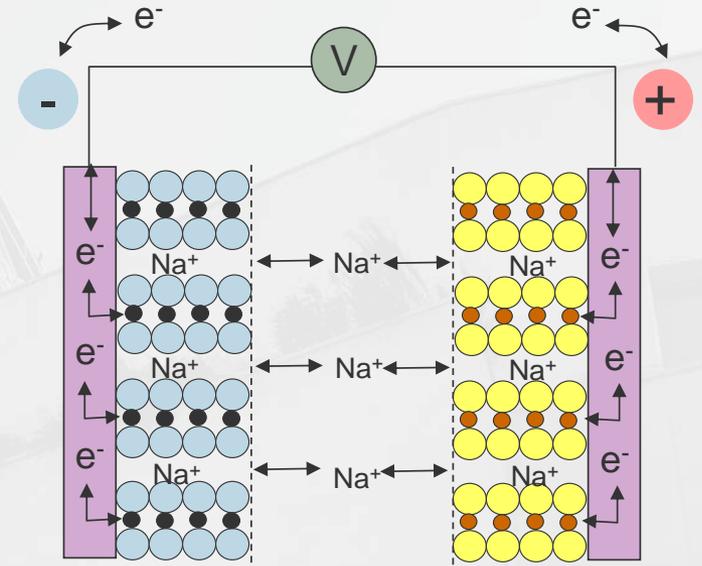
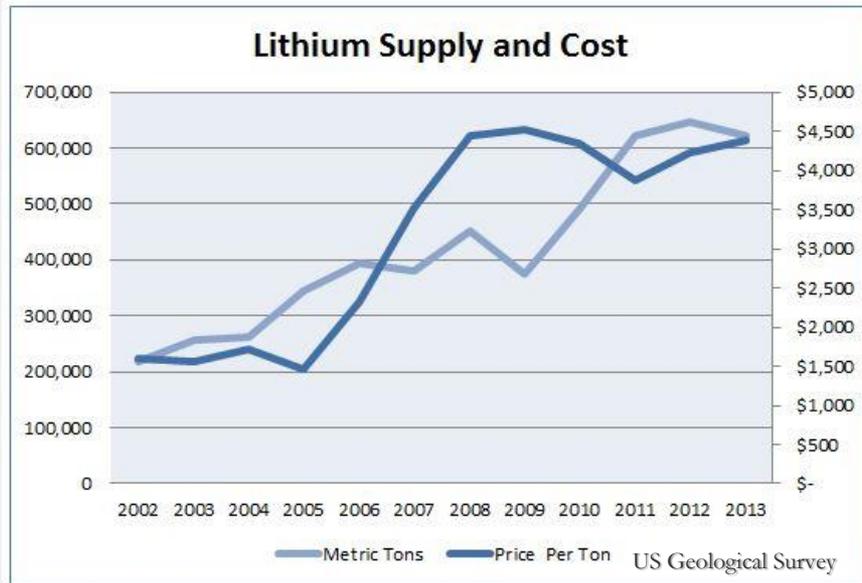


...a expensas de la estabilidad !!

Ejemplo 1: materiales comerciales (NMC)



Ejemplo 2: tecnologías en desarrollo: ión Na



→ recursos Na “ilimitados”

20 ppm

22700 ppm

corteza terrestre

→ potencial de reducción

-3.04

-2.71

vs. ENH

→ formación de aleaciones con Al

sí

no

Une start-up pour des batteries de plus en plus rapides



TIAMAT

6

partenariats en R&D

Et une équipe de recherche coordonnée par Jean-Marie Tarascon (Collège de France)



Power Battery Cells, fast charge, long lifecycle

TIAMAT VOUS PERMET D'AVOIR DES RECHARGES EN 5 MINUTES ET PLUSIEURS MILIERS DE CYCLES GRÂCE AU SODIUM-ION !



TEMPS DE CHARGE 10 FOIS PLUS RAPIDE

PUISSANCE NÉCESSAIRE

CHARGE RAPIDE

Batterie de puissance

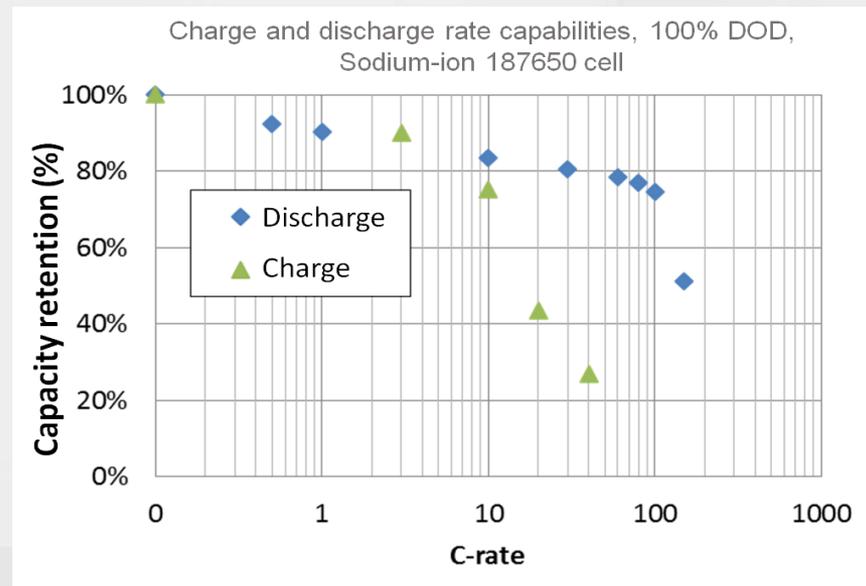
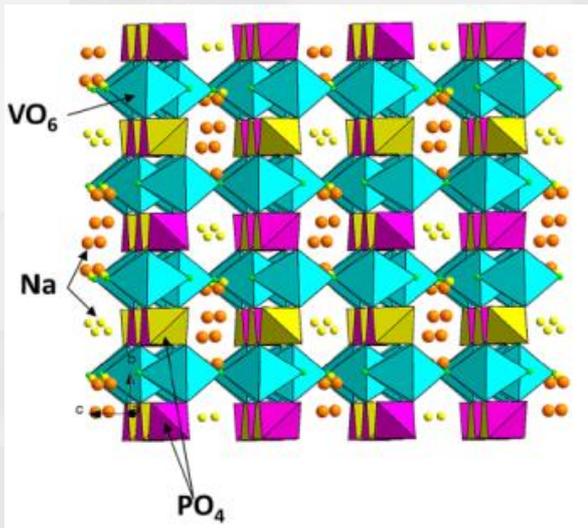
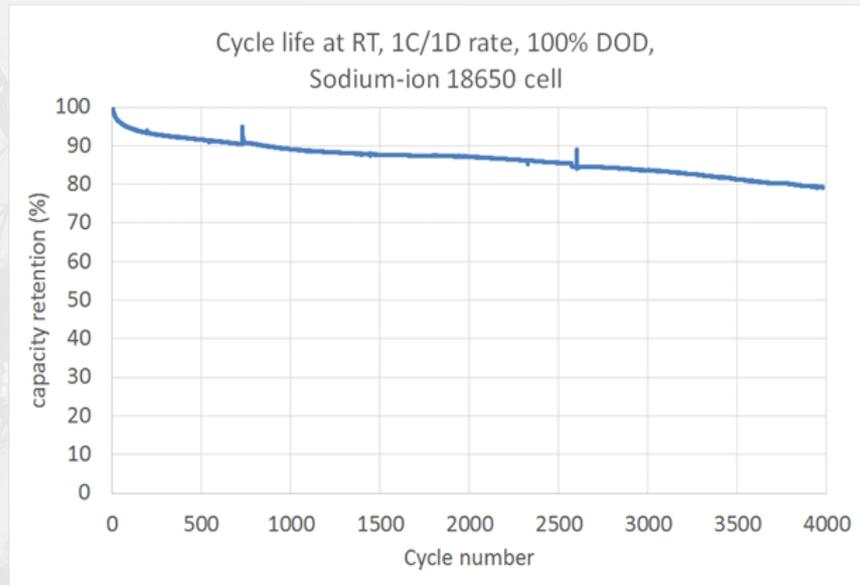
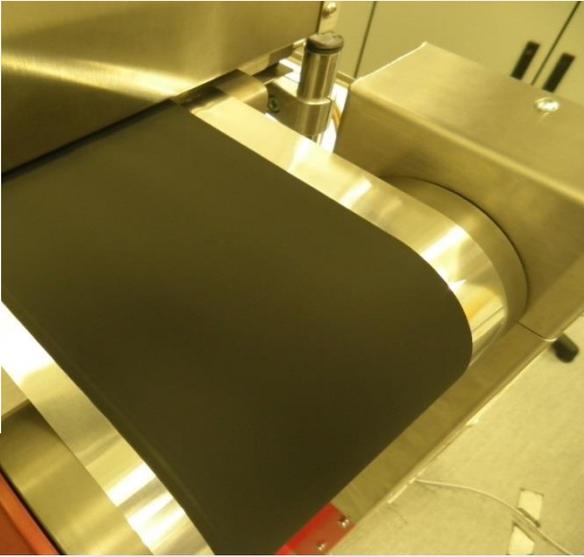
Longue durée de vie

Continuité de service

DURÉE DE VIE 10 FOIS PLUS IMPORTANTE

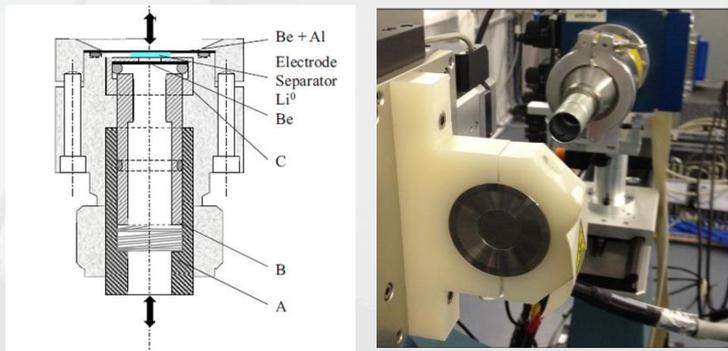
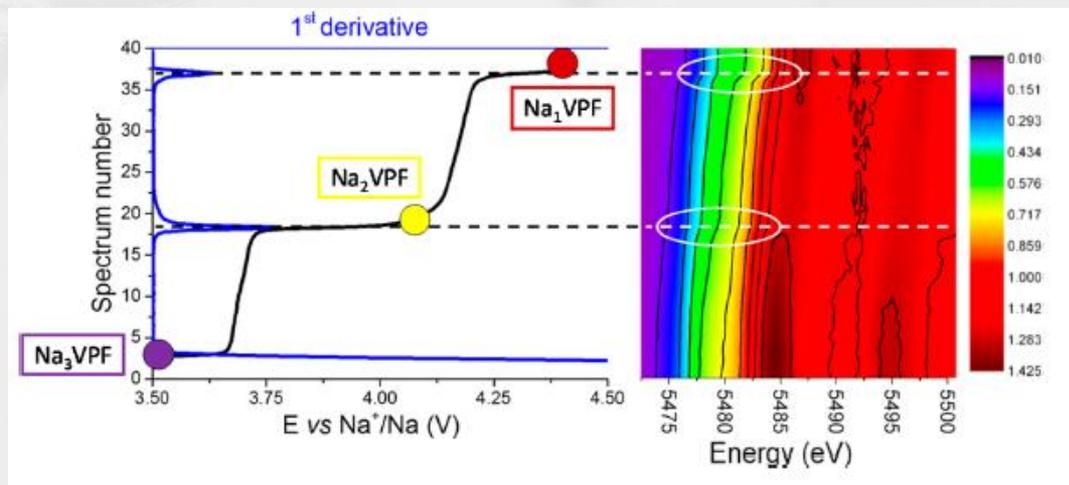
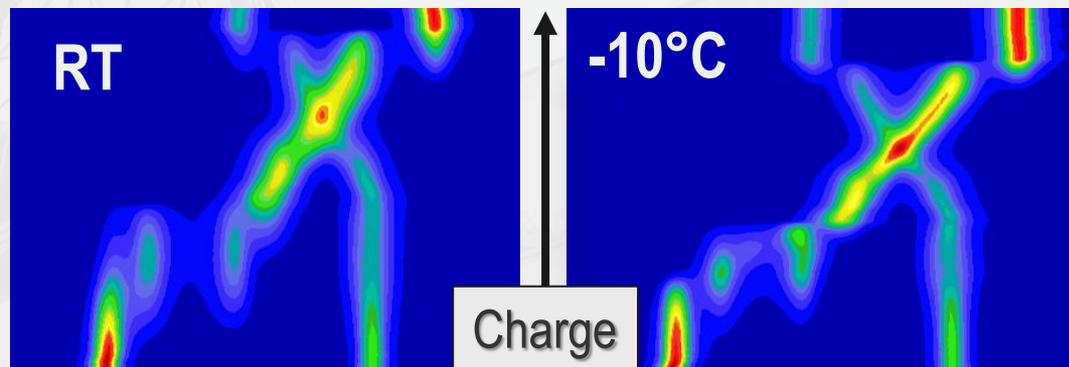
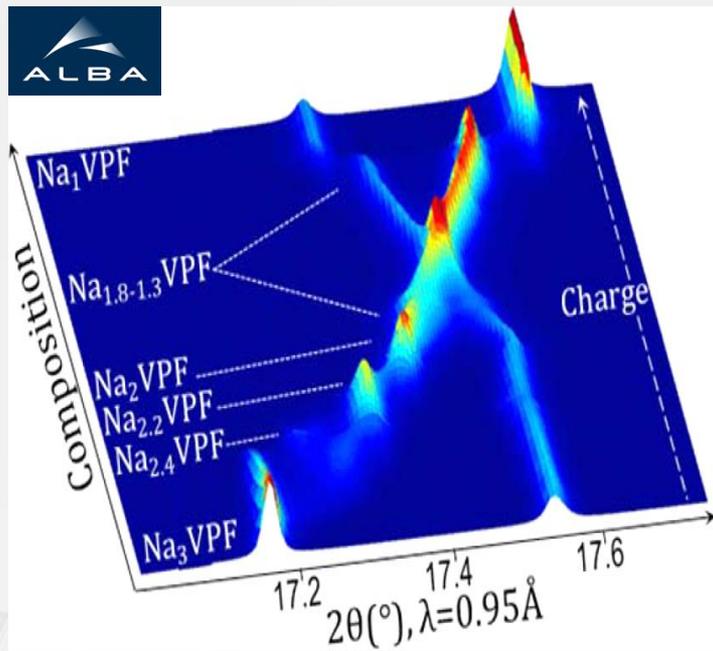
CONTINUITÉ DE PRODUCTION AVEC MOINS D'ÉQUIPEMENTS





$\text{Na}_3\text{V}_2(\text{PO}_4)_2\text{F}_3$

Estudio del mecanismo de reacción en celdas in situ, a diferentes velocidades y y diferentes temperaturas



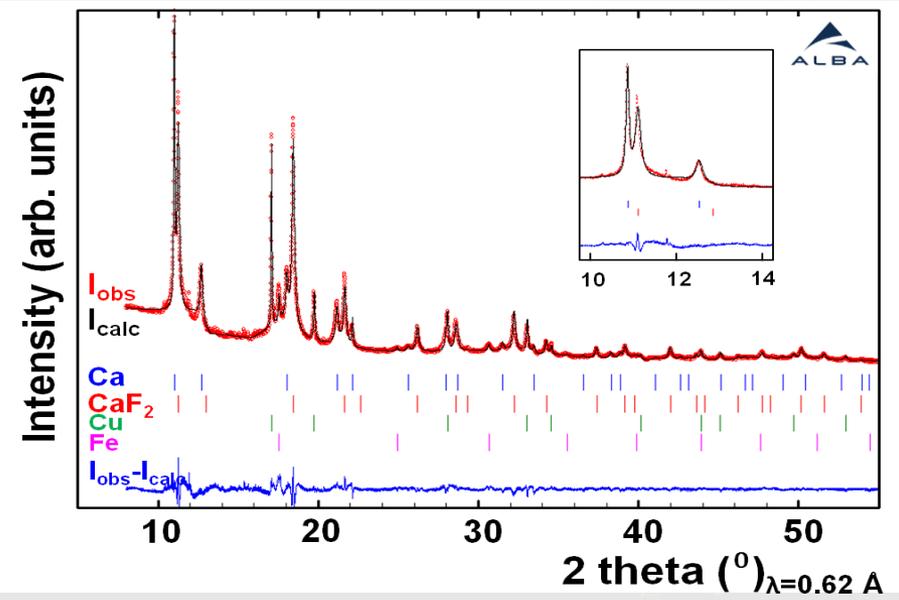
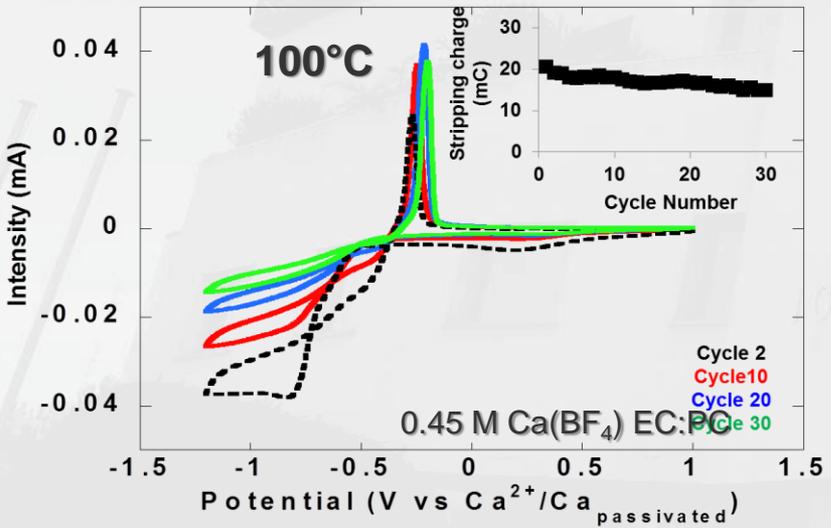
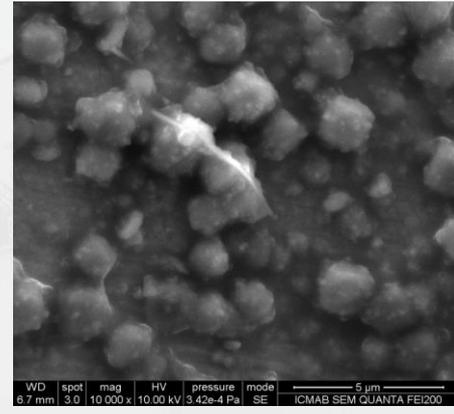
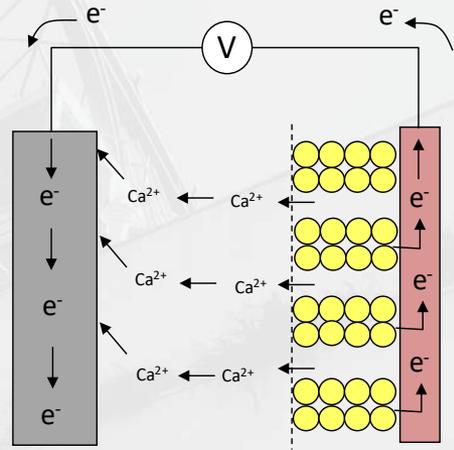
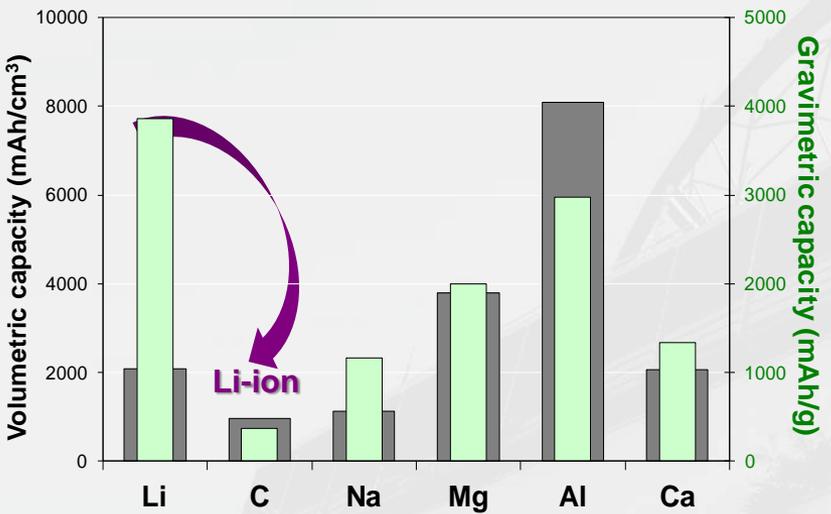
Bianchini et al., *Chem. Mater.*, 27(8), 3009 (2015)

Broux et al., *J. Phys. Chem C*, 121 (8), pp 4103-4111 (2017)

ALBA Beamlines: MSPD & CLAESS

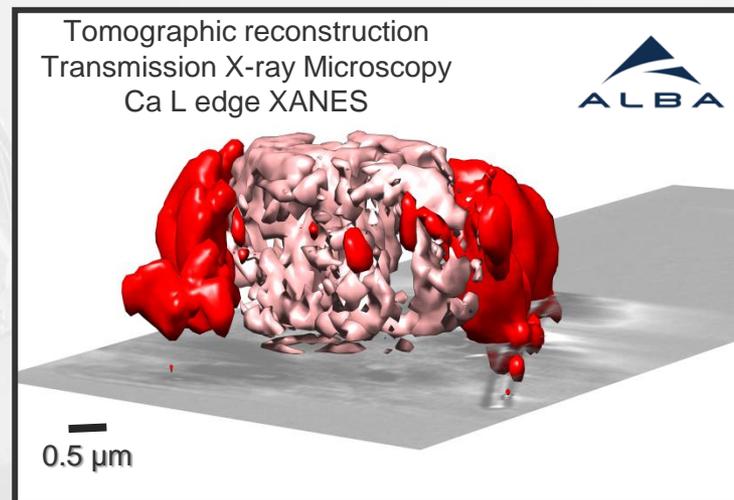
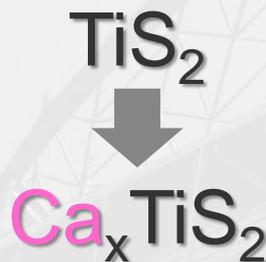
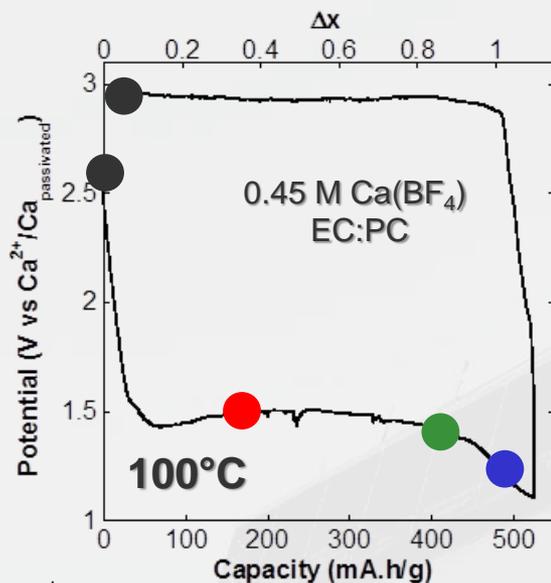
Ejemplo 3: nuevas tecnologías → Ca

Desarrollo de electrolitos para electrodepositar Ca metálico: viabilidad del ánodo

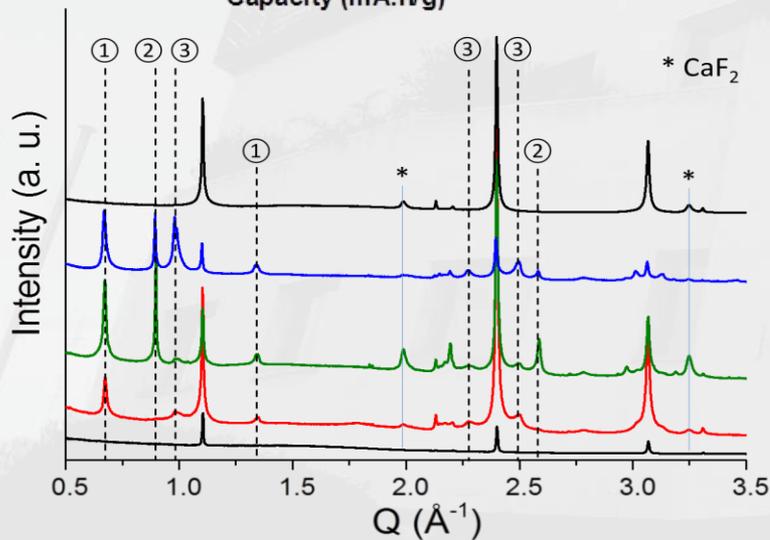


Ejemplo 3: nuevas tecnologías: Ca

Desarrollo de cátodos



ALBA Beamlines: MSPD & MISTRAL



CARBAT



Schematic of the Overall Battery R&D Process from Conception to Production

Concept Generation



Production

Concept Validation	Research	Applied Research	Development	Advanced Development
An idea in a creative mind	Scale-up experiments	Lab/prototype cells	Confirm research results	Design initial cell product



Timing

Staffing

Materials Batch

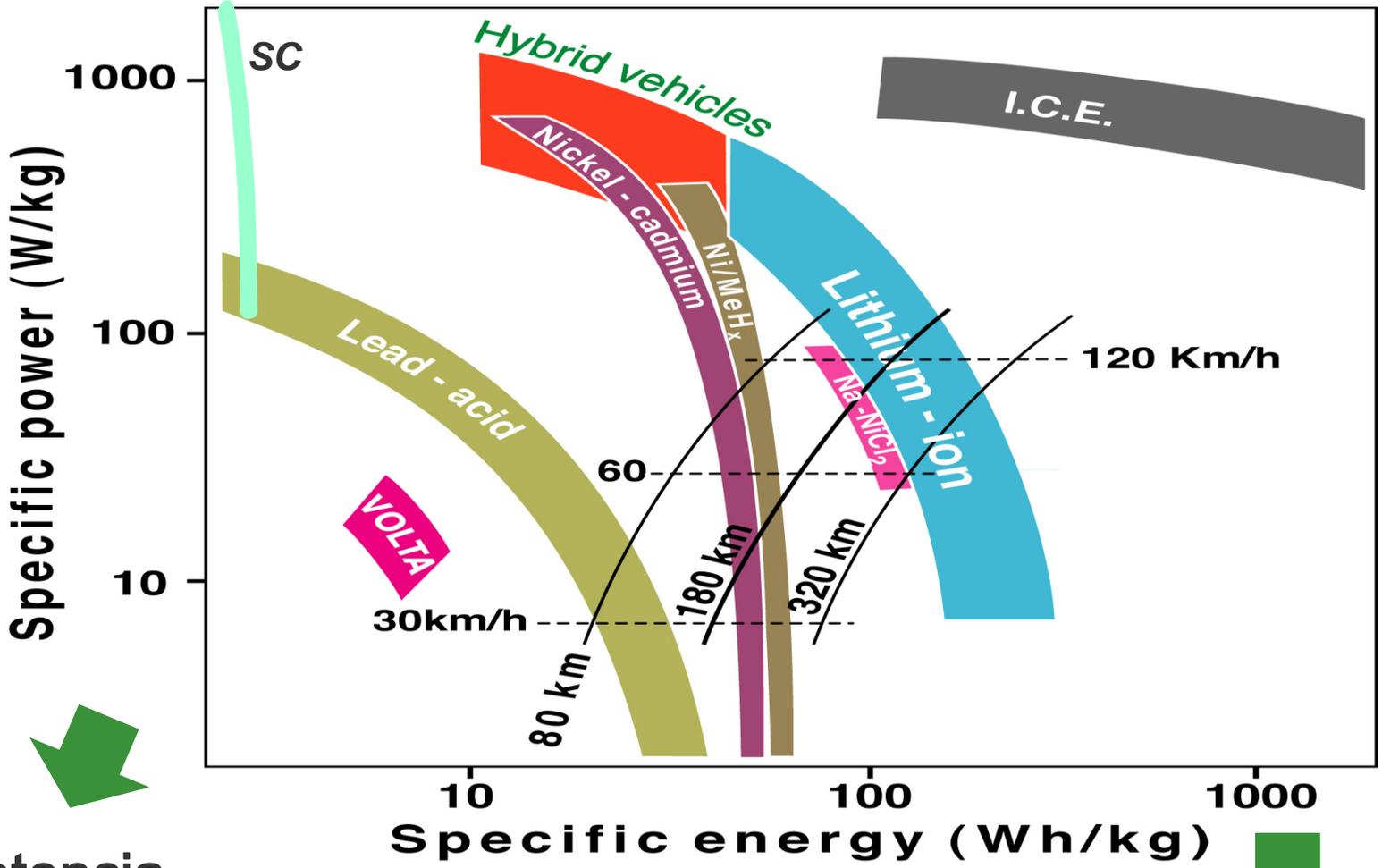
Rel. Cost Index

10-19!!!



😊
gràcies!!

CONSTRUCTEURS	FABRICANT DE BATTERIES	VÉHICULES	CATHODE	ANODE
Toyota	PEVE	HEV/PHEV	NCA	Graphite
Toyota VW/audi	Sanyo	HEV/PHEV	NMC	Soft C.
Mitsubishi, PSA	LEJ	EV	LMO/NMC	Soft C.
VW	Toshiba & EnerDell	EV	LMO	LTO
Hyundai GM Volt	LGC	HEV/PHEV	LMO/NMC	Hard C.
Nissan Renault	AESC	EV	LMO/NCA	Graphite
Nissan	AESC	HEV	LMO/NCA	Hard C.
Daimler S400, BMW series 7	JCS	HEV/PHEV	NCA	Graphite
Think Chrysler	A123	PHEV/EV	LFP	Graphite
Think Volvo	Enerdel	EV	NMC	HC
Fisker	Enerdel	HEV	LMO	LTO
BMW	SB-Limotive	PHEV/EV	LMO	Graphite
BYD auto	BYD	PHEV/EV	LFP	Graphite
Pinifarina	Bolloré	EV	LFP	Li
Heuliez	E4V	EV	LFP	Graphite



Potencia
(aceleración,
velocidad de carga)

Energía
(autonomía)