LC-BAT-1

Strongly improved, highly performant and safe all solid-state batteries for electric vehicles

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ASTRABAT, SAFELiMOVE, SOLIDIFY, SUBLIME

LC-BAT-1 Challenge and scope

- Aiming of balancing batteries safer and with higher energy density
- Develop further the current solid state battery technology and present solutions beyond the current state-of the art of solid-state electrolytes:
    1. Inorganic electrolyte;
    2. Polymeric electrolyte;
    3. Hybrid electrolyte
- Solid state technology classified in two technologies
    - So called generation 4a with conventional Li-ion materials (as NMC/Si) and
    - So called generation 4b with Li-metal as anode

Generation	1	2		3		4			5
		2a	2b	3a	3b	4a	4b	4c	
Type	Current	Current	State-of-the-Art	Advanced Li-ion HC	Advanced Li-ion HV	Solid State			Beyond Li-ion
Expected Commercialisation	Commercialised	Commercialised		2020	2025	>2025			
Cathode	• NMC/NCA • LFP • LMO	• NMC111	• NMC424 • NMC523	• NMC622 • NMC811 • NMC910	• HE NMC • Li-rich NMC • HVS	• NMC	• NMC	• HE NMC	• O_2 • S
Anode	• Modified Graphite • $Li_4Ti_5O_{12}$	Modified Graphite	Modified Graphite	Carbon (Graphite)+Si (5-10%)	Silicon/Carbon (C/Si)	Silicon/Carbon (C/Si)	Li metal		Li metal
Electrolyte	• Organic • $LiPF_6$ salts				• Organic+ Additives	• Solid electrolyte – Polymer (+Additives) – Inorganic – Hybrid			
Separator	Porous Polymer Membranes								

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LC-BAT-1 Impact

- For generation 4a, an energy density >350 Wh/kg and >1000 Wh/l, for generation 4b a higher energy density >400 Wh/kg and >1200 Wh/l ;
- Fast charge rates;
- Proven safety;
- Cost euro < 100euro/kWh;
- The European battery value chain towards cell production in Europe should be strengthened;
- Validation of a pre-industrial prototype in relevant industrial environment;
- Thorough Life Cycle Analysis cradle to cradle and consider recycling as far as possible.

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CLUSTER VALUE CHAIN

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LC-BAT 1: PROJECT COMPARISON				
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Consortium	14 organization (8 countries)	15 organizations (7 countries)	14 organizations (7 countries)	15 organizations (8 countries)
Coordinator	CEA (France)	CIC energiGUNE (Spain)	imec (Belgium)	FEV EUROPE GMBH (Germany)
Project length	42 months	48 months	48 months	48 months
Start date	January 2020	January 2020	January 2020	May 2020
Budget	7,8 M€	7,8 M€	7,8 M€	7,9 M€
Website	astrabat.eu	safelimove.eu	solidify-h2020.eu	sublime-project.eu
GA#	875029	875189	875557	875028

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LC-BAT 1: PROJECT TECHNOLOGY				
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Cell chemistry	NMC || Si-C	High Ni-NMC || LiM	High Ni-NMC || LiM	High Ni-NMC || LiM
Solid electrolyte	Hybrid electrolyte	Hybrid ceramic-polymer electrolyte (HCPE)	Solid composite electrolyte (SCE) based on polymer gel electrolytes	Sulfide
Demonstrator	1Ah -10Ah pouch cells	10 Ah pouch cells	10 Ah pouch cells	10 Ah pouch cells
TRL	From TRL 3 to TRL 4-5	From TRL 3 to TRL 6	From TRL 3 to TRL 6	From TRL 3 to TRL 6
Sustainability	LCA/Recycling	LCA/Recycling	LCA	Recycling

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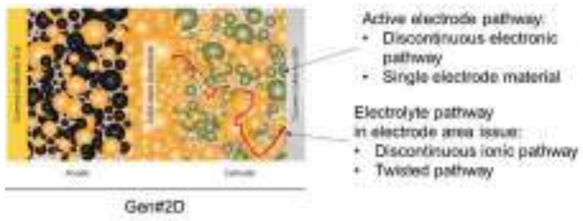
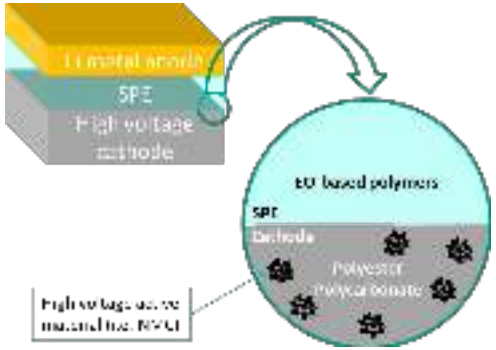
DISRUPTIVE TECHNOLOGY

ASTRABAT



- ❑ Processing techniques compatible with large scale manufacturing.
- ❑ Model of the all-solid-state battery (ASSB).
- ❑ Optimized ionic/electronic pathways.

SAFE Li MOVE



Bilayer electrolyte concept:

- ❑ HCPE for catholyte.
- ❑ HCPE for separator.
- ❑ Tune interfaces: between inorganic and polymer electrolyte; LiM coating, NMC particles coating.

(nano-)SCE concept:

- ❑ Liquid-to-solid approach for SCE | active material contact.
- ❑ nanoSCE as a thin separator with high conductivity.
- ❑ Protected NMC cathode for water-based processing.
- ❑ Protective coatings for thin Li foils.

SUBLIME

Application of sulfide electrolyte:

- ❑ Scalable production of sulfide electrolyte and preparation of thin electrolyte membranes.
- ❑ Protected cathode active material for composite cathode; lithium metal as anode.
- ❑ Evaluation of different processing routes for optimized performance.

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FUTURE OUTCOMES & CHALLENGES

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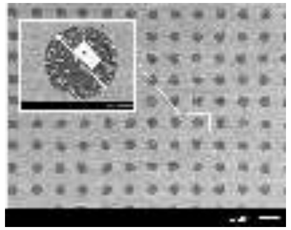
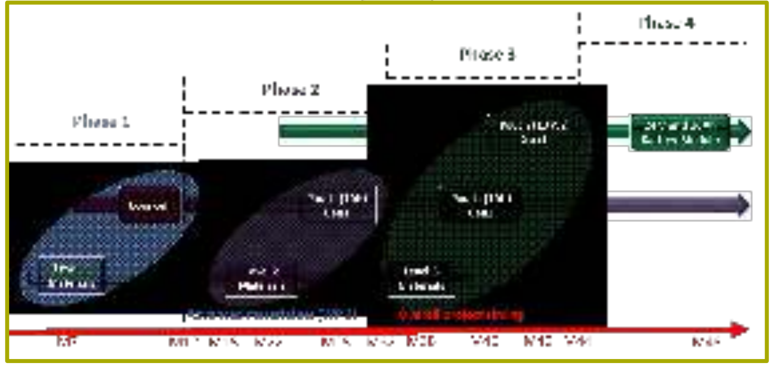
- Design of new electrode architecture
- Development of new 3D processes
- Decrease the operational temperature
- Development next generation Gen4b (Li-M)



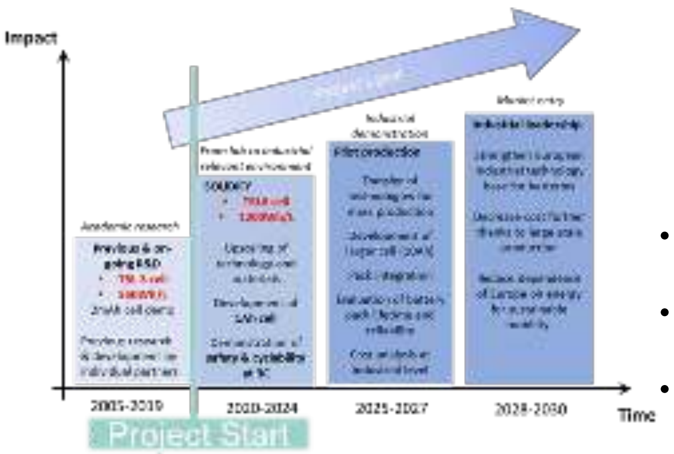
Pillar electrode structure obtained by inkjet printing

SAFELiMOVE

- Design of new manufacturing concept for SSBs
- Dry processing for cost impact
- Decrease the operational temperature



SOLIDIFY



- Upscaling cell components (reproducibility, uniformity)
- Efficient cathode impregnation (liquid to solid approach)
- Obtaining high c-rates (suitable nanoSCE ionic conductivity)

SUBLIME

- Development of the protective coating for lithium anode.
- Production of the multilayer pouch cell.
- Production of 1Ah-10Ah pouch cells.

The final target cell.

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