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Printable and flexible 3D micro-supercapacitor

Maziar Ahmadi Zeidabadi

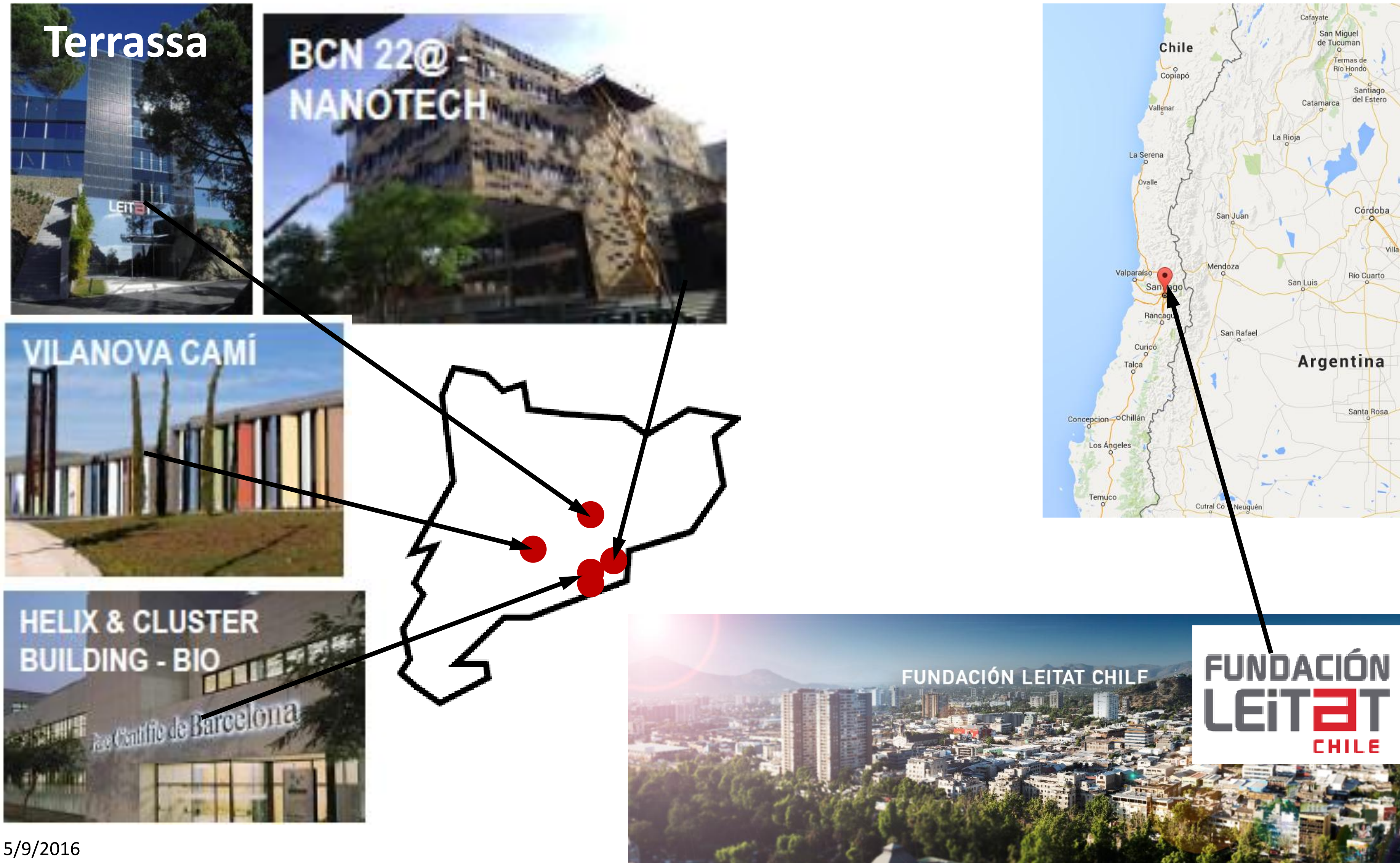
Senior researcher , Energy Storage Area

06/05/2016

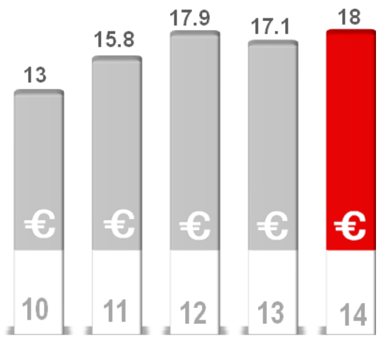
Content list

- Leitat overview
    - Nanocate Project
        - Supercapacitor
            - Electrode Material
                - Functionalization of Active materials
                    - Ink formulation
                        - Printed Supercapacitor

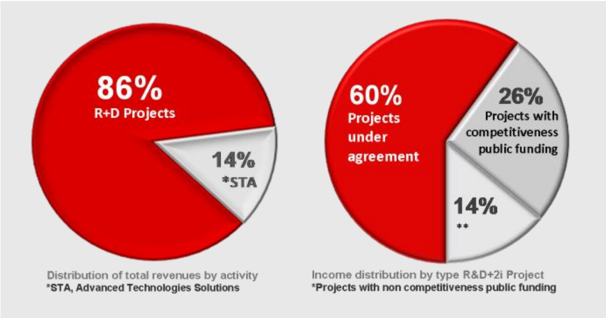
Leitat technological

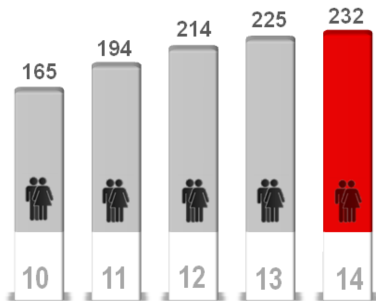


LEITAT 2014

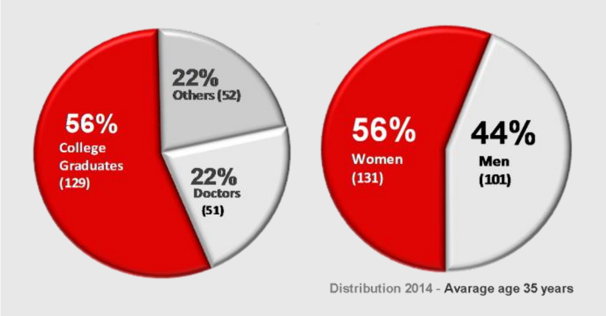


Revenue in Million Euros





Number of collaborators (average)



Figures 2014

265 Proposals managed
137 R+D+2i projects being executed*
4 Lead projects
240 Private R+D+2i projects
2.915 Advanced technology solutions
2 Patents

*We participate in European projects with **839** partners, overall budget of **432M €** and collaborating with **28** countries

+

Corporate Social Responsibility

Our customers' value: ***Quality, personal contact, clarity of results***
Society value: ***Innovation, sustainability and environmental responsibility, market orientation***
Level of loyalty (future collaboration and recommendation) **> 97%**

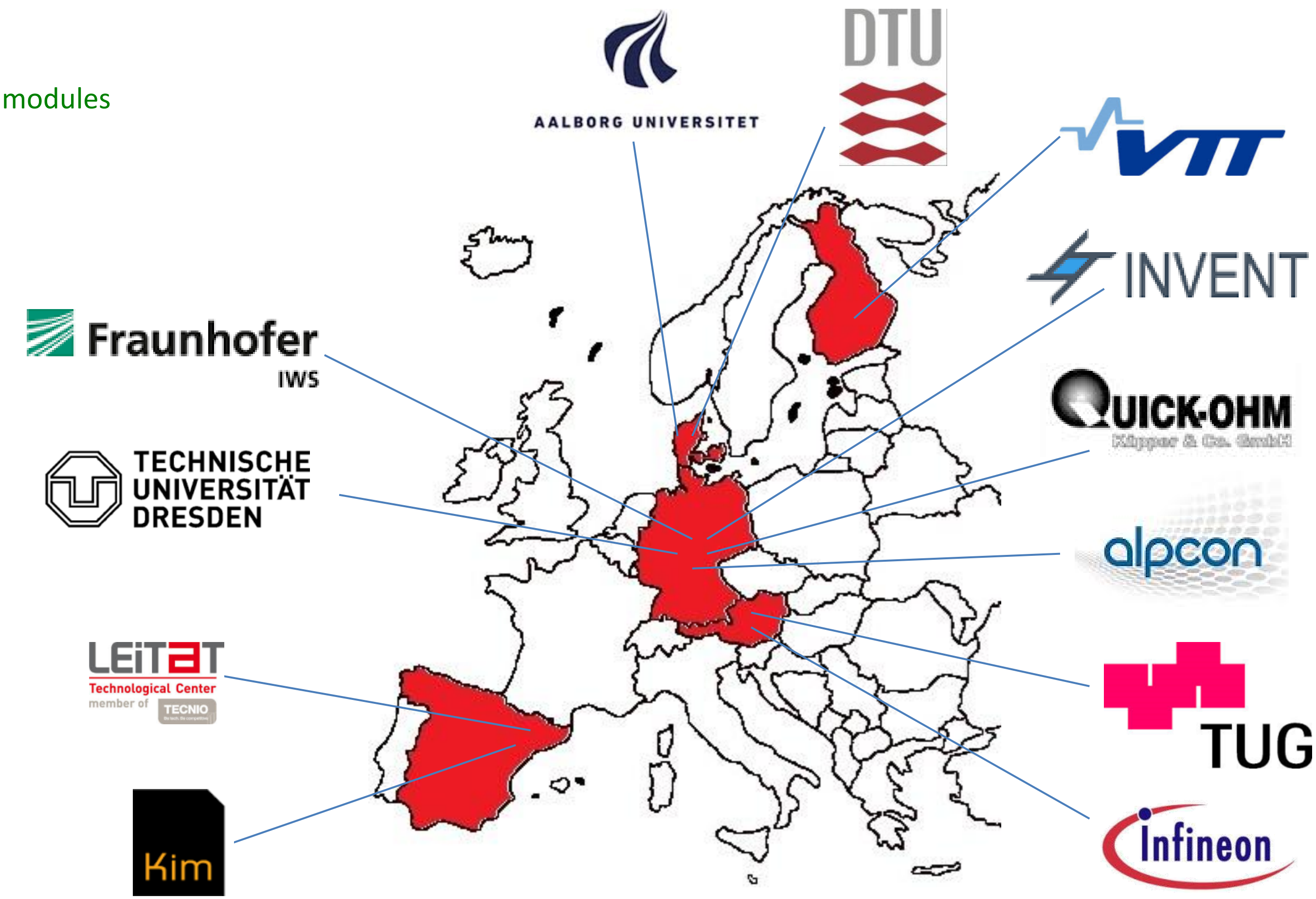
NanoCate Project

NanoCaTe

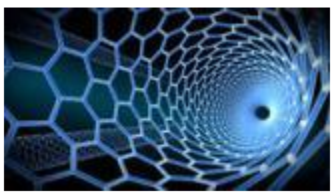
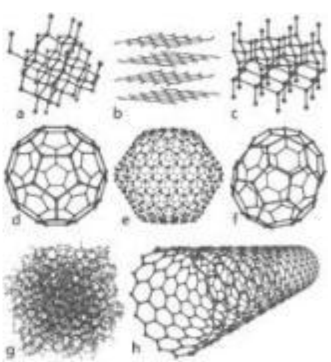
Nano-carbons for versatile power supply modules

FP7-NMP-2013-SMALL-7
Grant agreement n° [604647].
http://nanocate.eu/
EU contribution: 3,994,210.00 euros
Duration : October 2013 – September 2017
Coordinating by IWS Fraunhofer

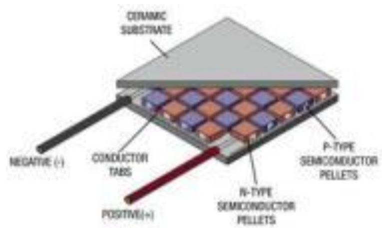
NanoCaTe, will develop a more efficient thermoelectric- and storage material based on nanocarbon to reclaim waste heat by thermoelectric generators and to storage the energy in super capacitors or secondary batteries for manifold applications like pulsed sensors or mobile electronic devices.



Concept

Nanocarbons



Thermoelectric generator (TEG)

Energy storage microdevices (battery/supercapacitor)

Printed flexible Micro device

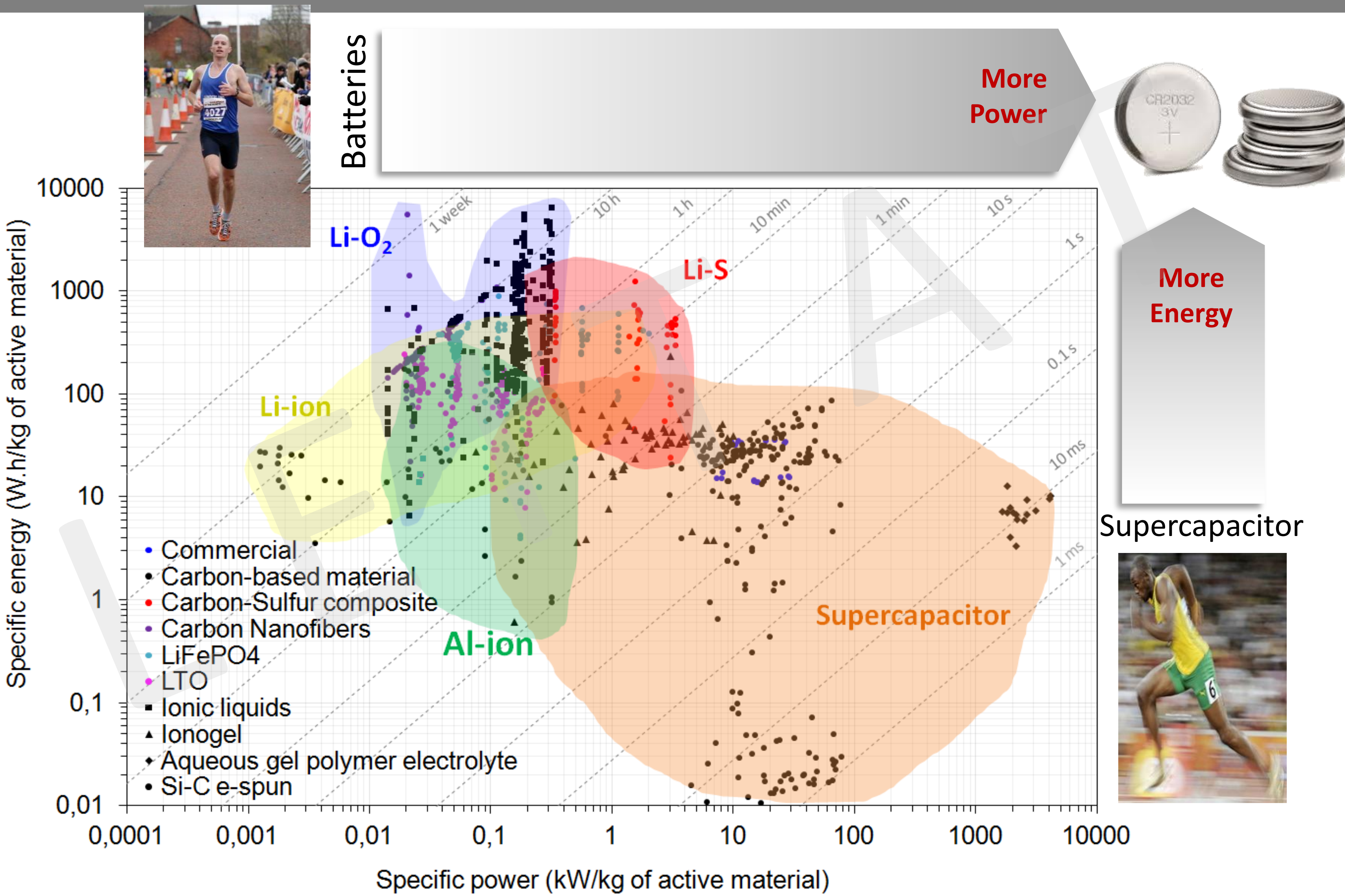
1) Body sensors

Graz University of Technology

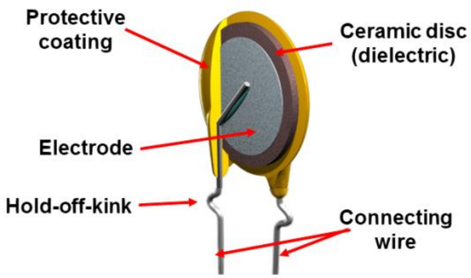
2) Spatial application

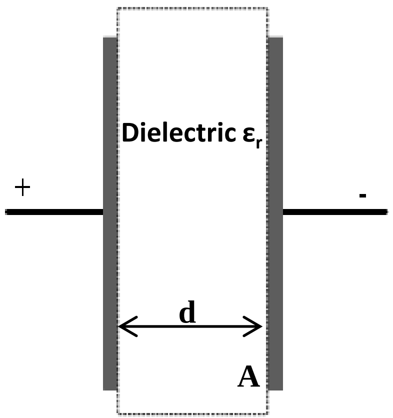
SOMP 2 [TU Dresden]

Battery vs. Supercapacitor

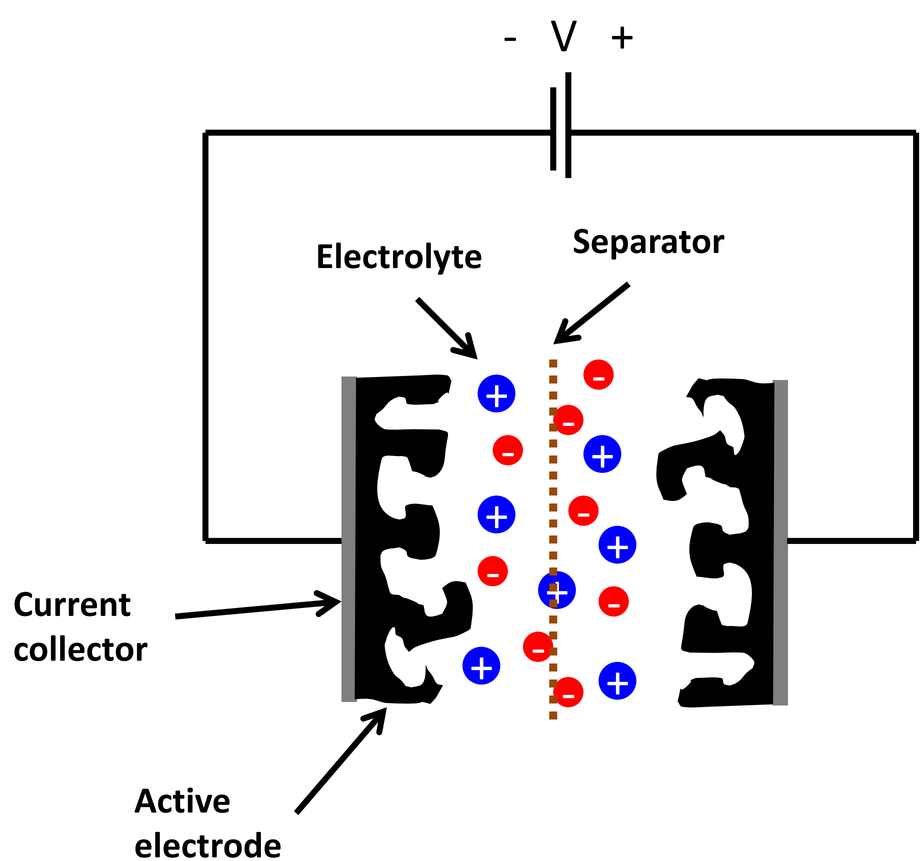


Supercapacitor (ECDL)





$$C(F) = \varepsilon_0 \varepsilon_r \frac{A}{d}$$



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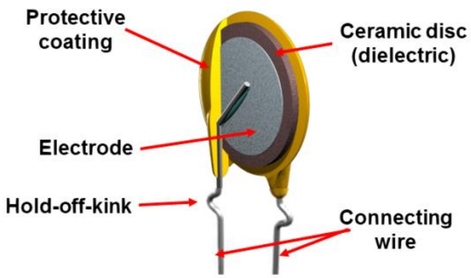
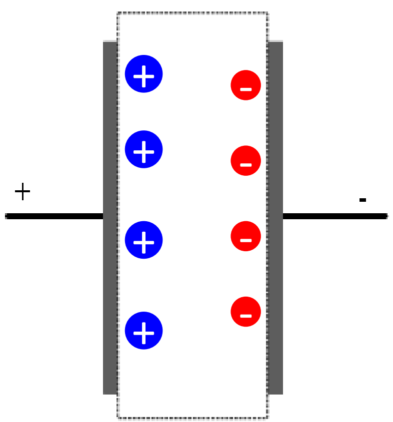
Supercapacitor (ECDL)





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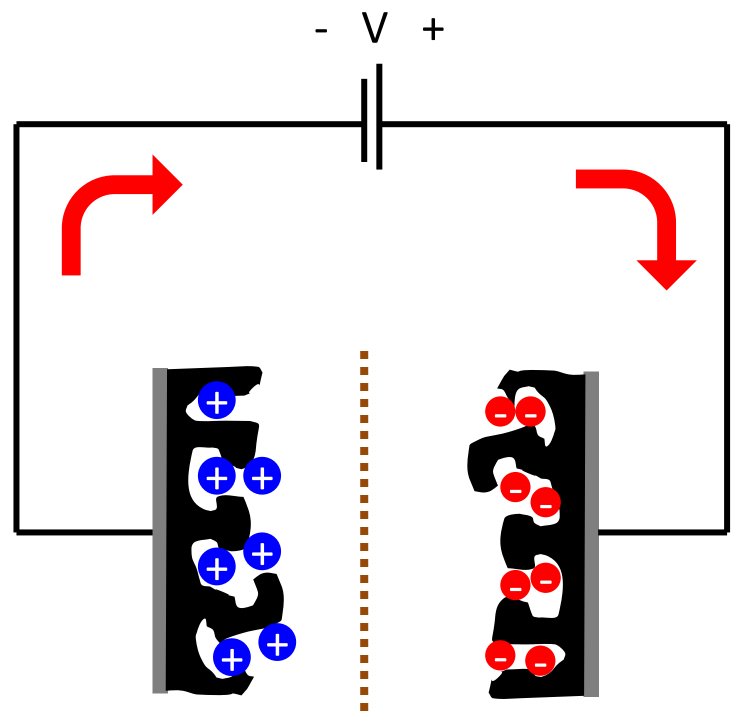


$$C(F) = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

Energy storage fabrication process

Ink formulation

Slurry

Electrode preparation

Coating

Calendaring
Standardization
Porosity adjustment

Slitting

Drying

Coin Cell Assembly

Stacking

Filling

Crimping

Pouch Cell Assembly

Tab welding

Stacking

Packaging

Filling

30
Characterization
Channel

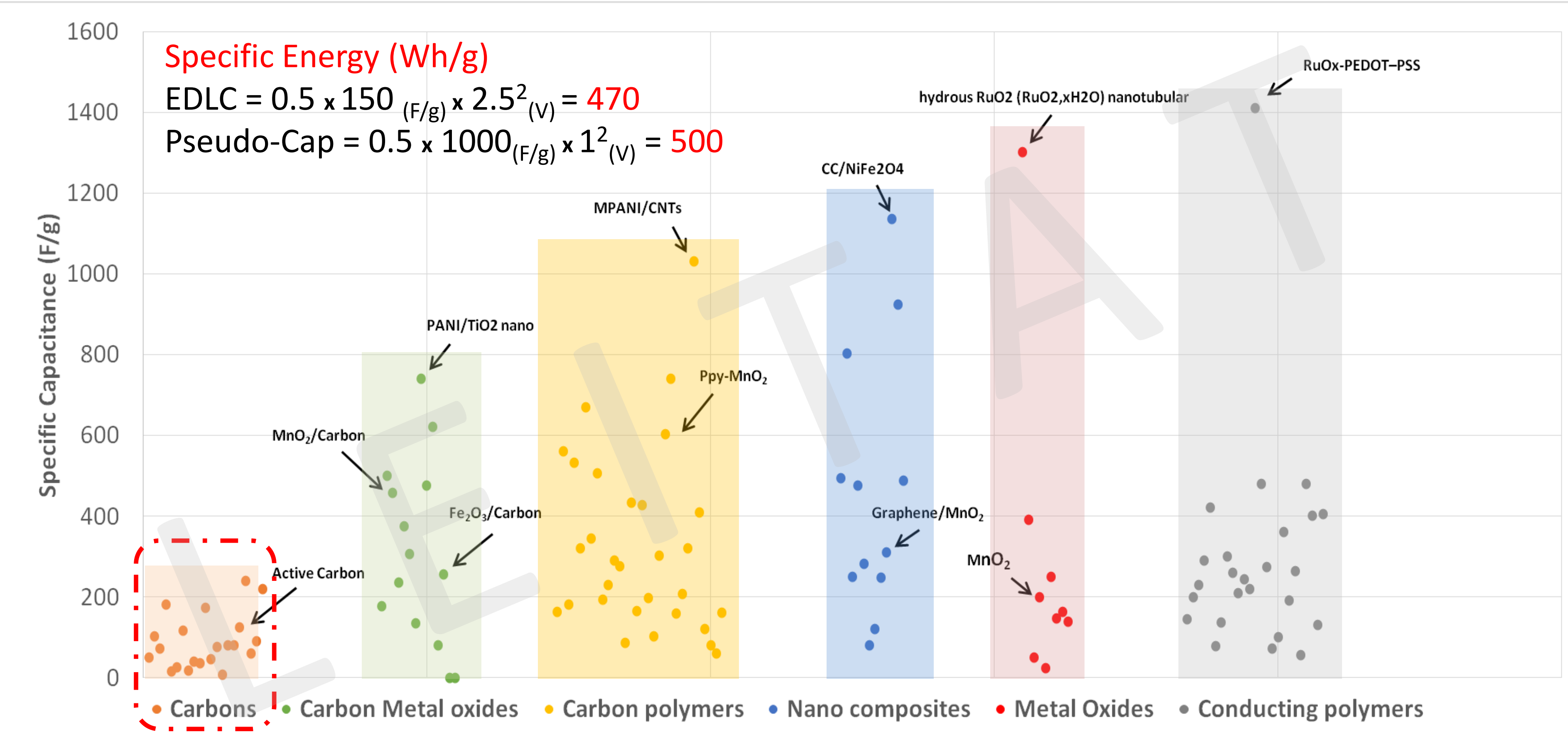
ELECTRICAL FORMATION
(SYSTEM DEPENDENT)

Formation

Final Storage and Testing

~7days

Electrode Materials for Supercapacitor



Cabonaceous Material for ECDL

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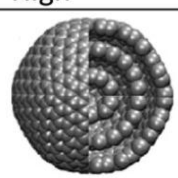
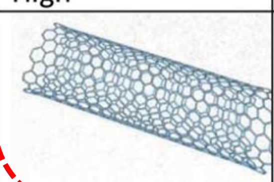
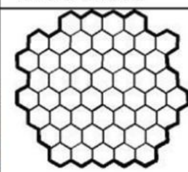
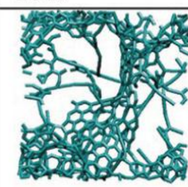
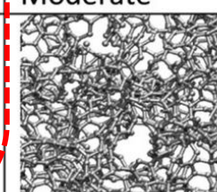
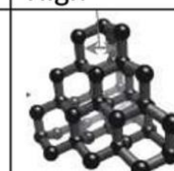
Advantages of Carbon Material

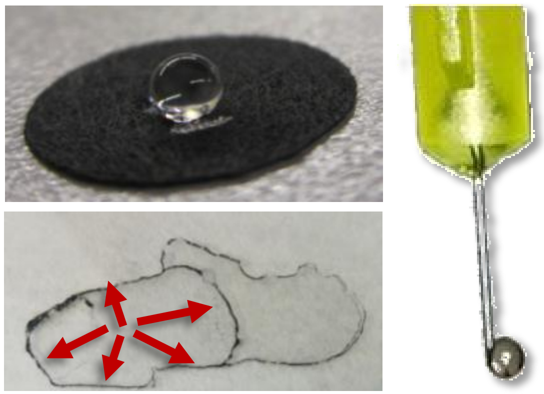
- ✓Ease of fabrication
- ✓High conductivity → High specific power
- ✓Controlable size of porosity → Better transmission of ions
- ✓Possibility of surface functionalization → Increase wettablity and reduce ESR
- ✓High volumetric energy and power
- ✓Low cost

Material	Carbon onions	Carbon nanotubes	Graphene	Activated carbon	Carbide derived carbon	Templated carbon
Dimensionality	0-D	1-D	2-D	3-D	3-D	3-D
Conductivity	High	High	High	Low	Moderate	Low
Volumetric Capacitance	Low	Low	Moderate	High	High	Low
Cost	High	High	Moderate	Low	Moderate	High
Structure						

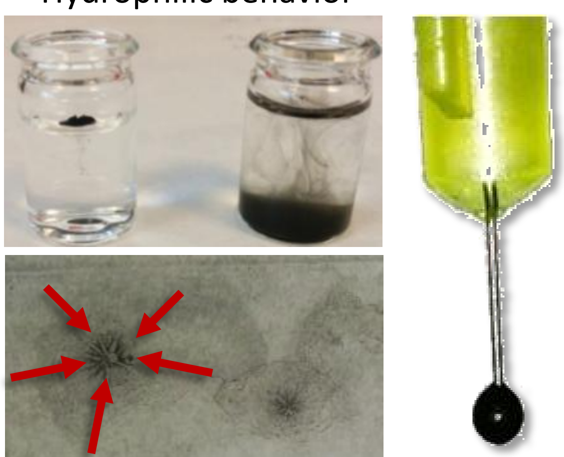
P. Simon , Y. Gogotsi, Acc. Chem. Res., 46, 1094 (2012)

Printable Electrode

Initial Carbon
Hydrophobic behavior

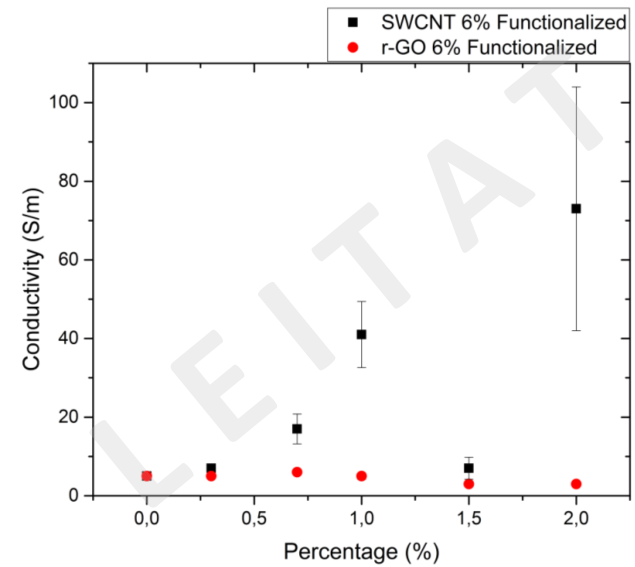


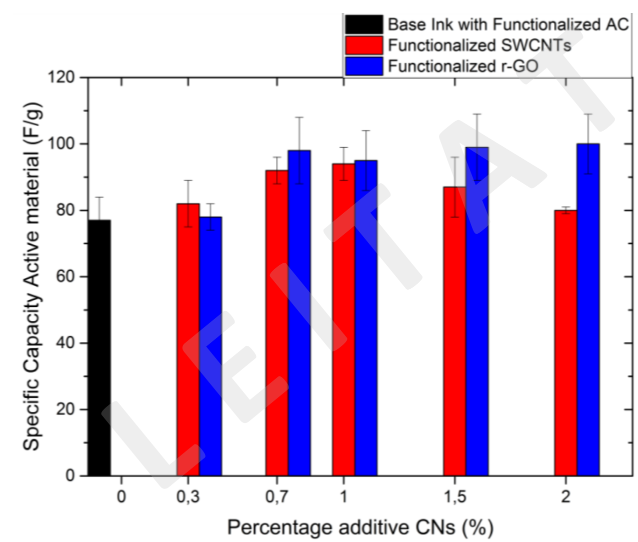
Treated Carbon
Hydrophilic behavior



Conductive
additive

additive
Capacitive





NanoCaTe

Printable Electrolyte

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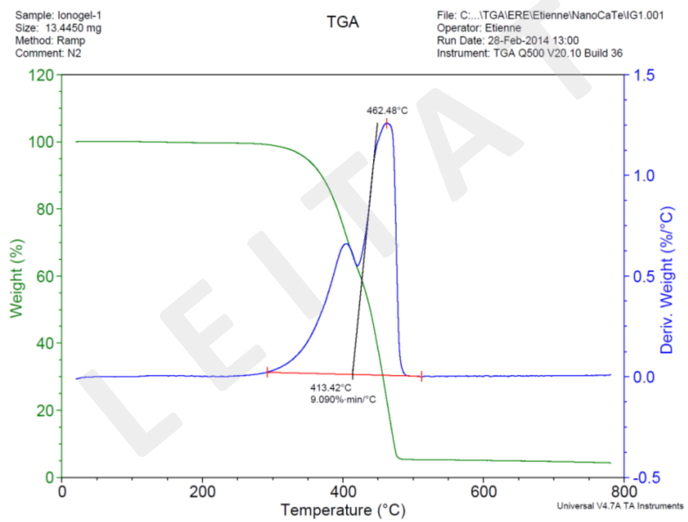
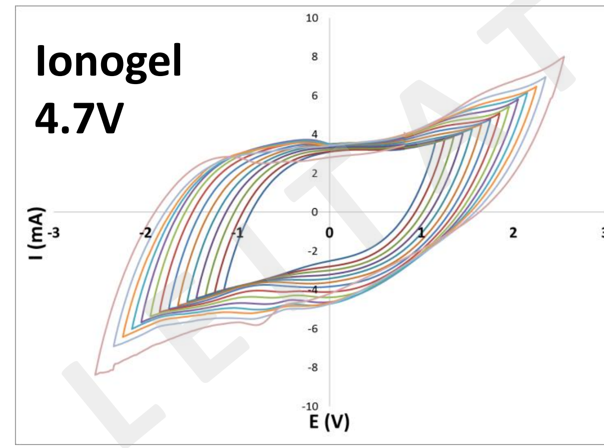
Printability

High working temperature

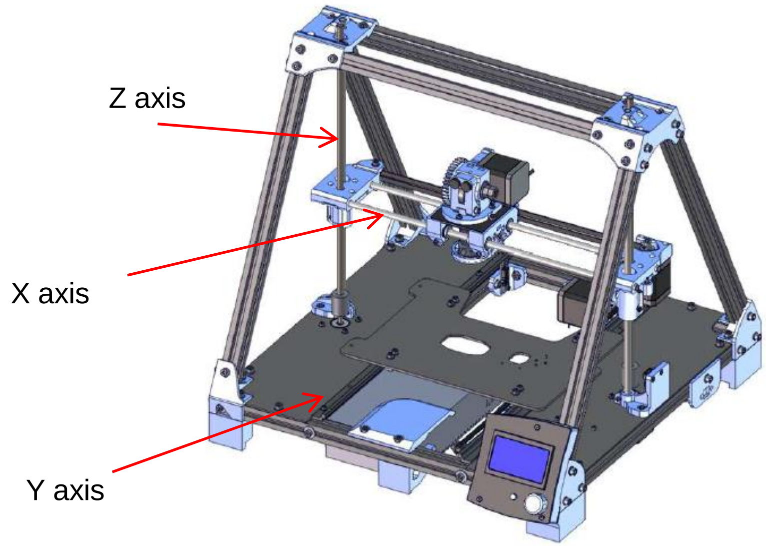


High windows potential

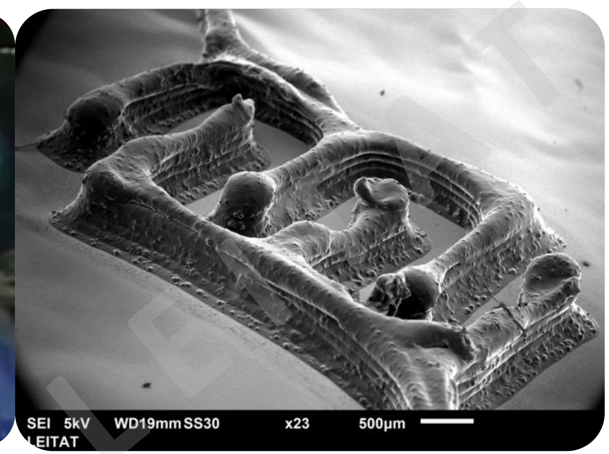


- Based on TEOS + RTILs mixture
- Tested in lithium ion, supercap and Hybrid
- High temperature resistance (350ºC)
- Wide potential window (4.7V), free water
- Cheaper (no salt)
- Less toxic (no solvent)
- No flammable

3D dispenser



Combination of inkjet and slot die (Casting) printing technologies. Suitable for printing 3D structures.



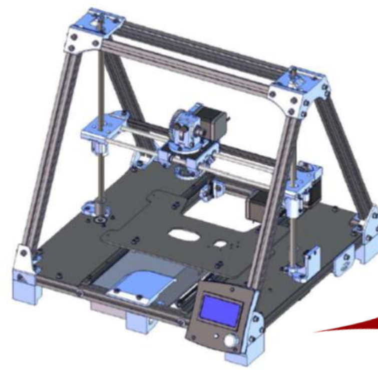
First 3D inter-digit printed Supercapacitor (height 500µm)

Printed Supercapacitor

Aqueous ink

+

Ionogel Electrolyte



	State of Art	LEITAT
Capacity (F/cm^2)	18	200
Energy (mJ/cm^2)	56.6	428.4
Voltage	2.5	3.5

European Activities

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Lithium Sulphur for PHEV, H2020 NMP-GV, 2015-2019, http://www.aliseproject.com/

- ❑ Coordination of the project and responsible of the administrative and scientific management of the project.
- ❑ Syntheses and characterization of Ionic Liquid.
- ❑ Manufacturing of electrode and membrane separator done by electrospinning.
- ❑ Surface modification by diazonium salt reduction

Aluminum Ion for stationary, H2020 NMP, 2015-2019, http://www.alionproject.eu

- ❑ Coordination of the project and responsible of the administrative and scientific management of the project.
- ❑ Synthesis of nanostructured Al anode by electroplating in ionic liquid electrolyte
- ❑ Battery cell characterization at the laboratory scale.
- ❑ Synthesis and characterization of Ionic Liquid.
- ❑ Surface modification by diazonium salt reduction

Lithium Ion for flexible printed, H2020 PILOT, 2014-2017, http://www.basmati-project.eu/

- ❑ Forrmlation and characterization of ink based on nanomaterial for inkjet, dispenser and screen printer printings methods.
- ❑ Nanosafety issue for both nanomaterials powders and inks
- ❑ Synthesis and characterization of nanomaterials
- ❑ Electrochemical characterization

Supercapacitor for flexible printed, FP7 NMP, 2013-2017, http://nanocate.eu/

- ❑ Synthesis and characterization of TEG and supercapacitor materials
- ❑ Ink elaboration and development of print process for both TEG and supercapacitors
- ❑ Modeling and design the entire assembling platform for the manufacturing of printed TEGs

Lithium Air for EV, FP7 NMP, 2012-2016, http://www.fp7-stable.com/

- ❑Synthesis of lithium nanorod by electro-deposition onto removable scaffold of conductive polymer
- ❑ Modification of LISICON layers
- ❑ Synthesis and characterization of nanostructured meseporous carbon materials
- ❑ Synthesis of nanostructured M-doped MnOx/C and PtAu/C catalysts
- ❑ Synthesis and optimization of other types of RTILs
- ❑ Simulation of Li-air cell performance
- ❑ Optimization and market worthiness

Leitat
Acondicionamiento Tarrasense
Tel. (+34) 93 788 23 00
Fax (+34) 93 789 16 06

www. leitat.org
info@leitat.org

Terrassa
C. de la Innovació, 2
08225 Terrassa (Barcelona)

Barcelona
Parc Científic de Barcelona
C. Baldiri Reixach, 15-21
08028 Barcelona

Igualada
IG-NOVA Technoespai
Av. Barcelona, 105 D-5
08700 Igualada

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XING

Thank you for your attention

Dr. Christophe Aucher
caucher@leitat.org, +34 93 788 2300 – Ext. 3226
Energy Storage Unit Principal Researcher
Device Design & Engineering Division
Principal researcher

Maziar Ahmadi Zeidabadi
mahmadi@leitat.org, +34 93 788 2300 – Ext. 3226
Energy Storage Unit Senior Researcher
Device Design & Engineering Division