POLITECNICO
MILANO 1863

Surface & Electrochemical Engineering Lab

APPLIED ELECTROCHEMISTRY RESEARCH GROUP – POLITECNICO DI MILANO

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SEE people

Luca MAGAGNIN
Associate professor

Luca NOBILI
Associate professor

Lab Supervisor

Simona IEFFA
M.Sc.

Lab Technician

Fabio PAGANO
M.Sc.

Ibrahim KHALIL
Post-Doc

Alireza MOLAZEMHOSSEINI
Post-Doc

Roberto BERNASCONI
Ph.D. Student

Francesco LIBERALE
3° year Ph.D. Student

Lorenzo PEDRAZZETTI
3° year Ph.D. Student

Gabriele PANZERI
2° year Ph.D. Student

Alessandra ACCOGLI
2° year Ph.D. Student

Mattia PALLARO
2° year ST Microelectronics Ph.D. Student

Federico CUNEO
2° year ST Microelectronics Ph.D. Student

Eugenio GIBERTINI
1° year Ph.D. Student

About 25 master students and 25 bachelor students

SEE people

Luca MAGAGNIN
Associate professor

Teaching in Materials Engineering and Nanotechnology Master
Surface Engineering
Materials for Electronics
Applied Electrochemistry

Publications (h-index 15)
> 100 articles, books, 8 patents

President Italian Association of Metal Finishing

Board member European Academy of Surface Technology

General Secretary International Union for Surface Finishing

Electrodeposition Division Officer

SEE partners

SEE interests

The lab research is focused on **surface finishing and engineering** of metallic, ceramic and semi-conductive materials.

Major technologies investigated are based on **electrochemical and vapor phase processes.**

Goals and interests:

- *Metallurgy and properties of metallic materials;*
- *Functional (anti-wear, corrosion protection, low friction, modified wettability) and decorative coatings;*
- *Galvanic coatings;*
- *Metal matrix composite materials;*
- *Electroforming and LIGA processes;*
- *Super-hydrophobic surfaces.*

SEE-Interests

Goals and interests:

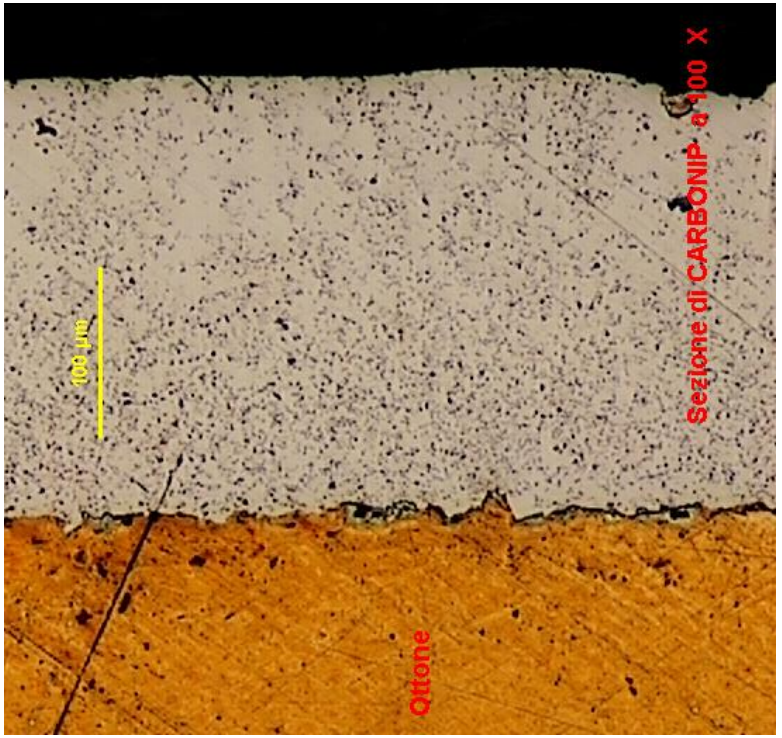
- *Electrodeposition in ionic liquids;*
- *Sensor, MEMS and energy harvester;*
- *Power generation devices;*
- *IC integration;*
- *Flexible electronics;*
- *Li-ion and vanadium batteries;*
- *3D-printed microrobots;*
- *Electrodeposition for PV cells;*
- *Electrochemical production of nanostructured materials;*
- *Inkject printing;*
- *Environmental electrochemistry: water remediation, CO2 reduction*

Composite Coatings @SEE lab

Metal Matrix Composites

Metal Matrix Composite *as antiwear coatings*

A material in which a continuous metallic phase (the matrix) is combined with another phase (the reinforcement) to strengthen the metal and increase mechanical properties, wear resistance and friction behavior.
MMC coatings can be applied to steels for improving functional properties and increase longevity.

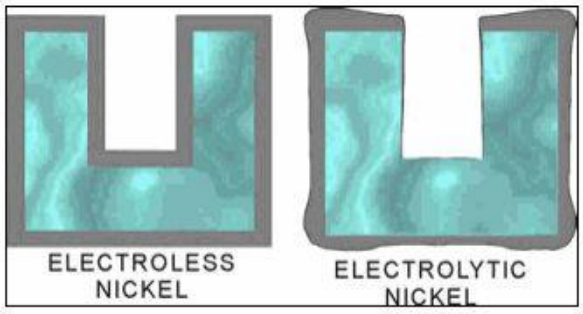


MMC as Erosion Resistant Coatings

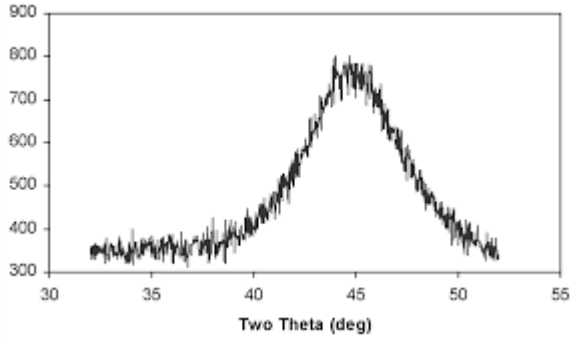
MMC can be synthesized via electroless deposition on any kind of material, shape and size. Thickness of the coatings is a function of deposition time.

- No current is required

- Conformal coatings

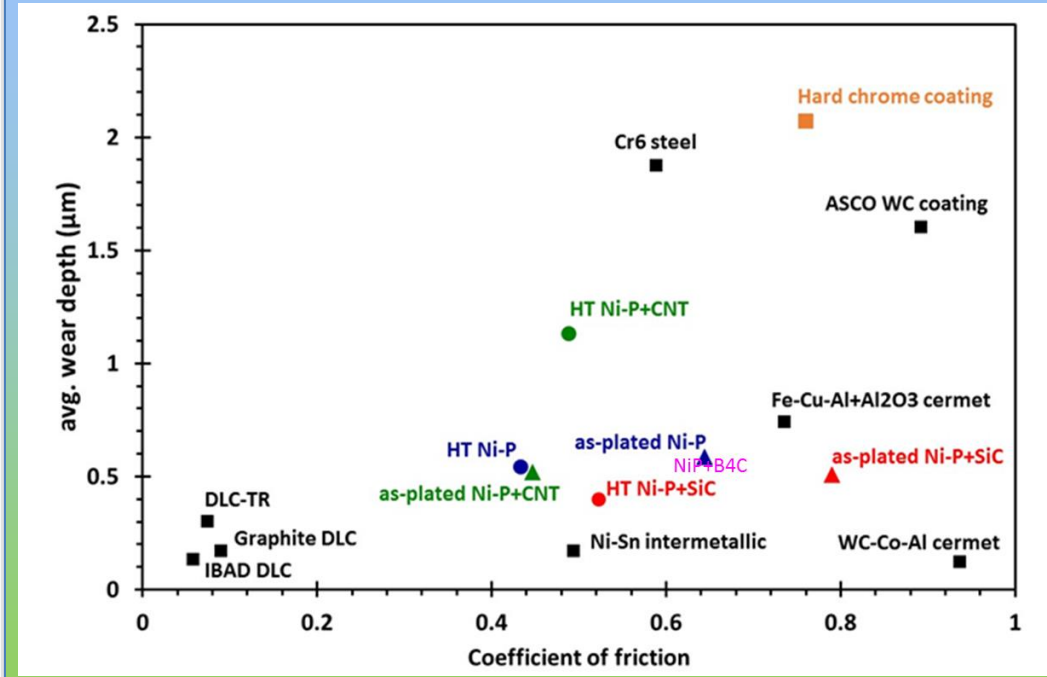


- Amorphous structure



MMC as Erosion Resistant Coatings

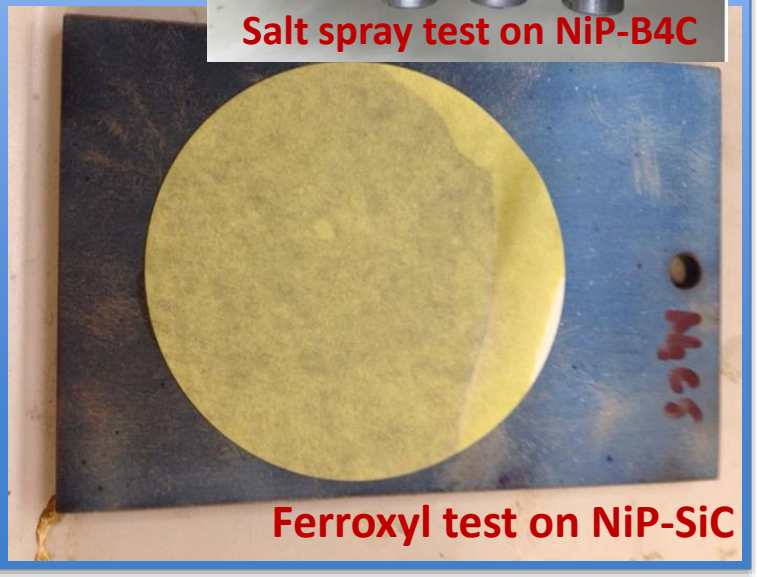
WEAR RESISTANCE



FP7: Research for the benefit of SMEs, HardAlt

CORROSION

Salt spray test on NiP-B4C



Ferroxyl test on NiP-SiC

Flame retardant treatments for textiles @SEE lab

Mixing with SBR or acrylic resins

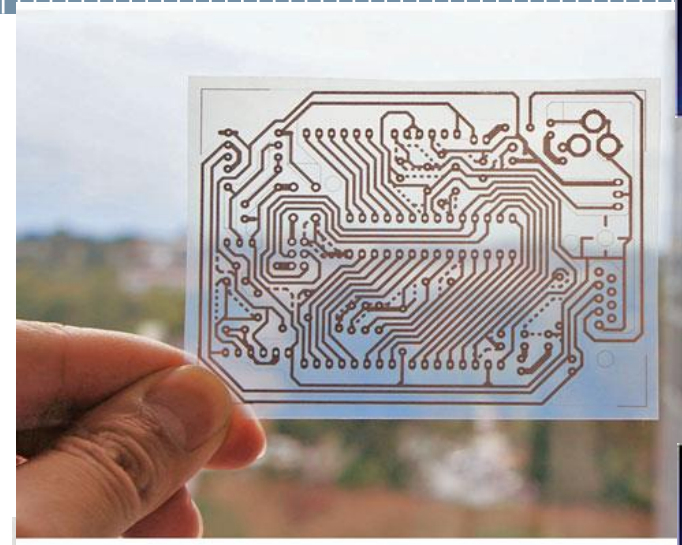
Fabric passing 20±1 s test

V / STELLA
VV OMBRIONE
UNI 124
VV ISL STAR
VV RIBALTA OA
CANNETTONE CINIGLIA
DV T0770
DELIRIUM
ECLISSI
UV TABOO

Flame test on ”Cannettone ciniglia” fabric with mixed resin

Inkjet printing @SEE lab

Inkjet Printing



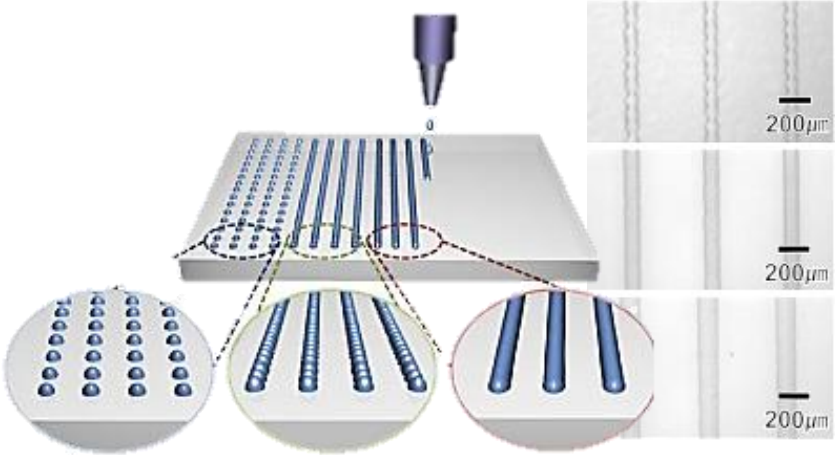
Displays

Life science

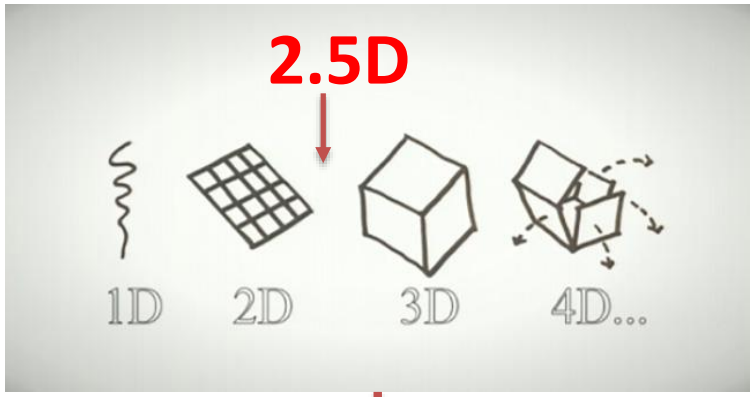
3D Mechanical

Photovoltaic

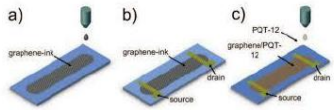
Optical

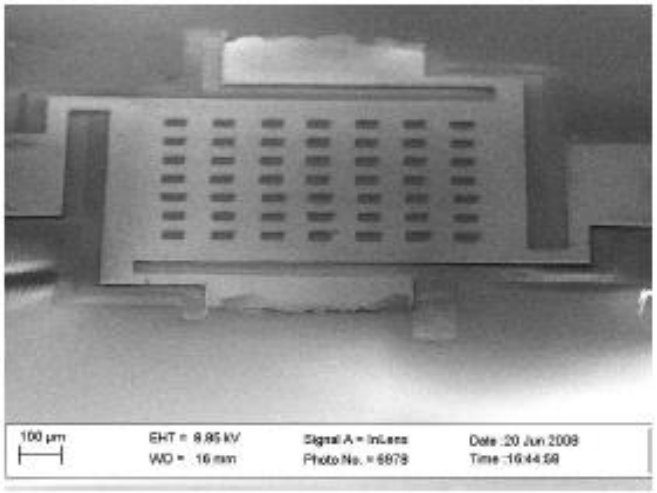


Inkjet Printing



Composites printing (polymeric binder + NPs or graphene)





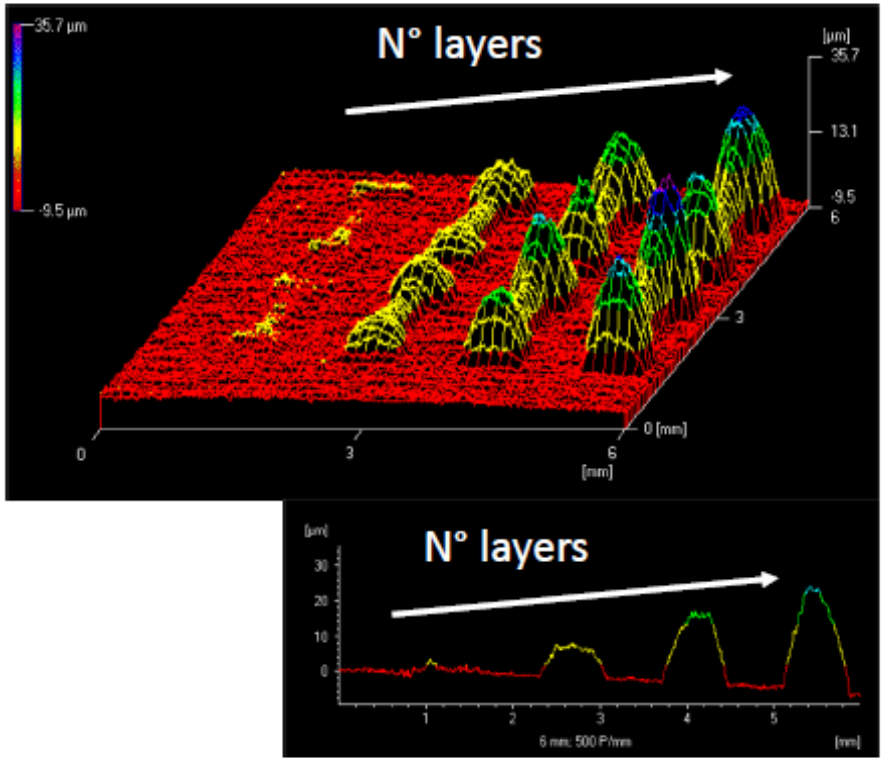
Inkjet Printing

Inkjet printing and curing of SU8 to obtain sacrificial or functional layers

FOUNDAMENTAL CHARACTERIZATION

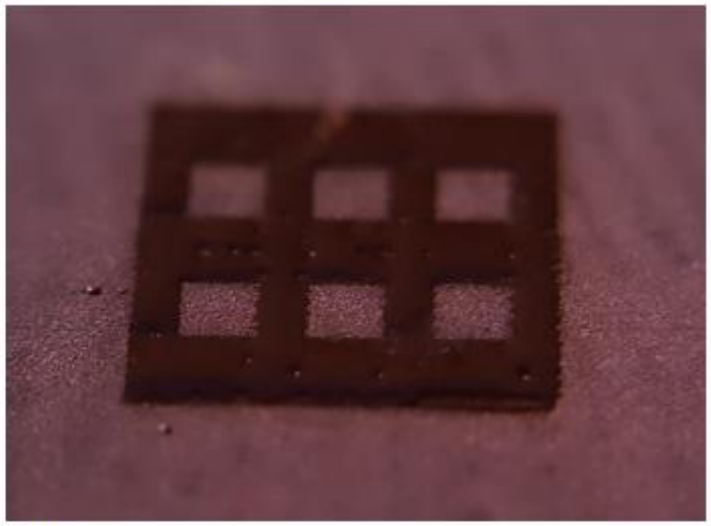
Influence of:

- Substrate
- Solvent
- Printing param.
- …

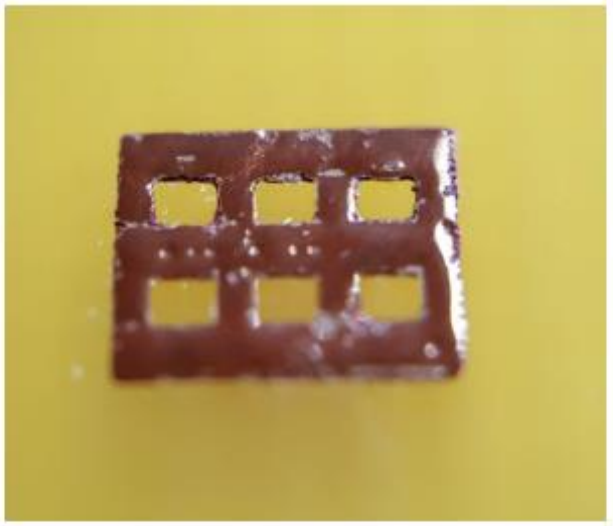


Inkjet Printing

Patterning with SU8 on PCB → Cu etching → SU8 stripping



SU8 on copper



Energy storage @SEE lab

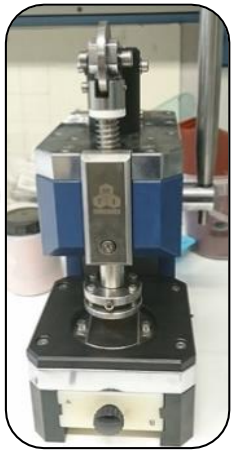
Ions based batteries

Pyrolized algae

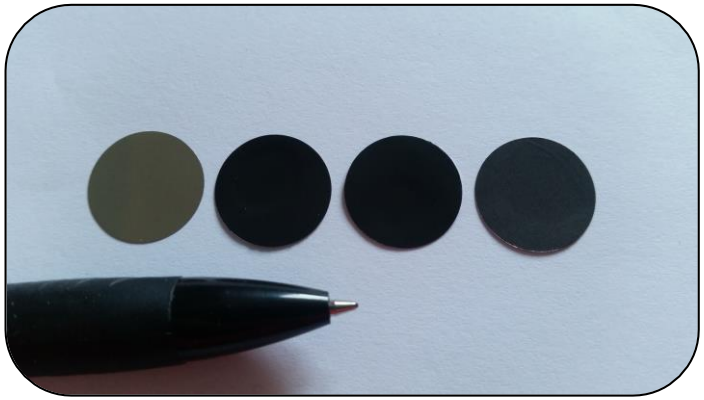
Ball milling

Electrode coater/Doctor Blade

Dried Electrodes

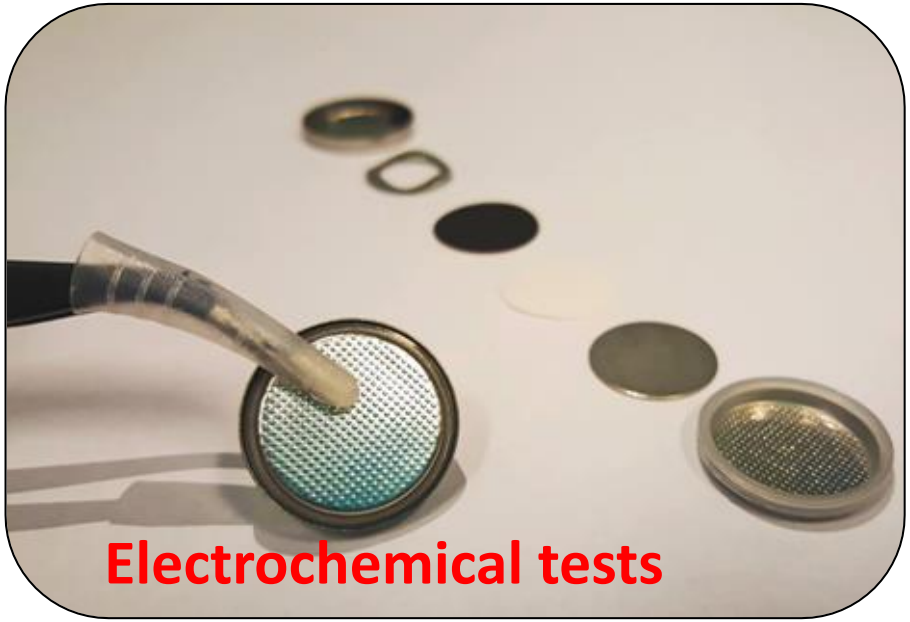


Punch cutter



Punched components

Ions based batteries



Ions based batteries

Materials

- HARD CARBON ELECTRODES
- IRON OXIDE ELECTRODES
- ELECTROSPUN PAN ELECTRODES
- HARD CARBON-RED P ELECTRODES
- IONIC LIQUIDS

Technologies

Sodium-ion batteries

- ❑ High-performance anodes from harmful algal blooms
  - – Algae treatment and reduction to Hard carbon
  - – Slurry preparation and electrode manufacturing
  - – Electrochemical cell characterization
- ❑ Iron oxide electrodes with and without NiP coating

Lithium -ion batteries

- ❑ Electrospun PAN electrodes
- ❑ Hard carbon- redP electrodes
- ❑ Hard carbon- iron oxide electrodes

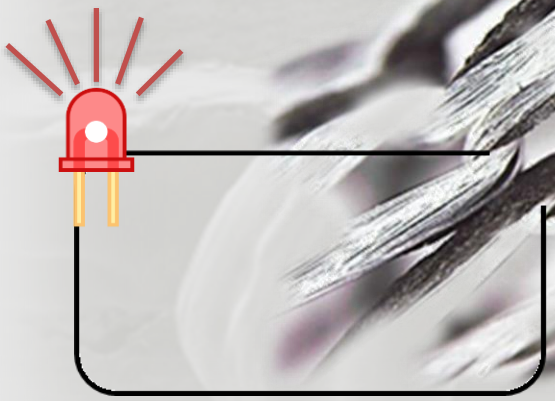
Aluminum-ion batteries

- ❑ Secondary aluminum batteries
  - Aluminun electrodeposition and stripping at the anode
  - Cathode materials which allows reversible reaction with Al-ions
- – *Ionic Liquid* based Al electrodeposition
- – Electrode materials (*HC as intercalation material*)

Our Projects

Fiber-Shaped Battery

Compatibility with fabric manufacturing



Integration in textiles for **wereable electronics**

Flexible electrodes for flexible device

Fiber-Shaped Battery

Development of new fiber shaped electrodes compatible with current Li^+ and Na^+ technology

Conventional natural and synthetic textile **fibers** are usually **10-20 µm** in diameter

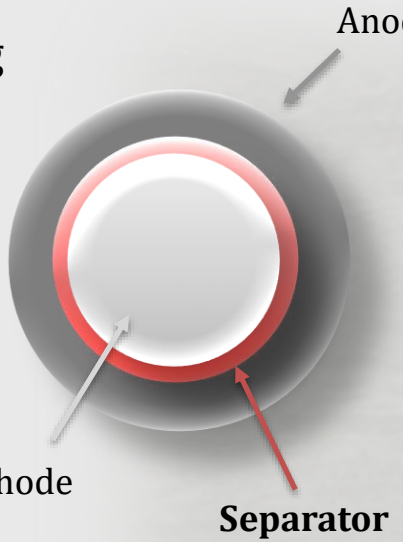
State of Art **carbon fiber based electrode 10-100 µm**

Thickness is a key factor !!

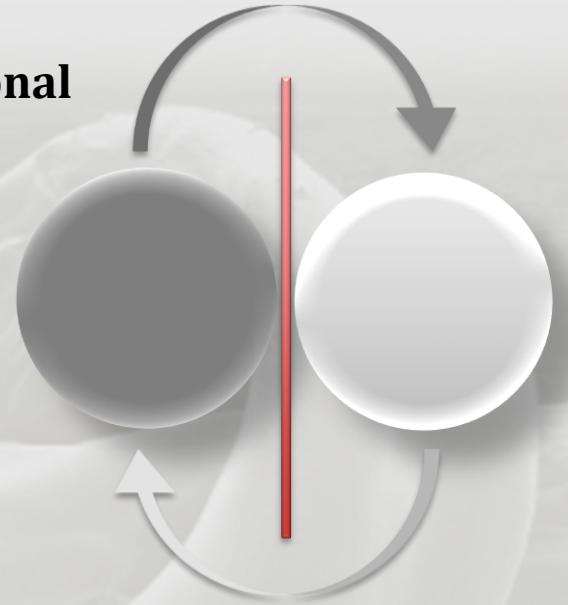
Maximum thickness of assembled wire battery **1000-500 µm**

Fiber-Shaped Battery

Coating



Conventional



Requisites

- **Flexibility**
- **Low thickness**
- **Stretchability**
- **Mechanical resistance**
- **Applicable as coating with uniform thickness (Dip Coating etc.)**

State of Art

Cellulose paper

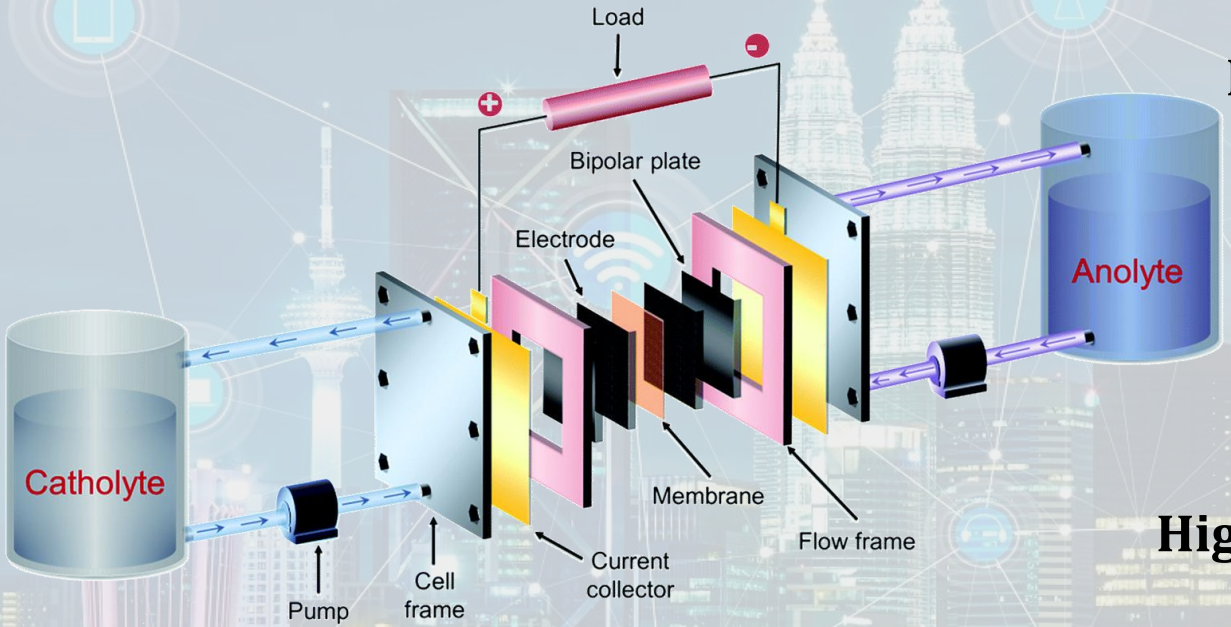
PVDF

Celgard 2400 porous PP

Cotton fibers

Rechargeable flow batteries

Redox reactions on the electrode surface → **No damage of the internal structure**



Long life cycles (10-20 y)

Easy **scalability**

Integration in **smart grid**

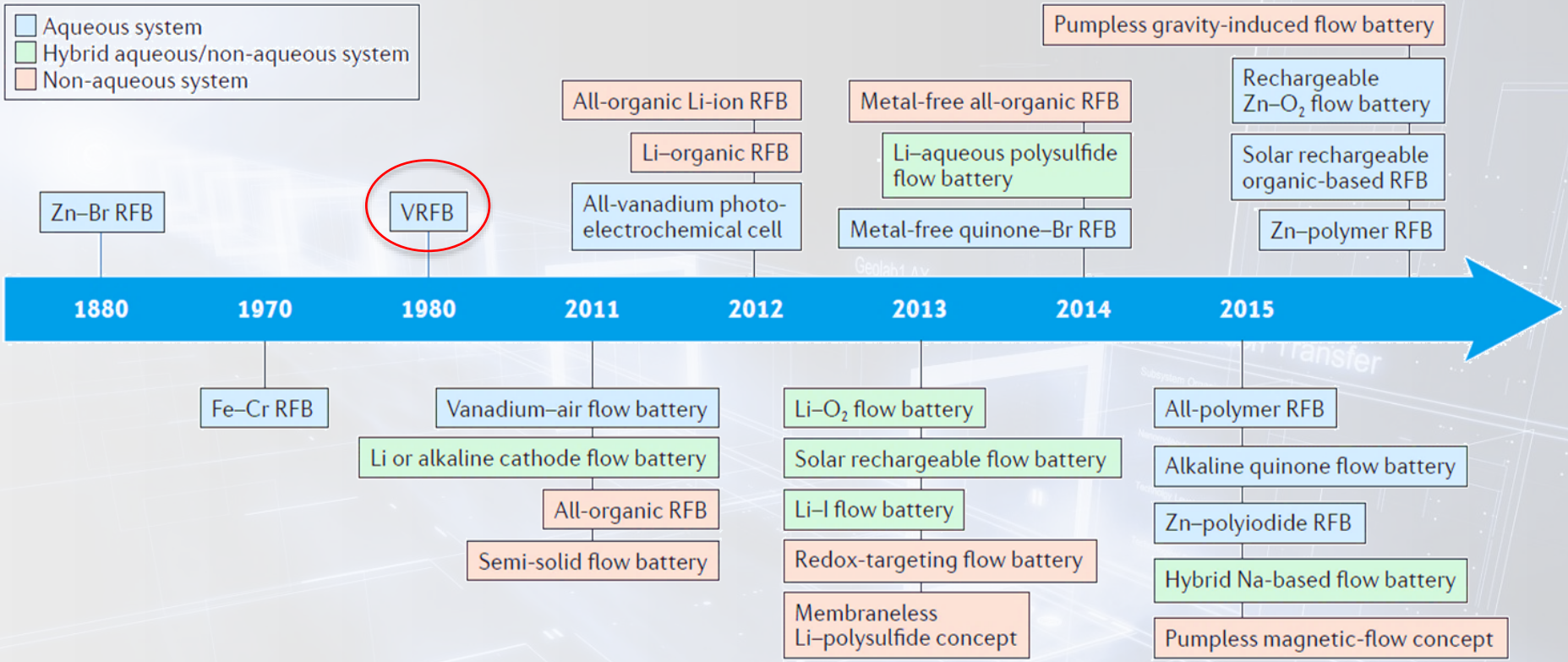
High Efficiency

Adjustable **energy and power output**

Lower maintenance costs

Can be charged **by renewable sources**

State of the Art



Next Generation RFB

Our Projects

New Flow Battery Approach

The **idea** was to study and develop **new higher energy density** flow batteries able to overcome many drawbacks of this kind of devices, following two approaches

Rechargeable aqueous or non-aqueous nanoelectrofuels

Semi-solid nano flow batteries

MANODYA

Manodya

	Continuo	MANODYA 1	MANODYA 2	MANODYA 2
η_e	0,832	0,845	0,871	0,927

Manodya→ Elevate efficienze

Miglioramenti possibili nell'intervallo 10-20%

Manodya

	Continuo	MANODYA 1	MANODYA 2	MANODYA 2
η_a			0,954	0,999

Manodya→ Elevate efficienze

Possibilità di scambio di carica senza perdite

Captive Systems' Technology

A Key Enabling Technology for metals recovery, water management and treatment based on Magnetic Fluids

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