Scientific Committee Labex CEMAM 2022

Center of Excellence on Multifunctional Architectured Materials

Centre d'Excellence sur les Matériaux Architecturés Multifonctionnels

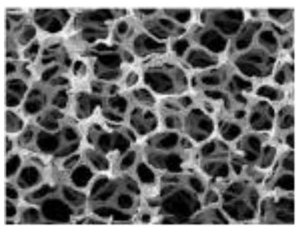
08/12/2022

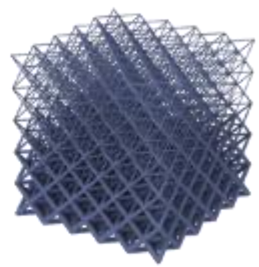
COS CEMAM 2022

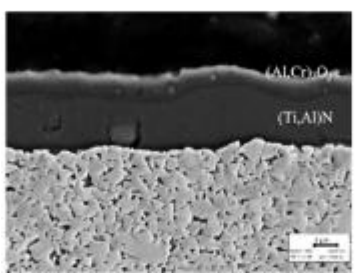
- Architectured Materials
- Identity Card
- Research
- Investments & Platforms
- Education & Scientific Animation
- Technology Transfer
- MateriAlps Project

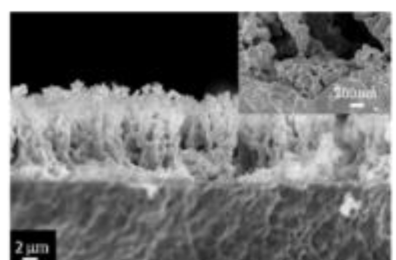
Architectured materials

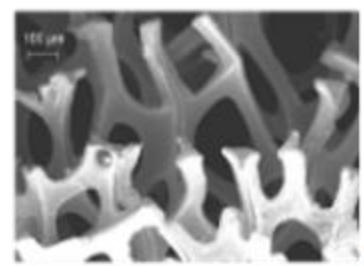
Multifunctional materials designed from usage requirements and characterized by controlled distribution of matter











Identity Card

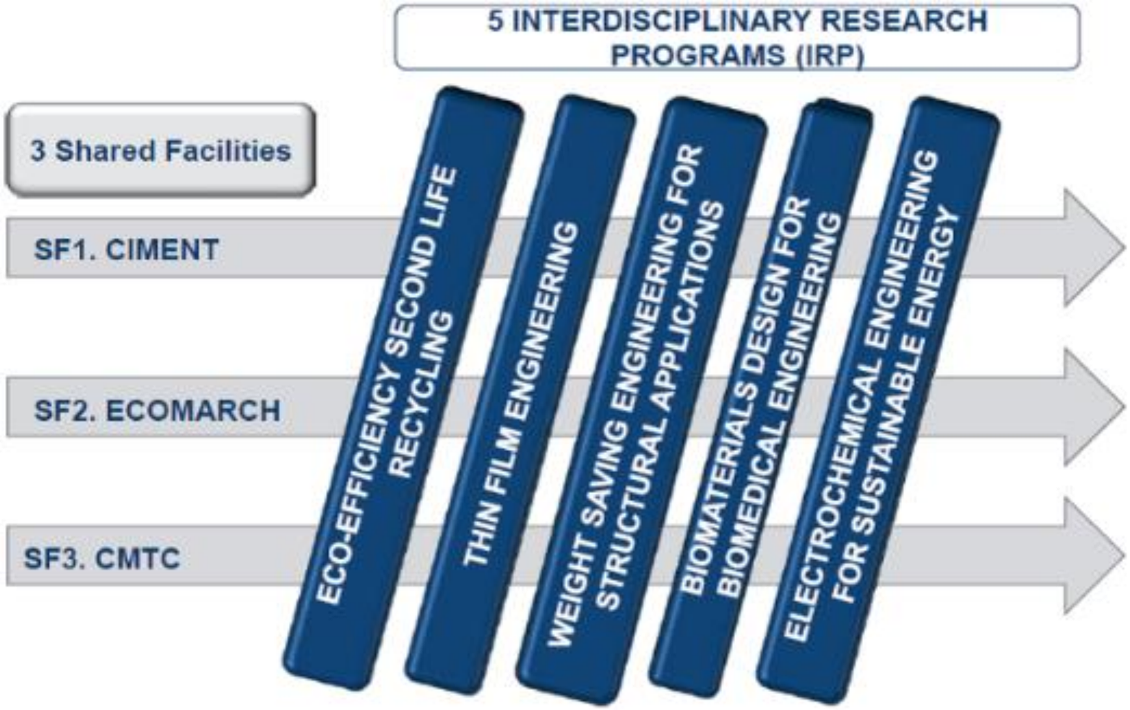
- Operation
  - Animation : A. Pasturel (retired) → J.J. Blandin (> 15/10/2022)
  - Secretary : S. Pagano (retired) → Y. Martinez (> 15/12/2022)

- Involved research teams
  - 10 teams Materials science and engineering (LEPMI, LMGP, SIMAP)
  - 1 team Physical biology (LiPhy)
  - 1 team Biomedical engineering (TIMC)
  - 1 team Eco-responsible design (G-SCOP)
  - 1 team in urban architecture (AAU)
  - ≈ 140 permanent members
- Budget
  - 0.75 M€ / year during 5 years

COS CEMAM 2022

Research

- 5 Interdisciplinary Research Programs (IRP)
- 3 Shared Facilities (SF)



Research

- IRP1 : Eco efficiency, second life(s), recycling
- IRP2 : Thin Film Engineering
- IRP3 : Weight saving engineering
- IRP4 : Biomaterials design for biomedical engineering
- IRP5 : Electrochemical engineering for sustanaible energy

- For each IRP
  - Brief description of IRPs
  - Focus on one project in progress

Research

- IRP1 : Eco efficiency, second life(s), recycling
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Research / IRP1 : Eco efficiency, second life(s), recycling

- Providing knowledge and tools to evaluate and to lower environmental impacts of architectured materials, from raw material extraction to final product and its end-of-life
  - Eco-efficiency of architecturation processes (Life Cycle Assessment, Product or process eco-design)
  - Second life(s) / recycling capacities taken into account from the design stage

Isabelle BILLARD

Damien EVRARD

Research / IRP1 : Eco efficiency, second life(s), recycling

- Recycling of cathode materials from used Li-ion batteries by hydro-metallurgy

Youssef KARAR (Post doc, started june, 2022- duration: 18 months), based on the Ph-D work of Delphine Yetim

New European directive (December 2020)
⇒ Increase battery recycling rate from 50% to 65% by 2025
⇒ Use of 12% recycled Co to manufacture new batteries

Li-batteries contain Co; multi-architectured material

Cathodes

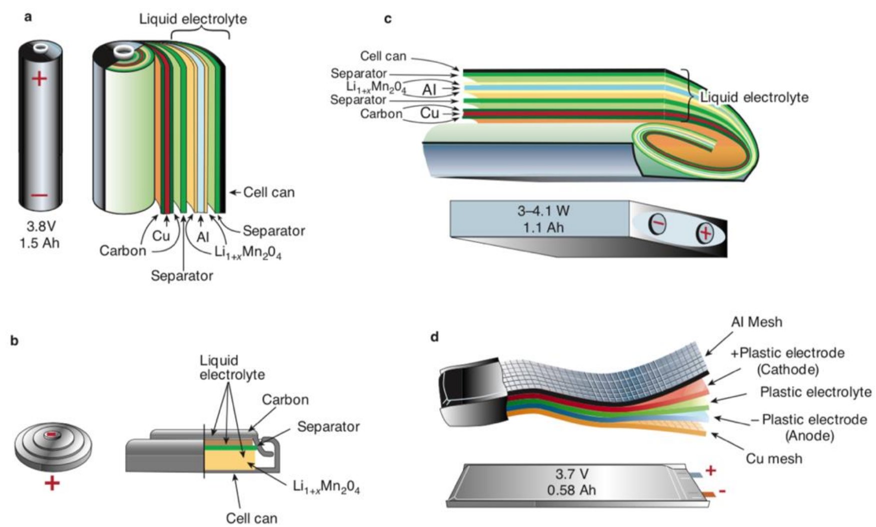
$LiCoO_2$ (LCO)
$LiNiMnCoO_2$ (NMC)
$LiNiCoAlO_2$ (NCA)
…

Anodes

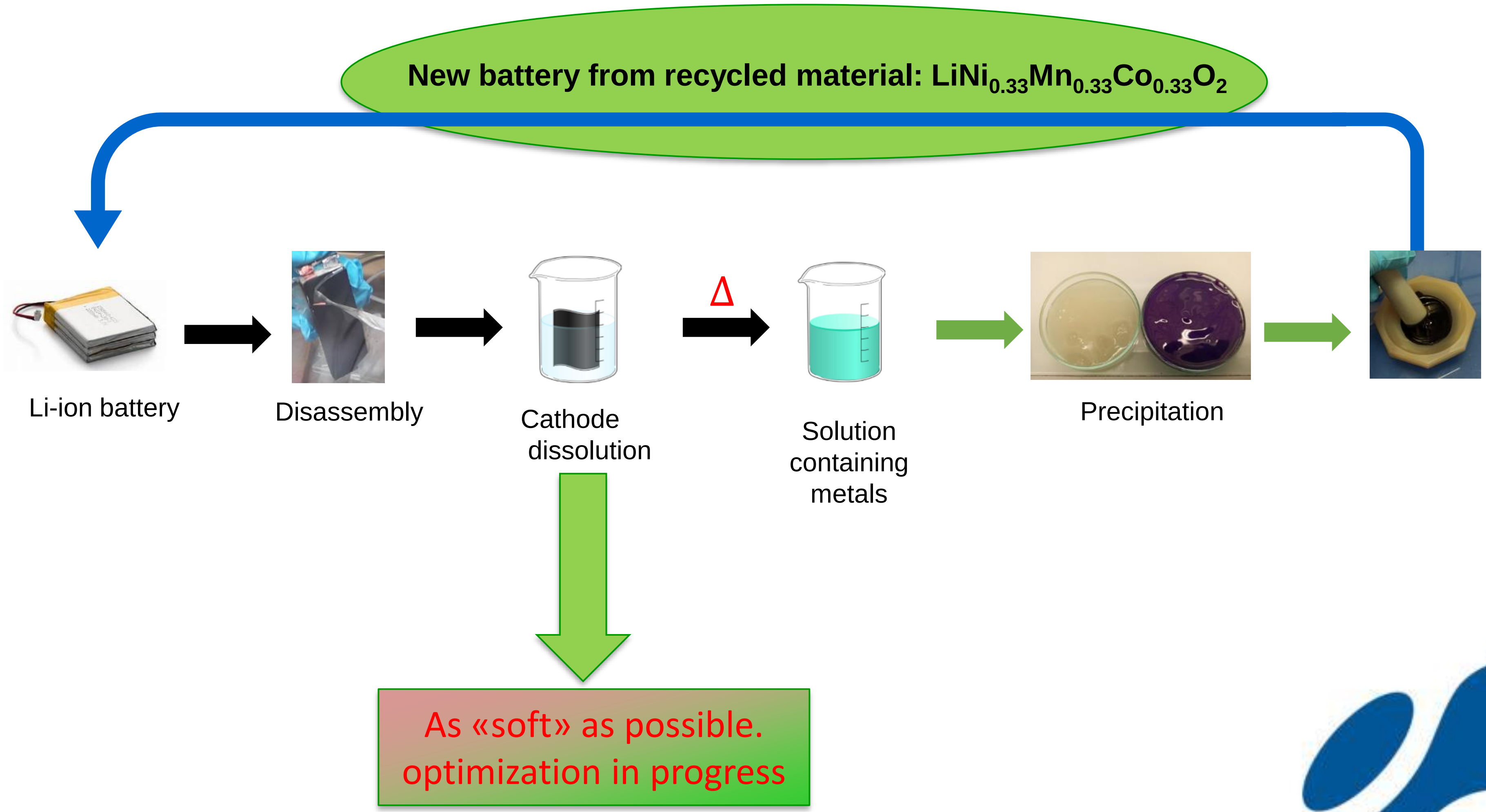
Lithium metal
Carbon

Electrolytes

Solid (Lithium polymer)
Liquid (Lithium-ion)
Gel

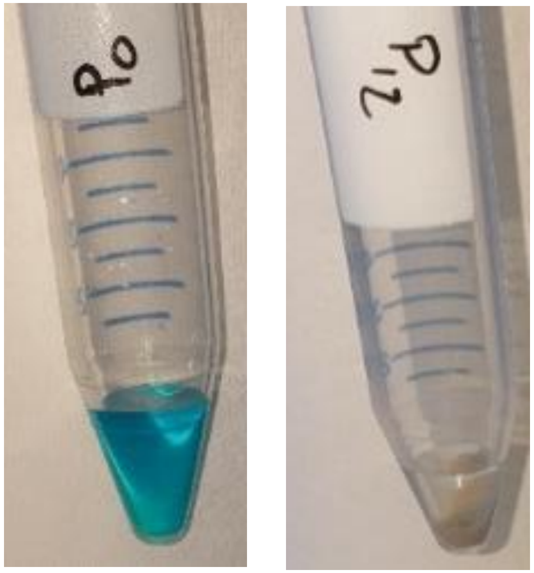


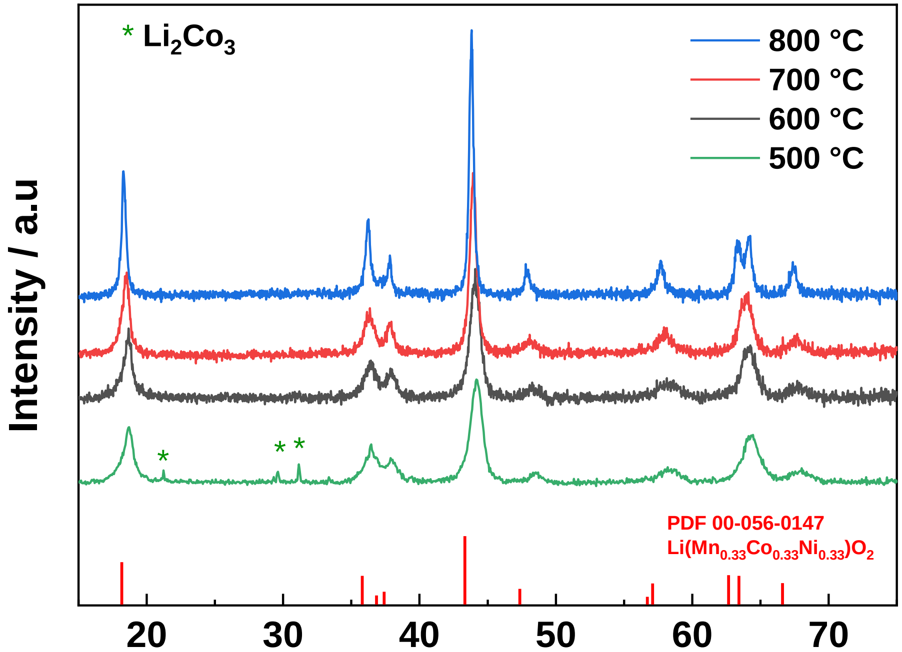
Overview of recycling process



Remanufacturing steps

Model material:
$LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$





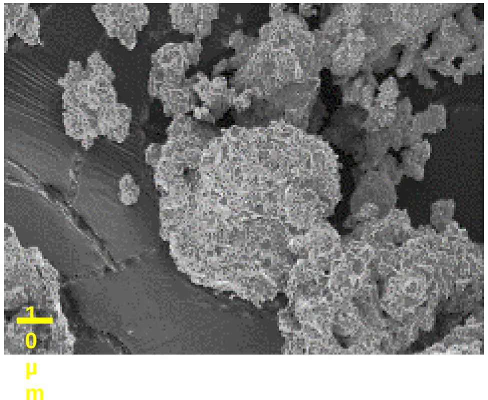
Coprecipitation of Co, Mn and Ni. Li is obtained by evaporation and added to the precipitate

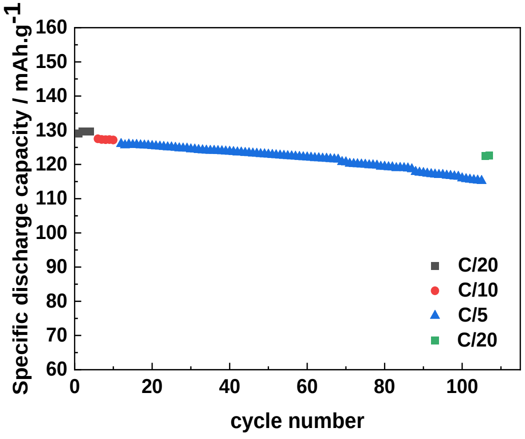
Heating rate = 10 C/ min
5 hrs isotherm @ 500° C
10 hrs isotherm @ 900 ° C.
Follow up by XRD.

- Peaks related to Li_2CO_3 completely disappear at 600° C. Lithiation occurs at 600° C. The heating step at 900° C insures a good crystallization of the material.

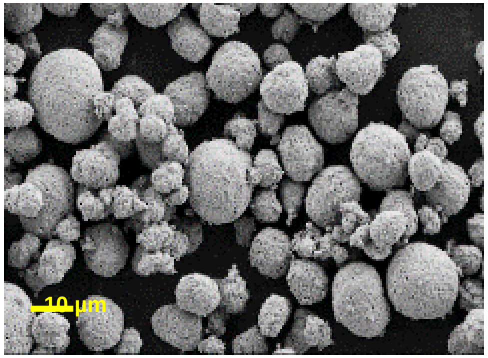
Results so far

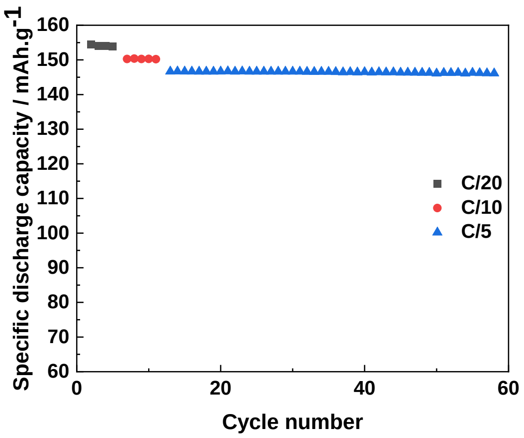
Recycled

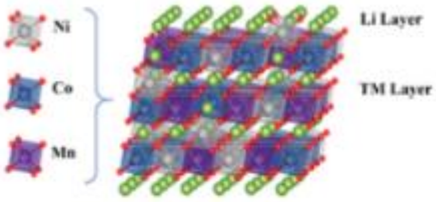




Commercial







The lack of Li in the crystalline structure most probably accounts for the observed differences in material performances

Future steps

- Optimization of leaching
- Work with realistic spent cathodes
- Demonstrate the versatility of the process by applying it to other Li-ion battery chemistries (NMC 811, NMC 622, etc.)
- Post-mortem analysis on the recycled batteries
- Life Cycle Analysis

Research

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- For each IRP
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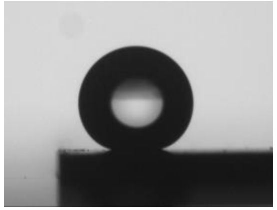
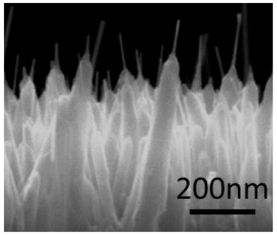
Research / IRP2 : Thin Film Engineering

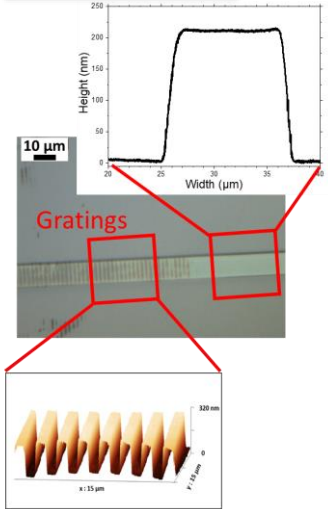
- High-performance coatings for mastering surface functionalization (at minimal energetic price and resource consumption)
  - Bio-inspired nano-architectured surfaces (Hydrophobic surfaces, water harvesting)
  - Coating on architectured materials (surface functionalization)
  - Active coatings (piezoelectric coatings, conductive materials for transparent electrodes)
  - Combinatorial design in thin films (high throughput analysis HEA, nitrides….)

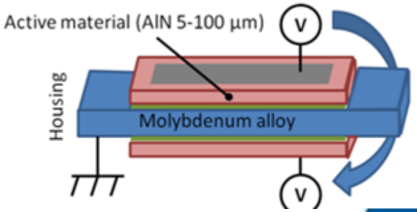
Vincent CONSONNI

David RIASSETTO





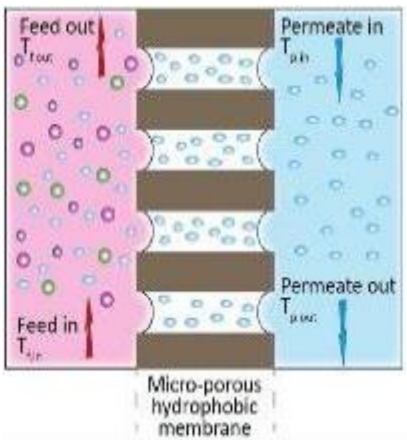


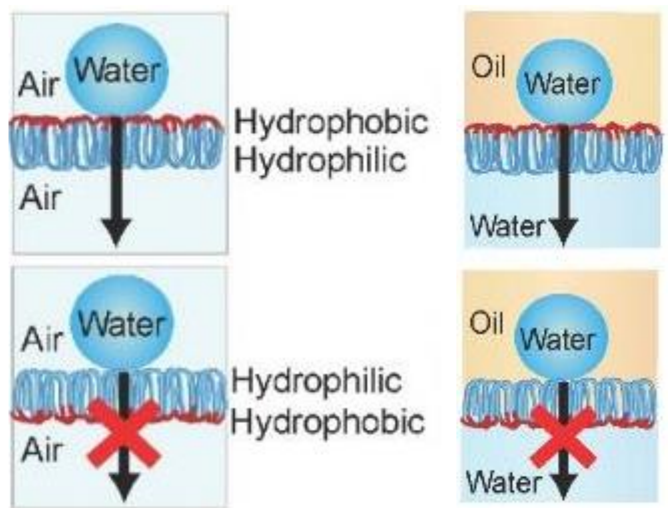


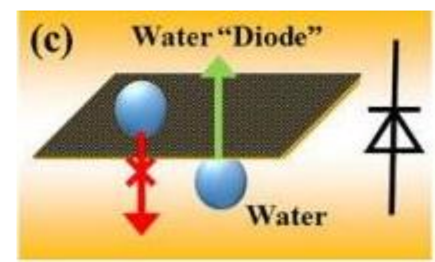
Research / IRP2 : Thin Film Engineering

Janus membrane for sea water desalination by membrane distillation

- Post doc Donaldo Fabio MERCADO CASTRO



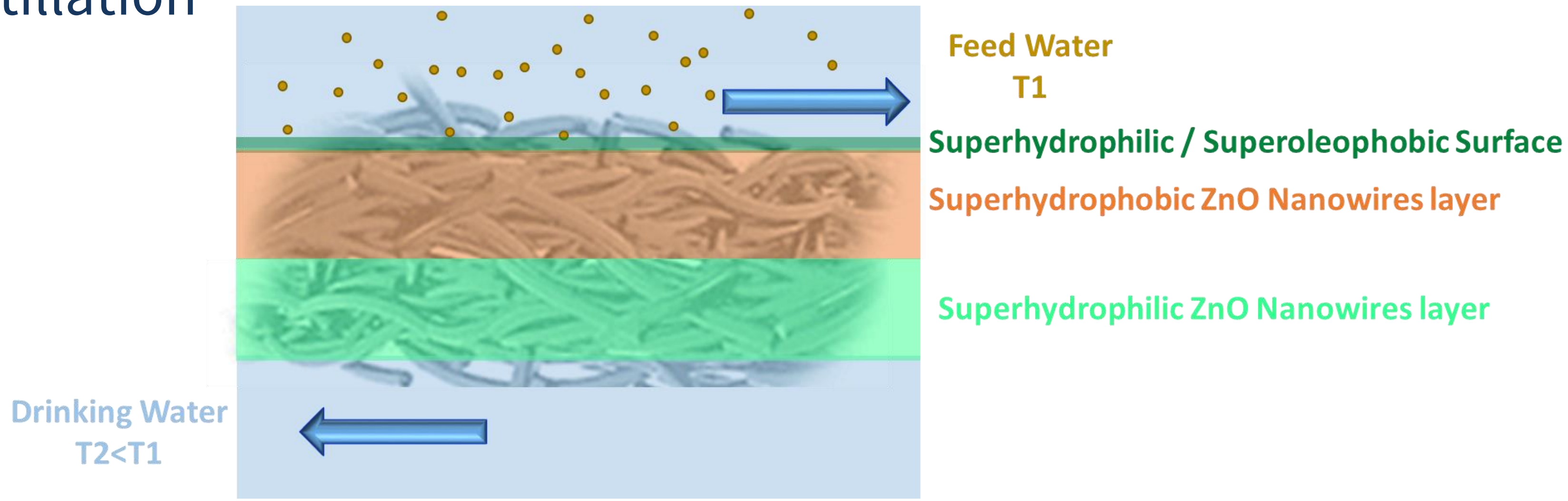




S. Yang et al., *Appl. Phys. Lett.*, **113,** 203701 **(2018)**
X. Tian et al., Adv. Funct. Mater., 24: 6023-6028 **(2014)**

Research / IRP2 : Thin Film Engineering

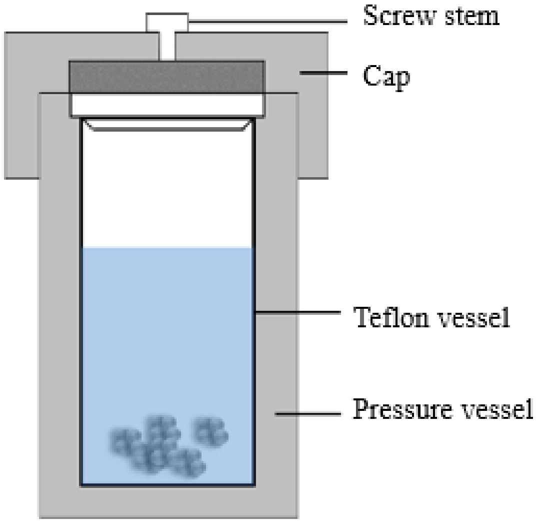
Janus membrane for sea water desalination by membrane distillation

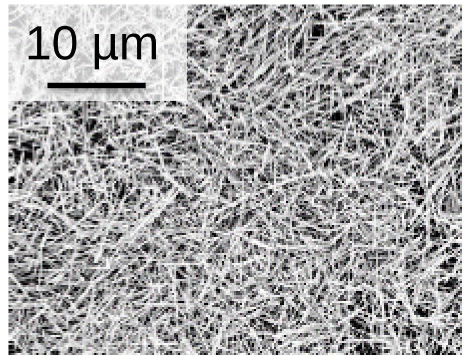


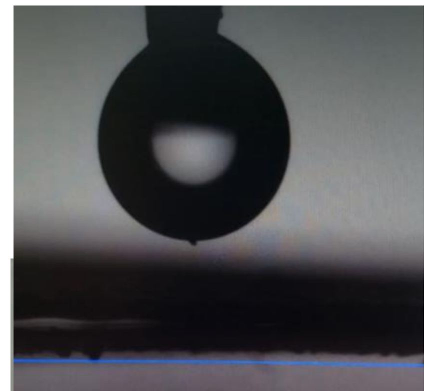
- Nano-Architectured
- Surface functionalization
- Life cycle assessment
- Global efficiency

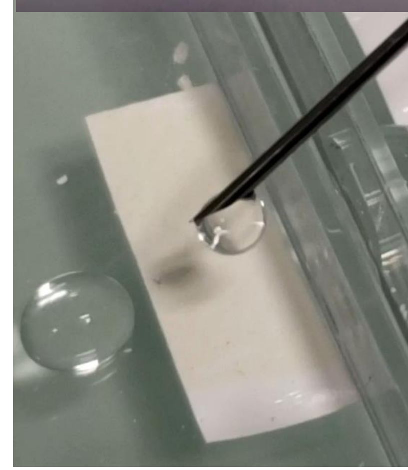
Research / IRP2 : Thin Film Engineering

Janus membrane for sea water desalination by membrane distillation









Research / IRP2 : Thin Film Engineering

Janus membrane for sea water desalination by membrane distillation

- ☑ Wanted Nanoarchitecture Definition
- ☑ Self-standing superhydrophobic ZnO nanowires membrane
- ☑ Superhydrophilic/under water superolephobic coatings
- ☐ Life cycle analysis
- ☒ Superhydrophilic/superoleophobic ZnO nanowires
- ☒ ZnO NWs Janus membrane
- ☒ Lab scale desalination plant
- ☒ Global efficiency

Research

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Research / IRP3 : Weight saving engineering

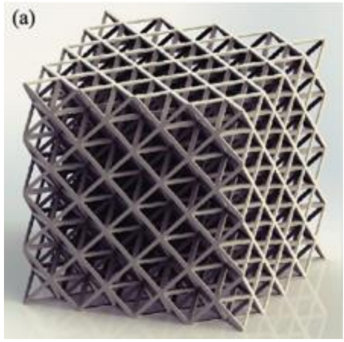
- Promoting strategies to improve durability of architectured materials for structural applications while using the minimum quantity of material
  - Multifunctional architectures (e.g. CVD coated lattice)
  - Damage tolerant architectures (e.g. strain hardenable Ti lattice)
  - Locally controlled architectures (e.g. microstructures, geometries)

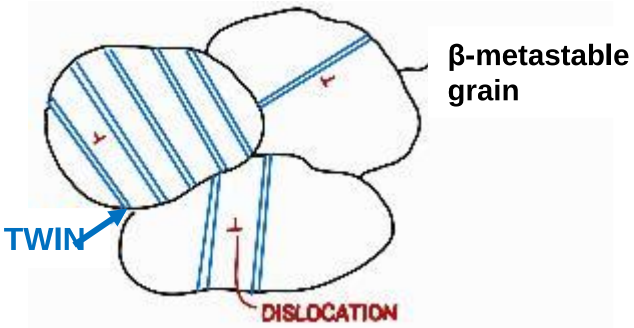
Hugo
VAN LANDEGHEM

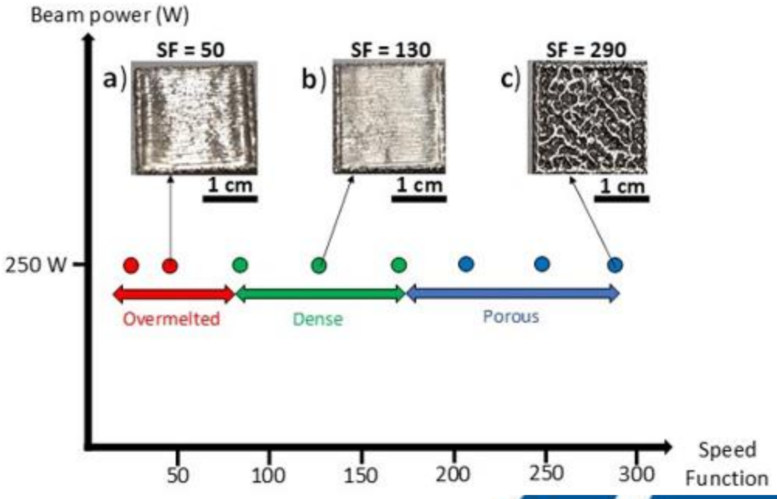
Jean-Jacques
BLANDIN

Research / IRP3 : Weight saving engineering

- EBM TWIP Ti-Mo lattice structures for mechanical energy absorption
  - **PhD Mathis DUPORT *(defence in course !)***, coll. Chimie Paris / UL Bruxelles (B)

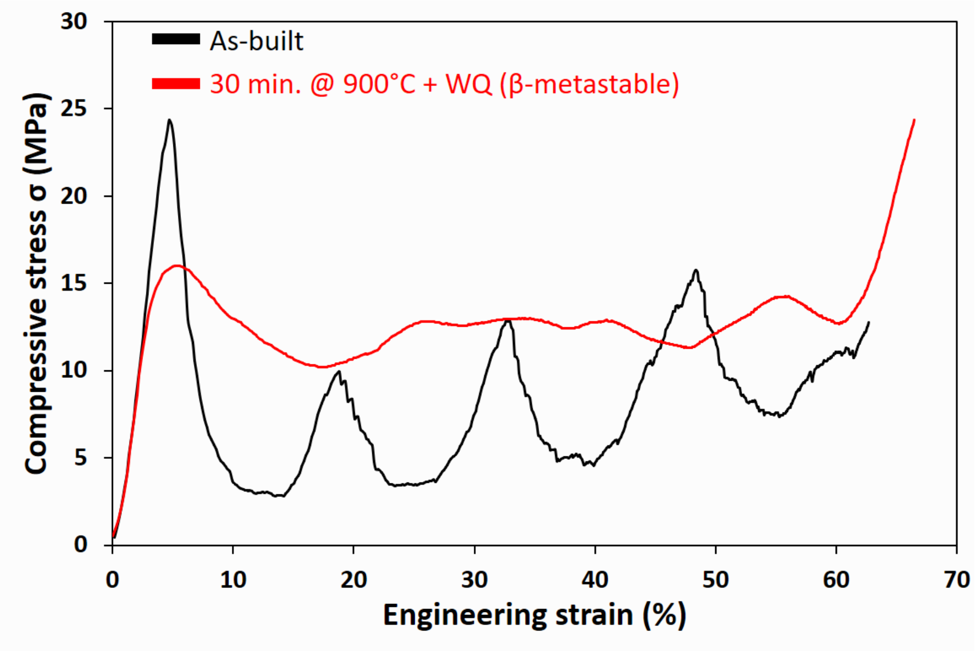






Research / IRP3 : Weight saving engineering

- EBM TWIP Ti-Mo lattice structures for mechanical energy absorption



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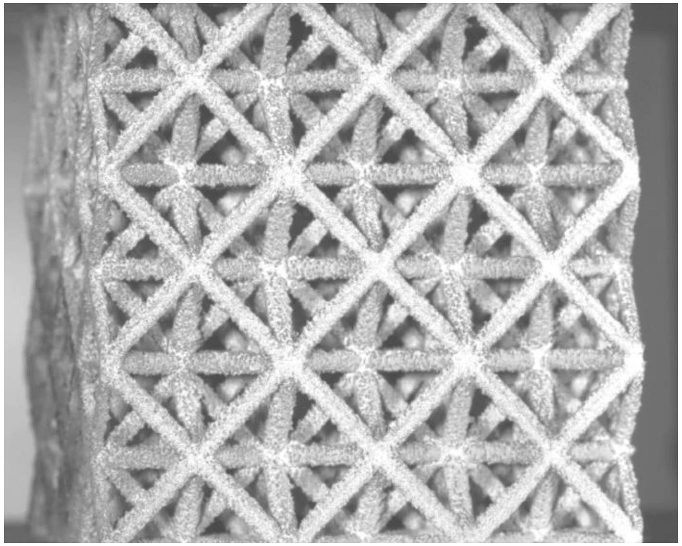

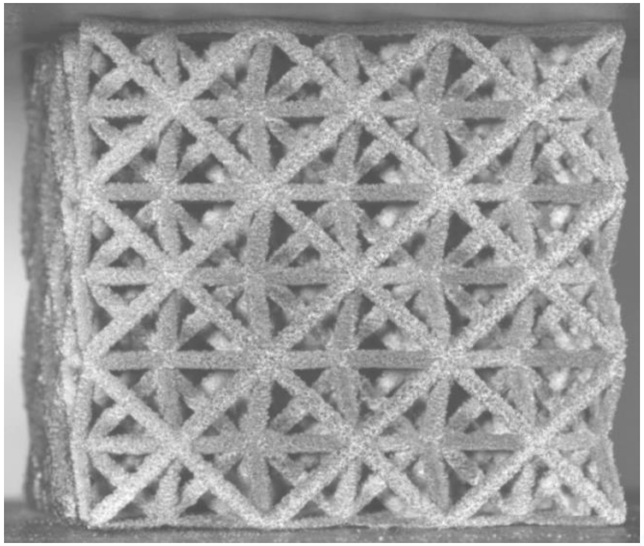

Research / IRP3 : Weight saving engineering

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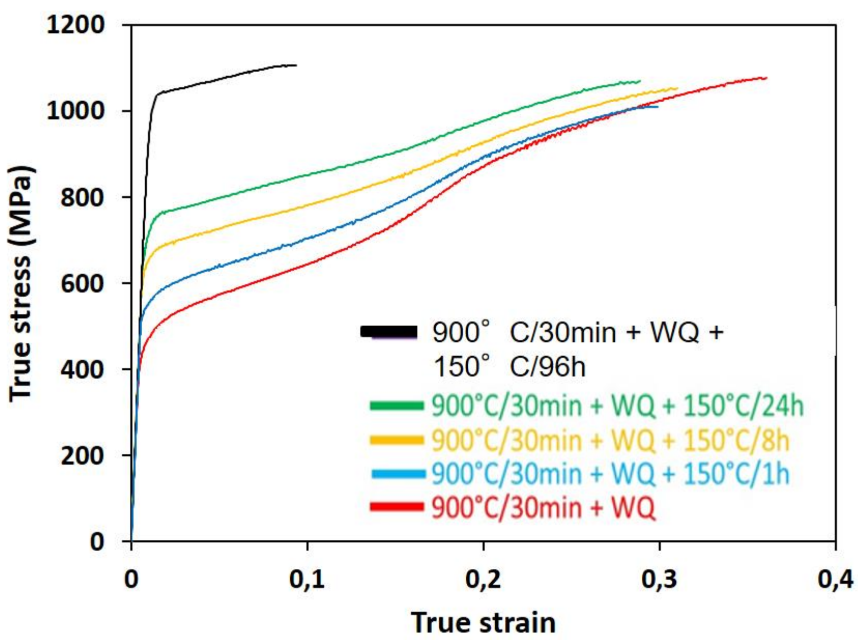

Research

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- IRP4 : Biomaterials design for biomedical engineering
- IRP5 : Electrochemical engineering for sustanaible energy

Research / IRP4 : Biomaterials design for biomedical engineering

- Design, fabrication and use of architectured biomaterials for biomedical engineering
  - Tissue regeneration, medical devices (e.g. biomaterials for enhancing functional recovery)
  - Biosensors (e.g. detection of biomolecules)
  - Innovative architectured microenvironments (fundamental biology of cells and tissues)
  - Multi-scale characterisation of tissues/organs (e.g. bone characterisation)

Mariane WEIDENHAUPT

Aurélien GOURRIER

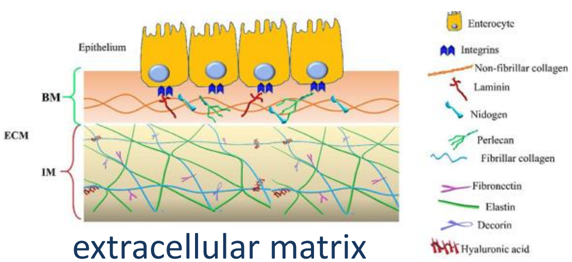
Highlight:

Influence of material properties on protein adsorption and self-assembly

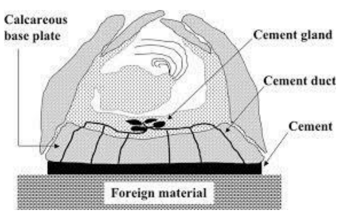
PostDoc Laurent MARICHAL, LMGP

Proteins at material interfaces

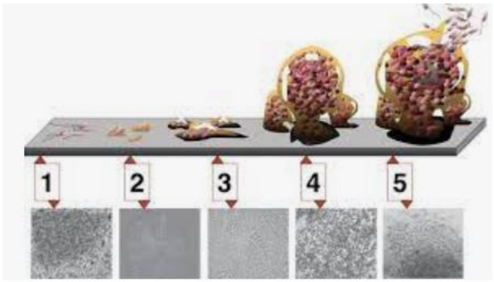
- Proteins can stick to any material surface… in air and in water
  - functional interface for cell attachment
  - functional structure for ex for prey capture



extracellular matrix



adhesive cement



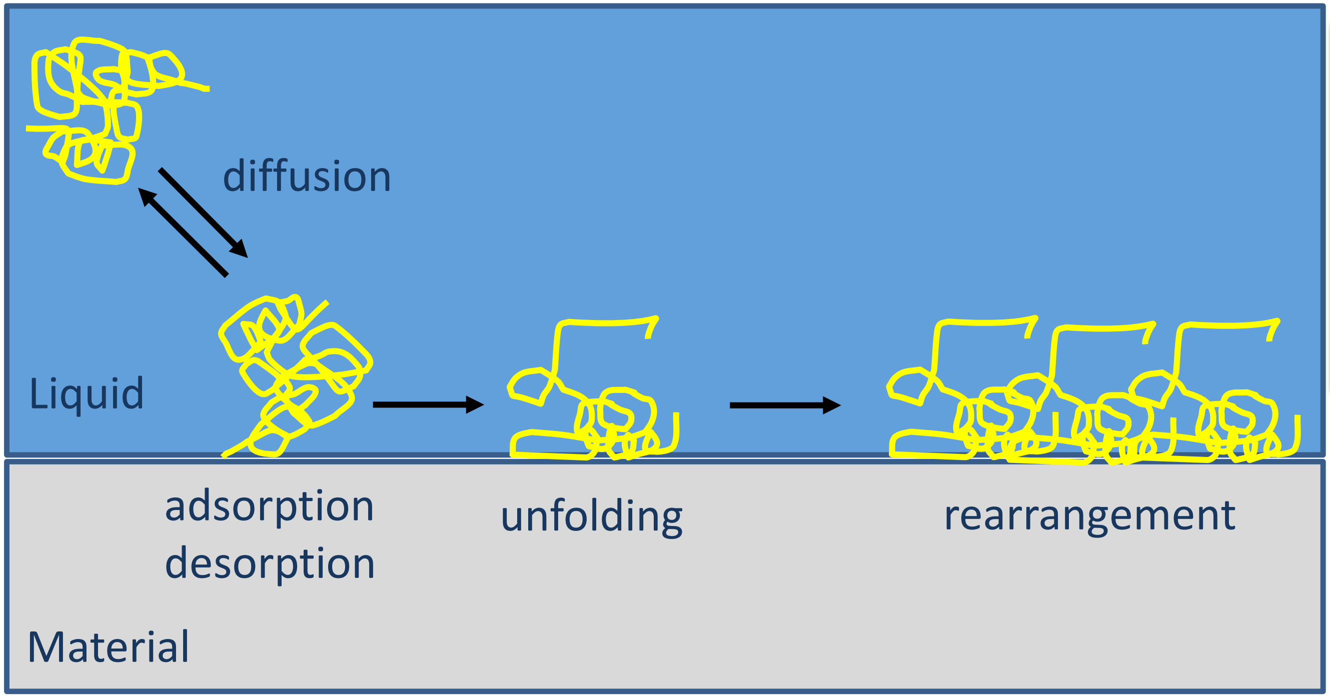
biofilm anchorage

spider web

Material surface properties

Protein adsorption and self-assembly

Interfacial phenomena



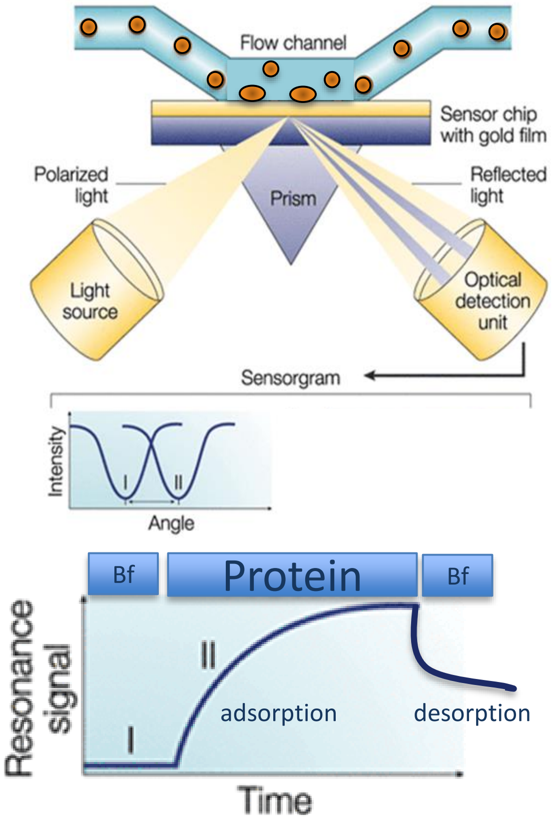
<u>protein solution:</u>
pH, ionic strength, additives
Protein: concentration, charge, size, shape

<u>material (solid):</u>
Hydrophobicity
Charge
Crystallinity
Topology

Study adsorption/desorption kinetics
adsorbed mass
conformation of adsorbed protein
As a function of material surface properties

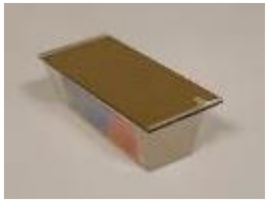
Surface plasmon resonance imaging SPRi

Protein adsorption in real time



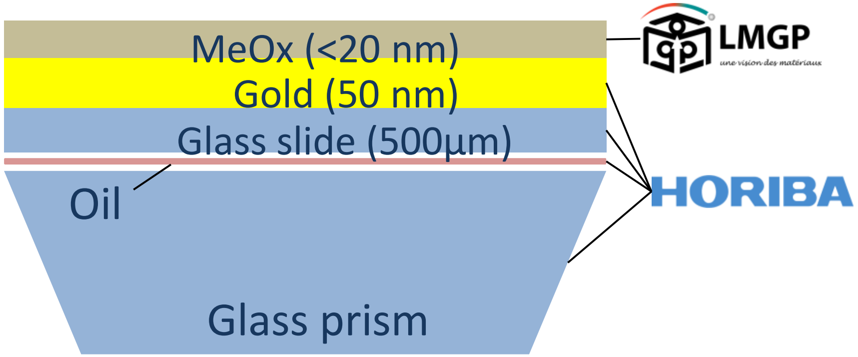
Deposition of metal oxide thin films by SALD

Al_2O_3, ZnO, Alucone



Surface layer needs to be:

- **thin (< than 20 nm)**
- homogeneous
- water/ethanol resistant
- stable

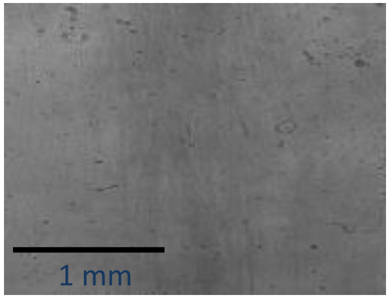


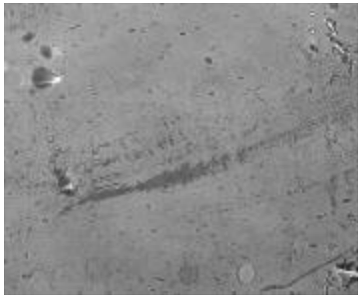
Deposition by Spatial Atomic Layer Deposition (SALD)
D. Muñoz-Rojas LMGP FunSurf

Protein adsorption measurements on deposited MeOx thin films

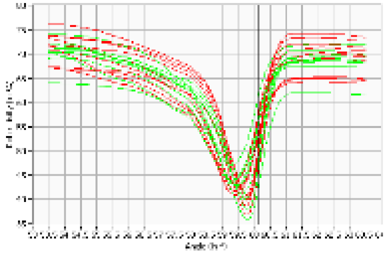
	Al_2O_3	ZnO	Alucone
MeOx layer thickness	12.5 and 15 nm	15 nm	5-15 nm ?

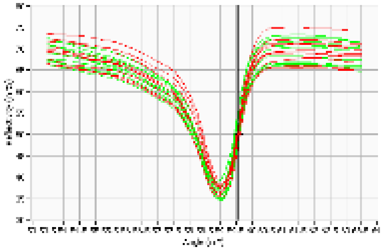
Surface imaging (SPRi)

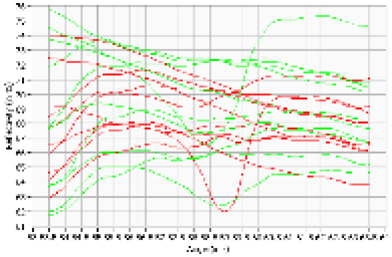




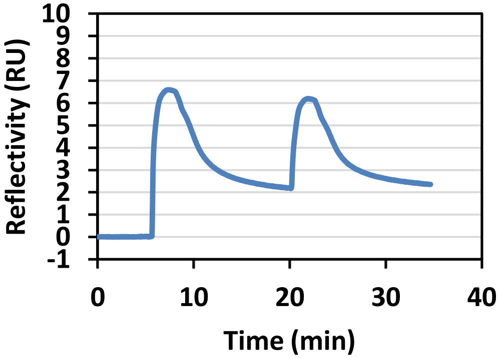
Plasmon detection

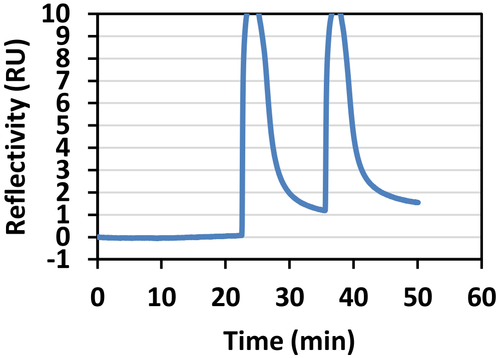






Protein adsorption measurable by SPRi on Al_2O_3 and ZnO





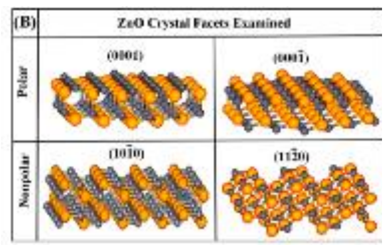
CEMAM is a « Labora

Perspectives

How do material surface properties influence protein adsorption and self organisation?

- material-guided protein adsorption

  adsorbed mass
  oriented self-assembly

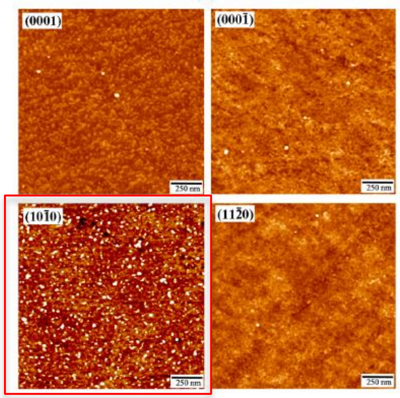


Langmuir 2015, 31, 10493–10499

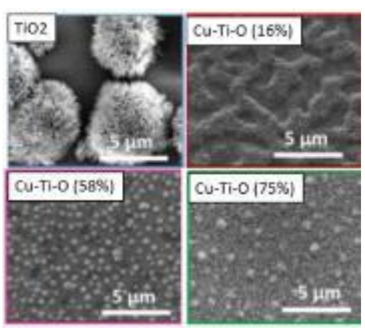
(A)

ZnO Crystal Facet	Average Number of Proteins per 1µm x 1µm area
(0001)	1.31 ± 0.58
$(000\bar{1})$	1.91 ± 0.48
$(10\bar{1}0)$	279.3 ± 32.94
$(11\bar{2}0)$	0.89 ± 0.41

(B)



Can we use material properties to control protein adsorption ?



TiO_2 microflowers:
Topography and density
photocatalytic properties

Antifouling coatings

Villardi de Oliveira 2020, Coatings 10 (2020), 779

Research

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Research / IRP5 : Electrochemical engineering for sustainable energy

- Developing new electrochemical energy storage and conversion devices that can operate beyond fossil fuels
  - Atomic-level design of nanomaterials for complex electrocatalytic reactions
  - Architectured electrodes for energy conversion and storage
  - Multi-functional electrolytes for energy conversion and storage
  - Architectured membrane electrodes assembly for high performance electrochemical generators

Cristina IOJOIU

Laetitia DUBAU

Research / IRP5 : Electrochemical engineering for sustanaible energy

- Optimization of high Performance nano-architectured electrode / electrolyte bilayer for Solid Oxide Cells
  - Sylvère PANISSET (PhD, 2021-2024)
  - Supervisors : Dr Monica BURRIEL (LMGP), Dr David JAUFFRES (SIMaP)

Research / IRP5 : Context

Conventional SOC

- ❑ **Very efficient energy convertor**
- ❑ **High energy density**
- ❑ Modular construction (planar, circular)
- ❑ Non-polluting (in use)
- ❑ Low maintenance
- ❑ Silent
- ❑ Safe

- ❑ **High operating temperature**
- ❑ **Slow start time**
- ❑ **Large amount of Critical Raw Material**
- ❑ Low power density
- ❑ Impurities in gas stream shorten the life time
- ❑ Expensive
- ❑ Lack of reliability

How to **reduce operating temperature,** while keeping **good electrochemical performance**?

Thin film SOC

- ❑ **Ohmic resistance** is reduced as the electrolyte thickness is largely reduced
- ❑ The need of Critical Raw Material is significantly reduced

T°C

- An **improved material durability** and cell reliability
- A faster start time
- The possibility of TF-SOC **integration in silicon technology**

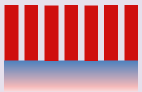
Oxygen electrode

The oxygen electrode is responsible for the **highest polarization resistance contribution** (→ cell performance)

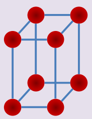
Research / IRP5 : Methodology

- ➔ Develop novel **electrode/electrolyte architectures** with improved performance
- ➔ Understand and quantify the combined effects on performance of i) architecture, ii) enhanced ionic conductivity, and iii) enhanced Oxygen Reduction Reactions kinetics

Apparent activity



Intrinsic activity



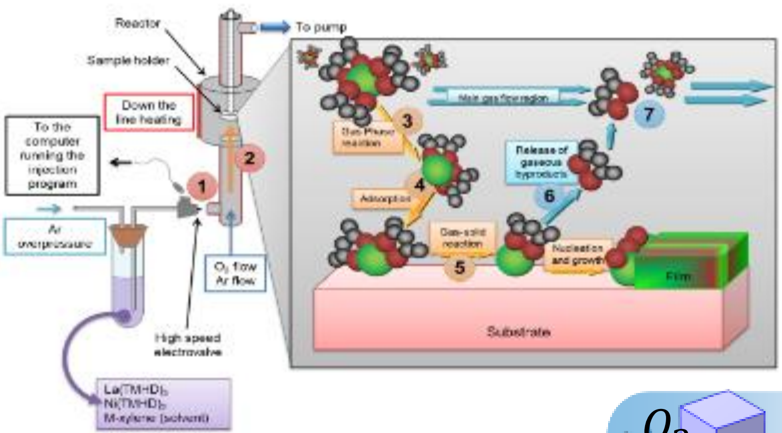
Methodology

- ➔ Implement a **3D FEM model** to study the impact of electrode/electrolyte architectur
- ➔ **Choose, deposit, and characterize** the oxygen electrode material
- ➔ Tune and optimize the electrode architecture

FEM = Finite Element Method

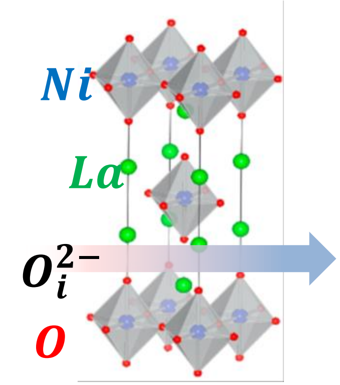
Research / IRP5 : Methodology

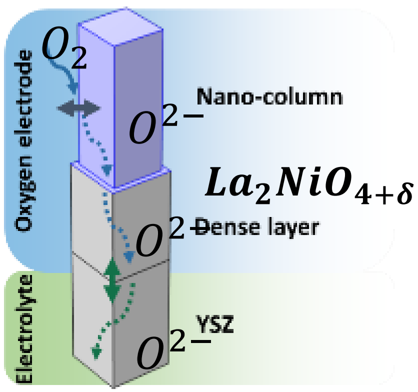
Oxygen electrode material deposition: Pulsed-Injection Metal Organic CVD

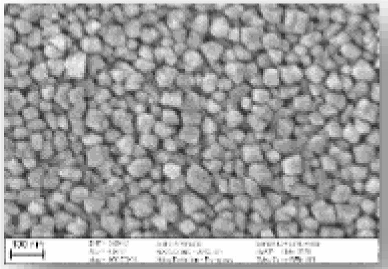


$La_2NiO_{4+\delta}$

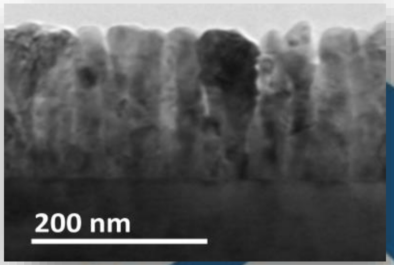
Ruddlesden-Popper phase





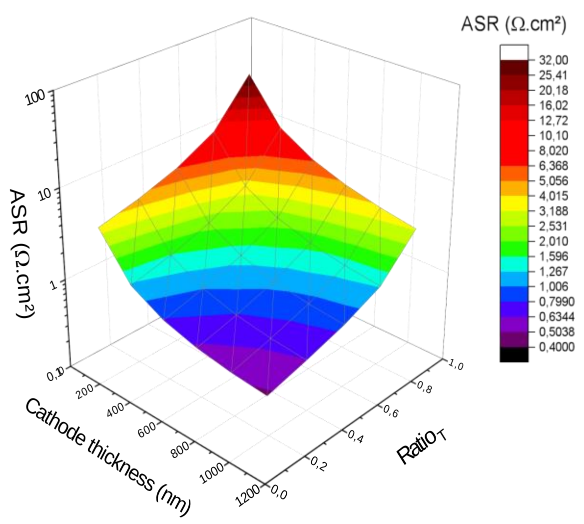


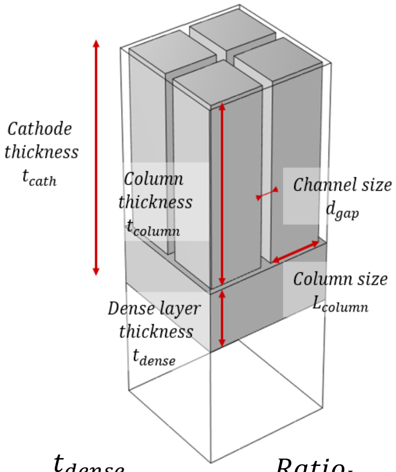
Stangl, A. et al. (2022). Journal of Materials



Research / IRP5 : Optimizing the nano-column morphology

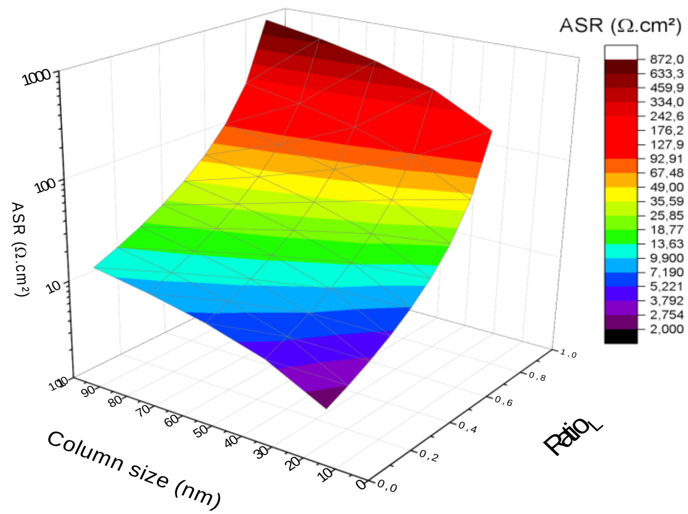
Influence of thickness





$$Ratio_T = \frac{t_{dense}}{t_{column}}$$

Influence of width

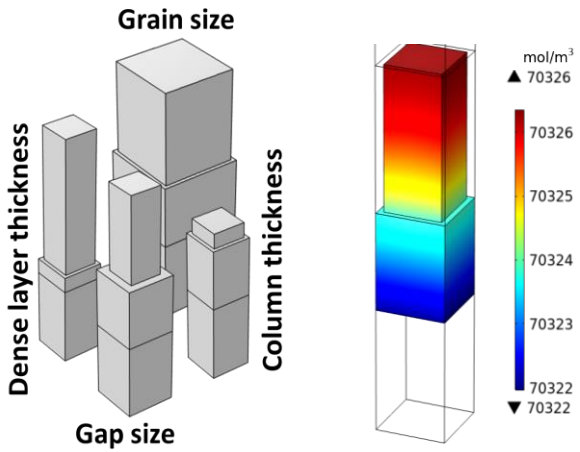


$$Ratio_L = \frac{d_{gap}}{L_{column} + d_{gap}}$$

Research / IRP5 : Optimizing the nano-column morphology

Step 1: Implement a 3D FEM model as versatile tool for electrode architecture optimization

- Calibrated from experimental results
- Investigating quantitatively the optimal film thickness and optimal nano-columns size
- Designing the optimal film architecture
- Applicable for other materials



➔ **Versatile tool for further explorations and studies**

Research / 6 new projects selected in 2022

- **Recycling of battery cathodes** of electric vehicles
  L. Svekova, LEPMI, Post doc 18 m. + Post doc 18 m. ADEME
- Optimisation of the **cathode microstructure** for high temperature CO_2 electrolysis C. Rossignol, LEPMI, ½ PhD + ½ PhD CDP DefiCO_2
- Multi electron transfers in **ion battery** using coordination Complexes
  J.C. Leprêtre, LEPMI, ½ PhD + + ½ PhD Labex ARCANE
- Innovative **coatings** for ski soles
  A. Mantoux, SIMAP, PhD
- AM of architectured structures in **metallic glass**
  R. Daudin, SIMAP, Post doc 12 m., + Post doc 12 m. VULKAM/CETIM
- **AI-guided super-resolution imaging** for multiscale porosity characterization of bone and teeth
  A. Gourrier, LIPHY, ½ PhD + + ½ PhD CDP Musitox, LabEx TEC21

Research / Call 2023

- 90 months post doc will be supported
- Calendar
  - December : call announcement then scientific animation by IRP coordinators
  - February : pre selection of projects
  - March : presentation of pre selected projects to the executive committee
  - April : selection of supported projects

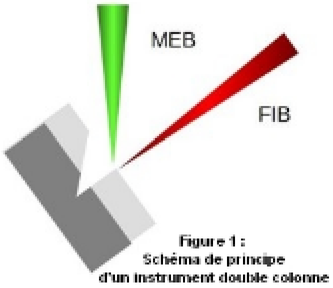
COS CEMAM 2022

- Architectured Materials
- Identity Card
- Research
- **Investments & Platforms**
- Education & Scientific Animation
- Technology Transfer
- MateriAlps Project

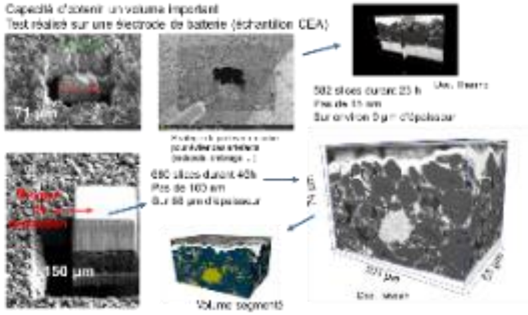
Investments / 2022

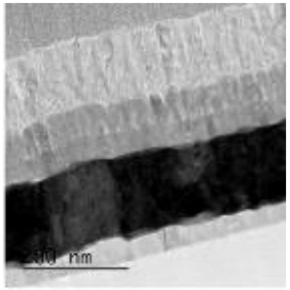
	Total cost	CEMAM funding	Co-funding
FIB	900	**270**	Grenoble INP / CEA
Ultrasonic Spray	120	**60**	AAP Grenoble INP
Calorimetry	60	35	AAP Grenoble INP
Instrumented Flash Sintering	90	45	AAP Grenoble INP / Labs
Femto Tools	115	15	AAP Grenoble INP Labs / TEC21
TOTAL	**1285**	**425**	

Investments / 2022



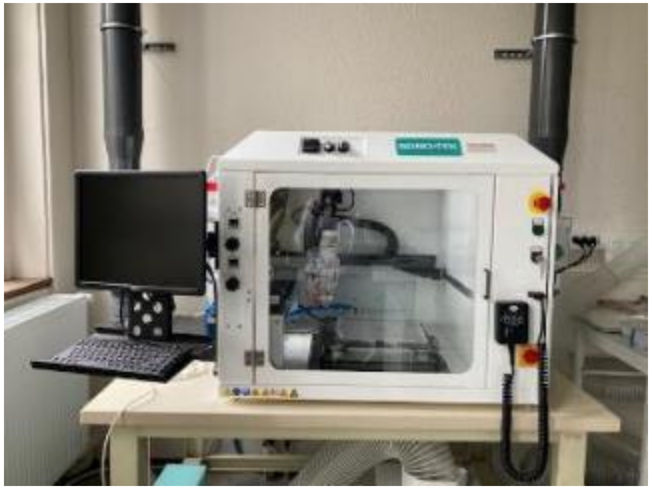
- New FIB SEM based on plasma focused ion beam
  - Total cost = 1032 k€ , **CEMAM** funding = 266 k€, **Grenoble INP** (250 k€) and **CEA** (516.137 k€)
  - **THERMOFISHER HELIOS 5 PFIB** Dual Beam, Xenon plasma FIB : high etching rate, currently being **installed on the CEA PFNC Platfom**
  - Dual Beam : combination of a high resolution scanning electron microscope (SEM) and focused ion beam (FIB) microscope in one single machine for TEM sample preparation, 3D characterization, cross-sectioning and micromachining

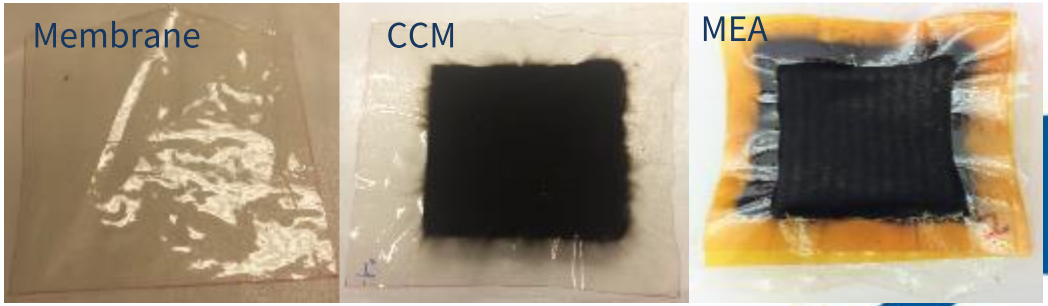




Investments / 2022

- Ultrasonic spray coating system (SonoTech)
  - Controllable coating thickness : typically from tens of nanometers to tens of microns
  - Spraying of different materials (polymer, composites – organic-inorganic on different substrates)
  - High uniformity of the catalyst layer (electrodes)
  - On going projects (+ industry)





Spraying of catalyst layer on membrane (PEMFC)
Catalyst coating membrane (CCM)
Membrane electrode ensemble (MEA)

Investments / Planned in 2023

	Total cost	CEMAM funding	Co-funding
Raman Spectroscopy	**450**	**70**	**AAP Grenoble INP, Phelma, Carnot, Labs**
X ray tomography	**925**	**60**	**CDP Musitox LabEx TEC21, Labs**
In situ gas analysis in CVD	70	35	Labs
Multimaterials Add Manuf	90	45	Labs
Monitored laser	90	40	Labs
TOTAL	**1625**	**250**	

Investments / Planned in 2023

- Raman spectroscopy

1. Raman imaging system (LMGP), excitations at 532 nm (Raman) and 457 or 404 nm (Raman + Photo Luminescence)
2. Portable Raman imaging system (LEPMI), excitations at 532 and 785 nm. Fibre-optic-coupled Raman analyser

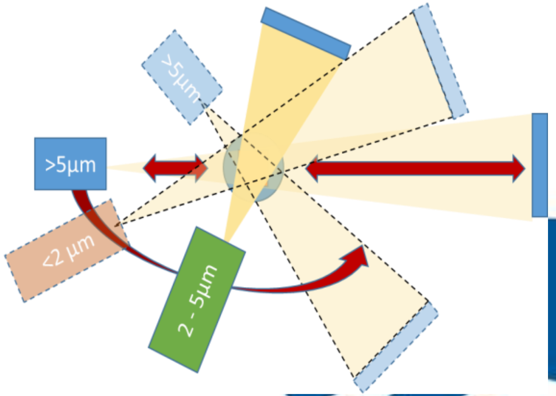
- Total cost = 450 k€, CEMAM funding = 70 k€, co-funding : Grenoble INP (150 k€), Phelma (50 k€), Carnot institute (80 k€), LEPMI (50 k€) LMGP (50 k€)

Investments / Planned in 2023

- X-ray microtomography

  - Simultaneous multiresolution X-ray tomography: developments, extensions and applications
  - Innovative modalities for 3D laboratory X-ray imaging, based on artificial intelligence.
  - To characterize simultaneously at different spatial scales in real time the evolving microstructures of complex and architectured materials in use or during processing

  - Total cost = 1 585 k€
    (660 k€ human resources + 925k€ investments)
  - IDEX 1250 k€, Labs (SIMaP, 3SR, IGE, ETNA, STROBE, LIPHY) 220 k€, TEC21 55 k€, **CEMAM 60 k€ (+ 1/2 PhD)**
  - Contribution of CEMAM for rotating stage, x-ray sources, detectors

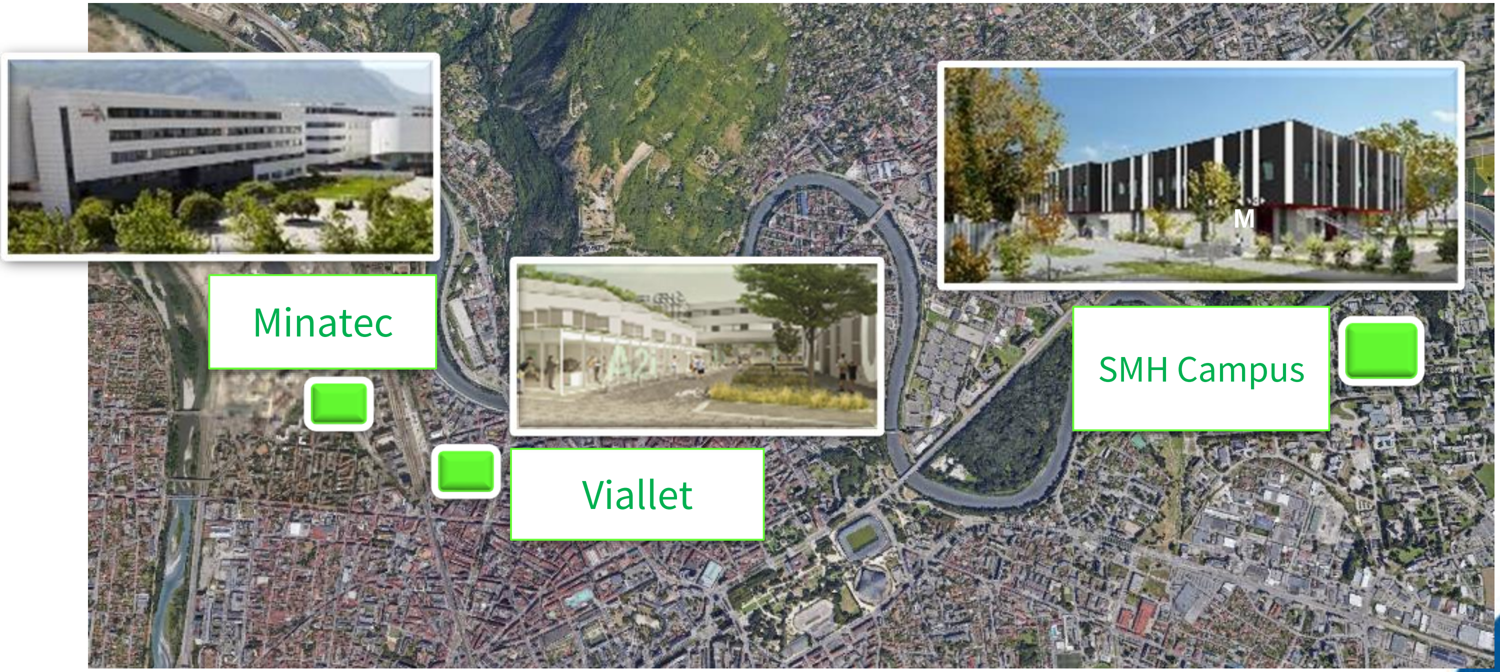


Platforms / CEMAM Architecturation Platforms

- Available equipments
  - Coating
    - CVD and MO-CVD reactors
    - Spatial ALD, Plasma Enhanced ALD
    - PVD
    - Electro Spray Deposition (including US)
    - In situ photo patterning of proteins and hydrogels
  - Sintering
    - Traditional sintering (including optical dilatometer)
    - Flash sintering
    - Microwave
  - Additive Manufacturing
    - Electron Beam Melting
    - Wire Arc Additive Manufacturing
    - Wire Laser Manufacturing
    - Indirect technology assisted sintering
    - High resolution 3D maskless lithography

Platforms / CEMAM Architecturation Platforms

- 3 three main locations



COS CEMAM 2022

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- **Education & Scientific Animation**
- Technology Transfer
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Education

- Materials Platform : fully operative (tutorials, training, projects)
  - Joint investments of INP Phelma / Labs / CEMAM
    - Elaboration (Metal Additive Manufacturing, Thermal Treatments, …)
    - Microstructural characterization (opt. microscopy, SEM, X-ray tomography…)
    - Mechanical characterization




Scientific animation

- 22/09/2022 Initiative 3D workshop
  - Metal Additive Manufacturing
  - Supported by CEMAM
  - Competitivity Cluster CIMES
  - 120 persons
  - 20 talks (news 2022 & industrial feedbacks)
  - 10 technical stands
  - German delegates from Formnext 2022

Scientific animation

- 06/10/2022 Scientific Imaging Day
  - Organised by CMTC
  - 10 talks + workshops, ≈ 100 participants

Scientific animation

- 30/10/2022 – 03/11/2022 School on Atomic Layer Deposition
  - Autrans, 35 persons

Ecole thématique SALAD
School on Atomic LAyer Deposition

Autrans – Grenoble – 31 octobre au 3 novembre

CEMAM Laboratoire d'excellence — cnrs — cnrs GDR Groupement de recherche RAFALD Réseau des Acteurs Français de l'ALD

https://rafald.org

Scientific animation

- 24/11/2022 CEMAM Junior day

Alliage de Ti-Mo via EBM pour la réalisation de structures treillis pour l'absorption d'énergie mécanique	M. Duport
Electrode au soufre multi-échelle architecturée pour batteries au lithium	R. Sajad
Importance of Materials on Therapeutic Proteins Stability: the Case of Insulin	L. Marichal
Optimization of high Performance nano-architectured electrode/electrolyte bilayer for Solid Oxide Cells	S. Panisset
Mécanisme d'endommagement par cloquage des revêtements : Influence de la microstructure et de l'endommagement plastique	K. Meng
Recyclage de matériaux de cathode de batteries Li-ion usées, par voie hydrométallurgique en milieu DES (Deep Eutectic Solvents)	Y. Karrar
Janus membrane mediated membrane distillation for seawater desalination	D. Mercado

COS CEMAM 2022

- Architectured Materials
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- Research
- Investments & Platforms
- Education & Scientific Animation
- **Technology Transfer**
- MateriAlps Project

Technology Transfer / Networks

- CIMES Competitiveness Cluster
  (CEMAM is one of the referency Labex of CIMES)

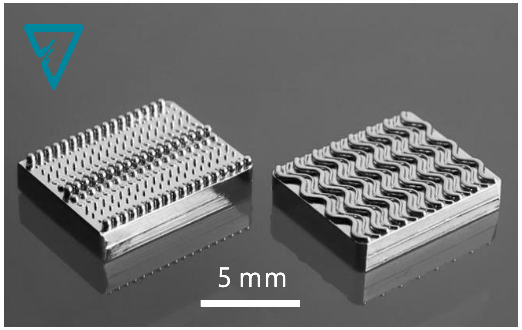
- Initiative 3D Network / National coordination
  (Metal Additive Manufacturing)

- RAFALD Network
  (Atomic Layer Deposition)

GDR RAFALD
Réseau des acteurs français de l'ALD

Technology Transfer / Start up support

- VULKAM (supported until 2019)
  - Micro-technical parts in amorphous metallic alloys
  - Today staff > 20 persons
  - Micronora 2022, winner Micron d'Or



Technology Transfer / Start up support

- CILKOA
  - Ceramic coatings on bio sourced materials
  - 14/10/2022, visit of Saint-Martin-d'Hères major (David Queiros) and « deputy prefect » (Samy Sisaid).

COS CEMAM 2022

- Architectured Materials
- Identity Card
- Research
- Investments & Platforms
- Education & Scientific Animation
- Technology Transfer
- **MateriAlps Project**

MateriAlps project / Objectives

- End of CEMAM LabEx in 2025? What after ?
- Importance to maintain UGA position in Materials Science after 2025
- Materials Science is not the addition of *“Materials for…”*
- Strengths of Grenoble in Materials Science
  - Metallurgy Engineering Ranking (Shanghai)
  - Architectured Materials (CEMAM)
  - Materials for Energy, Nanostructured materials…
  - At the same time and location : Modeling, Materials elaboration, Characterisation
  - Large facilities (ESRF, ILL) in town

MateriAlps project / Objectives

- Inventing new materials...
  - Requires new design methodologies (e.g. AI-assisted), development of new elaboration processes (tailor-made), ability to characterise at any scale to better understand structures and properties (e.g. operando)
  - Approaches guided solely by sectors of use ("Materials for...") do not make it possible to create breakthrough Materials → Necessity to rely on Materials Science as a discipline in its own right

- … in a sustainable development context.
  - Minimising environmental impacts
    - Non-critical elements, virtuous transformation processes, 100% efficient materials...
    - Time life, weight reduction, materials for the energy transition...
  - Optimising end of life
    - New recycling processes
    - Taken into account from the design stage (reuse potential, disassembly capacity, tolerance to impurities, "broad spectrum" materials, etc.)

MateriAlps project / Objectives

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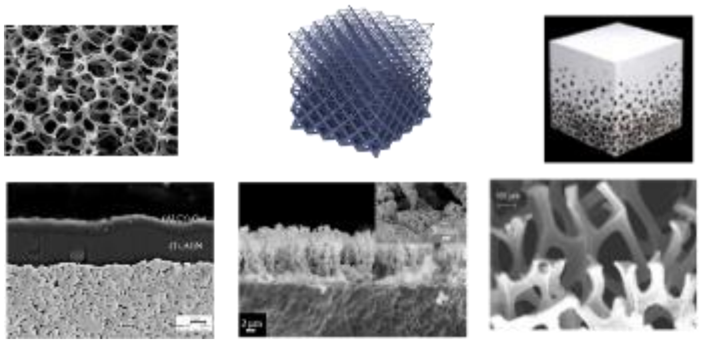
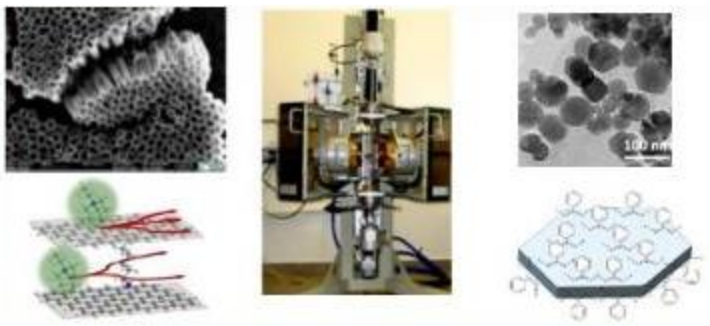
    - Taken into account from the design stage (reuse potential, disassembly capacity, tolerance to impurities, "broad spectrum" materials, etc.)

MateriAlps project / Strengths

- LabEx CEMAM
  - G-SCOP, LEPMI, LIPHY, LMGP, SIMAP
  - Architectured Materials
  - Architecturation and Characterisation Platforms

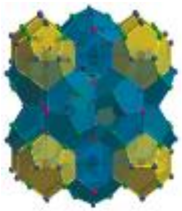
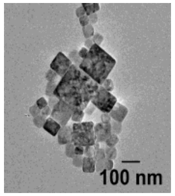


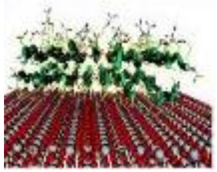
- Continuing structuration of the Materials community
  - Teams from 5 laboratories: NEEL, MEM, SYMMES, LITEN, CERMAV
  - Thematic reinforcement: Nanostructures, Hybrid materials, Life interactions, Ecodesign...,
  - Modelling, Elaboration (e.g. synthesis), Characterisation (G.I.)



MateriAlps project / Research Strategy

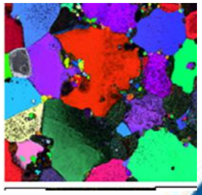
- 5 Research Programs
  - Complex phases and Crystals
  - Nanostructured Materials and Thin Films
  - Architectured Materials
  - Electrochemical and Ionic Materials
  - Materials and Living

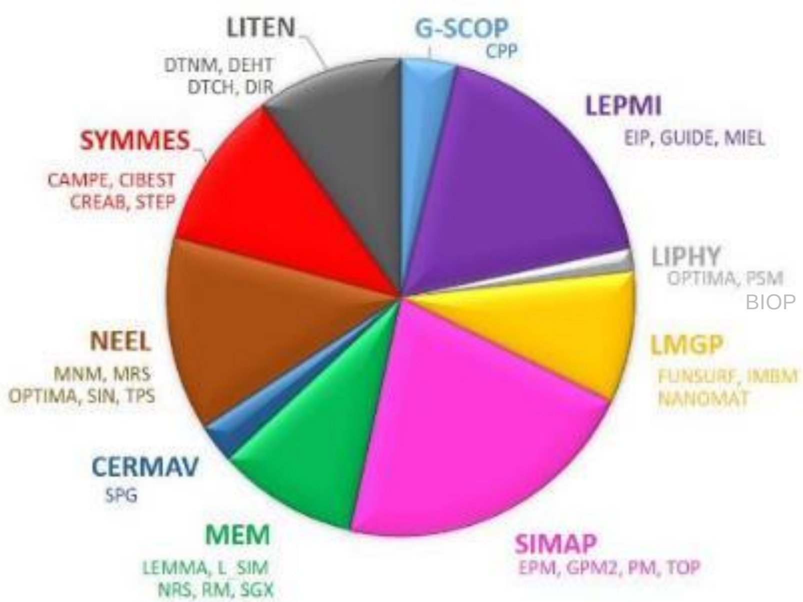



- 3 Transverses Methodologies
  - Modelling – Data
  - Processing
  - Characterisation






MateriAlps project / Partners and Local Synergies



≈ 260 Researchers → ≈ 2 x CEMAM

- **Large facilities** ESRF, ILL
- **LabEx** TEC21, QuantAlps, Minos, Arcane, DM
- CPER Ecomarch / A2I
- CDP Musitox, CO2, CDTool OTE…
- Education UGA / Grenoble INP
- MIAI Materials Chair
- LabComs 3Alps/Constellium, Li²/Blue Solution
- PEPR Diademe, Batteries, H_2
- Networks CNRS HEAD, ALMA, H2 – KiC Raw Materials
- Carnot Institute Energie du Futur / Polynat
- Industries and Start up

Scientific Committee Labex CEMAM 2022

Center of Excellence on Multifunctional Architectured Materials

Centre d’Excellence sur les Matériaux Architecturés Multifonctionnels

08/12/2022