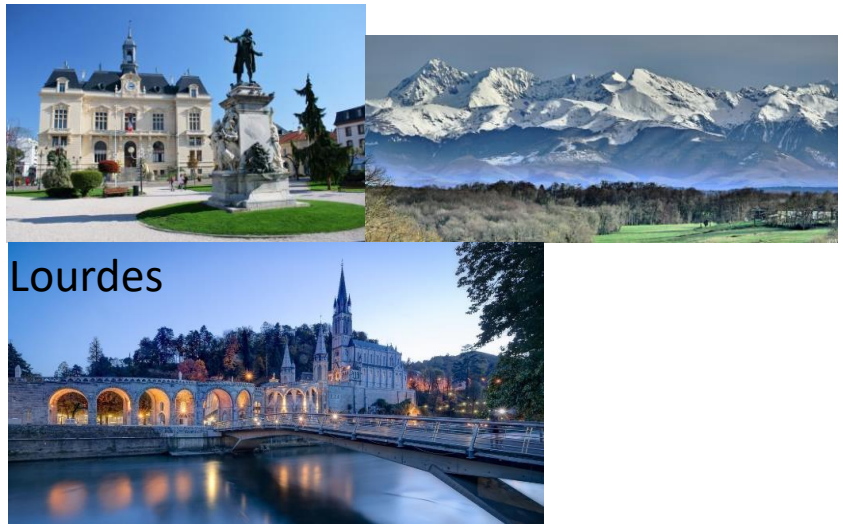
La Petite Histoire d'une équipe de recherche en génie électrique

Ou comment s’achèvent les discussions des « pause-café », entamées il y a 17 ans



Paul-Etienne VIDAL, PR, Ecole Nationale d’Ingénieurs de Tarbes, paul-etienne.vidal@enit.fr

Du génie électrique à Tarbes ?



En 2006

- 1 école d'ingénieur : l'ENIT – 1200 élèves
  - 2 dominantes : génie mécanique et gestion de production
- 1 Laboratoire Génie de Production : LGP – 45 EC
  - Dont un nouveau recruté en 63°
  - Pas de publications dans le domaine
- 5 départements d'IUT – tutelle Univ. Paul Sabatier Toulouse
  - Dont 1 dep. GEEI et 2 licences pro.
- 1 laboratoire commun : PEARL (avec ALSTOM)
  - LAPLACE, LAAS, CIRIMAT, LGP, LATEP

Du génie électrique à Tarbes !

En 2023

- 1 école d'ingénieur : l'ENIT
- 6 départements d'IUT

Se transforment en Univ. de Technologie

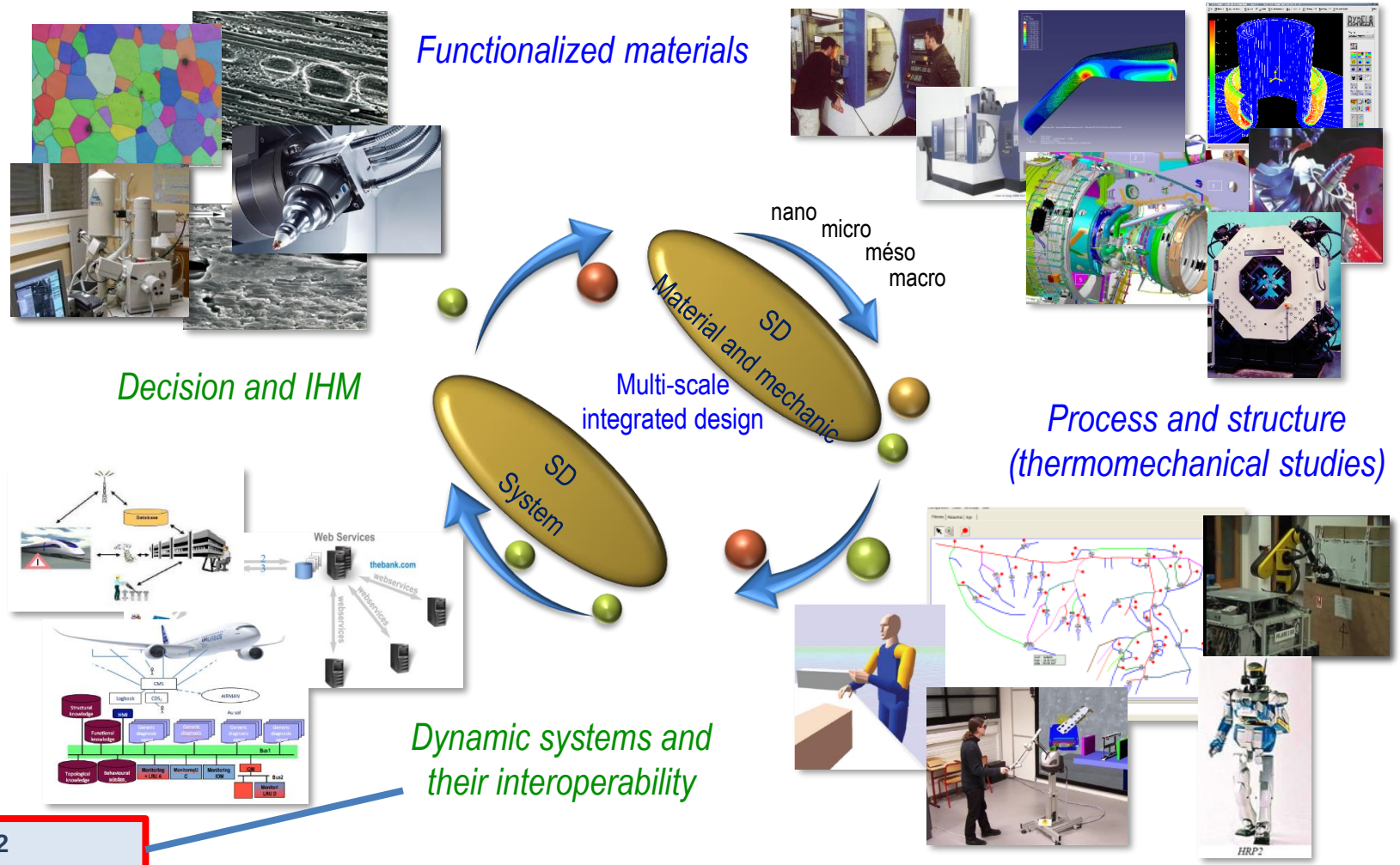
- 1 Laboratoire Génie de Production : LGP – **60 EC / ≈ 60 PhD**
  - Dont 5 en 63°
  - 1 PR, 4 MCF dont 1 HDR en préparation

- ≈ 6 autres laboratoires
  - rattachement des EC de l'IUT (≈ 40) - méca. matériaux, GI, génie élec, SHS

- 1 plateforme gérée par l'ENIT : PRIMES
  - Plateforme commune avec des industriels : ALSTOM, SAFRAN Tech, CISSOID, DEEPConcept, Selection ENR, aPsi3D, IT Saint-Exupery, …et le LGP

LGP
(≈120 researchers – 60 full and asso. Prof.)

- **2 scientific departements (SD)**
- **9 research-groups**
- **2 transverse-themes**



Research Group: **e-ACE²**

LABORATOIRE
GÉNIE DE PRODUCTION

Efficiency of Electric Power Systems

e-ACE^2

EfficAcité des systèmes de Conversion de l'Energie Electrique

Research Group - e-ACE²

Efficiency of Electric Power Systems*

*EfficAcité des systèmes de Conversion de l'Energie Electrique

Our expertise:

- Electrical Engineering - Power Electronics, Integration, Electromagnetic Interactions, Multi-physics Modeling, Electromechanical Conversion,
- Applied Automatic - Control, Pulse Width Modulation drive, Observation, Diagnosis

Our members in September 2023

Professors:

- S. Baffreau (IUT-GEII Tarbes – associate prof.)
- M. Kouki (ENIT – associate prof.)
- B. Trajin (ENIT – associate prof.)
- P.-E. Vidal (ENIT – full prof.)
- G. Viné (ENIT – associate prof.)

New collaboration with:

- P. Chalimbaud (IUT-GEII Tarbes – associate prof.)
- E. Laugh (IUT-GEII Tarbes - Tech)
- D. Dedecius (IUT-GEII Tarbes – associate prof.)

Temporary: PhD

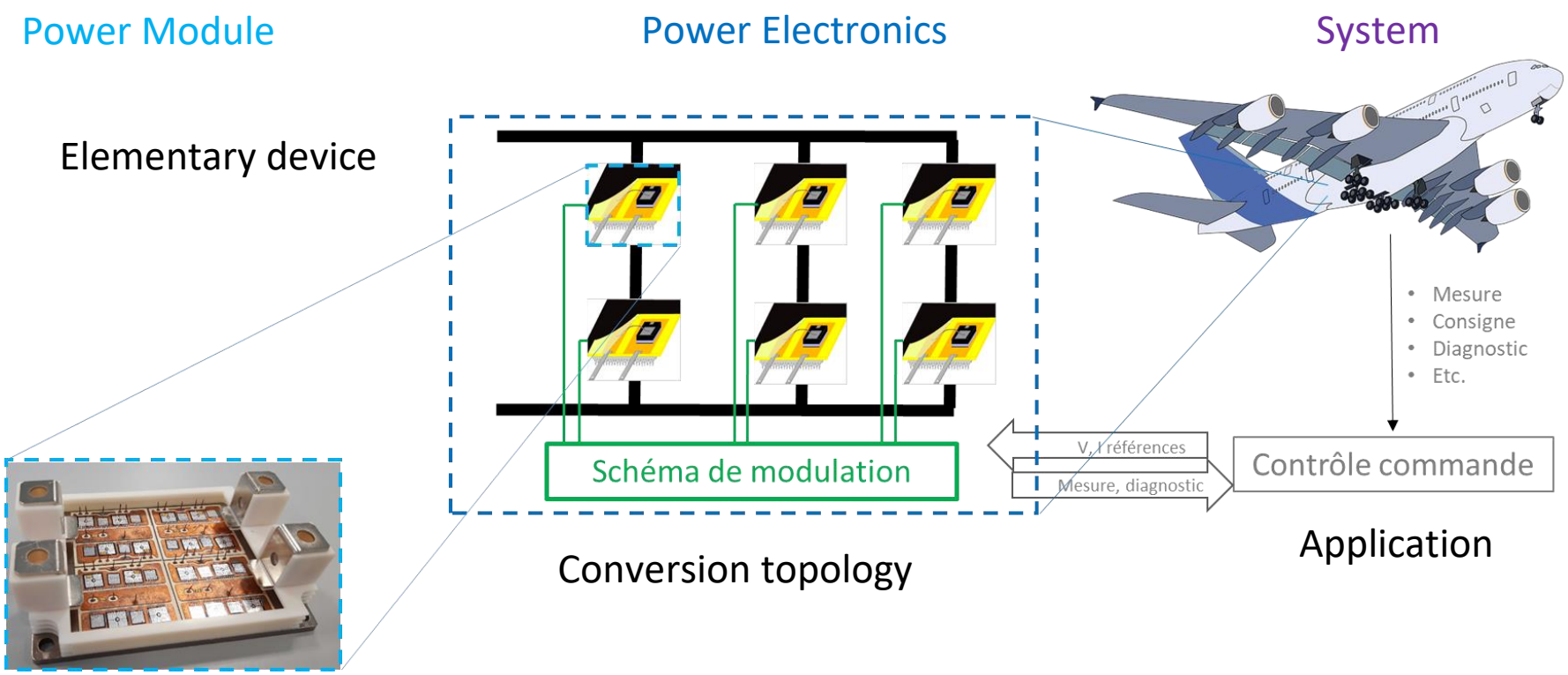
- A. Gopishetti (2020-2023)
- R. Raisson (2020-2023, codir. CIRIMAT)
- J. Fontaine (2021-2024)
- M. Khalili (2022-2025)
- B. Leye (2023-2026)
- A. Rashed (2023-2026 codir UPPA)
- X.Y en cours de recrutement

Masters:

M. Firas (04-09)
H. Gammoudi (04-09)
A.-Al. Portets (04-09)

Energy Efficiency

**Design an electrical energy conversion chain for its all life cycle:
from its materials, its management, its diagnosis, its experimental characterization
and its digital twin, to its end of life**



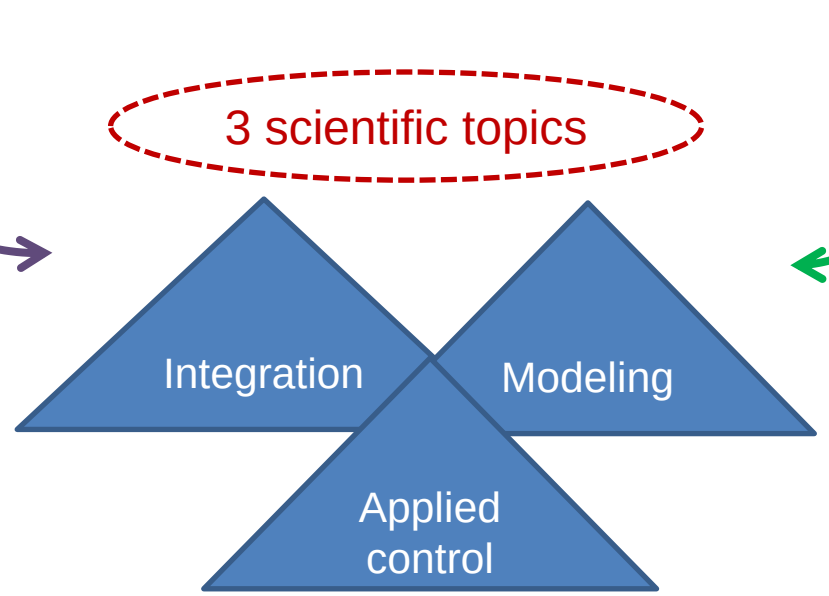
Challenges for Energy Efficiency

Scientific Challenges: model, control and design of optimized systems

- Efficiency
- Compacity
- Sustainability
- Severe environmental constraint functioning

Social challenges:

- Energy efficiency,
- Energetic transition
- More Electrical Mobility
- Low environmental impact



Generic research goals

Combined topics amongs:

- Material and processes
  - *Power electronics' devices, compact, efficient, innovative and sustainable, capable of working in highly constrained environments.*

- Multiphysic and wide frequency model
  - *Unified, broadband, multi-physics models for simulation, control implementation, and estimation for predicting device damage status.*
  - *Models of multi-energy conversion chains, electromechanical conversion chains, or objects of power electronics.*

- Applied automatic
  - *Observation, control and modulation scheme for efficiency gain, or monitoring of aging indicators or observation of variables for control.*
  - *Application to multi-energy smart grids, electromechanical conversion chains and power electronics' devices.*

More precisely our on-going activities:

- Material and processes
  - ***Sensor integration:*** design, integration and characterization of embedded sensors
    - currents sensors (500 A, BW: 10 Hz - 8 MHz) - DGA-RAPID AM:PM (2021-2023)
  - ***Passive elements integration:***
    - ceramic decoupling capacitors integration (design, integration process and characterization – toward several 100 nF) – EFICIENCE Chair (2020-2025)
    - Additive manufacturing for ceramic – CeraGaN (cofunded project 2023 - follower)
- Multiphysic and wide frequency models
  - ***Electro-thermomechanical model*** based on state space representation (with the help of Bond-Graph representation)
    - Modelling of electromagnetic couplings by a systemic approach– cofunded Region & e-ACE² (2022-2025)
    - Multi-physic model of dielectric behavior of cermaic substrate – EDENE funding (2023-2026)
  - ***Frequency Wide Band modeling*** of power modules
    - Non Destructive Testing method -characterization and prediction) – EFICIENCE Chair (2020-2025)
    - Parasitic elements of power module characterization – AMPERE (co-funding 2022)
- Applied control
  - ***Supervision - control***
    - Multiphysic source modeling, MonitoringSmart grid renewable Energy – mini projet Ghana (2023)
  - ***Pulse Width Modulation*** strategies
    - and system architecture – cifre IOTA (2020-2023)

On going activities

EFICIENCE 2020-2026
Partenarial senior chair, E2S project (Solutions for Energy and Environment) of UPPA

- Passive components integration: O1
- State of damage assessment for packaging: O2
- Combined technology-topology design for power electronics: O3

- Partnership:

- On going: 3 PhD
  - Anusha Gopishetti : 100% PRIMES – defense in december
  - Romain Raisson : along with CIRIMAT, 20 % PRIMES – defense in november the 24th
  - Babacar LEYE: start in Nov. 2023

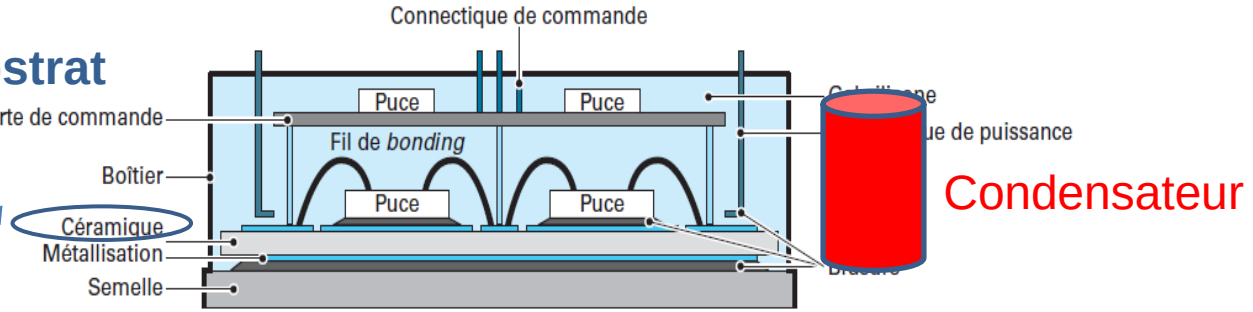
- **To be recruited:**
  - **Post-doc (Ceramic substrate along with SP sintering process knowledge)**

EFICIENCE 2020-2026

Partenarial senior chair, E2S project
(Solutions for Energy and Environment) of UPPA

De l'idée

Substrat



Techniques de l'ingénieur: Conditionnement des modules de puissance par Ludovic MÉNAGER, Bruno ALLARD, Vincent BLEY

On going activities

EFICIENCE 2020-2026

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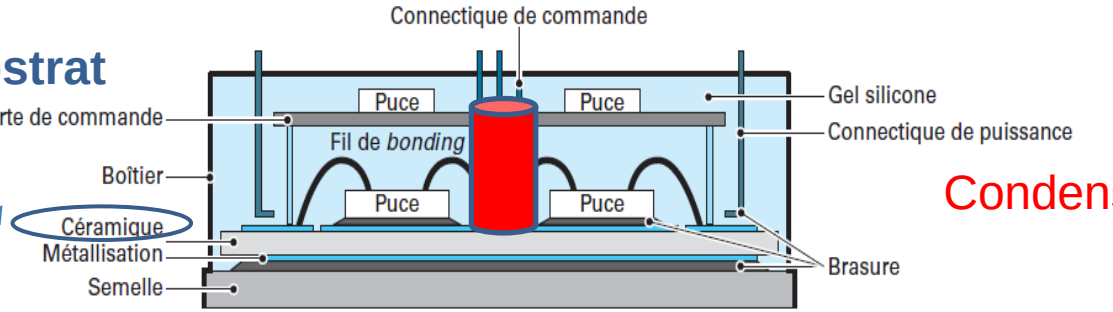

Condensateur

Techniques de l'ingénieur: Conditionnement des modules de puissance par Ludovic MÉNAGER, Bruno ALLARD, Vincent BLEY

On going activities

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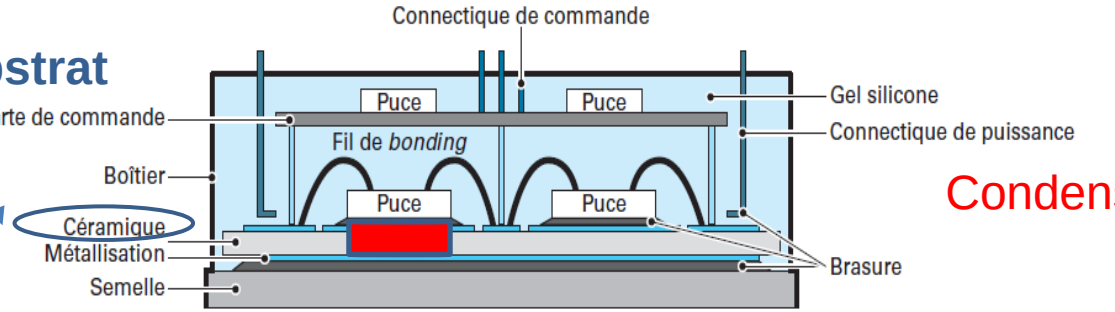

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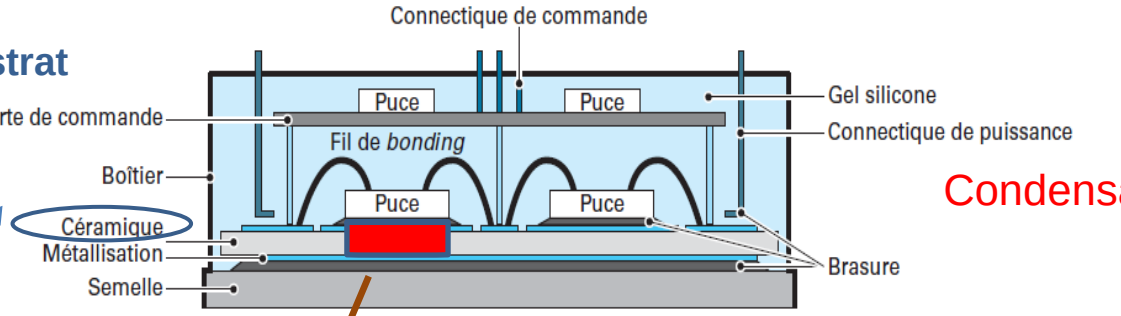
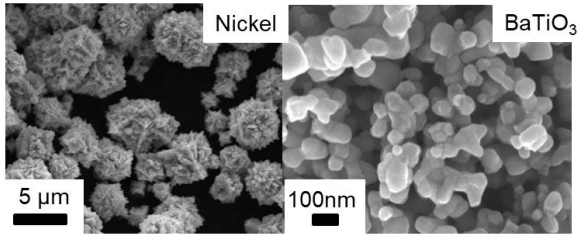


Condensateur

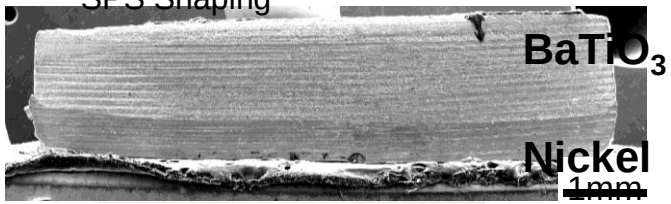
Techniques de l'ingénieur: Conditionnement des modules de puissance par Ludovic MÉNAGER, Bruno ALLARD, Vincent BLEY

Aux développements

Raw powders



SPS Shaping



On going activities

EFICIENCE 2020-2026

Partenarial senior chair, E2S project
(Solutions for Energy and Environment) of UPPA

De l'idée

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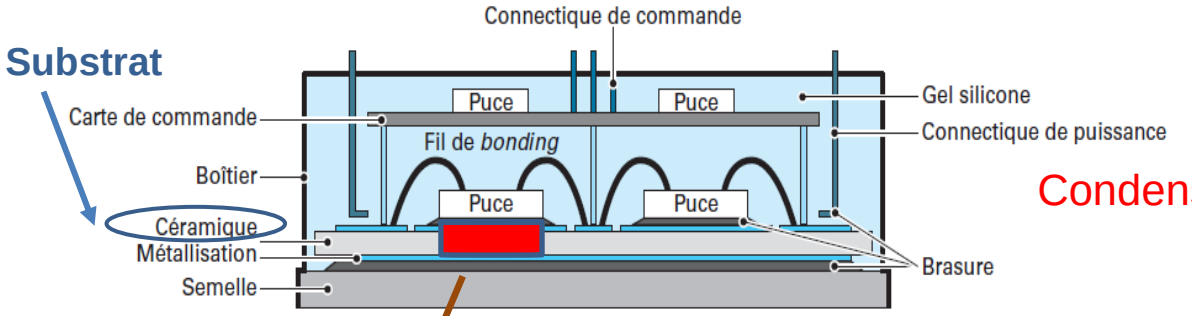

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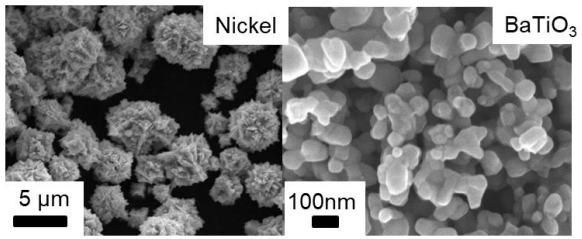
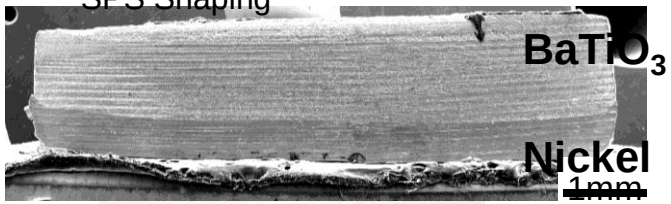
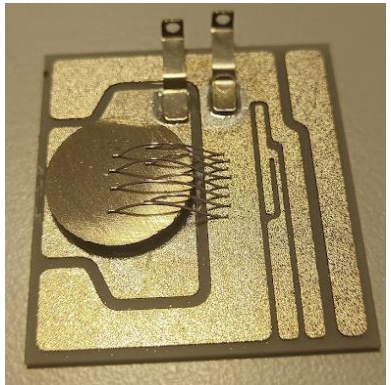


SPS Shaping



Au véhicule de test et caractérisations



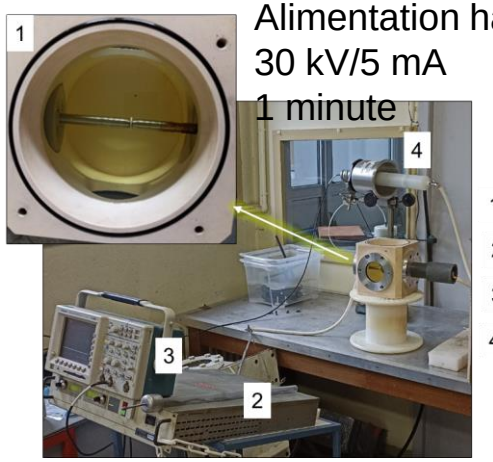
On going activities

EFICIENCE 2020-2026 + EDENE program (UPPA - H2020 Marie Curie COFUND)

Excellence PhD funding, co-leaded with V. Gavrilenko assoc. Prof. UPPA

Ab. Rashed starting in september 2023

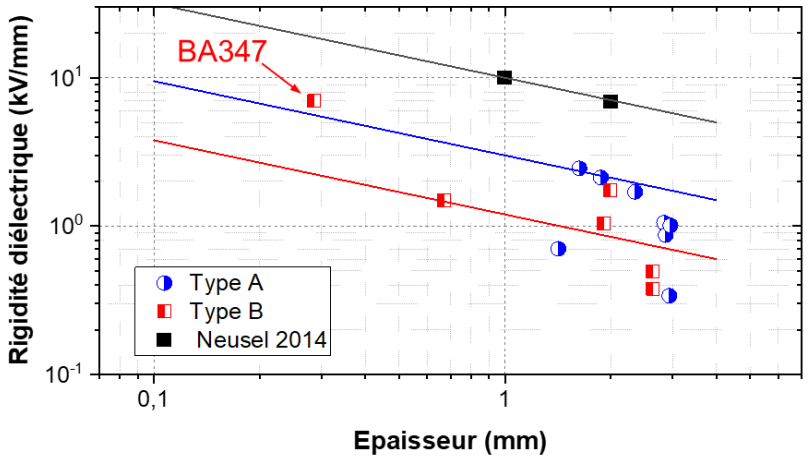
« Étude de la rigidité diélectrique de matériaux céramiques à base de titanates pour l'électronique de puissance »

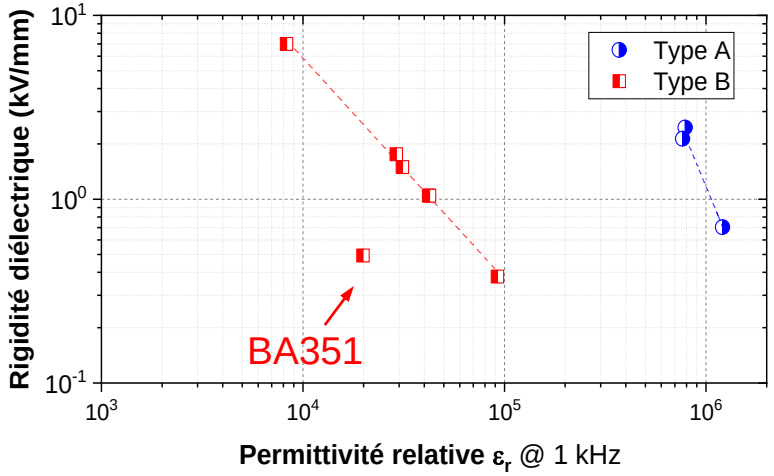


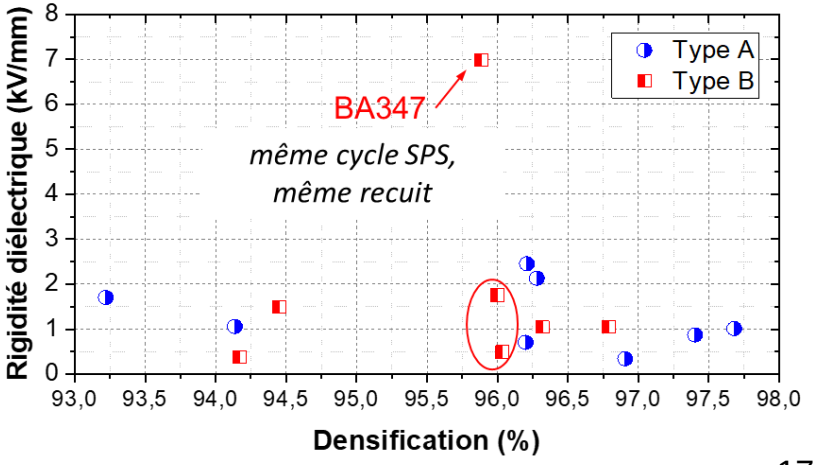
Alimentation haute tension (HT) DC :
30 kV/5 mA
1 minute

1 : Cellule de test
2 : Source DC
3 : Oscilloscope
4 : Sonde haute tension

Rigidité diélectrique des céramiques en fonction de la valeur de leur permittivité relative mesurée à 1 kHz, de la densité, du procédé etc.







DGA-RAPID AM:PM: academic-industrial collaborative project

Coordinated by DeepConcept

Design and characterization of an integrated current sensor for Additive Manufactured high voltage high current diode less SiC smart Power Module,

Partners: DEEP-Concept, SAFRAN, l'IETR & 1 sub-contractor (LGP)

De l'idée

3,3 kV – 500 A

MOSFET SiC

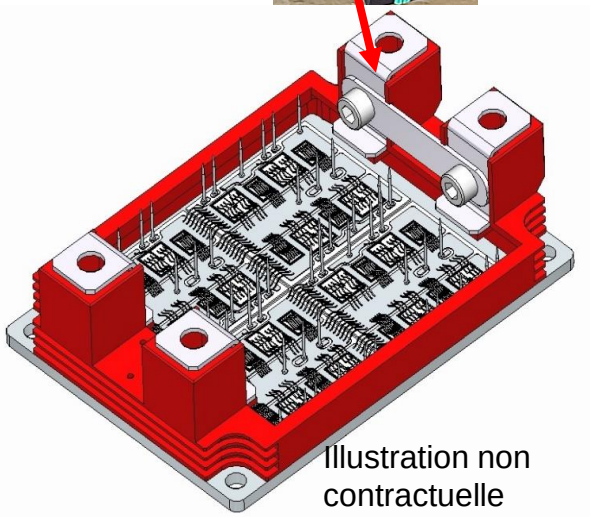
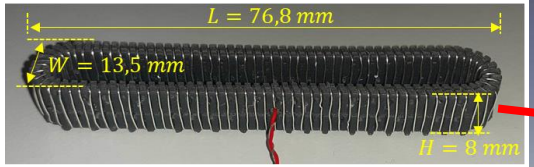
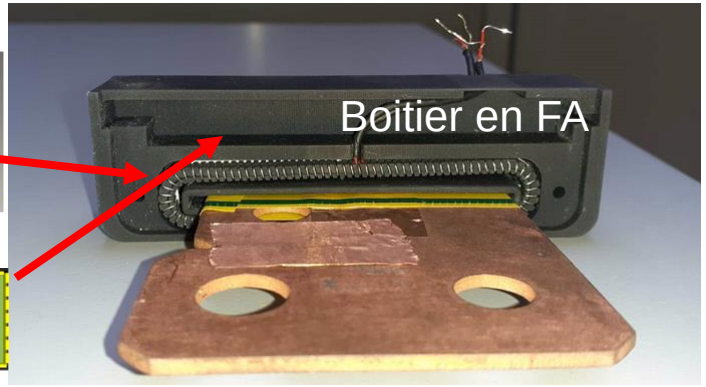


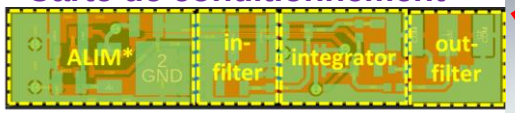
Illustration non contractuelle

A la réalisation, l'intégration, en passant par la caractérisation HF

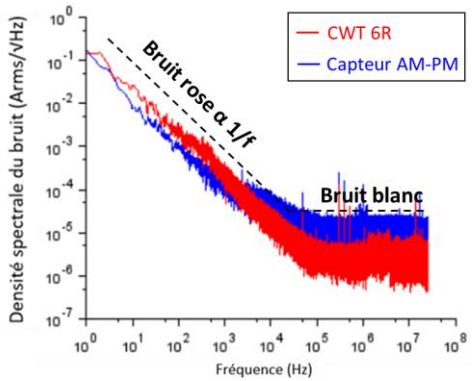


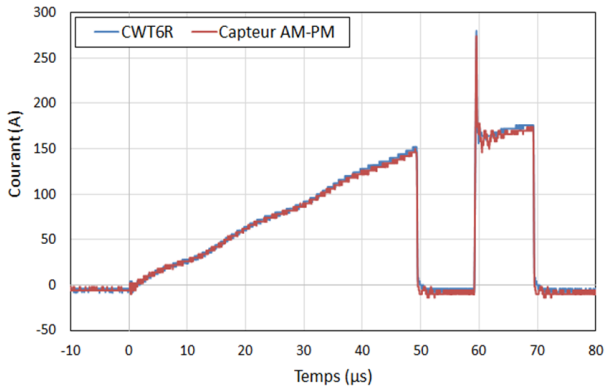


Carte de conditionnement



6.1cm x 1.1cm

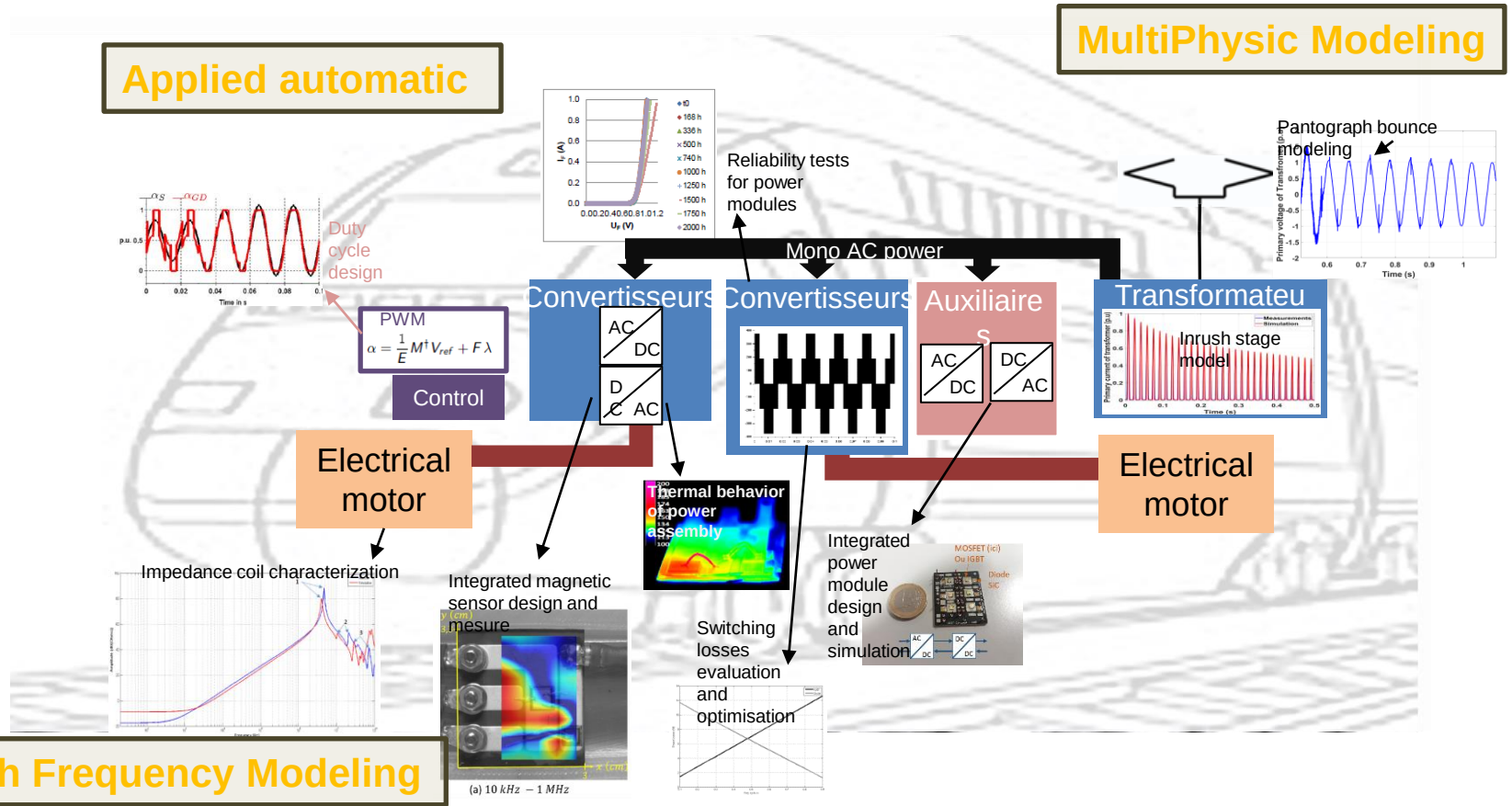




Efficiency of Electric Power Systems (e-ACE²)

Our expertise:

Example of achievements for a « more electrical mobility »:



Efficiency of Electric Power Systems (e-ACE²)

Our future strategy:

Skills portfolio:

- Material and processes
- Multiphysic and HF model
- Applied control

Platforms:

- PRIMES: packaging – power electronics
- GENHYO
- MOSAHYC

} Smart grids –H2

Smart grid

- Multisource multiphysic modeling
- Supervision strategy : diag and control
- Optimized and efficient architecture

Packaging / integration

- Advanced packaging – density
- Functionnalization
- Eco-friendly
- HF modeling/diag – health state
- Topologies

Application target:
Electromechanical chain and smart grids

Application target:
Power electronics

LABORATOIRE
GÉNIE DE PRODUCTION

Merci

Pic des 3 seigneurs, Ariège (09) – il y a plusieurs années