LAAS Days
Research & Technology

ENERGY Axis
Tackling energy transition challenges from microsystems to microgrids

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Context

- Climate change is a worldwide and pressing issue
  - Reduction of our CO_2 footprint
  - Reduction of our energy consumption
  - Massive introduction of renewable energies

- Occitanie Region:
  - ***Become the 1st Positive-energy Region in France by 2050 Horizon***

Motivation & Objectives

- Tackling energy transition challenges from microsystems to microgrids
  - Internet of Things (IoT): *energy autonomy issue*
  - Smart microgrid management and renewable energies: *towards zero-CO_2*

Objectives & challenges

- Internet of Things (IoT): *energy autonomy issue*

  - *Drastic energy consumption reduction*
  - *Improvement of energy efficiency*
  - *Energy harvesting*
- Smart microgrid management and renewable energies: *towards zero-CO_2*

  - *Energy consumption reduction*
  - *Minimization of conversion losses*
  - *Intermittency management*
  - *Demand-side management*

Long-term vision: Zero CO_2 Workday

100% Renewable-energies (RE) Workday

Smart management of 100%-RE, secure and resilient microgrid

Today, LAAS energy consumption ≈ 6 GWh/yr
82% related to the clean room

Energy autonomy of ADREAM building

Energy autonomy Building-mobility coupling

LAAS Energy Autonomy

Short term — Middle term — Long term

Key ICT Building Blocks

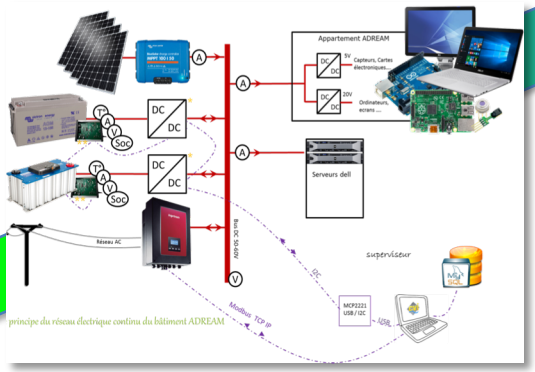
Long-term vision: Zero CO_2 Workday

From microsystems to building microgrid

Smart building microgrid management based on M2M platform

Autonomic cloud computing
Dynamic protection against attacks
Monitoring & diagnostic

Design & optimization of hybrid microgrid

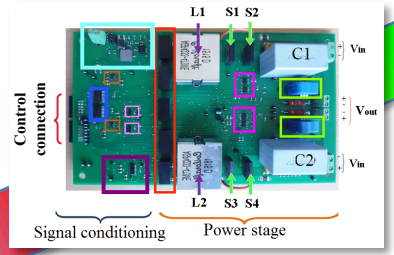


Efficient hybrid decision algorithms

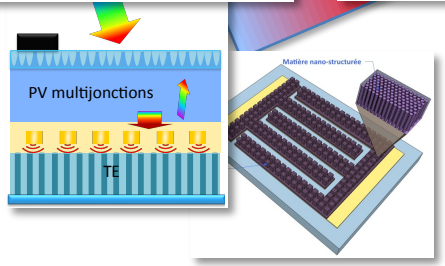
Predictive renewable source & storage modeling

Advanced modeling

Advanced control strategies & architectures for energy conversion



Energy efficient devices



Adaptive and hybrid dynamical modeling

Micro-nanotechnologies

Main figures

- Research staff (equivalent full-time): 66
  - Permanent researchers: 24
  - Engineers/technicians: 8
  - Ph.D./Post Doc: 34
- Platforms
  - Energy building
  - RENATECH clean room
  - Characterization platform

Visits

Research topics (1/2)

> Energy efficient devices

- Advanced power devices
- III-V nanowire-based technologies:
  - Ultra low-power CMOS
  - Thermogenerator
- High-efficiency III-V solar cells
- RF Energy harvesting & wireless power transfer
- Microsupercapacitors

> Challenges

- Efficiency improvement
- Miniaturization

Research topics (2/2)

> Smart energy management

- Advanced control strategies & architectures for energy conversion
  - Wide band-gap power devices
  - Adaptive and hybrid dynamical modeling
- Design & optimization of hybrid microgrid
  - Hybrid electrical microgrid based on modular and distributed approaches
  - Combinatorial optimization methods
  - Dynamic thermal modeling of buildings
- Smart building microgrid management based on M2M platform
  - Large-scale software architecture with energy constraints
  - Data management and usage
  - Global monitoring and diagnosis
  - Cybersecurity

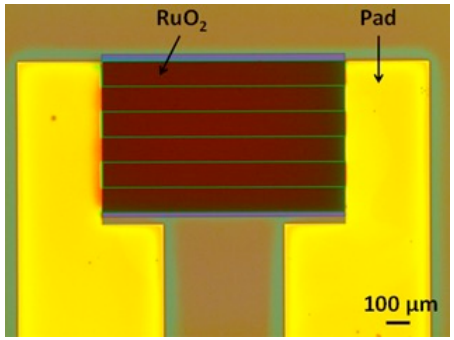
> **Challenges**: energy efficiency, scalability & modularity

Microsupercapacitors

> Integrated microstorage for IoT applications

> Strength:

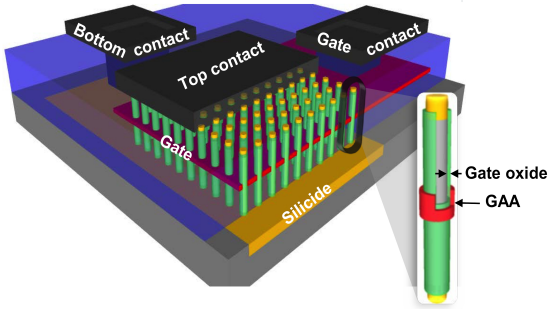
- Leader in the field: C up to **3.25 F/cm²**
- Technology platform
- Nanostructuration technologies
- Strong international cooperations
- ERC grant: **3D CAP project**

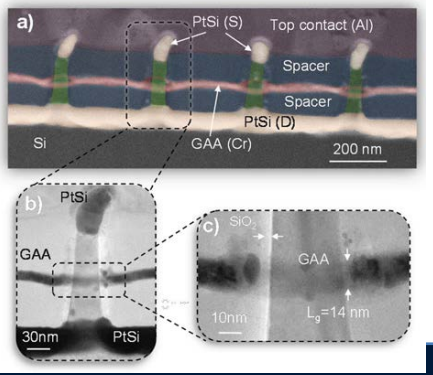


European Research Council
Established by the European Commission

III-V Nanowire-based Technologies

- From material science of 1D nanostructures to processing, integration, and characterization of related devices
- Strength:
  - Technology platform
  - Mastering of nanowire growth/structuration
    - Bottom-up growth by molecular beam epitaxy
    - Top-down approach: e-beam lithography and reactive ion etching
  - Si-nanowire CMOS*: Ion/Ioff > 10^5

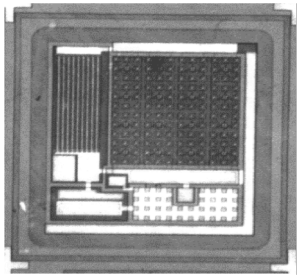


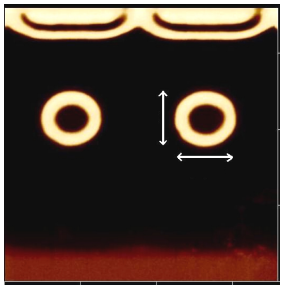


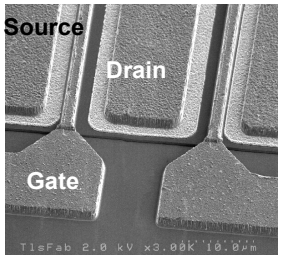
* G. Larrieu et X.-L. Han, *Nanoscale*, 2013, 5, 2437-2441.

Advanced Power Devices

- Research activity since LAAS creation in 1968
- Strengths:
  - Technology platform
  - Pioneer for new power device concepts
    - Functional power integration (1995)
    - FLYMOS (2004)
    - Multi phase converter with adaptive control for PV systems (2010)
    - Normally-off GaN power HEMT (2014)
  - Strong industrial partnership





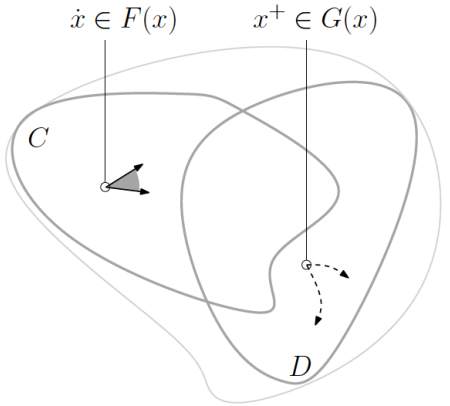


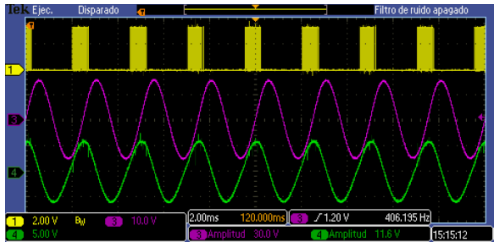
EXAGAN
Accelerate Power Transition

Joint demo

Hybrid control for power converters

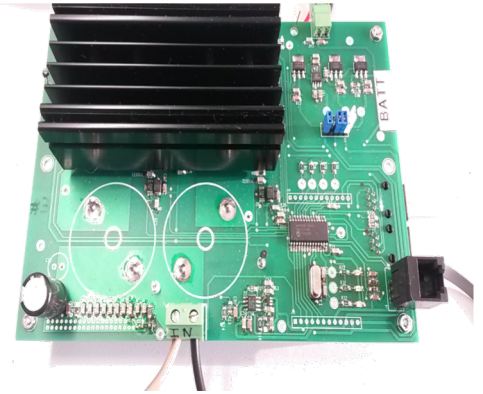
- Increase power converter efficiency and system lifespan
- Strengths:
  - Control theory and modeling
  - Hybrid dynamical systems approach
  - From theory to application





Hybrid electrical microgrid

- Hybrid AC/DC microgrid based on modular and distributed approaches to improve efficiency of renewable energies in a building
- Strengths:
  - Energy building platform
  - Strong expertise in modular and adaptive converters
  - Linear and non-linear control laws
  - Pluridisciplinarity
  - Strong industrial partnership



Demo in energy building

Combinatorial optimization methods

- Smart energy management of a microgrid based on renewable energies

- Strengths:
  - Strong expertise in scheduling and optimization methods: ROSETTA/Philae project
  - Original approach based on piecewise linear bounding of non-linear energy transfer/efficiency functions : **3rd 2018 ROADEF Award**

ROADEF
PRIX
ROBERT FAURE
2018

Partners

Industry

AIRBUS

ALTRAN

University

Towards 100% renewable energies

"When we are dreaming alone it is only a dream. When we are dreaming with others, it is the beginning of reality."

Hélder Câmara