

GEEPS - UMR 8507

GROUP OF ELECTRICAL ENGINEERING – PARIS



The laboratory GeePS is a joint unit of CentraleSupélec, Université Paris-Saclay, Sorbonne Université and CNRS. It is located on two sites: the CentraleSupélec campus of the Paris-Saclay University in Gif-sur-Yvette and the Pierre & Marie Curie campus of the Sorbonne University in Paris.

With 250 collaborators, including 130 permanent staffs (researchers, lecturer-researchers, engineers, technicians and administrates), about 80 PhD students and 40 visiting scholars, it is one of the most important laboratories in the field of "Electrical Engineering" in "Ile de France" region.

The research conducted in the laboratory combines a triple approach: theory - numerical modeling - experimental characterization/validation. It is distributed over **three research departments** that assure a continuum of activities that extend from materials to electronic systems or energy conversion systems.

The research activities are supported by **two transverse expertise centers**. The first center capitalizes the historical competence of the laboratory in numerical modeling of electromagnetic systems with an orientation towards multiphysics and coupled problems on the one hand, and the complex electromagnetic environment on the other hand. The second gathers together the numerous experimental platforms of the laboratory with the primary objective of pooling together instrumentation skills and sharing know-how and resources.

The three departments and the two expertise centers interact through **thirteen themes** (research groups) whose activities address five major societal issues as shown in figure next page.

MATERIALS: PHYSICS & COMPONENTS

In the "Materials" division, we are interested in new materials for applications in the field of electronics and energy, for better efficiency, lower cost, or to avoid toxicity problems, or to achieve better stability and offer greater durability.

We study the fundamental aspects of materials, their electrical properties, but also physical or physico-chemical properties, mechanical, magnetic, ferroelectric, piezoelectric aspects, along with multiphysical couplings. These studies extend to the operation and properties

of components made from these materials, which can be integrated into systems. We develop original characterization platforms and techniques, as well as adapted numerical modelling.

Our main application areas are in the themes: Photovoltaics, Nanoelectronics, Electrical Contacts and Connecting Devices, Power Electronics and Sensors and Functional Materials.

ELECTRONICS: WAVES, COMPONENTS, SYSTEMS

The electronics department aims to address the societal challenges defined within the GeePs scientific project, by offering a wide range of solutions and methods in the field of hardware information processing.

To this end, it is developing a strategy promoting transversality and studies at interfaces, and conducting research in close connection with the industrial partners and the academic world on a national and international level. It focuses its activities around:

- Ultra-low power consumption, miniaturization and reliability of integrated circuits and systems (autonomy of connected objects, bio-sensors)
- Control of the generation, propagation and detection of electromagnetic waves (detection, localization and focusing of energy and information)
- Multiphysical coupling of functional materials (energy transfer and energy harvesting)
- Electromagnetic control of complex media and CEM (modeling and inverse problem)

The Electronics Department, structured around five themes, three of which are cross-cutting, has strong skills in the field of integrated electronics, electromagnetic waves and sensors.

For all of these activities, Electronics Department relies on significant hardware and software resources embodied by the two centers of expertise of GeePs.

ENERGY – COMPONENTS, CONVERSION AND SYSTEMS

Electrical power systems must meet an increasing demand for integration to satisfy the constraints demanded of equipment whether in the field of land, air or space transportation, in the field of power generation and distribution, in isolated networks or in industrial

processes. The increase in the level of physics integration brings the elements closer together and reinforces the complexity of the system's behavior through new couplings and interactions.

The "Energy" department aims to design, model, control and optimize electrical and electronic energy systems in order to broaden the fields of use of these systems (more electric aircraft, carbon-free vehicles, smart-grids, biomedical applications, etc.) by meeting the challenges arising from the constraints on applications.

Among these, we note:

- Improving energy efficiency and performance (in particular through system design and control),
- Integration (compactness, miniaturization...),
- Reductions of mass and cost,
- Improving reliability (in diagnosis, detection, protection, ...).

Research groups address 5 major themes:

- Actuation,
- Power Electronics,
- Transmission and Distribution Electricity Networks,
- Electrostatic, Electrical discharges, Arcs, Plasma Processes.
- Non-contact Energy Transfer.

THE TWO EXPERTISE CENTRES

Electromagnetic and Multiphysics Modeling

The Expertise Centre "Electromagnetic and Multiphysics Modeling" results from a historical expertise and a significant role played by the laboratory in developing of numerical models and simulation tools in Electrical Engineering. This is supported by over twenty modelling servers run by the department with access to the *CentraleSupélec Mesocentre* computing platform providing computing power, and electrical engineering and multiphysics modelling software both in-house and commercial.

This expertise is connected to various research subjects carried out within the different groups in GeePs. Researchers develop their own original dedicated modeling approaches, open source tools, or even use well known commercial software. An important target of the Expertise Center concerns the dissemination of know-how.

The objectives are as follows:

1. Maintain and disseminate the expertise related to modeling and numerical methods. Promote modeling / simulation tools between the different groups of GeePs. To this end, the center organizes scientific meetings or discussions for better dissemination of skills around modeling methods and software.
2. Set up Master level scientific animation courses / internships related to electromagnetic and multi-physics modeling in connection with the research topics of the laboratory.
3. Identify, share, and optimize computing resources within the constituent research groups and the different

sites in coordination with the CRI (the digital resource center), and promote local communication and remote access to simulation tools via the expertise center.

Characterization Instrumentation Platforms

The disciplinary fields of the GeePs laboratory, which range from materials physics to component and systems engineering. In each of its domain of expertise, a recognized and solid know-how in both material and electrical characterization has been acquired over time. Through its research activities, the laboratory has a long history, and the skills, in the development of original instrumental devices to extend its experimental analysis capabilities. When appropriate, those devices can be commercialized. The GeePs has also invested in high end, specialized, complementary equipments assuring its leading position locally and nationally.

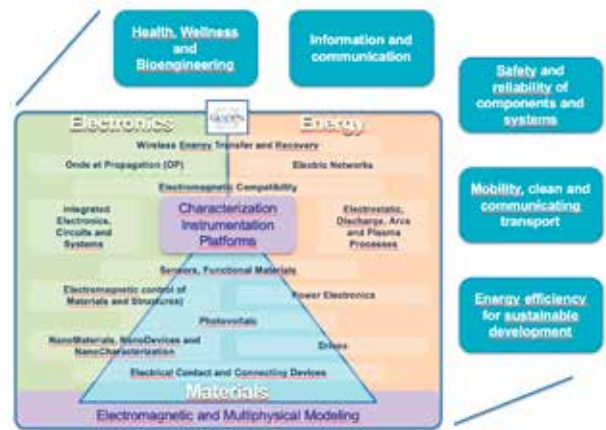
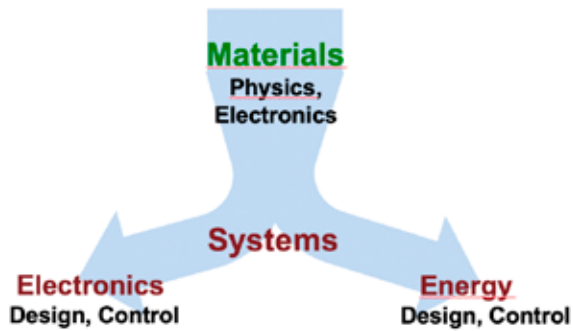
The expertise center has the mission of supervising the experimental platforms and its equipments. Its main objectives are focused on:

- The identification of equipment, expertise, and instrumental developments in order to facilitate the provision of equipment,
- The promotion of internal know-how,
- The listing of equipments, instrumental developments, and software requirements to set up training and funding actions following the scientific orientations of the laboratory's themes,
- The communication on our technical resource and expertise in order to stimulate the use of specific equipments for service providing,
- Setup price list for internal and external provision of service.

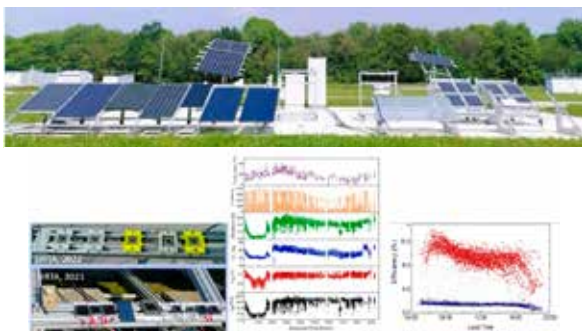
HIGHLIGHTS 2022

- **Abhijit Pramanick** awarded the d'Alembert Chair at the University of Paris-Saclay
- Selected **ANR Projects**: ORGANIST, HELLO_PV, PIMCOMAP, ENCORE
- Selected Horizon Europe project: **TRIUMPH**
- Selected PEPR TASE project: **IOTA**
- First experimental demonstration of rapid characterization techniques for MEMS resonators on ONERA's VIG gyroscopes - published at the Eurosensors 2022 conference in Leuven (BE).
- Launch of the **Juice mission**, including a magnetometer whose front-end was designed by GeePs (CPMC site).
- Design of power converter switching with GaN devices and planar transformer at high frequency 1kW, 400V to 18-36V, 45A and 1MHz.
- Special issue in **EPJ-Photovoltaics** edited by A. Vossier, M. Gueunier-Farret, J.-P. Kleider and D. Mencaraglia.
- **Publication** of 3 chapters dedicated to the characterization of semiconductors from photoconductivity techniques: Uniform and monochromatic illumination, uniform and polychromatic illumination, and photocarrier grating techniques, in **Photoconductivity and photoconductive materials, Fundamentals, techniques and applications**, edited by Safa Kasap, Wiley (2022), ISBN-10: 1119579112, ISBN-13: 978-1119579113, pages 89-177.

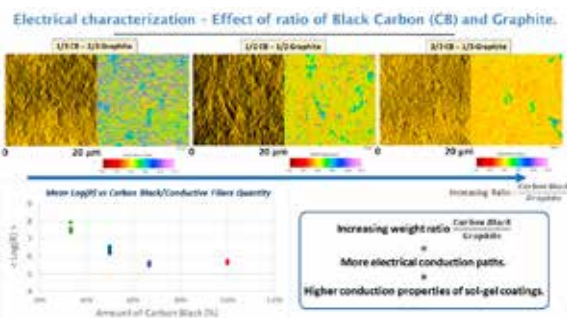




Organization of the laboratory

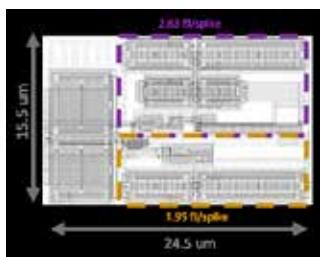


PV platforms at SIRTA and long-term evolution of the output PV parameters of perovskite solar cells

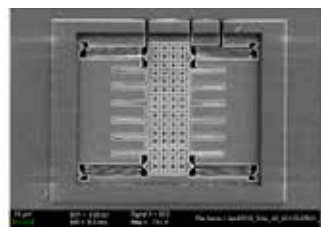


Characterisation by conductive probe AFM (Résciscope) of sol-gel coatings with two types of fillers (carbon black and graphite) for conducting properties. Sol-gel coatings with three different compositions are shown here. For each image: topography on the left and electrical resistance on the right (J. Acquadro PhD).

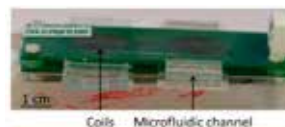
Materials: Physics & Components department



New design of ultra-low power neuro-inspired device



Micro electronic design for vibratory energy harvesting



Lab-on-chip, detection of biological agents



Transducer for remote supply



Data and Energy focusing: antenna arrays and metasurface antenna

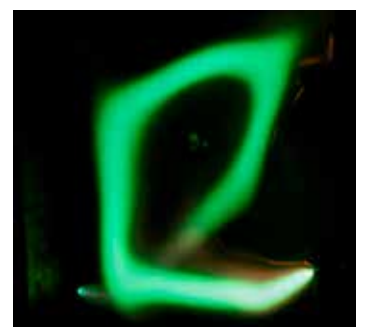
Electronics: Waves, Components, Systems Department



Design and realization of a three-phase full bridge MMC converter with 6 levels



Power transformer for electrical converter (ENERSYS collaboration)



Spatial extension of an electric arc at 540 VDC between two copper electrodes

Energy - components, conversion and systems Department

Industrial Partners

- Airbus Helicopters
- Amphenol Socapex
- CEA
- CETIM
- DGA
- EDF
- EFI Automotive
- FORVIA
- IFP Energie Nouvelle
- Leroy-Somer
- ONERA
- Quantom
- Renault
- RTE
- Safran
- SNCF
- Stellantis
- Thales,
- Valeo
- ITE IPVF
- VeDeCom
- SuperGrid,
- IRT: SystemX

Academic Partners


L2S, C2N, Esycom, ESTACA, LMD, LPGP, MSSMAT, SATIE, LIMSI, XLIM, IMN, ICMMO, LSPM, Inst. Fresnel, IRDL, GScop, Hôpital Marie Lannelongue, GdRs SEEDS / Ondes / SOC2, FedPV, GDRi Sinergie, ELyT-Max, Texas University, Politecnico Turin, Univ. Patras, Univ. Rep. Paraguay, Univ. Jiao Tong XiAn, Univ. Rabat, Nanyang Technological University of Singapore, LRI 3288 CINTRA (Singapore), KEK Tsukuba (Japon), Chang Gung University (Taiwan), Chulalongkorn University (Thailand), UFSC (Universidade Federal de Santa Catarina), Aalto (Finland).

Key figures

• Professors, Associate Professors & Researchers	97
• Engineers & Administrative staff	34
• PhD Students	84
• PostDocs	18
• Visiting Professors	16
• Publications of the year (WoS)	114

www.geeps.centralesupelec.fr

Director: Claude Marchand

 +33 (0)1 69 85 16 31

 claude.marchand@geeps.centralesupelec.fr

Administration: Séverine Lebouvier

 +33 (0)1 69 85 16 32

 severine.lebouvier@geeps.centralesupelec.fr

CentraleSupélec
Campus Paris-Saclay
Breguet building
3 rue Joliot-Curie
91190 Gif-sur-Yvette

