

INSIS - Institute of engineering sciences and systems INP - National physics Institut

GREMI - UMR7344

Research Group in the Energetics of Ionized Media

The **GREMI** is a joint University of Orleans-CNRS research unit focusing on plasma and laser processes and their applications in a wide range of fields: energetics, materials, micro-electronics, nanotechnologies, metrology, radiation sources, biomedicine, propulsion, transport, and the environment.

These scientific and technological applications exploit the thermal, reactive, conducting and radiative properties of plasmas, properties which vary considerably depending on the production mode. This variety means that plasmas can be adapted to a large number of potential applications.

While the main thrust of our research concerns technological development, fundamental research is also an important feature of our work, and is generally approached with a view to industrial applications.

The laboratory facilities comprise a substantial experimental infrastructure dedicated both to **the production of plasma media and to state-of-the-art plasma diagnostics**. Modeling, which is now increasingly linked to experimentation, is also an important aspect of our expertise.

High-speed (>10<sup>7</sup>cm/s) transient cold plasma at the tube exit, for medical applications



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Magnetron plasma deposition of an FeCoNi mosaic target for the design of high-entropy alloys



5 support staff

**Keywords** Laser and plasma processes, plasma diagnostics, thin films, reactive surfaces, nanomaterials, nanotubes, nanoparticles, electric discharges, UV, VUV, XUV and X radiation, electric arcs, plasma deposition, ion propulsion, fuel cells, photovoltaics, MEMS, MOEMS, hydrogen production, production of synthesis gas, microelectronics, nanotechnology, plasma applications in medicine, microdischarges, metrology, flow modification, biomass, combustion, modeling, numerical simulation, spectroscopy, energy transfers.



For teaching and research purposes, the laboratory is connected with the Ecole Polytechnique de l'Université d'Orléans (**Polytech'Orléans**) and the Science Faculty of Orléans University.

- Doctoral School in Energy, Materials, Earth and Universe Sciences
- Masters «Energy and Materials (Media and Materials under Extreme Conditions)», «Instrumentation, Metrology, System Performance Management»

INDUSTRIAL COLLABORATION : ALCATEL, Alpha Test, ALTA SPA, AMMS, Aprim Vide, ATANOR, Bideau, Bree, CILAS, CNRT R2A, CTAS/Air Liquide Welding, DB Technique, DELPHI, Dior, EDF, EFS, EXOSUN, FART, Germitec, IAMS, INASMET, INEL, Ion Beam Services, METRAWARE, MHS Equipment, Philips, PSA-Renault, Saint Gobain, SAGEM, Schneider Electric, SILIOS, SNECMA, S'TILE, STMicroelectronics, THALES, Thégal, UNAXIS, WIRECOM, XbyBus



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GREMI 🖊

## **Research Focus**

The GREMI is one of the major **plasma processing laboratories** in France, and is equipped with a broad spectrum of reactors and systems.

Our expertise is internationally recognized in many areas that use plasma properties. The research effort of all the members of the laboratory is geared towards **understanding fundamental mechanisms** (ranging from diluted matter to condensed matter), based on experimental observation combined with modeling.

The activities of the laboratory can be grouped into two main research directions:

The first concerns Plasma and Laser Processes for the design of thin films and nanomaterials, focusing in particular on:

- Storage, energy conversion, and the development of new materials for applications in photovoltaics and transparent electronics, fuel cell and microbattery design, and the design of new, high-entropy anti-adhesive alloys.
- Nanotechnologies such as plasma etching, carbon nanotube electrical connections and heat sinks, laser surface treatment, and fast Pyro/Reflectometry.
- **Dusty plasmas**, covering the study of the growth, behavior and functionalization of nanopowders as well as the metrology of nanopowders and the characterization of nanomaterials.



Nanotube carpet obtained by PECVD then metal-coated for use as heat sinks in microelectronics



Steam reforming from alcohol by non-thermal arc Production of hydrogen or synthesis gas

## Experimental facilities

Large number of low- and high-pressure plasma reactors, Wide range of lasers (ps, ns, continuous), Fast high-current and high-tension impulse discharges, Lambdameter, joulemeter, X, VUV, UV and VIS spectrometers, cameras, PMT, Integrator sphere (1 m), IR time-resolved optical pyrometer Optical microscope, SEM/EDX, AFM, STM Ellipsometers, FTIR, Chromatographs, Mass spectrometers, Ultra-fast oscilloscopes.

**Our second** research focus targets the development of plasma sources for novel applications:

- We investigate the links between **plasmas and energy** for aeronautical and terrestrial applications such as satellite propulsion, arc discharges, and flow modification.
- We use the chemical properties of plasmas for environmentally-orientated research such as the valorization of hydrogenated and hydrocarbon compounds and of biomass, depollution treatment of gaseous effluents, and ignition in internal combustion engines.
- We explore radiation sources and new biological applications of plasmas based on the development of X and UV sources for imaging, the use of plasmas in medicine (in particular anti-cancer treatment), and micro-discharges.

Our activities also encompass **interdisciplinary expertise** in **plasma diagnostics** (optical spectroscopy) and **interfaces** (plasma/surface energy transfers), as well **as modeling and numerical simulation.**