

# LMOPS - EA 4423

## LABORATOIRE MATÉRIAUX OPTIQUES PHOTONIQUE & SYSTÈMES

LMOPS



The LMOPS laboratory is composed of 24 faculty members, among which 19 permanent researchers from Lorraine university and 5 from CentraleSupélec, along with 14 PhD students and 5 post-doctoral staff. The laboratory is mainly situated on the Metz Technopole campus, and has two local branches in Thionville-Yutz and Saint-Avold.

### OPTICAL MATERIALS, PHOTONICS & SYSTEM

LMOPS is divided in four research groups, respectively devoted to Functional Materials, Photonics, Spectrometry of complex heterogeneous materials and Photovoltaics. It also has a running chair program (Chair in Photonics) and two experimental platforms respectively dedicated to spectroscopy and electrical measurements.

LMOPS also actively participates to the PIA2 IDEX / I-SITE *Lorraine Université d'Excellence* (LUE) project promoted by Lorraine university. The goals of the LUE initiative are to develop the international leadership of the Lorraine site, on engineering viewed from a systemic perspective around major economic and societal challenges.

### FUNCTIONAL MATERIALS TEAM

At the end of 2018, three researchers from the *functional materials team* joined the *photovoltaic systems team* to form a group around global photovoltaics; *photovoltaic Materials, Components and Systems*. Consequently, the activities of the functional materials team were then reorganized around two major themes: the growing of bulk materials for non linear optics and the study of fire behavior and fireproofing of polymer materials (*nanocomposite polymers* theme). The bulk material theme is focused on the study of growth and characterization of new materials that are more effective and more resistant allowing the realization of VUV sources ( $\lambda < 300\text{nm}$ ) of high power and stable in the time. For this, two experimental methods are available in the laboratory: the "micro-pulling down" technique ( $\mu\text{PD}$ ) and the Czochralski method. Concerning the fire retardant research, a booming research topic is the study of flame

retardancy of continuous fiber thermoplastic composites. This subject is directly related to the needs of the socio-economic environment of the East-Moselle. The influence of aging on the fire performance of these complexes flame retardant polymer systems is also studied.

### PHOTONICS TEAM

The Photonics research team's main theme is nonlinear optics, a domain which is studied using several distinct approaches. Optically induced waveguides and the experimental link they allow between optics and quantum physics using the analogy between optical and quantum behavior equations are studied to provide efficient experimental ways to investigate otherwise unreachable quantum behaviors. Spatio-temporal nonlinear dynamics are also investigated as they lead to an intriguing self-organisation property of light itself. The temporal side of these dynamics leads to chaos that could be used for ultra-efficient all optical encryption. Finally, optical neuro-inspired computing based on reservoir computing is a new topic that is rapidly gaining importance in the team. Hybrid, as well as all-optical approaches are investigated for various prediction or recognition tasks. The team has today gained an unchallenged international recognition with paper published in prestigious journals and has a running chair program on photonics with unprecedented funding from both the public and private partners of the laboratory.

### SPECTROMETRY OF COMPLEX HETEROGENEOUS MATERIALS TEAM

The objective of this team is to study disturbances and order breaks in various materials (crystals, polymers, solutions) through Raman signatures related to point or extended defects, doping, phase or phase transformations, domains, components of a mixture, crystallites, etc, but also to perform metrology and control of complex environments by attempting to establish a link between the characteristics of the Raman line (position, width, intensity) and a physical parameter: strain, electrical field, temperature, concentration, size, etc. One of the important topics is the correlation with other techniques (X-Rays measurements, dielectrics, optics, etc.) and the coupling with Raman measurement (DSC/Raman, WAXS or SAXS/Raman, Rheology/Raman).

## PHOTOVOLTAIC MATERIALS, COMPONENTS AND SYSTEMS TEAM

The MCS-PV team results from an internal restructuring of the laboratory following the development of new activities in the domain of Earth-friendly photovoltaic materials. Currently, the MCS-PV team global theme concerns the optimization of the various parts of energy production systems starting upstream by the development, i.e. growths, characterizations of the structural, electrical and optical properties and modeling of new photovoltaic materials, layers and cells, to downstream with the optimization via experimental implementations and validations, then modeling of the efficiency of photovoltaic modules – converters – generators – structures. The activities are devoted to photovoltaic systems, which is its mainstream research,

but also to more general renewable energy sources. The activities are based on important know-how bringing together various specialties and skills of the different members of the team namely: physics, materials, electronics, optics and systems. Concerning the growth of new photovoltaic materials, the team acquired in 2018 a new spray-pyrolysis equipment (funded by CentraleSupélec) allowing a rapid return of the results of characterizations and modelizations on the growth and structure of the layers and cells. Moreover, the team is also studying photovoltaic cells and modules from other laboratories for specific properties such as aging, effects of thermal and electrical stresses, properties of certain layers (eg transparent conductive layers, absorbent layers) as a function of doping, growth conditions of the gap profile, etc.

## HIGHLIGHTS 2022



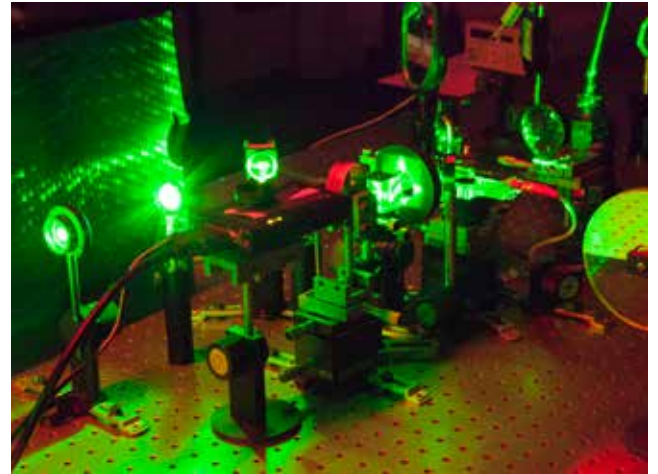
The **Chair in Photonics** from the LMOPS laboratory, founded in 2017, has decided with actors from the Grand Est region to come together to create a **Photonics Institute**. This initiative was announced at the SPIE Photonics Europe congress in April 2022 in Strasbourg.

The Consortium under construction, led by CentraleSupélec, already brings together the University of Technology of Troyes, the University of Lorraine, the University of Strasbourg, INSA Strasbourg, the University of Haute Alsace, the companies GDI Simulation and Green Tech Innovation, as well as local and regional innovation support players, SATT Sayens, the Materialia competitiveness cluster, the Grand E-nov+ innovation agency and many other players. The Institute of Photonics will take the form of a unifying network of partners and sites covering the territory of the Grand Est, with a main site in Metz. It will ensure missions of animation, coordination, research, innovation, training and dissemination of scientific culture.





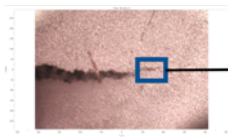
Functional Materials



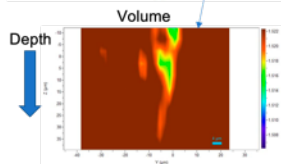
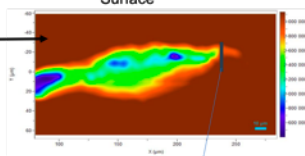
Photonics

Study of surface and volume heterogeneities of medical materials

Mapping of the intensity of Raman line  
 → volume damage inside the craze and at the surface craze tip.



Craze in strained sample (3.4%)

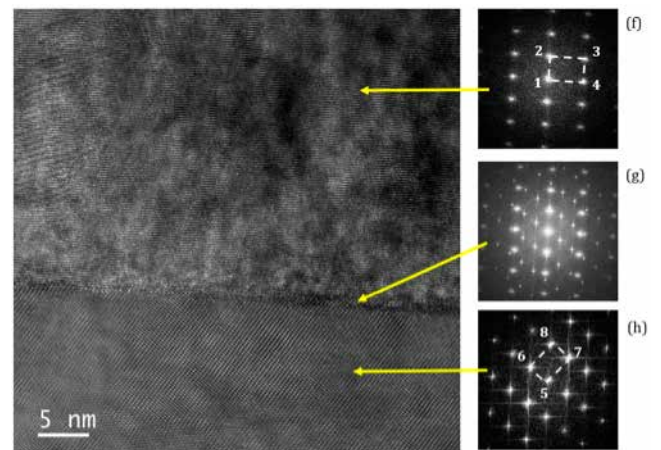


**Experimental Conditions**

- Raman HR evolution
- Laser 532 nm, Polarised // to the tensile direction
- Swift mode  $t = 0.15$  sec/spectra
- Step  $1 \times 1 \mu\text{m}$

1

Spectrometry of complex heterogeneous materials team



Photovoltaic Materials, Components and Systems team

## Industrial Partners

- AIRBUS -GDI Simulations,
- ARCELORMITTAL,
- ARKEMA,
- Cristal Laser,
- EDF,
- Institut de Soudure,
- M-Optics,
- Pôle Matériaux,
- SAFRAN,
- SHASTA CRYSTALS,
- TOTAL.

## Academic Partners

Institut Jean Lamour (IJL), Laboratoire d'Etude des Microstructures et de la Mécanique des Matériaux (LEM3), Laboratoire de Chimie et Physique - Approche Multi-échelle des Milieux Complexes (LCP-A2MC), Laboratoire de Cristallographie, Résonance Magnétique et Modélisations (CRM2), UMI2958 Georgia-Tech-CNRS, Institut Lafayette, Laboratoire de Nanotechnologies et d'Instrumentation Optique (LNIO), Université du Luxembourg, Ecole des Mines d'Alès, Luxembourg Institute of Science and Technology, Universités de Bruxelles, Institute for Color Science and Technology (Tehran, Iran), Université de Padoue (Italie), Osbnabrück, Institute for Physical Research (Yerevan, Arménie), Université de l'Oural (Russie), Université de Tlemcen (Algérie), ICube, Laboratoire Charles Coulomb, Laboratoire de Physique des Lasers, Institut des Nanotechnologies de Lyon...

## Key figures

• Professors, Associate Professors & Researchers	22
• Engineers & Administrative staff	6
• PhD Students	12
• Publications of the year (WoS)	72

<http://lmops.univ-lorraine.fr>

Director: Thierry Aubert

+33 (0)3 72 74 88 07

thierry.aubert@univ-lorraine.fr

Assistant: Stéphanie Vergerio

+33 (0)3 72 74 88 00

stephanie.vergerio@univ-lorraine.fr

LMOPS / CentraleSupélec  
2, rue E. Belin  
57070 METZ (France)