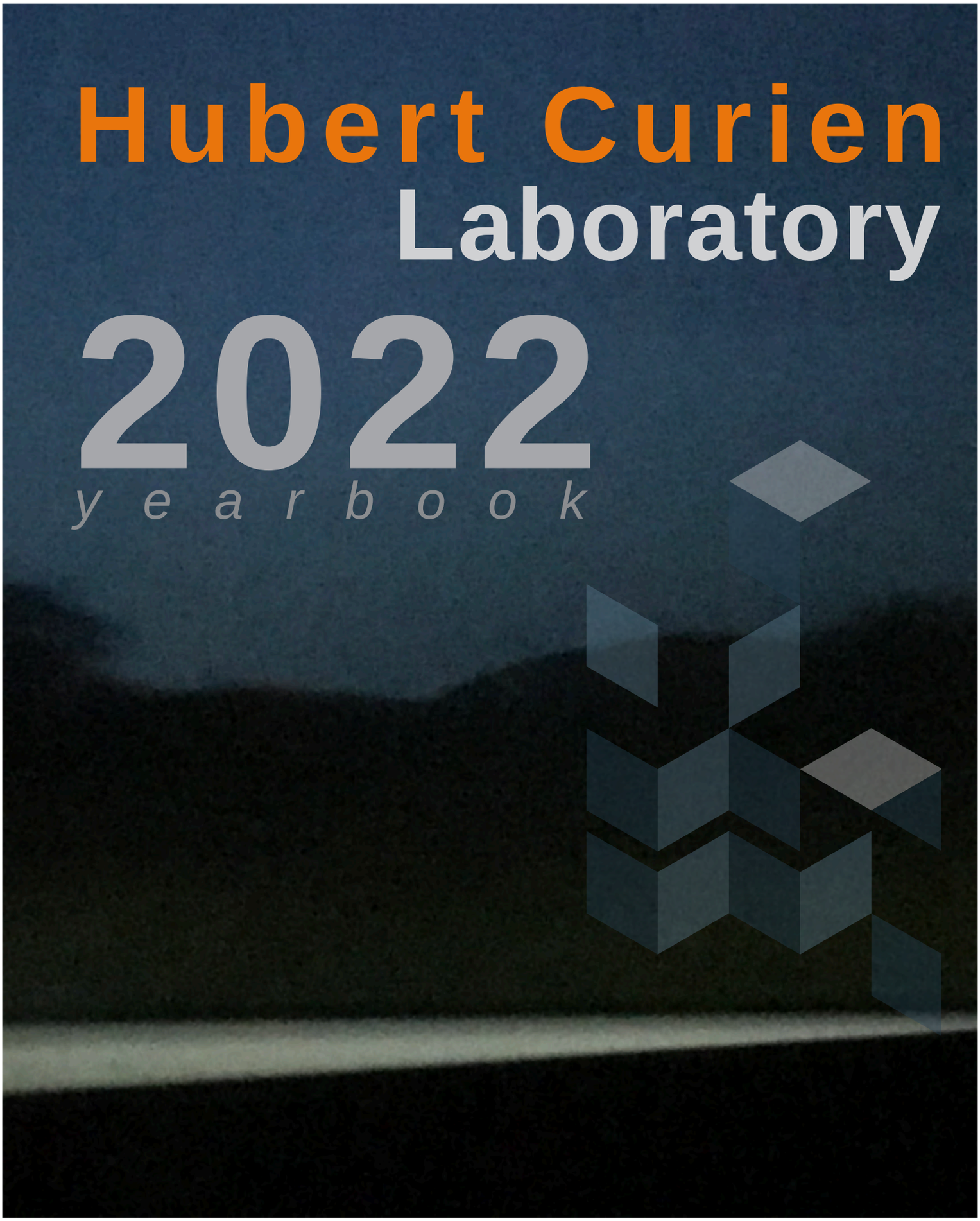
Hubert Curien Laboratory

2022

yearbook



cnrs

UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech

LABORATOIRE HUBERT CURIEN

UMR • CNRS • 5516 • SAINT-ETIENNE

EDITO

As I approach the mid-term of my second - and last - mandate as Director of the Hubert Curien Laboratory, I am delighted to present the very first edition of our yearbook, presenting our activities over the past year. Our objectives for this new communication medium are to highlight and share with you recent facts, news, and achievements of our lab. Despite the recent difficulties that our society has been facing, which continue to affect us both personally and professionally, 2022 has indeed been an exceptionally rich year in terms of scientific results for our lab. None of it would be possible without the backing of the University Jean Monnet, the CNRS, and the Institut d'Optique Graduate School, to which the Hubert Curien Lab is affiliated. I would like to take this opportunity to thank these institutions for their continual support.

After a broad presentation of our laboratory, we dedicate a section of this document to a few subjects that have particularly marked the past year. We highlight the Lumina project, carried out in collaboration with the European Space Agency, the CNES, CERN, and within the framework of our LabH6 joint lab with the company Exail (ex-iXblue). We unveil the launch of the LAMCID joint lab, which consolidates an existing partnership with the manufacturer of ID documents HID Global CID, as well as the creation of the CNRS International Research Project - IRP Polaris, an exciting new collaborative venture with the renowned Centre for Research in Photonics of the University of Ottawa in Canada. Overall, we have tried to convey the great dynamism that animates our teams and the remarkable quality of their work, illustrated by the numerous projects and outstanding international publications they are contributing to, their constant engagement in the dissemination of their knowledge and the marks of recognition they receive from their peers. We also allocate a section to our partners' teaching programs, emphasizing the continuum around our training-research-innovation key principle. We list out all our new doctors and latest recruits, including 6 new teacher-researchers and 4 new technical and administrative staff, bringing our lab's total number of permanent members to 114.

Whether as a collaborator, actor of our region's development, or an organization sharing our professional interests, I truly hope that you will appreciate this edition. Do not hesitate to get back to us for any queries you may have. Finally, I would like to thank all our members for their contribution to the lab's success, and specifically our new communication manager Elisabeth Reby, who has coordinated the conception and design of this document.

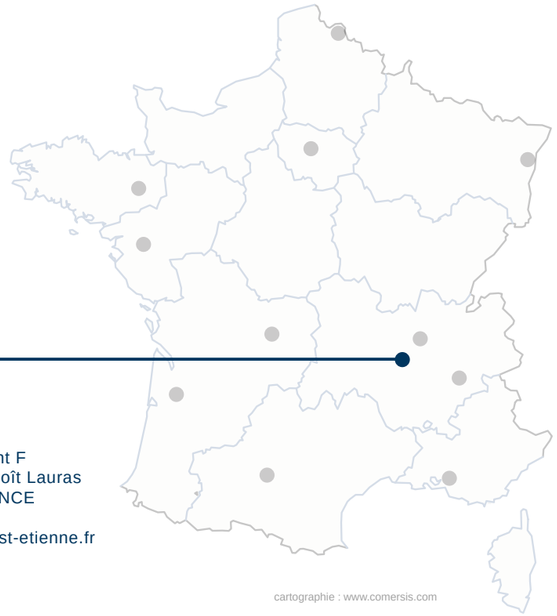
Florence Garrelie
Director of the Hubert Curien Laboratory

CONTENT

THE LAB

LOCATION

The Laboratoire Hubert Curien is a joint research unit of the University Jean Monnet Saint-Etienne and the CNRS, with the Institut d'Optique Graduate School as secondary institutional sponsor. It is located in Saint-Etienne, the 2nd largest city of the Auvergne - Rhône-Alpes Region, in an environement particularly favourable to the development of its research and entrepreneurial activities.



cartographie : www.comersis.com

Université Jean Monnet
Saint-Etienne

LABORATOIRE HUBERT CURIEN
UMR • CNRS • 5516 • SAINT-ETIENNE

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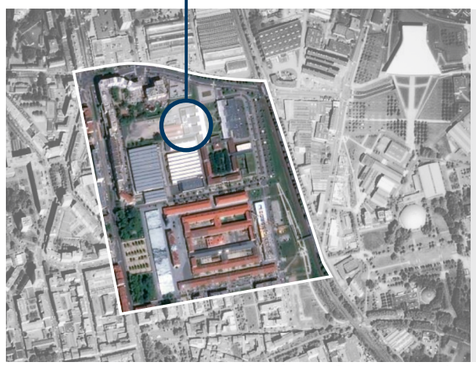
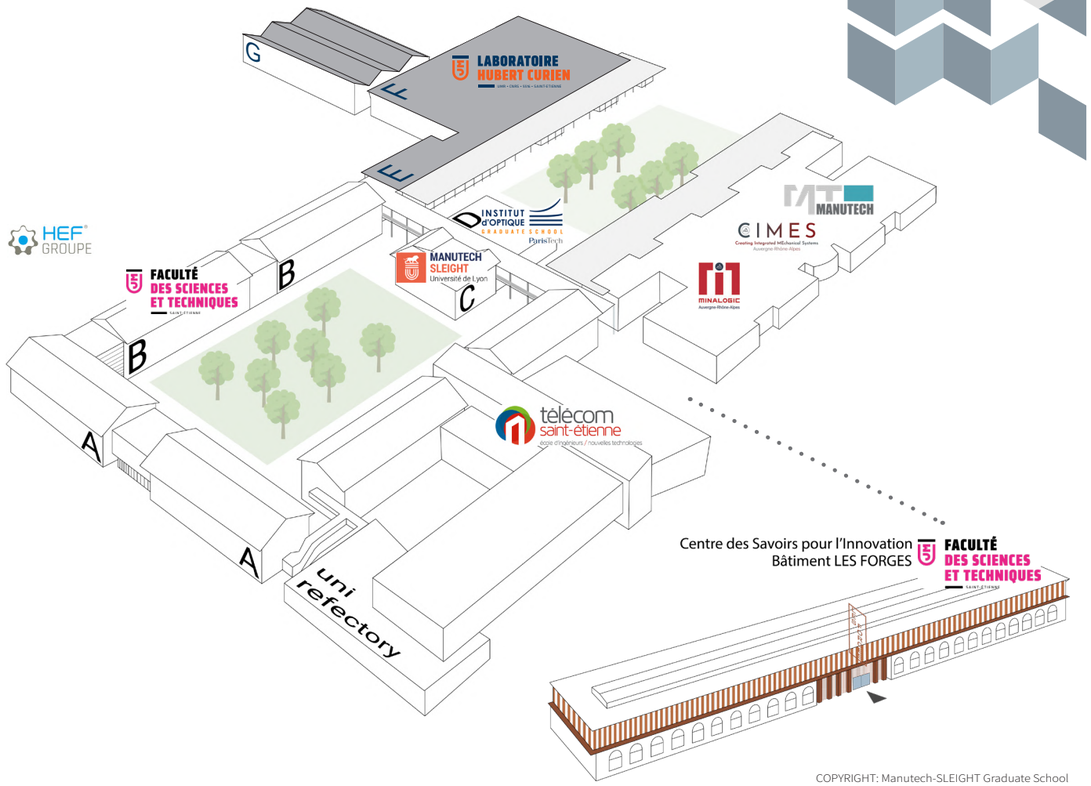


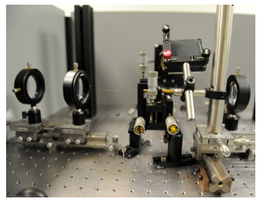
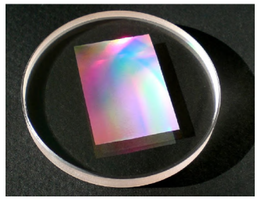
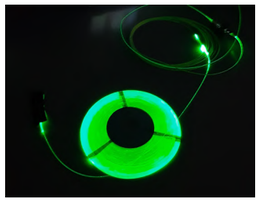
Manufacture Campus aerial view
(Imagery ©2023 CNES / Airbus, Maxar Technologies, Map data ©2023)

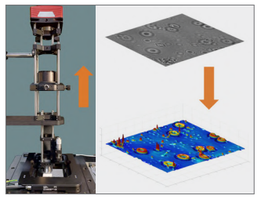
The Hubert Curien Laboratory is situated at the heart of the «Manufacture Campus», established on the historic site of the former Saint-Etienne's arms factory. The lab benefits from exceptional surroundings including cultural, industrial, teaching and research activities as well as housing, sport and leisure facilities.



The Manufacture Campus houses the university's Faculty of Science & Technology, its Physics & Computer Science departments as well as its «Télécom Saint-Etienne» engineering school. It was selected by the Institut Optique Graduate School to set up an antenna outside the Paris area. Minalogic and Cimes, 2 local industrial «competivity clusters» occupy the site, together with the Economic Interest Group GIE Manutech USD. The companies HEF R&D (surface engineering and micro/nanostructuring) and Keranova (design of ultrafast laser-based surgical ophthalmology equipment) have established their premises on the site, reinforcing the status of the Manufacture Campus as an emblem of an ecosystem that closely links the university and the business world.

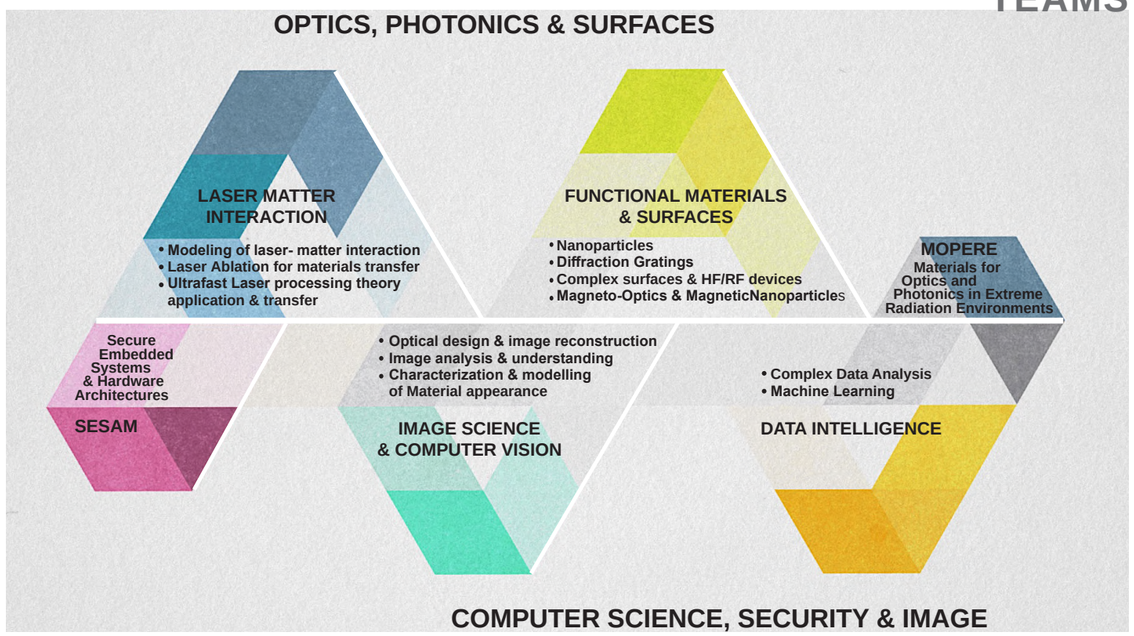
OUR ACTIVITIES
at a glance




The lab covers a spectrum of research activities structured around 2 scientific departments: «Optics, Photonics & Surfaces» and «Computer Science, Security & Image». Our main expertise lies in Surface engineering, 2D & 3D materials' micro/nano structuring, Ultrafast laser processing, Electromagnetic modelling, Material resistance in harsh environments, Machine learning, Complex data analysis, Unconventional imaging, Computer vision, Material appearance and Hardware security. Many research projects at the interface of these disciplines lead to innovations and scientific breakthroughs.

TEAMS



KEY FIGURES

114 permanent staff members

90 researchers

18 Post-docs

24 engineers, technicians & admin

76 PhD students

252 international publications on average per year

6 experimental platforms

109 research contracts

2 industrial joint labs

implication in **3** LabEx

1 graduate school (EUR)

7 coordinated international masters

our place within the Lyon / Saint-Etienne
ECOSYSTEM

The Hubert Curien Laboratory is involved in several programs of excellence that have enabled the emergence of a large consortium of public and private partners in the Lyon/Saint-Etienne area. These programs contribute to an emulating spirit of interaction within our economic environment. 3 of these programs revolve around our «Manutech» brand. A LabEx was created in 2011 with 3 private companies undertaking R&D activities, whilst the founding of an EquipEx that same year operates today under the form of an Economic Interest Group involving 3 industrial partners and 4 research institutions. The setup of a Graduate School (EUR) in 2018 was done in collaboration with several partners and research laboratories from our region. Futhermore, our lab participates in the activities of various research federations that have been set up in the Lyon/Saint-Etienne area.

LABEX MANUTECH-SISE
UNIVERSITÉ DE LYON

LABEX Manutech-SISE - Surface Interface Science Engineering
Manutech SISE is a "Laboratoire d'Excellence" governed by the Université de Lyon and coordinated by the Hubert Curien Lab. It brings together the complementary skills of 6 academic labs (Hubert Curien Lab, LTDS, Georges Friedel Lab, LaMCoS, LMI, MATEIS) and several other institutions and companies involved in surface and interface-oriented themes, including IREIS, GIE MANUTECH-USD, CIMES, CETIM and the EUR Manutech-SLEIGHT.

LABEX MILYON
UNIVERSITÉ DE LYON

LABEX MILYON - Mathématiques et Informatique Fondamentale
Our institution is part of this group of Mathematics and Computer Science labs gathering 450 researchers from 5 research units of the Lyon/Saint-Etienne area (ICJ, UMPA, LP, LIP, Hubert Curien Laboratory). MILYON focuses on 4 key objectives, including excellence in research (with multidisciplinary scientific projects), education (with innovative research-oriented curriculums), outreach (disseminating scientific culture among the general public) and transfer of technology to the Industry (through research partnerships, training or internships).

LABEX PRIMES
UNIVERSITÉ DE LYON

LABEX PRIMES - Physics, Radiobiology, Medical Imaging and Simulation
The Hubert Curien Lab participates in the LABEX PRIMES, supported today by the Institut de Physique Nucléaire of Lyon (IPN-L, radiation for radiotherapy and imaging) and the CREATIS laboratory (medical imaging). Gathering more than 190 expert researchers from 16 academic institutions as well as several clinical partners, PRIMES' primary objective is to develop new concepts and methods for the exploration, diagnosis and therapy of cancer, and aging-related pathologies.

MANUTECH
SLEIGHT
Université de Lyon

Manutech-SLEIGHT Graduate School - Surfaces Light EngineerinG Health and SocieTy
Our lab has largely contributed to the setup of this Graduate School (Ecole Universitaire de Recherche) which provides an international integrated MSC/PhD program in the domain of Surfaces Light EngineerinG Health and SocieTy. It brings together a consortium of 12 public and private partners located in the Lyon/Saint-Etienne area, including 7 academic institutions (Universities, Engineering Schools), 2 national research organisations and 3 economic stakeholders, with the main goal to weave links between education and research.

MANUTECH

Manutech USD GIE - Groupement d'Intérêt Économique
The Manutech USD GIE gathers public research and industry stakeholders around an EQUIPEX (EQUIPement d'EXcellence Manutech USD - Ultrafast Surface Design) which the Hubert Curien Laboratory helped create in 2011. The GIE's main objective is to explore and exploit scientific and industrial possibilities offered by femtosecond lasers, providing solutions for surface texturing. Our lab is historically and heavily involved in the GIE. Several of our reseachers and engineers have developed or are developing activities around the Manutech-USD platform.

Ingénierie Lyon · Saint-Etienne
Inge'LySE

IngeLySE - Fédération de recherche en ingénierie de Lyon - Saint Etienne.
The IngeLyse research federation brings together 24 laboratories representing nearly 2300 researchers, lecturers, technical staff and PhD students under the supervision of the INSIS Institute, the CNRS and the Université de Lyon. It is the largest group of research units in France, covering most of the existing engineering scientific disciplines. The role of the IngeLyse Federation is to animate the vast array of skills represented by these laboratories, and facilitate the interaction between different disciplines in order to enable the emergence of technological innovations.

FRAMA

FRAMA - Fédération de Recherche André-Marie Ampère
Together with 5 other CNRS affiliated research units (CRAL, IP2I, INL, ILM, LP-ENSL), our laboratory is a member of FRAMA, a structure which mission is to organise, lead and coordinate research activities in physics and astrophysics in Lyon and Saint-Étienne. The main objectives of FRAMA are to coordinate common scientific actions, enable inter-laboratory projects, promote interactions between labs and other disciplines, organise seminars and conferences, support science through calls for innovative projects, financially support technological platforms and facilitate their development.

Fédération
Informatique
de Lyon

FIL - Fédération Informatique de Lyon
Supported by the CNRS and the INRIA Institute, the FIL gathers around 870 members from 5 research labs (LIRIS, LIP, CITI, CREATIS, Hubert Curien) and aims to address the many societal challenges raised by computer science & digital technology. Its main objectives are to promote scientific exchanges and common actions, reinforce the computer science discipline's visibility around Lyon, be a privileged interlocutor for local and national authorities, enable coordinated responses to calls for proposals, and increase the attractiveness of the discipline in the region.

INSTITUT
CARNOT
Télécom & Société numérique

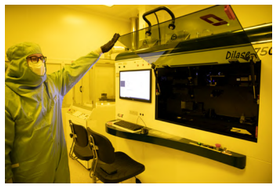
Institut Carnot TSN - Télécom et Société numérique
Our lab is a member of the Institut Carnot TSN through the Télécom Saint Etienne Engineering School. Carnot is a label of excellence awarded by the Ministry of Higher Education, Research & Innovation, encouraging research work by public labs in partnership with socio-economic stakeholders. It is organised around several Institutes working on the same theme. As a major player in R&D and digital innovation, the Carnot TSN facilitates companies' access to the skills of its 11 affiliated research establishments.

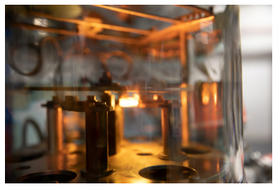
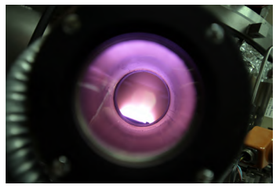
our technical

PLATFORMS

Most research activities of the Hubert Curien Laboratory are supported by several technology platforms fitted with specific state-of-the-art experimental tools. The equipment is operated, supervised and maintained by experienced technical and scientific staff working closely with our research teams.

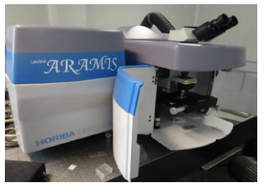
NanoSaintÉtienne

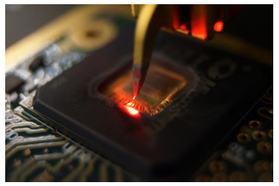


Our *Renatech+* affiliated NanoSaintÉtienne platform includes planar technology instruments dedicated to 4 main activities: gratings elaboration, thin film deposition, substrates processing and profile analysis. Managed by a team of 7 people, this micro-nano technological facility is open to industrial and academic partners.

Spectroscopic Characterization



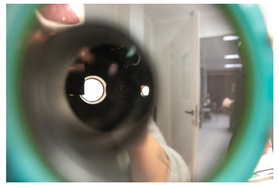

Our Spectroscopic Characterization platform is dedicated to laser inscription and spectral analysis by laser excitation (Raman and photoluminescence). It is equiped with spectroscopy and micro-nano-structuring instruments.

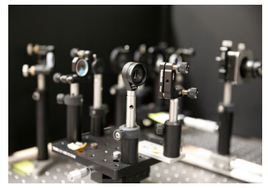
Electron Microscopy



This platform is dedicated to improve the knowledge of condensed matter structure from atomic to microscopic scale, in order to support the activities of our research teams. It is fitted with state-of-the-art equipment, including a CLYM affiliated JEOL NeoARM 200F Transmission Electron Microscope (TEM) - equiped with EDS and EELS - and a JEOL IT 800 SHL Scanning Electron Microscope (SEM).

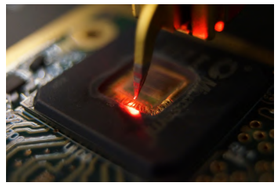
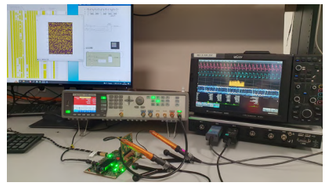
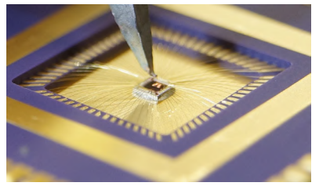
Femtosecond Laser



Our Femtosecond Laser platform is fitted with 6 ultrashort lasers working at different wavelengths, repetition rate and energy, including all working environments. The platform operates various devices around the ultrafast lasers, such as OPA for wavelength tunability, burst modes and variable frequencies, high-precision stages and scanners, spatial, temporal and polarization shaping of ultrashort laser pulses, or ultrafast spectroscopy systems. This facility mainly supports the scientific activities of our Optics, Photonics and Surfaces Department teams.

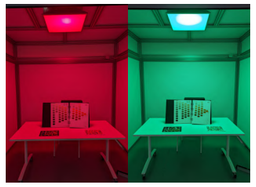
Computer Science, Security & Image

This platform mainly offers support and services to our Computer Science, Security & Image Department's teams. The available equipment includes various tools such as a computer cluster (incl. GPUs and CPUs), cameras, lenses, laser/lighting systems. It is also equipped with high performance oscilloscopes, arbitrary waveform generators, a real-time spectrum analyzer, a climate chamber for stress and stability tests and several testbenches for cryptographic applications. The platform provides help desk, training and user support activities.

IXR - Imaging and Extended Reality



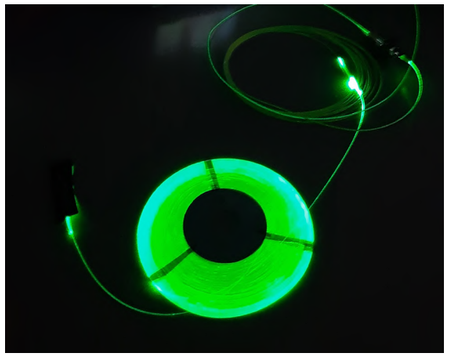

The IXR platform is a modular space that provides equipment dedicated to Imaging and eXtended Reality with AR/MR/VR devices, innovative screens, and a wide range of imaging sensors: color, stereo, LIDAR, multi- and hyper-spectral, 360° and 3D scanners. Sensors, screens and XR devices can be combined with innovative lighting, such as a 24-channel spectral light, and a motion capture system.

2022 HIGHLIGHTS

The year 2022 has been marked by some events and projects of high importance for the Hubert Curien Laboratory. The following pages present four of these subjects that are particularly standing out.

LUMINA project

On 18th August 2021, astronaut Thomas Pesquet installed a fiber-optic dosimeter on board the International Space Station, as part of his European Space Agency (ESA) ALPHA mission. The project, called “Lumina”, was developed under the CNES leadership in partnership with the Hubert Curien laboratory’s MOPERE team, Exail (ex-iXblue) - within the LabH6 JointLab - and the CERN. The ISS is associated with a complex radiation environment that requires bespoke and effective radiation monitoring systems. The Lumina dosimeter incorporates two fiber-optic coils that experience a partial loss of transmitted power and darkens, when exposed to space radiations. This optical loss, called “radiation-induced attenuation”, can be accurately measured and correlated to the radiation dose exposure in the station, even at very low levels. The fiber-optic used is unique, being sensitive to not only protons, photons and electrons, but also to neutrons. «We had been working on fiber-optics with the CNES and Exail for several years, but on different topics» says Sylvain Girard, coordinator of the Lumina project at the Hubert Curien Laboratory. «We were actually and originally trying to develop fiber-optics resistant to radiations. It is whilst finding fibers that do not resist to radiations that we got the idea to develop a dosimeter. The team’s main objective was to analyse the data being received in real time from the ISS, in order to establish our lowest radiation levels detection’s capacity. We were also able to adjust certain parameters for Thomas Pesquet to calibrate during his mission».
This has allowed the team to optimise the performance of the dosimeter, for them to now start envisaging future potential developments for the technology. Data will continue to be collected from the ISS for several years, and be regularly sent back to Earth for analysis. Future space stations will be located closer to the moon and therefore much more exposed to radiations. The Lumina team expects to test a new fiber-optic dosimeter that will measure radiations with greater accuracy, whilst indicating their direction and trying to predict incoming radiation waves. This dosimeter could therefore be used for future long-distance space missions to Mars, to alert astronauts of imminent solar storms. Back on Earth, potential applications in the medical and nuclear fields are already being explored.
Lumina is a project that encompasses the major components of a success story for our lab: we have collaborated with several renowned institutions and an industrial partner within the framework of a JointLab; the work is singular (we have sent something into space!); we are contributing to the future of space exploration, with potential applications of the technology in several fields. Finally, the project has received wide media coverage that raises the profile of our lab among the public and among the research community.



Illustrations above:
An Alpha Mission sticker signed by Thomas Pesquet;
The fiber-optics used for dosimetry applications;
Thomas Pesquet installing the dosimeter in the ISS
(Image credit: ESA/NASA).

MOPERE team
Scientific Head: Sylvain Girard
Aziz Boukenter
Emmanuel Marin
Adriana Morana
Youcef Ouerdane
Fiammetta Fricano
Martin Roche

LAMCID Joint Lab
Hubert Curien Laboratory / HID Global CID

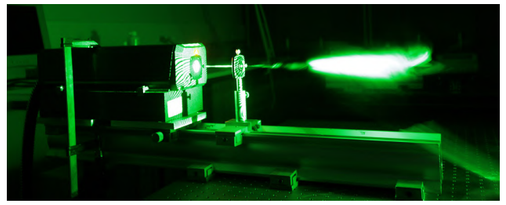
The present yearbook features a high impact scientific article published by our Functional Materials and Surfaces team, titled «Anti-Counterfeiting White Light Printed Image Multiplexing by Fast Nanosecond Laser Processing» (see page 38). This article was the result of a long-term collaboration between the Hubert Curien Laboratory and HID Global CID, a company specialised in the development and manufacture of ID documents. This collaboration, headed by Prof. Nathalie Destouches, has led to a new joint venture with the creation of LAMCID - LAsers, Materials and Colors for citizen Identify Documents - a Joint Lab (LabCom) that was officially inaugurated on 9th June 2022.
A “Laboratoire Commun” or “LabCom” is a large-scale research partnership between a private company and a public research institution, over a minimum period of time of 3 years. The main objective of such a collaboration is to jointly carry out several clearly identified research projects relevant to a specific scientific topic, with the aim to find industrial applications to research results. Collaborating with public research structures allows companies to access skills not available internally, develop new products, conquer new markets and secure Intellectual Property rights. For scientific labs, these partnerships ensure a long-term investment of their research and constitute an additional tool for the acculturation of scientists, doctoral researchers and students to the industrial and business environments. These collaborations can take many forms, however a LabCom is the most advanced type of structure available today.
This is the 2nd initiative of the sort by the Hubert Curien Laboratory, after the creation of the “LabH6” joint lab in 2018 by our MOPERE team with the company Exail (ex-iXblue), designer and manufacturer of photonic devices. Working around the theme of special optical fibres in harsh environments for the nuclear, space & health sectors, LabH6's research and experiments have resulted in, among other achievements, the development of the fibre-optic dosimeter that was tested by Thomas Pesquet during its ESA ALPHA Mission. The renewal of the LabH6 contract planned for this year attests the success of this collaboration.
The Hubert Curien Lab's knowledge and know-how in various disciplines (laser- matter interaction, plasmonics, sol-gel, materials' appearance, science of colour, secure images, machine learning, laser micronanostructuring) is being combined with HID's industrial expertise in identity documents manufacturing, to be applied to various projects.
The team’s objective is to further develop and broaden the innovative techniques so far jointly developed within the general framework of laser inscription of images on polycarbonate substrates. With the support of our Image Science and Computer Vision team (Prof. Mathieu Hébert), the group will develop the necessary tools, methodologies, software and know-how for further securing the authenticity of ID documents in ways that could revolutionize the ID cards and passports systems. In particular, methods of multiplexed images printing implemented inside polycarbonate cards are being explored. Another aspect of this joint work involves the non-multiplexed laser inscription of colour images within cards, in order to create extremely realistic rendered colours in different modes of observation and illumination such as reflection or transmission.
This work will help create images with special visual effects, for the inscription of portraits onto ID cards for example.
Specific equipment and premises are also being shared, thanks to the installation of HID Global CID's French R&D offices on our Manufacture site, within the Centre des Savoirs pour l’Innovation Building. This move helps shortening the experimentation process through direct interaction between both teams, allowing them to work on materials and products as close as possible to the final product, and by following manufacturing processes similar to those used in the HID production plants.
The collaboration between the Hubert Curien Laboratory and HID, initiated in 2016, has already generated several papers published in highly ranked international journals, whilst 3 patents have been granted. It has so far supported several PhD and post-doctoral staff, and led to the recruitment at HID of Nipun Sharma and Nicolas Dalloz, both PhDs from our lab.

With these already productive activities, we can look forward to a prosperous future for LAMCID!

Functional Materials and Surfaces team
Scientific Head: Nathalie Destouches

IRP POLARIS
Ultrafast photonics for surface engineering
CRPuO Centre for Research in Photonics, Ottawa
Hubert Curien Laboratory

The Hubert Curien Laboratory and the Centre de Recherche Photonique of University of Ottawa (CRPuO) have recently formalised a collaboration project initiated in 2018, in the form of a new CNRS International Research Project (IRP, formerly known as LIA - Laboratoire International Associé).
The collaboration aims to develop state-of-the-art research on photonics for surface and materials engineering, in a top-down application-oriented approach in the fields of sensors, energy and security. Both partners intend to combine their respective skills in nanostructuring, ultrafast dynamics of ultrashort laser processes, modeling of laser-matter interaction, plasmonics, sensors in harsh environments or 3D optical systems, to develop a better understanding of the modification and control by light of a surfacefunctionalities. The project will be coordinated by our Laser-Matter Interaction team member Jean-Philippe Colombier for the French side, and Pierre Berini for the CRPuO.
This form of international association is the first to be created in our University, and constitutes one of the tools put in place by the CNRS to encourage and help researchers organize collaborations between its research units and leading laboratories around the world. The IRP is a 5-year collaborative research scheme between one or more CNRS laboratories and one or two laboratories from foreign countries, dedicated to strengthen previously-established collaboration through short and medium-term scientific exchange.
The collaboration between our institutions began in the summer of 2018, when Physicist and Photonics specialist Sylvain Charbonneau, Vice-President for Research and Innovation at Ottawa University, came to visit our facility. Lab directors Florence Garrelie and Pierre Berini then decided to strengthened the relationship between the two labs, and after a series of fruitful exchanges and visits, the idea of a joint laboratory emerged. In October 2019, two theses in joint supervision between the two laboratories were started, followed by several scientific publications that were presented and published at international conferences and journals.
The objective of the IRP POLARIS is to study, in a complementary way, the various scientific aspects allowing to answer a range of scientific and technological issues in the field of light-surface interaction with regards to the design, manufacture, observation and functionalization of surfaces.



Laser Matter Interaction team
Local Scientific Head:
Jean-Philippe Colombier (Hubert Curien Lab)

It will be structured around 4 axes, involving 3 different teams within our lab (Laser Matter Interaction, Functional Materials & Surfaces, MOPERE), each working on a specific subject but all seeking scientific and societal results:

- Light as a manufacturing process
  Structural and chemical surface functionalization by ultrashort laser pulses;
  Florent Bourquard & Florence Garrelie

- Light as a means of ultra-rapid diagnosis
  Observation and simulation of the dynamics of matter with sub-femtosecond resolution;
  Jean-Philippe Colombier, Elena Kachan, Jérémy Rouxel, Razvan Stoian

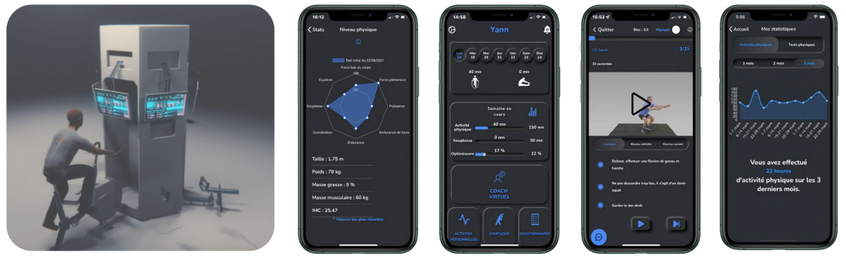
- Light as a means of detection
  Development of plasmonic biosensors by surface photolithography and magneto-optical modulation;
  Nicolas Crespo-Monteiro, Yves Jourlin, François Royer

- Light for communication purposes
  Development of fiber optic sensors for severe environments;
  Emmanuel Marin

Responding to a variety of societal challenges through the manufacture of surfaces by action of light, the two labs will commit to the establishment of a creative and multidisciplinary research and innovation field, in support of surface engineering.
By permeabilizing complementary activities between targeted researchers, the new IRP aims at further enabling exchanges between both labs. International high-impact publications and communications are soon expected. From a strategic point of view, this project will offer great international support to our lab and to initiatives of excellence such as the Manutech-SLEIGHT Graduate School. The CRPuO being undoubtedly the most important Canadian research center in optics/photonics and one of world's leading in the field, the Laboratoire Hubert Curien is proud to have established such a partnership.

Started in January 2023, the scientific programme of POLARIS is scheduled to run until December 2027, with an official inauguration planned for April 2023.

LIBM / Hubert Curien Laboratory
A virtual coach to personalize exercise prescription



Left: A visualisation of the mobile self-evaluation station; Right: 4 views of the mobile app's personal profile, virtual coach recommendations and progress monitoring.

Another story worthy of a special mention in this edition is that of our work on a virtual coach for exercise prescription, composed of a self-autonomous evaluation station, and a personalized training algorithm, with the aim of improving quality of life and physical capacities of sedentary adults. This project is carried by Yann Le Mat's PhD thesis at LIBM (Laboratoire Interuniversitaire de Biologie de la Motricité, Jean Monnet University), done under the supervision of Guillaume Millet (LIBM), Jérémy Rossi (LIBM) and member of our Data Intelligence team Mathias Géry.
It is well known that regular physical activity not only decreases the prevalence of certain medical conditions and diseases, but also alleviates chronic fatigue, as well as improving well-being and quality of life. However, changes in our lifestyles have driven us towards more sedentarism and inactivity, a tendency that has been reinforced by the Covid crisis. The team has developed a mobile self-assessment station that first tests a user's physical abilities such as endurance, strength, power, flexibility, strength endurance, coordination and stability on different self-made ergometers. Those ergometers have been developed from the sensors to the user interface (using open-source technologies) in order to be operated independently of any investigator's intervention. The station is then connected to an app that can prescribe personalised recommendations of physical activities. These recommendations are based on the data collected by the station, the user's profile, as well as their personal choices and preferences. The app therefore works as a virtual coach, making individualised physical activity programs accessible to all.

The project is currently in a phase of scientific validation, that will hopefully demonstrate its ability to significantly improve physical fitness and quality of life. A total number of 135 persons have been enrolled, with one group following the recommendations of the app, and another following those of the World Health Organization (i.e. 150 minutes of moderate-intensity aerobic physical activity per week, for everyone). The data collected will also help refining the recommender system (optimizing the parameters of the ranking function between a user's profile and a predefined set of physical activities), as well as the overall concept. After the scientific validation phase, the team intends to create a startup, with the objective of installing of mobile self-assessment stations in various locations, covering for instance the large network of Maisons Sport-Santé recently created in France. We can also imagine stations installed in offices at work, or being used during large private or public events. The particularity of this project resides in the fact that it considers users' individual characteristics in order to provide some personalised training sessions without any human coach intervention, and offers a time-saving and playful experience. The system thus has the capacity to revolutionise the health and wellbeing through sport concept. The project was awarded the «α-pouss label» by the startup accelerator Pulsalys, and was mentioned on 21st July 2021 at the Assemblée Nationale by Régis Juanico (deputy for the Loire department), co-author of an information report on public health's national, policies. It was described as a "very promising initiative which would enable to reach people remote from physical activities".

Data Intelligence team
Local Scientific Head: Mathias Géry (Hubert Curien Lab)
PhD student: Yann Le Mat (LIBM UJM)
Supervisor: Guillaume Millet (LIBM UJM)
Co-supervisor: Jérémy Rossi (LIBM UJM)

RESEARCH & CONTRACTS & PARTNERSHIPS

Our lab is consistently pursuing a policy of very active engagement in national and international projects.
In this section, we compile our on-going projects supported by the European Commission, the ANR, the Auvergne-Rhone-Alpes Region and by our industrial partners. A small selection of these projects are also developped here.

Our research teams are currently working on approximately 100 funded projects, including 10 European contracts, 26 ANR projects granted until 2022 as well as 14 region-financed projects. Several of our doctoral students are working under CIFRE or other industrial contract theses.

KEY TO TEAMS:

Functional Materials & Surfaces	FMS
Materials for Optics & Photonics in Extreme Radiation Environment	MOPERE
Laser Matter Interaction	LMI
Image Science & Computer Vision	ISCV
Data Intelligence	DI
Secure Embedded Systems & Hardware Architectures	SESAM

ongoing 2022 ANR PROJECTS

Project acronym & title		Ref. no: ANR-	Team
FIDELIO	*Fiber-based In-vivo Realtime Dosimetry for Pulsed Radiotherapy*	20-CE19-0024	MOPERE
NOEMR	*Nano-structured smart hybrid polymeric composites with internal architecture towards improving ultra-high absorbance of ElectroMagnetic Radiation*	20-CE06-0003	FMS
SEGSED	*Size Segregation in Sediment Transport*	16-CE01-0005	ISCV
DIKÉ	*Bias, fairness and ethics of compressed NLP models*	21-CE23-0026	DI
APRIORI	*A PAC-Bayesian Representation Learning Perspective*	18-CE23-0015	DI
SMARTL	*Self-organized multifunctional multi-material structures for LED lighting*	19-CE08-0001	FMS
MEGALIT	*Metal Glasses functionalization by ultrashort Laser-Induced topology and phase Transition*	18-CE08-0018	LMI
CRUMBLE	*Chromium-based coatings for lasers*	21-CE24-0034	FMS
HORUS	*High Optical Resolution for Unlabelled Samples*	18-CE45-0010	ISCV
UNDERNEATH	*Understanding Deep Neural Networks with Game Theory*	21-CE23-0022	DI
INTRALAS	*Unraveling intra-pulse dynamics and fast energy transfer in silica glass - a pathway for smart processing using ultrafast lasers*	19-CE30-0036	LMI
COSWOT	*Constrained Semantic Web of Things*	19-CE23-0012	DI
ARCHI-SEC	*Micro-Architectural Security*	19-CE39-0008	SESAM
ASTRAL	*Statistical learning for multi-dimensional SAR imagery*	21-ASTR-011	ISCV
NITRURATION	*Manufacturing process of micro-nanostructured metal nitrides*	21-CE08-0042	FMS
MIXUP	*Color images multiplexing by laser structuring of plasmonic materials for security and personalization of ID cards*	18-CE39-0010	FMS
MUDIALBOT	*Multi-party perceptually-active situated Dialog for human-robot interaction*	20-CE33-0008	ISCV
GESPAD	*Ge-based Single Photon Avalanche Diodes: from comprehensive characterization to advanced simulation*	20-CE24-0004	ISCV
HYPERSOL	*Interfaces management of Hybrid Perovskite based Solar cells*	18-CE05-0021	ISCV
TAUDOS	*Theory and Algorithms for the Understanding of Deep learning On Sequential data*	20-CE23-0020	DI
DENSE	*Dense structures on the nanoscale*	21-CE08-0005	LMI
ROIi	*Rey's Ornament Image investigation*	20-CE38-0005	ISCV
POP	*Power-OFF laser attacks on security Primitives*	21-CE39-0004	SESAM
CAPTAIN	*Optical sensors for air quality monitoring (gaz NO_2, O_3)*	18-CE04-0008	FMS
SAFE	*Controlling networks with safety bounded & interpretable machine learning*	21-CE25-0005	DI
PHOTOMAGNET	*3D photostructuring at submicon scales of functional magnetic nanocomposite materials*	16-CE09-0017	FMS

35 ongoing 2022 **INDUSTRIAL PROJECTS**
16 ongoing 2022 **CIFRE thesis**

ongoing 2022 EUROPEAN COMMISSION PROJECTS

Project acronym & title		Team
RADNEXT	*RADiation facility Network for the EXploration of effects for indusTry and research*	MOPERE
EMPIR BxDiff	*New quantities for the measurement of appearance*	ISCV
PREMIERE	*Performing arts in a new era: AI and XR tools for better understanding, preservation, enjoyment and accessibility*	ISCV
EURIPIDES/PENTA FA 4.0	*Key for reliable electronic devices in smart mobility and industrial production*	ISCV
SWISSMODICS	*Development of a Sensor with WIde Spectrum Sensitivity for MOnitoring of Damage and Defects In Composite Structures*	MOPERE
PHOTONHUB	*Services to support your innovation in Photonics*	MOPERE
EURAD (MODATS)	*European Joint Programme on Radioactive Waste Management*	MOPERE
LASERIMPLANT	*Laser-induced hierarchical micro-/nano-structures for controlled cell adhesion at implants*	LMI
ACTPHAST 4 R	*Access CenTer for PHotonics InnovAtion Solutions and Technology*	FMS
ACTPHAST 4,0	*Access CenTer for PHotonics InnovAtion Solutions and Technology*	FMS
GREAT	*Grating Reflectors Enabled laser Applications and Training*	FMS
SERECO	*Semantic, Reasoning and Coordination - Creation of a Franco-German doctoral college*	DI

ongoing 2022 AURA REGION PROJECTS (Auvergne-Rhône-Alpes)

Project acronym & title		Team
SLIM	*Innovative Laser Additive Synthesis for Magnetic Materials*	FMS
PAI 2021	*Lighting and mixed reality for the assistance of the visually impaired*	ISCV
FORMEL	*Functional transformation of metallic glass surfaces by laser irradiation*	LMI
PAI 2019	*Light-surface interaction: from nanostructuring to functional detection*	LMI
VASOC	*Towards the Security Audit of Connected Objects*	SESAM
DIAGHOLO	*Microbiological Diagnosis by Holographic microscopy*	ISCV
SECURE-RISC-V	*Secure version of the Risc-V architecture*	SESAM
TADALoT V	*Anomaly Detection by Machine Learning using Atypical Losses and Transfer-learning*	DI
BOOSTER VISIOFEM	*Vision-assisted non-planar machining of surfaces*	ISCV
GRAFEM	*Femtosecond laser engraving machine*	LMI
MICROSOLEN	*Direct Microstructuring of Sol-gel layers for Energy*	FMS
CAPTHY	*Optical Sensors for Hydrogen detection*	FMS
BOOSTER QABOT	*Question Answering & Chatbot*	DI
COCOLI	*Color Constancy in various Lighting environments using new sensors/display devices*	ISCV

new 2022 ANR projects

In 2022, no less than 8 projects submitted by the Hubert Curien Laboratory were selected for an ANR AAP 2021 funding.
The list of these projects reflects the variety and quality of the research carried out in our lab.

PRCE PROJECT: DENSE
Project coordinator: Laboratoire Hubert Curien
Partners: LaMCoS, FEMTO-ST, LGF, LGL.
Lab's coordinator: Razvan Stoian
Laser Matter Interaction team

DENSE - "Dense structures on the nanoscale"
The project suggests an innovative technique to create new material structures & high density structural packing in fused silica & related materials, from high density vitreous phases to new crystalline forms. This is based on ultrafast laser-induced extreme conditions confined in a nanoscale solid volume as means for novel material phases & polymorphs.

JCJC PROJECT: NITRURATION
Project coordinator: Laboratoire Hubert Curien
Lab's coordinator: Nicolas Crespo-Monteiro
Functional Materials & Surfaces team

NITRURATION - «Manufacturing process of micro-nanostructured metal nitrides»
The goal of this project is to develop a process for metal nitride films micro-nanostructuring from the nitriding of metal oxide sol-gel coatings (TiO_2, ZrO_2, etc.) micro-nanostructured. This innovative approach would enable to obtain micro-nanostructured coatings of metal nitride on various types, shapes & sizes of substrates. It would also allow a direct micro-nanostructuring method by optical lithography or by embossing (NanoImprint), thus facilitating its industrial valorization.

PRCE PROJECT: SAFE
Project coordinator: Laboratoire Hubert Curien
Partners: Université Rennes 1, Université Poitiers, Huawei and QoS Design.
Lab's coordinator: Kamal Singh
Data Intelligence team

SAFE - "Controlling networks with safety bounded and interpretable machine learning"
This project aims to design safety bounded and interpretable ML solutions for controlling networks. An innovative approach is adopted where intelligence will be distributed in the network between a global AI module (at the central level) and different local AI modules (at the edge level) collaborating with each other by integrating traditional models with graph neural networks and reinforcement learning. The method, developed for partially or completely observable/controllable environments, will natively integrate safety bounds, interpretability and provide self-adaptive systems for routing, traffic engineering and scheduling.

PRCE PROJECT: DIKÉ
Project coordinator: Laboratoire Hubert Curien
Partners: Laboratoire ERIC (Lyon2), NaverLabs Europe
Lab's coordinator: Christophe Gravier
Data Intelligence team

DIKÉ - "Bias, fairness and ethics of compressed NLP models" *(See special focus on page 14)*
The DIKÉ project aims at identifying, explaining and mitigating biases in compressed Language Models used in Natural Language Processing for the automation of any written text's processing. It focuses on fairness & ethical biases appearing after compression of such models, especially transformer-based text encoders. By creating bilingual dataset of bias, fairness & ethics, the research team looks to devise evaluation metrics, perform evaluation campaigns on compression techniques and suggest new neural architectures for less biased, fairer & more ethical compression techniques of Language Models.

JCJC PROJECT: UNDERNEATH
Project coordinator: Laboratoire Hubert Curien
Lab's coordinator: Ievgen Redko
Data Intelligence team

UNDERNEATH - "Understanding Deep Neural Networks with Game Theory"
The team aims to explore the relationship between Deep Neural Networks (DNNs) and game theory by studying congestion games and their connection to linear and non-linear DNNs, and their loss surface properties. This research could lead to a promising new tool for analyzing DNNs and help solving open problems related to DNN optimization inefficiency and new optimization strategies proposals.

PRC PROJECT: POP
Project coordinator: Ecole des Mines de Saint-Etienne
Partners: Laboratoire Hubert Curien, TIMA, LCIS (Valence)
Lab's PI: Viktor Fischer
SESAM team

POP - «Power-Off laser attacks on security Primitives»
The main goal of this project is to guarantee the integrity of hardware security primitives, when the logic devices are attacked by laser beams while their power supply is off. It will be achieved in two main steps: 1/ assessing & modelling of power-off laser attacks on an experimental basis; 2/ developing & validating countermeasures against this type of attacks.

PRCE PROJECT: CRUMBLE
Project coordinator : IMEP-LAHC Grenoble (L. Bastard).
Partners: ICCF Clermont, Laboratoire Hubert Curien, TeemPhotonics SA.
Lab's PI: François Royer
Functional Materials & Surfaces team

CRUMBLE - «Chromium-based coatings for lasers».
The objective of this project is to design microlasers with shorter pulses (500 picoseconds instead of 700), for applications in telecoms & micromarking. A material with specific saturable absorption & gain medium properties will be developed. It will consist of yttrium-aluminium oxide nanocrystals doped with chromium atoms, embedded in a sol-gel matrix. This material will be used in integrated optical devices on glass.

ANR PROJECT: ASTRID « ASTRAL »
Project coordinator: Télécom Paris
Partners: CNAM Paris, ONERA , Laboratoire Hubert Curien
Lab's PI: Loic Denis
Image Science & Computer Vision team
+ Data Intelligence team

ASTRAL - «Statistical learning for multi-dimensional SAR imagery»
The project's main objective is to develop new approaches for analyzing & interpreting scenes from SAR data, by including the physics of SAR within the learning technique. The work revolves around 3 axes: 1/ representation of knowledge in deep networks; 2/ learning strategies in the case of a small number of labeled data; 3/ development of applications for the characterization & monitoring of the urban environment in SAR imagery.

PEPR projects

Many members of the Hubert Curien Laboratory are involved in the follow-up of the «France 2030» programs, initiated in 2021 by the French Governement. As such, Priority Research Programs and Equipment (PEPR) aim to build or consolidate French leadership in scientific fields linked to technological, economic, societal, health or environmental transformation, and which are considered as priorities on a national or European level. We present here a list of the selected programs in which the lab is involved.

PEPRs exist in 2 forms: “national acceleration strategy PEPRs” and “exploratory PEPRs”. These programs benefit from a state financial support, and are managed by the National Research Agency (ANR). Each scheme is either an existing, already mature project for which a contract binding a coordinating establishment and the ANR is established, or a project selected following an open call for proposals (AAP) or calls for expressions of interest (AMI), and related to the program’s thematic.

National Acceleration Strategy PEPRs:
These PEPRs support transformations already underway with well-identified products, services, uses and actors. Approximately 20 acceleration strategy PEPRs have been identified, most of which are piloted or co-piloted by the CNRS.

Cybersecurity PEPR:
With a budget of 65M€, this PEPR aims to support upstream cybersecurity research by exploring new avenues potentially leading to breakthrough innovations to the benefit of the French sector.
The Laboratoire Hubert Curien’s SESAM team is involved in this program through the 550k€ “Secure architectures for embedded digital systems” (ARSENE) project, headed by Lilian Bossuet. The project focuses on hardware security and heavily constrained processors for embedded computing, such as headsets or on-board computer systems in cars.

Quantum Technologies PEPR:
For reasons of national and European sovereignty, the French state is seizing on the problem of quantum technologies’ development. It seeks to reach the highest level of international scientific and industrial competition, and hopes for France and Europe to gain their independence in this key area thanks to a 150M€ program that should enable the development of its own solutions.
With his «Post-quantum padlock for web browser» project, SESAM’s team leader Lilian Bossuet is answering the problematic of this program.

Electronics PEPR:
Electronics is a core issue regarding the digital functionalities of products and services in our societies. This 86M€ program is aimed at generating innovations to accelerate growth and relocate the manufacturing of certain products to France or Europe.
Our NanoSaintEtienne (RENATECH+) platform will benefit from part of the 39M€ of this PEPR dedicated to support the equipment of the CNRS RENATECH / RENATECH+ infrastructures.

Our lab is also involved in the Artificial Intelligence PEPR and the TASE-Advanced Energy Systems Technologies PEPR.

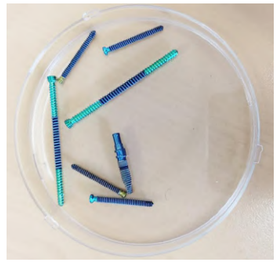
Exploratory PEPRs
With these PEPRs, the State intends to support the exploration of emerging transformations’ potentials. Projects should here follow a scientific policy aligning with national and European interests, with potential multiple outcomes.

Origins PEPR:
This 45 M€ PEPR intends to remove scientific barriers related to the study of life and the universe, with a view towards multiple implications on the national technological expertise and, consequently, on the country's economy, health and environment.
Our lab is involved in this program as part of a work package, led by Loïc Denis, grouping AI activities for the processing of multivariate data for the detection and characterization of exoplanets and disks.

Luma PEPR - Promoting Light-Matter Interactions:
Light, omnipresent in our natural and technological environment, is the subject of this 40M€ program. Luma aims to study, understand and develop this unique tool as a means of exploring and controlling physico-chemical and biological systems, at the interfaces between physics, chemistry, engineering and life sciences, and between health and environmental / climate science. The objective is to enable interdisciplinary synergies and cross-fertilisation for a new science.
This program is divided into 4 major work packages: Moonshot projects, Infrastructure, Innovation/incubators and Management/coordinated actions. Nathalie Destouches, together with Dario Bassani from ISM Bordeaux, is co-hosting the Moonshot Project MP2 "Smart Photoprocesses at Ultimate Space and Time Resolutions". The 3 teams of our Optic-Photonic Surfaces department are involved in this program. This PEPR will also fund the access (50 days/year) to the lab’s NanoSaintEtienne and Femtosecond Laser plateforms, as well as access to the GIE Manutech USD.

Our lab further contributes to the Diademe - Integrated Devices for Accelerating the Deployment of Emerging Materials PEPR and the Spin - SPINtronics innovations for a frugal, agile and sustainable digital technology PEPR.

EIC ‘LASERIMPLANT’ project
European Commission



Laser-Matter Interaction team
Local Scientific Head: Sedao
Start Date: January 2021
Contract duration: 27 months
Partners:
Hubert Curien Lab + Sainbiose
Manutech-USD
Bundesanstalt für Materialforschung und prüfung, Germany
JoHannes Kepler Universitat Linz, Austria
Danube Private University, Austria
HOFER Medical Solutions, Austria
Total budget: 2 M€

A large application area of medical implants are currently dental prostheses which should provide good and fast osseointegration into the jaw bone. In other applications, (e.g. screws and plates), the implants may have to be removed after several months or years, and should not be completely overgrown by the bodies’ cells. A one-step laser-based surface functionalization of implant materials for controlling the cell growth is therefore highly desirable.
The objective of the European Innovation Council (EIC) Pathfinder pilot project LaserImplant - Laser-induced hierarchical micro-/nano-structures for controlled cell adhesion at implants - is the cooperation between academia, research centers, laser-processing device developers and implant producers for the development of smart medical implants addressing wide-spread patients’ needs in the fields of dental prostheses, screws and plates for bone regeneration. The project consortium is widely interdisciplinary, combining renowned academic and industrial experts from the fields of medicine, surface chemistry, physics, materials sciences, laser-matter interaction and laser processing. The joint project consortium forms an excellent base for fundamental and applied research in the field of medical surfaces.
After 27 months of fast-paced research activities, 1 book and 11 papers have been published in highly-ranked peer-reviewed scientific journals, of which 6 have been co-authored by researchers of the Hubert Curien Laboratory. Further discussions on potential exploitations of the project research results are underway.

BxDiff *EMPIR project*

Surface appearance is critical to many manufacturing processes, and new measuring solutions are emerging. In order to certify these new measurement systems, national metrology centres are defining precise measurands, developing primary metrology instruments and creating standard samples. However, this task is far from being complete and still requires fundamental research. The European project "BxDiff - New quantities for the measurement of appearance" (2019-2022), founded by the European Metrology for Innovation and Research (EMPIR) program, could make a significant contribution thanks to a big consortium of 16 public institutions from 15 countries around the world, and numerous industrial companies. Among the many topics addressed in the project, the Hubert Curien Laboratory (Pierre Chavel, Mathieu Hébert), CNAM (Gaël Obein, Lou Gevaux), Institut Pprime (Lionel Simonot) and IOGS (Yvan Sortais) focused on the specific issue of measuring the bidirectional reflectance distribution function (BRDF) of a surface at very high resolution, close to the visual acuity of the human eye. This requires illuminating the surface with a very collimated light beam, i.e. a very spatially coherent wave, and leads to a speckle phenomenon considered as noise by primary metrologists. Solutions to eliminate this effect have been successfully explored in the thesis of Thomas Labardens by averaging several measurements in different positions on the sample, and thus reviewing the definition of BRDF.

Image Science and Computer Vision team
Local Scientific Head: Mathieu Hébert
Contract duration: 3 years
Start Date: May 2019
Partners: Hubert Curien Lab
+ 2 academic institutions
+ 9 national metrological institutes
+ 5 industrials
Total budget: 1.6 M€

PREMIERE project
European Commission

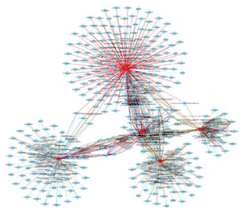
Image Science and Computer Vision team
Local Scientific Head: Alain Trémeau
Contract duration: 36 months
Starting Date: October 2022
Partners: Hubert Curien Lab
+ 11 european institutions
Total budget: 3,9 M€

The PREMIERE project is an illustration of the growing importance of the interrelationships between AI and XR technology developments, and an example of their potential extensive applications.
Focusing on dance and theatre, PREMIERE seeks to modernize the performing arts by using advanced digital technologies to support the whole lifecycle of performances: from their production and curation by both amateurs and professionals, to their delivery and understanding from the audience, as well as their analysis and interpretation by art scholars.
In doing so, PREMIERE will contribute to the following general goals:

- Broaden accessibility to audiences that cannot attend live performances due to physical distance (audience in remote areas such as islands or villages, international audience), health reasons (e.g. elderly, reduced mobility or economic reasons (low income);
- Enhance the understanding of present and past performances by audiences with diverse cultural, social, historical and educational backgrounds;
- Enrich the creative process by adding new elements, dimensions and capabilities offered by advanced digital technologies, while enabling international (and therefore inter-cultural) collaboration;
- Increase the visibility of performances by supporting spectators in their search for relevant content, as well as assisting producers/curators in the communication of their work to the most relevant audiences.

The overall objective of PREMIERE is thus to develop and validate a comprehensive ecosystem of digital applications, powered by leading edge AI, XR and 3D technologies. It is designed to fulfil the needs of diverse end-user communities involved in the main stages of the performing arts productions’ lifecycle; these include amateur and professional performers, performance art producers and curators, performance art spectators and scholars.

CODANA project
International Emerging Actions(IEA - CNRS)
Alberta Machine Intelligence Institute (Amii)

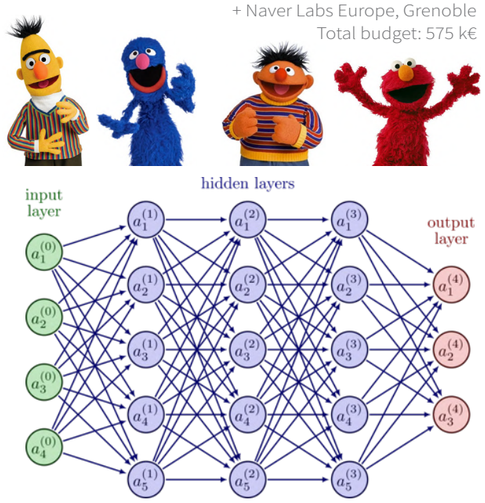


Data Intelligence team
Scientific Head: Christine Largeron
Contract duration: 24 months
Starting Date: December 2021
Partners: Hubert Curien Lab
+ Amii, Alberta University, Canada

The Hubert Curien Lab‘s Data Intelligence team is collaborating with the Alberta Machine Intelligence Institute (Amii) at Alberta University (Canada), within the CODANA IEA project’s framework.
International Emerging Actions (IEA) are PI-to-PI projects supported by the CNRS, with the purpose of exploring new fields of research and international partnerships.
Benefiting from the expertise of both the Hubert Curien Laboratory and Amii, CODANA (Data mining and Machine Learning for Complex Data Analysis) aims to address challenging AI field’s topics related to Machine Learning and Data Mining for complex data analysis. The joint team will notably study complex networks in presence of incomplete/uncertain data, and design explainable and interpretable representation learning models for complex data.

DIKÉ *ANR project*

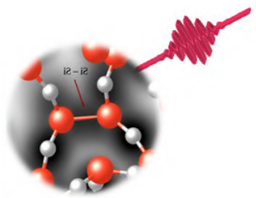
Data Intelligence team
Local Scientific Head: Christophe Gravier
Contract duration: 48 months
Start Date: January 2022
Partners: Hubert Curien Lab
+ Laboratoire ERIC, Lyon
+ Naver Labs Europe, Grenoble
Total budget: 575 k€



Natural Language Processing (NLP) is a subdomain of Artificial Intelligence which goal is the automation of processing any written text. It supports a wide range of text analysis applications (classification, sentiment analysis, grammar checker, spam detection, etc.) but also generation tasks such as machine translation, text summarization, conversational agents (chatbots), question answering, etc. Nowadays, most tasks are tackled using models trained as deep neural networks, so called Language Models (LM).
The ANR funded Diké project focuses on fairness of these language models. More precisely, it aims at identifying and mitigating bias issues (fairness and ethical biases) when compressing NLP models, especially transformer-based text encoders (BERT, GPT, etc.). If language models are the most essential method for creating modern NLP systems, they become so parameter-hungry that they must rely on compression techniques for deployment by NLP practitioners. However, it seems that all current compression techniques only focus on preserving the model accuracy on a given task, leading to potential ethical harmful effects. Most models being within any developer's reach, the fact that their compression could compromise their fairness and ethics constitutes a major issue that the DIKÉ project intends to tackle. By creating bilingual (English and French) bias, fairness and ethics datasets, the research team looks to devise evaluation metrics and perform evaluation campaigns on compression techniques, and propose new neural architectures for less biased, fairer and more ethical compression techniques of language models.

INTRALAS *ANR project*

Laser-Matter Interaction team
Scientific Head: Jean-Philippe Colombier
Start Date: April 2019
Contract duration: 48 months
Partners: Hubert Curien Lab
+ Max-Born Institute, Berlin
Total budget: 600 k€



INTRALAS - Unraveling intra-pulse dynamics and fast energy transfer in silica glass; a pathway for smart processing using ultrafast lasers - is an ongoing project funded by the ANR and done in collaboration with the Max-Born Institute. The research team aims at significantly advance the understanding of primary processes under light, suggesting original methods and experimental/modelling strategies, with great potential benefits related to material transformation and laser matter interaction at ultrashort timescales.
Nowadays, micro/nano- technologies are critically dependent on the development of precise and controllable processing tools able to structure materials with utmost precision. With its intrinsic processing capabilities well into the nanoscale, ultrashort laser processing seems to be the ideal technology to take up this challenge. To optimize structuring in terms of yield and scale, the concept of smart laser material processing has emerged, based on the spatiotemporal design of irradiation to the material's response. Defining advanced processing strategies requires an understanding of the primary electronic processes governing laser energy deposition and relaxation paths (electronic vs vibrational) towards structural modifications. Little information is available at the moment. This pertains to processes occurring on the timescale of the pulse, notably material dynamics during the excitation phase. In this project, the team targets functional glasses in view of their nonlinearities and fragile structures, and their potential for 3D design. They submit a time-resolved introspection into electronic and structural evolution in fused silica upon ultrafast laser irradiation. The objective is to elucidate primary pathways of coupling and depositing energy during the timescale of the processing pulse.

ROIi *ANR project*

ROIi Rey's Ornament Image investigation

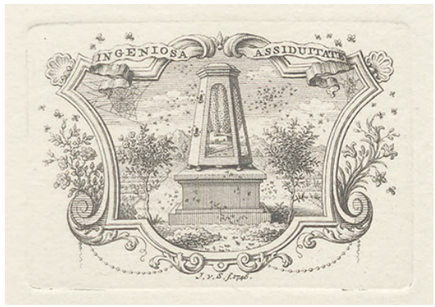


Image Science & Computer Vision team
Local Scientific Head: Thierry Fournel
Contract duration: 4,5 years
Start Date: March 2021
Partners: Hubert Curien Lab
+ Laboratoire IHRIM, Saint-Etienne
Total budget: 300 k€

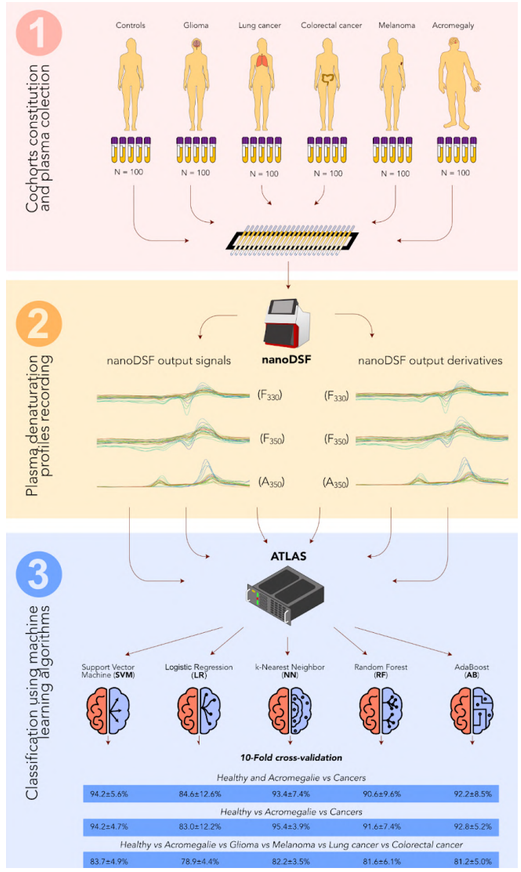
ROIi (Rey's Ornament Image investigation) is an ANR funded project that brings together researchers from digital humanities, computer vision and machine learning. Started in March 2021 for a duration of 4.5 years, this multi-disciplinary project is coordinated by Christelle Bahier-Porte from the Laboratoire Ihrim (Institut d'histoire des représentations dans les modernités), at Jean Monnet University, in collaboration with our lab's Image Science & Computer Vision and Data Intelligence teams. The aim of the ROIi project is to create an ornaments' database associated with new models for ornament analysis, to help with the attribution of Enlightenment-era books published under fictitious or counterfeit names or addresses. The ornaments to be catalogued are those by the famous bookseller Marc Michel Rey (1720-1780).
Beyond the Ihrim and the Hubert Curien Laboratory, the project involves several entities such as the Bibliothèque municipale de Lyon (for collecting the source images and testing the developed models) or the TGIR Huma-Num (that will host the resulting database and the project's results). The project also includes experts in old ornaments from the Bibliothèque Cantonale et Universitaire de Lausanne and from the University of Birmingham, UK. It also benefits from the technical support of the University of Oxford's Visual Geometry Group (VGG), for the implementation of the Visual Image Search Engine, a tool playing a pivotal role in major (ornaments) databases. The ROIi project was presented at the latest Digital Humanities Conference (DH2022), as part of a four-papers panel* to suggest even finer pattern analyses to better assist human expertise.

**Computer Vision for the Study of Printers' Ornaments and Illustrations in European Hand-Press Books;* C. Bahier-Porte; G. Bergel; A. Dutta; T. Fournel; D. Thomas; F. Vial-Bonacci; H. Wilkinson; A. Zisserman; L. Denis; R. Emonet; A. Habrard; V. Ventresque; T. Gautrais.

AI4OP

Artificial Intelligence for Onco-Plasma

Data Intelligence team
Local Scientific Head: Rémi Eyraud
Contract duration: 3 years / Start Date: December 2020
Partners: Hubert Curien Lab
+ Institut de NeuroPhysioPathologie, Marseille
+ Laboratoire Informatique et Systèmes, Marseille
Total budget: 327 k€



AI4OP is a 3-year project (2020 - 2023) funded by the national action “Plan Cancer”, via the INSERM-MIC program. This interdisciplinary project gathers biophysicists, clinicians and machine learners seeking to create a universal and non-invasive method to help diagnose cancers. The suggested method is based on the existence of unique Plasma Denaturation Profiles (PDP) for different types of cancers. The plasma denaturation profile represents the total denaturation curve (under the influence of temperature) of its constituent proteins. Due to homeostasis, the plasma denaturation profiles of healthy individuals do not vary significantly. However, due to the disease, the composition of the blood or the thermal stability of circulating proteins may change, thus altering the plasma denaturation profile.

The project aims at demonstrating that:

1. PDP can unambiguously distinguish several types of cancers using state-of-the-art machine learning methods from a simple plasma sample;
2. this approach can help determine a tumor response or progression when under treatment, thus evaluating the possibility to use our approach for monitoring purposes;
3. it is possible to provide a comprehensive classification of PDPs, allowing a tumor molecular subgroups classification.

In order to achieve these objectives, the team works closely with oncologists to select cohorts of blood plasma from patients with different types of cancers including lung, colorectal, breast, gliobastoma, melanoma, etc., as well as from healthy donors. The generated profiles are stored in a database with a web interface developed for this project, and are automatically classified using machine learning methods also designed within the framework of the project. Interpretability of machine learning decision is another important element under investigation.

POTIC project

BPI France

MOPERE
+ Functional Materials and Surfaces teams
Local Scientific Head: Emmanuel Marin
Start Date: March 2021
Contract duration: 3 years
Partners: Hubert Curien Lab
+ AIRBUS
LIEBHERR
HUTCHINSON
SERMA
SILMACH
OLIKROM
ONERA
Total budget: 20 M€

The POTIC project - “POTentiel de vie Individualisé des Components” focuses on the study of aircrafts’ structural components and the monitoring of their behaviour throughout their use. POTIC is coordinated by Airbus and funded by the Direction Générale de l’Aviation Civile (DGAC). The project brings together 8 partners: 6 manufacturers (AIRBUS, LIEBHERR, HUTCHINSON, SERMA, SILMACH, OLIKROM), 1 public research centre with industrial and commercial operations (Office National d'Etudes et de Recherches Aérospatiales - ONERA) and 1 academic institution (University of Saint-Etienne). The objectives of the MOPERE and Functional Materials and Surfaces teams are to develop fiber optic Bragg grating sensors to measure vibrations and/or loads, as well as develop Sol-Gel sensors for impact detection. In this context, the Hubert Curien Laboratory is in charge of designing the entire measurement chain, from source to detector, including the signal acquisition and processing software.

udd@Orano project

BPI France

MOPERE team
Local Scientific Head: Sylvain Girard
Contract duration: 36 months
Starting Date: December 2021
Partners: Hubert Curien Lab
+ 8 industrial partners
(Aeraccess, Axionable, Diota, Ob’dO, Shark Robotics, Sileane, Predict, Probayes)
+ 2 research institutions
(CEA, Ecole des Mines de Saint-Etienne)
Total budget: 17 M€

The «Usines De Demain sur les sites industriels d’Orano» project - coordinated by the international industrial group Orano - aims at accelerating the deployment of the «factory of the future» at the heart of the group’s nuclear industrial sites. The objective is to combine the partners expertise to develop and implement new technological solutions to improve performance, production, factories competitiveness and operators’ safety. Innovative solutions are under development, such as miniaturized sensors for more efficient radiological measurements, new algorithms based on Artificial Intelligence to facilitate decision-making and anticipation of actions, mixed reality platforms based on 3D digital models and dematerialization of flows to assist operators in their missions, new robots for remote complex operations and automation of simple tasks. These new solutions will not only be applicable to Orano’s industrial sites, but also to the nuclear industry and the French industry as a whole. Meeting the criteria of the «France Relance - BPI France» plan, the udd@Orano project benefits from the financial support of the French government.

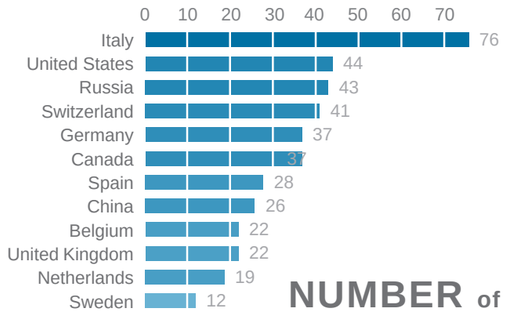
RESEARCH

SCIENTIFIC PUBLICATIONS

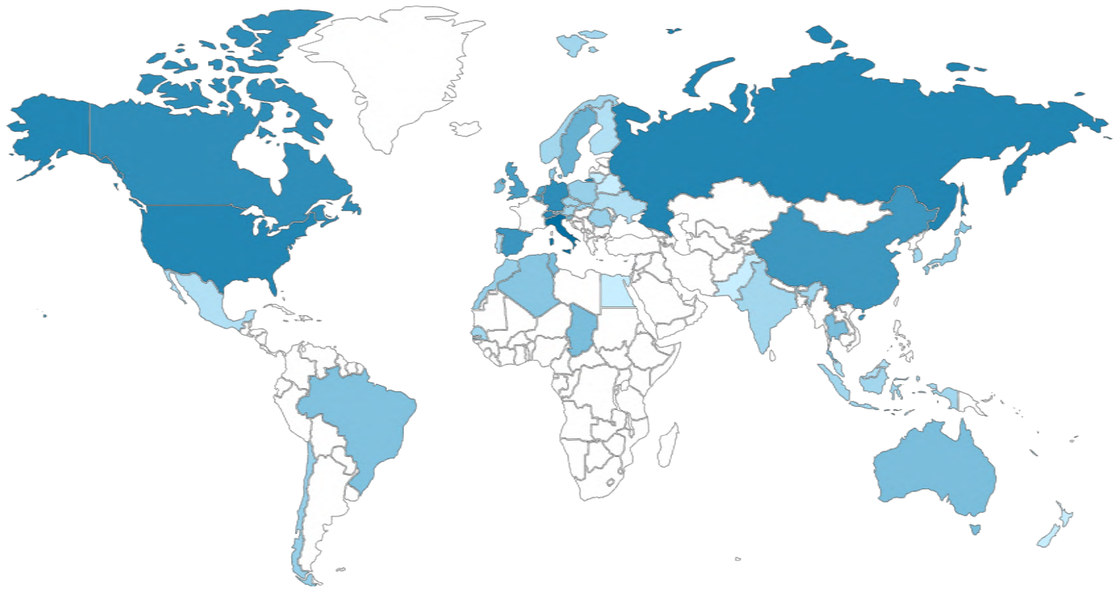
The Hubert Curien Laboratory is an internationally recognised and highly productive research institution. The following pages present an overview of our international publishing influence, as well as a selection of a few key papers published over the year 2022.

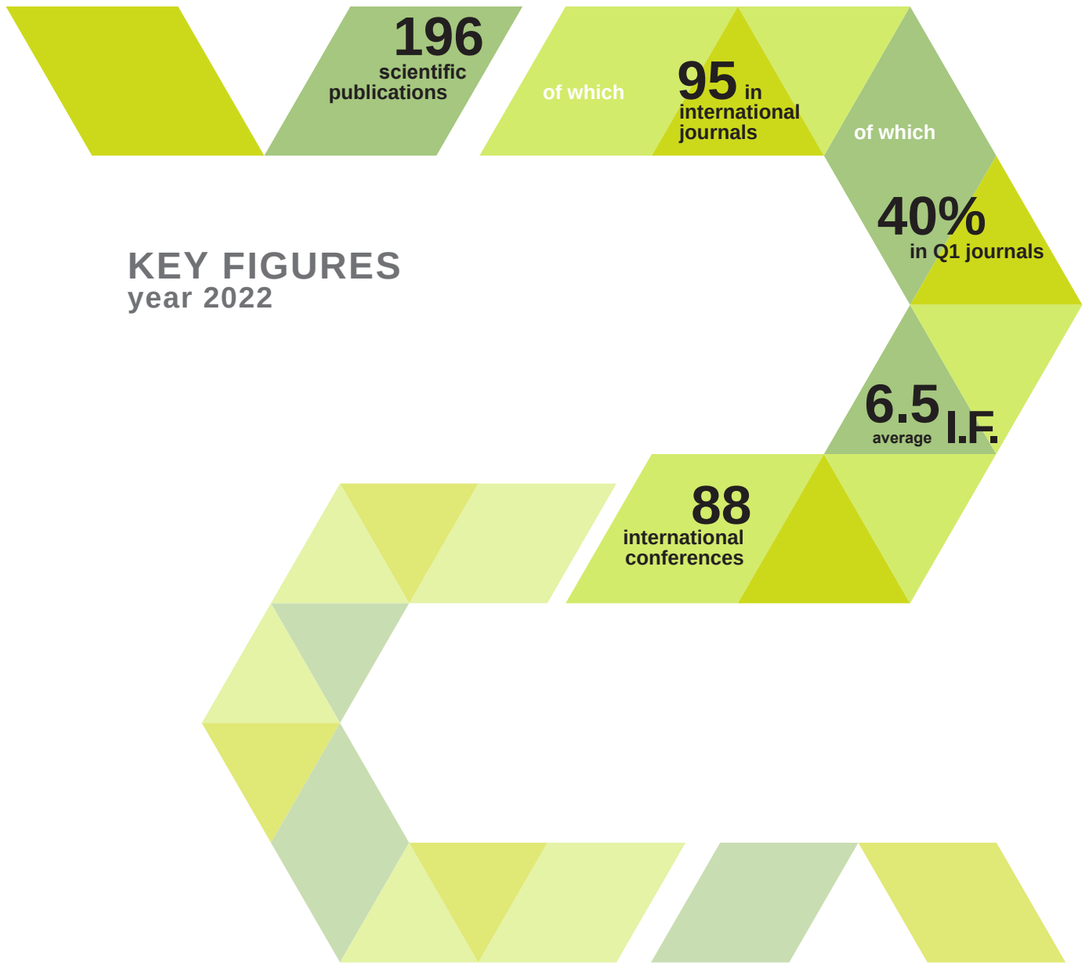
PUBLICATIONS
overview

Our research collaborations are considerably spreading beyond the national stage to reach all continents.
Below are some graphics illustrating the geographical location of the institutions we have published with since 2018, also indicating the number of publications by individual country.



NUMBER of publications with an author from this country
last 5-year period - 2018 to 2022 (non-exhaustive list)





KEY FIGURES
year 2022

Advanced Materials

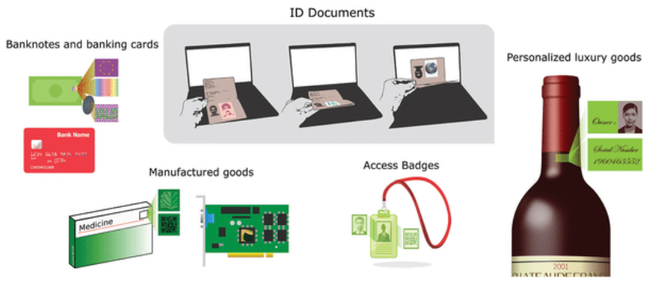
Anti-Counterfeiting White Light Printed Image Multiplexing by Fast Nanosecond Laser Processing

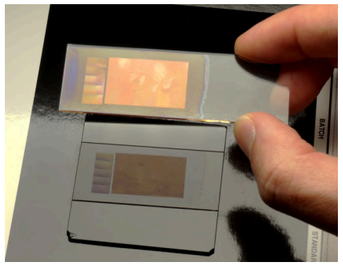
Nicolas Dalloz, Van Doan Le, Mathieu Hebert, Balint Eles, Manuel A. Flores Figueroa, Christophe Hubert, Hongfeng Ma, Nipun Sharma, Francis Vocanson, Stéphane Ayala and Nathalie Destouches.

An article written by the Hubert Curien Lab's Functional Materials and Surfaces team was published in Advanced Materials, a very high impact interdisciplinary journal published by Wiley-Blackwell.

Encoding several images in a single thin layer in such a way that they could be revealed independently by altering the conditions of observation of the layer has great potential for high-end anti-counterfeiting applications. Recently, the high contrast and dichroic properties of plasmonic colours have been soundly used to develop image multiplexing. Researchers at Hubert Curien Laboratory and HID Global CID have developed a laser processing technique that allows printing large multiplexed images at low cost, with a high flexibility and within very short times.

The laser beam tunes the statistical properties of the nanoparticle assemblies, like their size-distribution, their shape anisotropy, and their average spatial distribution through self-organization mechanisms. Yet, the laser processing reproducibly controls the macroscopic optical properties of these random plasmonic metasurfaces, and interestingly creates optical properties that are not accessible by other means. The team has demonstrated two- and three-image multiplexing under non-polarized white light, making the technology useful for real applications where an authentication is expected in few seconds.





Illustrations above:
Left: Applications of white light printed image multiplexing:
secure and personalized anti-counterfeiting protection for manufactured goods and documents.

Right: Two images combined in one, printed by a single laser beam in a thin layer (100 nm) of Ag:TiO_2, which are revealed independently in reflection and in transmission.

Adv. Mater., vol. 34, no. 2 (2021) p. 2104054.

Optical Materials Express - Special issue

Magnetic nanocomposite films with photo-patterned 1D grating on top enable giant magneto-optical intensity effects

Laure Bsawmaii, Emilie Gamet, Sophie Neveu, Damien Jamon and François Royer.

The Hubert Curien Lab's Functional Materials and Surfaces team published last year an article on magneto-optical resonant devices in Optical Materials Express, a journal covering advances in and applications of optical materials.

The article was featured in one of Optical Materials Express special issue, dedicated to Modern Magnetophotonic Materials and Applications. It explores the subject of magneto-optical (MO) planar devices, especially those providing enhanced sensitivity, and which are of high interest for several practical cases like biosensing or non-destructive testing.

MO enhancements are commonly obtained through the combination of a plasmonic resonance and a MO material, or through the micro-structuration of such materials. However, the devices often suffer from weak optical signal due to metal absorption, or require fastidious lithography processes hardly convenient for low-cost production. The authors present a much simpler device which consists of a photoresist 1D grating processed on top of a MO composite planar waveguide. This latter is formed by magnetic nanoparticles embedded in a silica matrix by a sol-gel process. Such all-dielectric device leverages from the good optical quality and low absorption of the film to produce much higher Q-factor (~300 instead of ~10) resonances which finally result in giant magneto-optical intensity effects in transmission and reflection. The magnitude of these effects, combined with the ability of the device to be processed on large scale and various substrates, are very promising for a wide range of sensing applications.

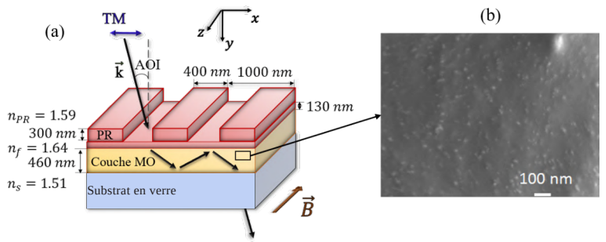


Illustration above:
Left: Schematic of the device under consideration.
Incident light (TM polarized) is resonantly reflected at a dedicated wavelength depending on the angle of incidence (AOI).
The magnetic field induces a spectral shift of this resonance leading to a modulation of the reflected and transmitted light intensity, as illustrated by the figure on the right: SEM picture of the nanocomposite material showing magnetic nanoparticles (~ 10 nm) embedded in a silica matrix.

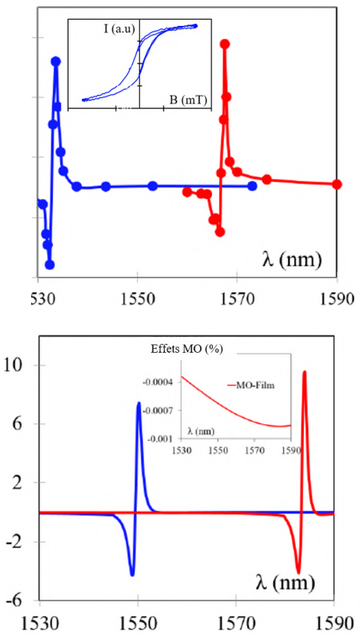


Illustration above:
Modulation (in %) of the transmitted light intensity as a function of the wavelength for two angles of incidence: 2° (Blue) and 4° (red). Top graph relates to experimental measurements (the inset shows the modulation as a function of the magnetic field).
Bottom graph relates to numerical simulations (The inset shows the effect obtained on a film without grating).

Opt. Mater. Express 12 (2022), 513-523

Optics Letters

Effect of roughness on surface plasmons propagation along deep and shallow metallic diffraction gratings

Hugo Bruhier, Isabelle Verrier, Thiaka Gueye, Christelle Varenne, Amadou Ndiaye, Olivier Parriaux, Colette Veillas, Stéphanie Reynaud, Jérôme Brunet and Yves Jourlin.

In January 2022, an article written by the Hubert Curien Lab's Functional Materials and Surfaces team was published in Optics Letters, a biweekly peer-reviewed scientific journal covering all topics pertaining to optics and photonics.

In their publication, the authors show the influence of roughness on plasmon resonance in the case of deep and shallow sinusoidal metallic diffraction gratings, and suggest ways to counteract these effects in sensor applications. The standard SPR case excited by a shallow grating (0th order) is investigated, as well as the "optical switching effect" that exploits both 0th and −1st diffracted orders within deeper gratings (above hundreds of nm for subwavelength gratings). The experimental results obtained in the case of the switching mechanism are discussed, highlighting the importance of taking into consideration the grating roughness effect on the sensor response in the case of deep gratings.

This work was funded by the Agence Nationale de la Recherche within the framework of the ANR CAPTAIN project (ANR-18-CE04-008).

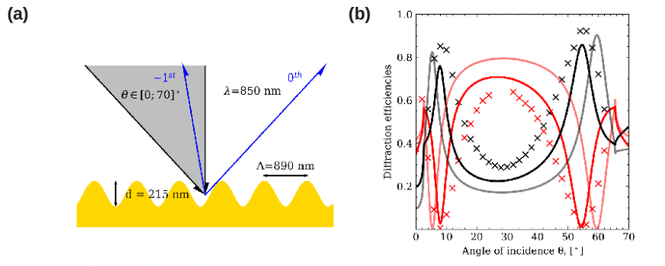


Figure 1 :
(a) Scheme of the deep sinusoidal gold grating (Λ = 890 nm, d = 215 nm) under a TM incident beam at λ = 850 nm, (b) Measured efficiencies (crosses) of the -1st order (red) and 0th reflected order (black) versus incidence angle compared to simulations (solid lines) where roughness ratio are ζ = 1.4% (grey and pink) and ζ = 2.6% (black and red).

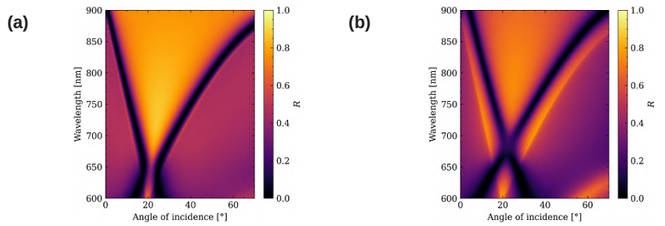


Figure 2 :
2D plot of the diffracted -1st order TM intensity versus incidence angle and wavelength for the deep grating (Λ = 890 nm, d = 215 nm): (a) smooth, (b) rough (roughness ratio ζ = 2.6%).

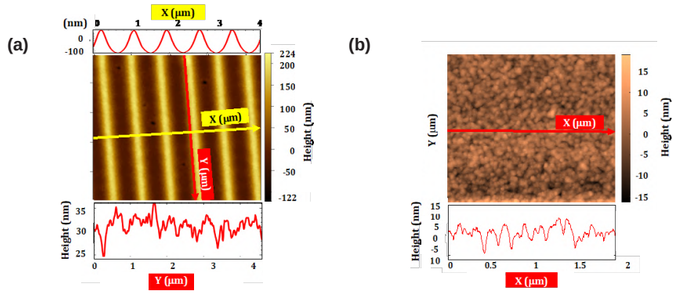


Figure 3 :
AFM scans and profiles: (a) at the edge of the line of the deep gold grating (Λ = 890 nm, d = 215 nm), (b) on the flat surface.

Opt. Lett. 47 (2022), 349-352

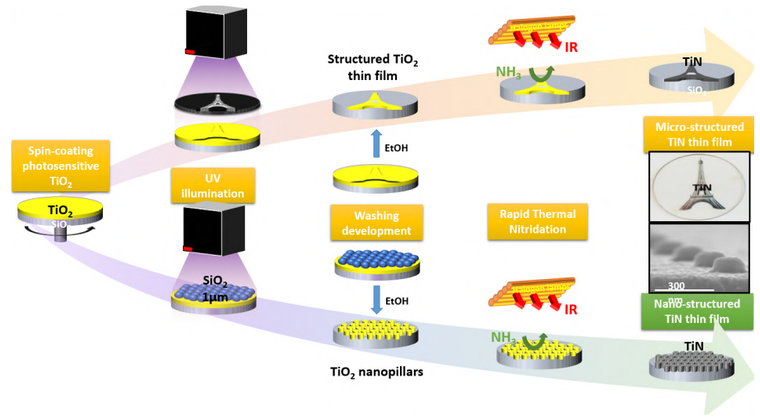
Surface and Coatings Technology

Optical, electrical and mechanical properties of TiN thin film obtained from a TiO2 sol-gel coating and rapid thermal nitridation

Arnaud Valour, Maria Higuita, Gaylord Guillonneau, Nicolas Crespo-Monteiro, Damien Jamon, Marion Hochedel, Jean-Yves Michalon, Stéphanie Reynaud, Francis Vocanson, Carmen Jiménez, Michel Langlet, Christophe Donnet and Yves Jourlin.

An article by our Functional Materials and Surfaces team was published in Surface and Coatings Technology, a journal dedicated to significant developments in surface and interface engineering.
Titanium nitride (TiN) is an attractive alternative material to replace gold and silver in plasmonic applications, particularly in the visible to near-infrared spectral range. TiN layers have indeed intrinsic physico-chemical and optical properties that make them very promising: low resistivity, high reflectance in the infrared spectral range, good corrosion resistance, good chemical inertness, good thermal stability (melting temperature at 2930°C), and high hardness (~30GPa). Manufacturing TiN films generally requires a vacuum technology, such as reactive magneton sputtering, molecular-beam epitaxy, chemical vapor deposition (CVD), atomic layer deposition (ALD) or pulsed laser deposition (PLD), under a nitrogen or ammonia atmosphere. Unfortunately, due to its good hardness and chemical resistance, TiN is difficult to micro-structure or etch directly.

An alternative solution proposed in many studies consists in using titanium dioxide (TiO_2) as starting material, as it is easier to structure, and then use a nitridation reaction to obtain TiN. During the nitridation reaction, ammonia breaks down into hydrogen and nitrogen; hydrogen facilitates the creation of oxygen vacancies, and the nitrogen reaction fills the vacancies, thereby transforming TiO_2 material into TiN material. The advantage of this process is that the structuring process is easy and compatible with sol-gel approaches. However, the nitridation reaction between the ammonia gas (NH_3) and TiO_2 occurs at high temperatures (~1000 °C), and the process is usually carried out in traditional ovens with a long exposure time (several hours) which limits its use to substrates that remain stable at high temperatures, limiting its industrial use.
In this article, the authors show the possibility to use a rapid thermal nitridation (RTN) process, allowing to obtain TiN coatings in very short time (a few minutes) and under much less restrictive conditions.



Above: Illustration of the process to obtain a titanium nitride film (structured or not) from a TiO_2 sol-gel coating and rapid thermal nitridation.

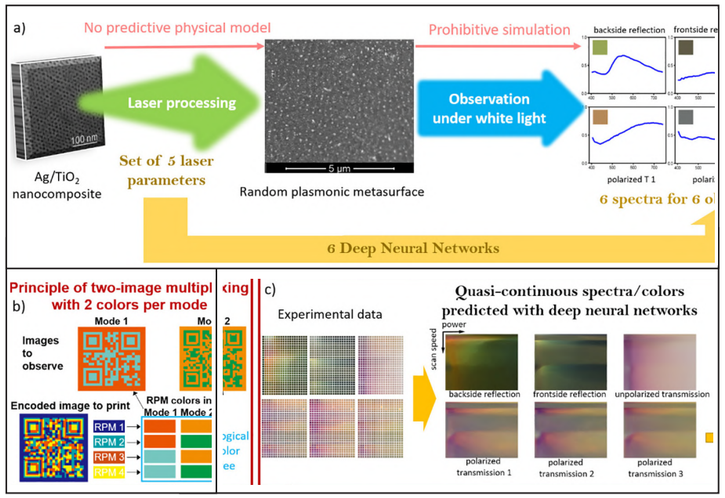
Surf. Coat. Technol., 413 (2021), Article 127089

ACS Nano

Predicting Laser-Induced Colors of Random Plasmonic Metasurfaces and Optimizing Image Multiplexing Using Deep Learning

Hongfeng Ma, Nicolas Dalloz, Amaury Habrard, Marc Sebban, Florian Sterl, Harald Giessen, Mathieu Hebert and Nathalie Destouches.

ACS Nano is an international journal publishing articles on nanoscience and nanotechnology research at the interfaces of chemistry, biology, materials science, physics and engineering. An article, result of a collaboration between our Functional Materials & Surfaces and Data Intelligence teams, was featured in their June 2022 edition.
Random plasmonic metasurfaces (RPMs) generated by laser processing display high brightness and dichroic properties. However, predicting the generated structures and simulating their colors in different modes is prohibitively expensive in terms of characterization and computation. This makes their use in novel image printing applications, such as image multiplexing, challenging. The present article proposes to optimize the selection of RPM by training deep neural networks and using a custom mining algorithm on an experimental RPM database. The deep neural networks accurately simulate the colors of the RPMs in six different modes, generating an enhanced RPM database. Mining this database allows to select optimized RPMs sets and realize image multiplexing.



Figures above:
a.) Rationale for the use of deep neural networks to predict the spectra and colors exhibited by a laser-processed random plasmonic metasurface (RPM) in various modes of observation.
b.) Logical color tree fulfilled by a set of four RPMs, solution for two-image multiplexing, with bicolor images. The encoded image printed by laser contains the four RPMs and displays to two different images when observed in modes 1 and 2.
c.) Six deep neural networks are trained from experimental data to predict the colors observed in the six modes. A mining process allows extracting all combinations of laser parameter sets that enable image multiplexing. One laser parameter set leads to one random plasmonic metasurface.

ACS Nano, 16, 6 (2022), 9410–9419

Nanophotonics

Mechanisms driving self-organization phenomena in random plasmonic metasurfaces under multi-pulse femtosecond laser exposure: a multitime scale study

Balint Eles, Paul Rouquette, Jan Siegel, Claude Amra, Julien Lumeau, Antonin Moreau, Christophe Hubert, Myriam Zerrad and Nathalie Destouches.

Our Functional Materials and Surfaces team have published an article in Nanophotonics, a scientific journal focusing on the interaction of photons with nano-structures, such as carbon nano-tubes, nano metal particles, nano crystals, semiconductor nano dots, photonic crystals, tissue and DNA.

In this article the authors describe a detailed study combining a broad range of experimental characterizations with numerical methods investigating the laser-matter interactions in ensemble of random plasmonic nanoislands encapsulated in a multilayer system. The interplay of laser-triggered mechanisms on multiple timescales results in a complex material response depending on the actual state of the gradually evolving system.

The study explores the prominent roles of the direct interaction of the nanoisland ensemble with the electromagnetic field, the laser-induced temperature rise and the material relaxation on multiple timescales, eventually resulting in laser-induced anisotropy and emerging self-organized nanopatterns. The observed structural transformations are interpreted by numerical investigations of the laser-induced temperature rise considering the effect of thousands of pulses, and electromagnetic calculations revealing the quantitative origin of the self-organization phenomenon. Based on the team's results, laser-processed plasmonic metasurfaces could converge to realization in applications that strongly rely on laser-induced optical dichroism, such as the technique of printed image multiplexing, data storage and digital fabrication of nanoscale electronics.

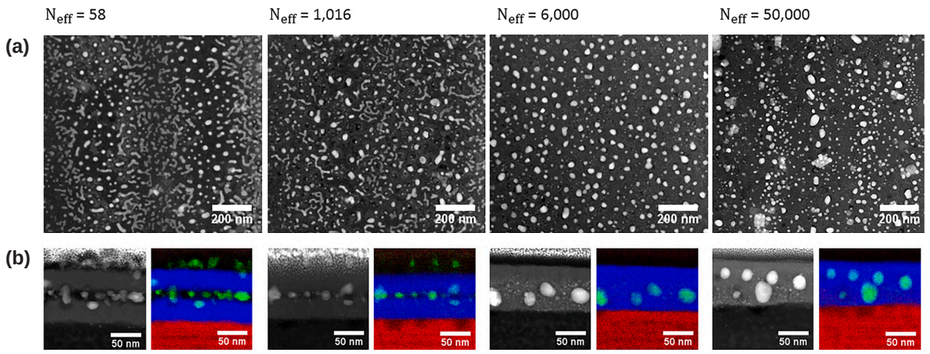


Figure above : Electron microscopic characterizations of ultrafast laser-written lines for Neff = 58, 1016, 6000, and 50,000 revealing the morph logical evolution of the sample.
(a) Plan-view HAADF-STEM images and
(b) HAADF-STEM images of the corresponding cross sections and chemical mappings indicating Ag (green), Ti (blue), and Si (red).

Nanophotonics, vol. 11, no. 10 (2022), pp. 2303-2318

Advanced Materials Interfaces

Versatile Micro and Nano Patterning Technique for TiO_2 and TiN-Based Sol–Gel Thin Films

Arnaud Valour, Marion Hochedel, Maxime Royon, Maria Alejandra Usuga Higuita, Nicolas Crespo-Monteiro and Yves Jourlin.

An article written by our Functional Materials & Surfaces team was published in September 2022 in Advanced Materials Interfaces, a journal dedicated to top-level research on functional interfaces & surfaces, and their specific applications.

Titanium dioxide (TiO_2), as well as titanium nitride (TiN) layers, are two highly studied materials widely used in various fields due to their intrinsic properties. TiO_2 layer is non-absorbent in the visible range with a high index. It finds many applications including photocatalysis, anti-reflections or decorative coatings. On the other hand, TiN is a highly reflective metal layer with good mechanical and chemical properties. Besides the golden color that makes it particularly attractive as a decorative coating, it can be used as a substitute for gold or silver in the field of plasmonics and metasurfaces, when a micro-nanostructure is added to the coating. However, most technologies achieving micro and nanopatterning of both TiO_2 and TiN films, as commonly found in the literature, are not suitable for the production of complex patterns (shapes, micro-nanostructures, etc.). This is particularly true for TiN. Due to its intrinsic properties, especially its hardness and chemical resistance, TiN is indeed difficult to pattern. Existing techniques allowing the formation of TiN micro-nanostructures are difficult to implement and very time-consuming, with a multiple etching process making them unsuitable for the production of complex patterns. A simple alternative method, developed in our laboratory, has allowed to more easily obtain TiO_2 and TiN micro / nano-structures. For this purpose, the team have elaborated an innovative and direct rapid thermal nitridation (RTN) process that has enabled to obtain TiN layers from a photo-patternable TiO_2 sol–gel coating using relatively soft nitriding conditions [1].
In this article, the authors present a versatile technology for the elaboration of micro-nanopatterned TiO_2/TiN layers, by combining different patterning techniques (mask lithography, colloidal lithography, and direct writing) on a photo patternable sol–gel with rapid thermal annealing and nitridation process. The structured TiN layers show a good stability up to 1000 °C under vacuum and 400 °C under air. This work significantly expands opportunities to obtain TiN-based metasurfaces on various substrates (glasses, plastics, etc.) in complex shapes (non-planar-based surfaces). For example, these layers could be intended for metasurfaces, sensors, or for applications in the luxury and decor industries.

[1] A. Valour, M. A. Usuga Higuita, N. Crespo-Monteiro, S. Reynaud, M. Hochedel, D. Jamon, C. Donnet, Y. Jourlin, J. Phys. Chem. C 2020, 124, 25480.

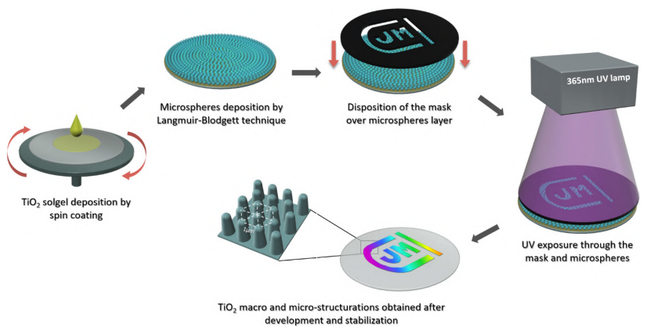


Figure above: Illustration of the process showing the steps used to combine macro- and micro-structuring on the same substrate, using colloidal lithography and UV illumination through a macroscopic mask before development and stabilization of the microstructured films.

Figure right: Example of TiO_2 and TiN micro-nanostructured samples obtained by various patterning techniques on different types of substrate.

Adv. Mater. Interfaces, 9 (2022), 2201159

Journal of Applied Physics

All-dielectric magneto-photonic metasurfaces

Daria O. Ignatyeva, Denis M. Krichevsky, Vladimir I. Belotelov, François Royer, Sushree Dash and Miguel Levy.

A Perspective Review paper was published in September 2022 by our Functional Materials & Surfaces team in the Journal of Applied Physics, which covers diverse topics reflecting the most current applied physics research.

The design of the meta-atoms forming a metasurface makes it possible to tune not only the optical properties of the structure, but also its magneto-optical response when a magneto-active material is part of the photonic device. This gives an exciting possibility to “construct” the desired magneto-optical effect enhanced by the metasurface design at a resonant wavelength: non-reciprocal behavior (the properties of the light beam depends on the propagation direction), or magnetic beam steering (Fig 1).
Recent studies reviewed in the present Perspective showed that the magneto-optical effects, such as transverse, longitudinal, polar Kerr, and Faraday effects, could be enormously enhanced in the magnetic metasurface at a resonant wavelength determined by metasurface parameters rather than a material composition. Such enhancement reported on Fig2c can be employed to increase the sensitivity of sensors, but also to induce the excitation of spin waves (Figure 2).

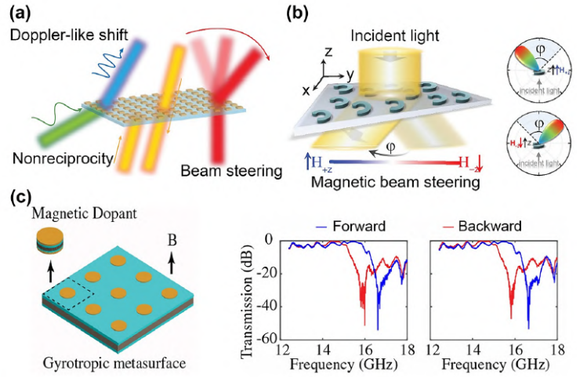


Figure 1: Magnetic field controlled active and nonreciprocal metasurfaces.
(a) Schematic of spatio-temporal metasurfaces for Doppler-like shift, nonreciprocity, and beam steering;
(b) An active metasurface based on BIG split-ring resonators for optical beam steering;
(c) A gyrotropic nonreciprocal metasurface comprising YIG disks and its transmission spectrum in the microwave frequency.
Adapted from:
(https://doi.org/10.1515/nanoph-2021-0719)

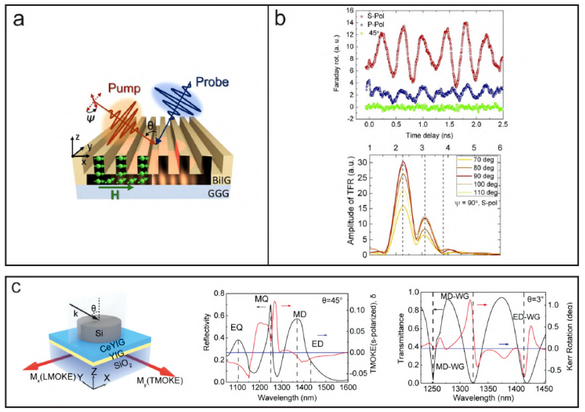


Figure 2:

(a) 1D all-dielectric metasurface for excitation of high-order spin wave modes;
(b) time-resolved spin oscillations and its corresponding FFT spectra in the 1D all-dielectric metasurface;
(c) TMOKE observed in s-polarized light due to the effective gyromagnetic response (left) and giant Kerr rotation observed at the small angle of incidence (right) in the Mie-supporting metasurface.

Journal of Applied Physics 132 (2022), 100902

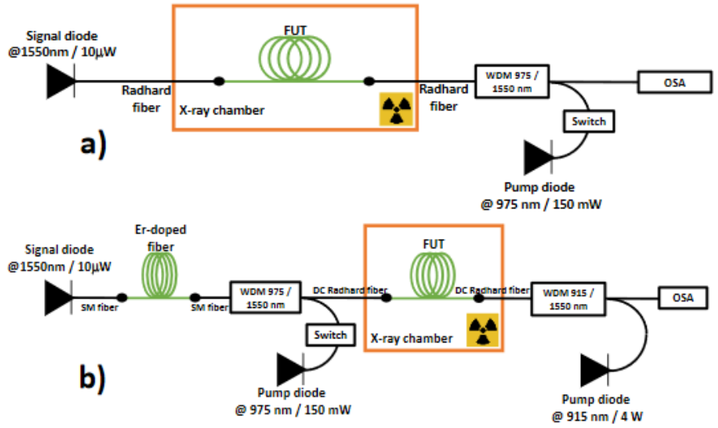
IEEE Transactions on Nuclear Science

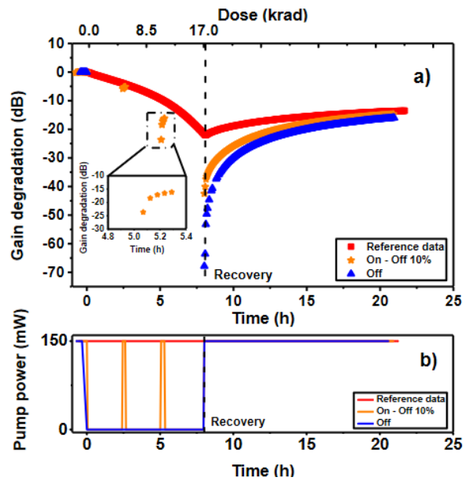
Optimization of the Radiation Response of Backup Optical Fiber Amplifiers for Space Missions

Marine Aubry, Adriana Morana, Arnaud Laurent, Luciano Mescia, Julien Mekki, Nicolas Balcon, Thierry Robin, Emmanuel Marin, Youcef Ouerdane, Aziz Boukenter and Sylvain Girard.

Last year, an article by the Hubert Curien Lab's MOPERE team was published in IEEE Transactions on Nuclear Science. The work was produced within the "LabH6" Joint Lab framework, uniting the University of Saint-Etienne, the CNRS and the company Exail (ex-iXblue).

Optical fiber-based amplifiers embedded in spacecrafts are susceptible to degradation due to the harsh environment of space, and specifically due to radiation. However, a greater degradation of the backup device was observed, compared with that of the main device in operation. The purpose of this paper was to investigate how the backup device could be more impacted by its «OFF» state and how the pump, used when amplifiers are running, could allow the backup device to be less degraded if injected into the fiber from time to time.





Illustrations:

Above:
Amplifier Radiation-induced gain degradation measurement setup for a) EDFA and b) the EYDFA.

Left:
a) EDFA1 gain degradation as function of the time and dose, at the three different pumping conditions;
b) Pumping conditions for the three EDFA1 tests.

IEEE Transactions on Nuclear Science, vol. 69, no. 7 (2022), pp. 1500-1505

Sensors

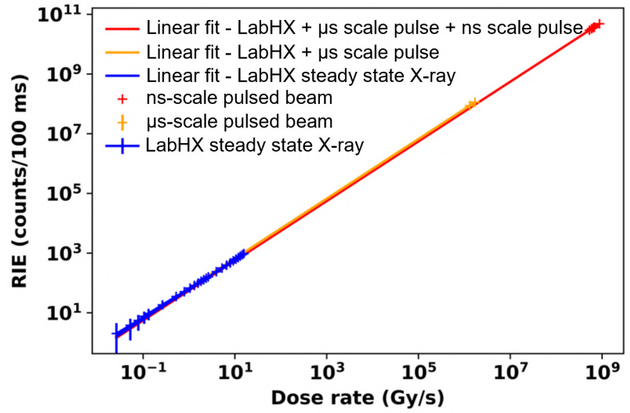
Monitoring of Ultra-High Dose Rate Pulsed X-ray Facilities with Radioluminescent Nitrogen-Doped Optical Fiber

Jeoffray Vidalot, Cosimo Campanella, Julien Dachicourt, Claude Marcandella, Olivier Duhamel, Adriana Morana, David Poujols, Gilles Assaillit, Marc Gaillardin, Aziz Boukenter, Youcef Ouerdane, Sylvain Girard and Philippe Paillet.

An article by the Hubert Curien Lab's MOPERE team, in collaboration with CEA DAM, was published last year in Sensors, the leading peer-reviewed international journal on the science and technology of sensors.

In the last three decades, the development of radiation sources has generated the need for different beam instrumentation and radiation sensors. In radiation testing for space or other applications, tests with pulsed beam are needed to study the influence of dose rate on device degradation basic mechanisms. For some therapy treatments based on the use of X-rays to cure tumoral cells, the radiation dose deposited in the tissue of a patient needs to be precisely quantified. However, most technologies used for radiation monitoring are not well adapted to the ultra-high dose rates encountered in new radiation environments. Pulse discrimination is also a crucial aspect for most of the targeted applications.
In this context, specialty silica-based optical fibers (OFs) with appropriate core doping are emerging as promising radiation sensors and dosimeters. Previous studies have shown that optical fibers doped with nitrogen (N) exhibited a strong Radiation Induced Emission (RIE) signature in the visible domain, adequate for the flux monitoring of X-rays or 63 MeV protons. In this article and within the framework of a collaboration between the CEA DAM and University Jean Monnet, the authors characterize the potential of optical fibers doped with nitrogen (N) to monitor the very high or ultra-high dose rates associated with high-energy X-ray flash facilities. They show that the RIE linearly depends on the dose rate over more than 10 decades of dose rate, opening the way to the development of dosimeters for emerging needs in medicine and physics-devoted facilities.

Illustration below:
Comparison between the nitrogen-doped optical fiber RIE dose rate dependencies as measured with steady-state 40 keV X-ray source and µs (up to 19 MeV) and ns (~1 MeV) scale pulsed X-ray sources.



Sensors, vol 22, no. 9 (2022), p. 3192

Scientific Reports

Photocycle of point defects in highly- and weakly-germanium doped silica revealed by transient absorption measurements with femtosecond tunable pump

Vincenzo De Michele, Alice Sciortino, Monika Bouet, Geraud Bouwmans, Simonpietro Agnello, Fabrizio Messina, Mario Cannas, Aziz Boukenter, Emmanuel Marin, Sylvain Girard and Youcef Ouerdane.

Result of a collaboration between the University of Palermo and our MOPERE team, a paper was published last year in Scientific Reports, a journal dedicated to research from across all areas of the natural sciences, psychology, medicine and engineering.

Pure and doped amorphous silica (SiO_2) has been extensively studied in the last decades, allowing the development of high impact optical technology devices with applications in different fields: telecommunications, optics, sensors, diagnostics and many others. Being an archetypal transparent solid, it has also contributed to improve our fundamental knowledge on the dynamics of point defects embedded in solid matrices, which play a cardinal role on the optical responses of wide bandgap materials. Point defects can be pictured as deformations in the matrix, being able to absorb light from the near-infrared to the vacuum UV, degrading the transmission properties of transparent solids. The authors report here the transient absorption (TA) response of the Germanium Lone Pair Center (GLPC), known point defect observed in germanium-doped silica, which represents a model structure for molecular-like systems embedded in transparent materials. Indeed, by TA measurements based on a sub-picosecond pulse laser, it is possible to follow the defect's photocycle just after the laser pulse, up to a few nanoseconds. The changes in the TA spectrum are probed in the UV-visible range at various delays after photoexcitation, and analyzed as a function of the UV excitation energy in single-photon absorption conditions. The experiment provided sufficient information not only to propose a revised model for the GLPC photocycle, highlighting new features in a time window from hundreds of femtosecond to the nanosecond scale, but also on the unexpected role of the germanium concentration on short defects dynamics. This approach demonstrates how ultrafast tunable pump-probe measurements represent the state of the art for investigating defect excitation/relaxation channels and dynamics.

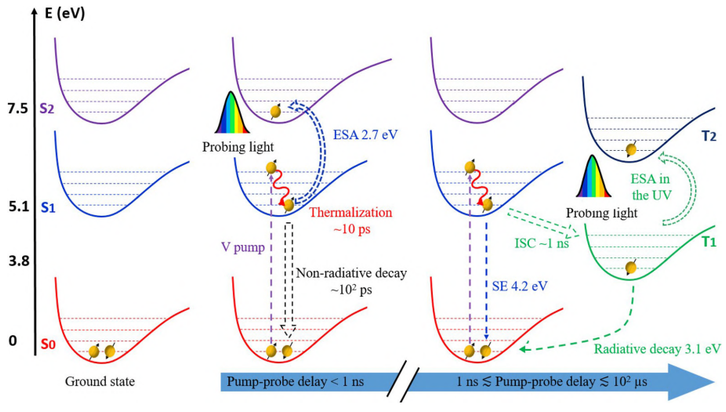


Illustration above:
GLPC's photocycle in low Ge-content sample: the yellow spheres represent the electrons occupying the electronic levels with the corresponding spin states (black arrow up and down), dashed arrows indicate the different transitions characterizing the GLPC's excitation/relaxation dynamics, purple and blue arrows are related to the incoming pump and probe pulse, respectively. In the figure are pictured respectively the GLPC in the ground states, the processes for pump-probes delays shorter than 1 ns and the dynamics between 1 ns and ~ 10^2 µs leading the system newly to the ground states.

Sci Rep, 12 (2022), 9223

Sensors

Radiation Effects on Fiber Bragg Gratings: Vulnerability and Hardening Studies

Adriana Morana, Emmanuel Marin, Laurent Lablonde, Thomas Blanchet, Thierry Robin, Guy Cheymol, Guillaume Laffont, Aziz Boukenter, Youcef Ouerdane and Sylvain Girard.

A paper was published in October 2022 by our MOPERE team in Sensors, an international bimonthly journal providing an advanced forum for the science and technology of sensors and their applications. The article summarizes most of the team's work related to radiation effects on Fiber Bragg Gratings, highlighting the results obtained over the last ten years. A lot of this research was done in collaboration with CEA Saclay and with the private company Exail (ex-iXblue) within the framework of our joint lab LabH6.

A Fiber Bragg Grating (FBG) is a punctual Optical Fiber Sensor (OFS) photo-inscribed with a laser beam inside the core of an optical fiber. In this sensor, the information is "wavelength encoded": the position of the dip in the fiber transmission or the peak in the reflection spectra is known as the "Bragg wavelength". It spectrally shifts when environmental parameters such as temperature, strain, pressure or humidity evolve around the fiber. This type of sensor is easily multiplexable and, unlike other OFSs, presents a fast response to fast dynamics monitoring.
FBGs have been largely investigated for their applications in harsh environments subjected to radiations and/or extreme temperatures e.g. space or nuclear power plants. However, radiations can generate point defects inside the pure or doped silica matrix by ionization or displacement damages. At very high total ionizing doses or high neutron fluences, densification is also observed. These two radiation effects will degrade the optical fiber and then the fiber grating performances. Because of the radiations, as shown in Figure 1, the Bragg peak amplitude can be reduced and its position can shift, inducing an error on the measurement parameters: this is known as Radiation-Induced Bragg Wavelength Shift (RI-BWS).
Various types of FBGs exist with different inscription processes, different thermal and radiation resistances. The magnitude of the error induced under radiation will indeed depend on the radiation-rich environments conditions and on the grating itself, as highlighted in Figure 2. For example, type I gratings, especially those written with an UV laser, are the easiest to manufacture and also the ones with the largest RI-BWS. As very small shifts have been observed during irradiations performed at high temperature – contrary to results observed under room temperatures – regenerated gratings have been considered for nuclear reactor applications, subjected to high doses/dose-rates radiations and to temperatures up to 800°C with a high neutron fluence. Types II and III gratings, written with a fs-laser, showed a good radiation resistance at different temperatures comprised between -100°C and ~300°C, however this can be strongly dependent on the inscription conditions.

Figure 1

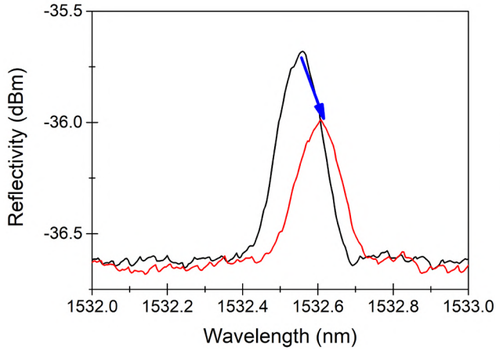


Figure 2

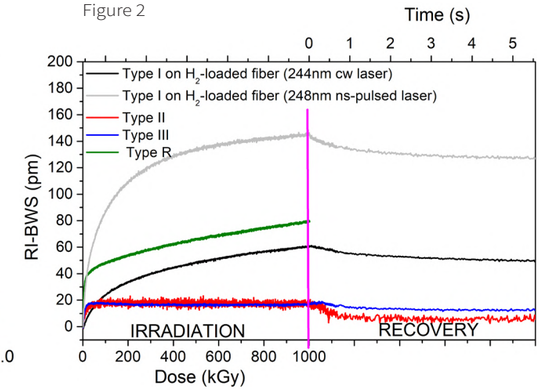


Figure 1:
An example of the radiation-induced effects on a Bragg peak reflection spectrum, before (black line) and after (red line) an X-ray irradiation.

Figure 2:
Bragg Wavelength Shift induced by X-rays at room temperature, as a function of the time (or dose), on different types of FBGs. The vertical line indicates the irradiation end.
Type II and type III are the most promising for applications in harsh environments.

Sensors, 22(21) (2022), 8175

Scientific Reports

Super-efficient drilling of metals with ultrafast non diffractive laser beams

Huu Dat Nguyen, Enrique Moreno, Anton Rudenko, Nicolas Faure, Xxx Sedao, Cyril Mauclair, Jean-Philippe Colombier and Razvan Stoian.

A publication led by our Laser-Matter Interaction team's post-doctoral student Huu Dat Nguyen has appeared in Scientific Reports, a journal from the publishers of Nature.

The team have developed an efficient laser-based method for the deep drilling of metals, based on a self-sustained propagation of non-diffractive beams. Simulations of beam propagation and interaction with matter (E. Morenos and A. Rudenko) support the experimental observations.

A highly efficient drilling process is found in non-transparent metallic materials enabled by the use of non-diffractive ultrafast Bessel beams. Applied for deep drilling through a 200 µm-thick steel plate, the Bessel beam demonstrates twofold higher drilling efficiency compared to a Gaussian beam of similar fluence and spot size. Notwithstanding that surface ablation occurs with the same efficiency for both beams, the drilling booster results from a self-replication and reconstruction of the beam along the axis, driven by internal reflections within the crater at quasi-grazing incidence, bypassing potential obstacles. The mechanism is the consequence of an oblique wavevectors geometry with low angular dispersion and generates a propagation length beyond the projection range allowed by the geometry of the channel. With only the main lobe being selected by the channel entrance, side-wall reflection determines the refolding of the lobe on the axis, enhancing and replicating the beam multiple times inside the channel. The process is critically assisted by the reduction of particle shielding enabled by the intrinsic self-healing of the Bessel beam. Thus, the drilling process is sustained in a way which is uniquely different from that of the conventional Gaussian beam, the latter being damped within its Rayleigh range. These mechanisms are supported and quantified by Finite Difference Time Domain calculations of the beam propagation. The results show key advantages for the quest towards efficient laser drilling and fabrication processes.

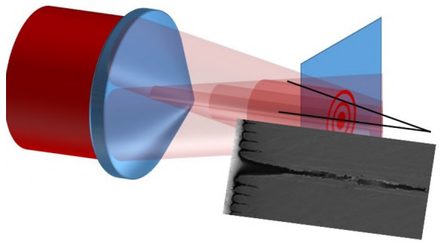
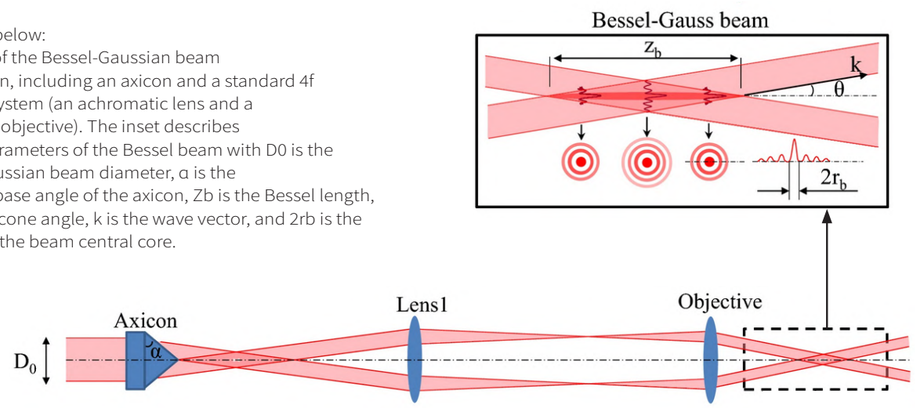


Illustration above:
Diagram illustrating the generation of a non-diffractive laser beam, and its drilling result.

Illustration below:
Schematic of the Bessel-Gaussian beam configuration, including an axicon and a standard 4f telescopic system (an achromatic lens and a microscope objective). The inset describes standard parameters of the Bessel beam with D0 is the incident Gaussian beam diameter, α is the physical or base angle of the axicon, Zb is the Bessel length, θ is the half cone angle, k is the wave vector, and 2rb is the diameter of the beam central core.



Sci Rep, 12 (2022), 2074

Applied Surface Science Advances

Numerical Study of the Wetting Dynamics of Droplet on Laser Textured Surfaces: Beyond Classical Wenzel and Cassie-Baxter Model

Ilemona S. Omeje and Tatiana E. Itina.

An article by the Hubert Curien Lab's Laser Matter Interaction team was published last year in Applied Surface Science Advances. The work has been produced within the FET Laser Implant project (EU HORIZON 2020, Grant agreement ID: 951730) and the French Ministère de l'Education Nationale, de la Recherche et de la Technologie (MENRT).

The classical wetting models, such as the Wenzel and Cassie-Baxter have been extensively used to quantify the wettability of laser-textured surfaces. However, these models do not provide any description of the corresponding droplet dynamics. In this work, the authors use a continuum-level modelling method such as Level Set Method (LSM) to model the wetting dynamics of a water droplet on Ti-6Al-4V alloy.
The wetting studies are performed on 2 types of flat surfaces: one with triangular reliefs, the other with two different periods and heights.

The spreading parameter (or diameter) of the droplet as a function of the contact time is used to examine the short-scale droplet dynamics on several textured materials. Firstly, on a plane Ti-6Al-4V surface, the droplet spread parameter agrees well with the experimental values. Figure 2. shows how small submicrometre surface reliefs affect the droplet speeding. In fact, as shown on Figure 3, the considered triangular relief with one period changes the wetting dynamics and increases the spreading parameter. Interestingly, the one with two periods and heights helps to furthermore confine the droplet, so that the droplet spreading is even more decreased. The team conclude that triangular surface reliefs (or typical HSFL) alone are probably not well suitable for the increase in hydrophobic properties, but rather two-period (or more complex combinations of LSFL with HSFL of a femtosecond laser system) provide additional droplet capturing effects and are more promising for the wettability control.

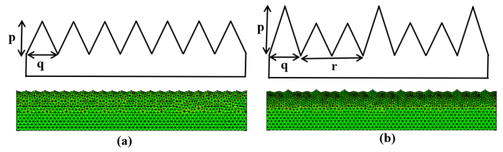


Figure 1:
Triangular and (b) two-period reliefs with different heights used in the calculation.

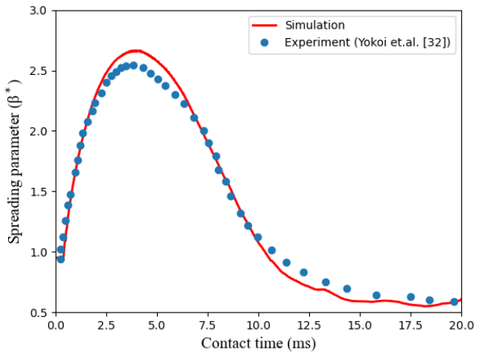


Figure 2

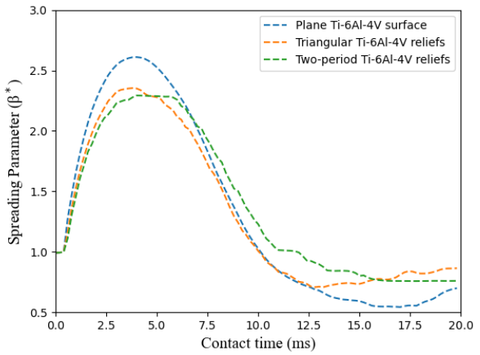


Figure 3

Appl. Surf. Sci., 9 (2022), Article 10025

Nano-Micro Letters

High-Density Nanowells Formation in Ultrafast Laser-Irradiated Thin Film Metallic Glass

Mathilde Prudent, Djafar Iabbaden, Florent Bourquard, Stéphanie Reynaud, Yaya Lefkir, Alejandro Borroto, Jean-François Pierson, Florence Garrelie and Jean-Philippe Colombier.

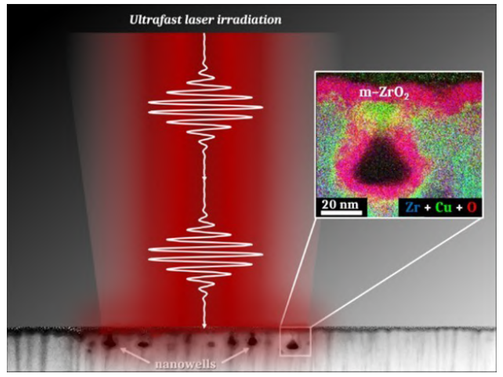


Image above: Nanowells generated on a thin layer of metallic glass irradiated by ultrafast laser pulses.

In April 2022, an article by the Hubert Curien Lab's Laser Matter Interaction team was published in Nano-Micro Letters, a journal focussing on science, experiments, engineering, technologies and applications of nano- or microscale structure and system in various scientific disciplines.
The miniaturization of surfaces structuring is a perpetual challenge as it allows to broaden the fields of applications in nanotechnology. Particularly, the process can find applications in biochemistry, biomedicine or renewable energies. More specifically, amorphous metals, also called "metallic glasses", are the subject of much research for they have unique characteristics such as a smooth surface without any roughness, a good mechanical behavior and an increased corrosion resistance. Their longevity makes them prone to be used for the manufacturing of, for example, small components present in watches, or as coatings for turbines. Their biocompatible properties also make them an ideal type of coating for surgical tools.
It is on thin film metallic glasses that our team has experimented and developed, in collaboration with the Jean Lamour Institute (University of Lorraine, CNRS), an ultrashort laser irradiation process allowing to modify their chemical properties and their topographical characteristics.
The project initially aimed at creating periodic structuring at the nanometric scale "nanorides » - on these coatings made with a selected composition of zirconium and copper (Zr-65Cu35).
An unexpected consequence of this work was the discovery of networks of dense nanowells, formed spontaneously on the surface of the irradiated zone, with dimensions as low as 20 nm. The flared shape of these wells proves to be ideal for ensuring the immobilization or the controlled release of chemical or biological compounds. In addition, the localization of the nanowells can be modulated thanks to the control of the initial morphology of the films deposited on their substrate by sputtering. Topographic functionalization is accompanied by structural functionalization, characterized by the creation of monoclinic zirconia nanocrystals that develop within the material.
This laser irradiation process therefore has promising application potential for the storage and gradual release of chemical or biological elements, allowed by the flared shape of the nanowells. Being able to control their size and their concentration on the surface would also allow to adapt them for targeted applications.
One can imagine, for example, the development of an orthopaedic implant covered with a thin layer of metallic glass textured with nanowells. Bioactive liquids would thus be released in a local and controlled manner to avoid possible infections induced by the placement of this implant. Mastering the characteristics of these nanowells also opens the way to other applications related to the "wettability" of certain surfaces, for example in the medical field, but also for the waterproofing of electronic equipment.

Nano-Micro Lett., 14 (2022), 103

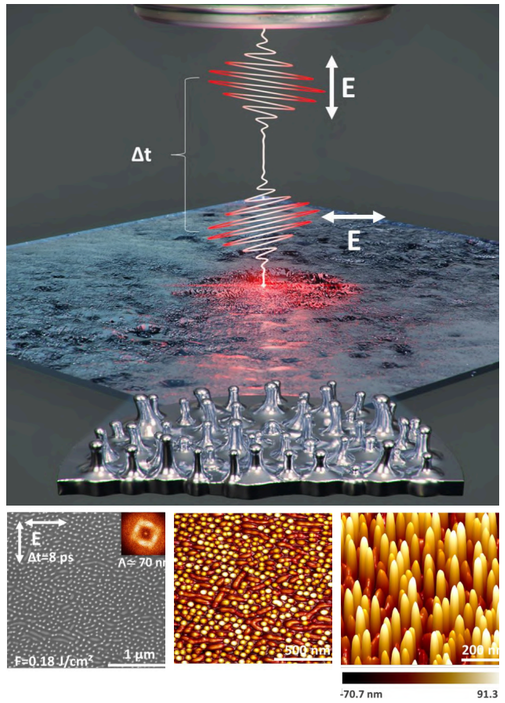
Advanced Science

Boosted Spontaneous Formation of High-Aspect Ratio Nanopeaks on Ultrafast Laser-Irradiated Ni Surface

Anthony Nakhoul, Anton Rudenko, Claire Maurice, Stéphanie Reynaud, Florence Garrelie, Florent Pigeon and Jean-Philippe Colombier.

An article by the Hubert Curien Lab's Laser Matter Interaction team was published last year in Advanced Science, a leading peer-reviewed interdisciplinary journal covering fundamental and applied research in materials science, physics and chemistry, medical and life sciences, as well as engineering.
Biomimicry is often at the origin of the manufacture, at the nanometric scale, of certain surfaces with extraordinary properties. In particular, surfaces characterized by special topographies allow today to reproduce, for example, the extreme hydrophobicity of the lotus leaf's surface, the high adhesive force of a gecko's feet or even the anti-reflection properties of the moth's eyes. The research team has developed an ultrashort laser irradiation process allowing to turn a flat surface into a "forest of nanopeaks" of the highest aspect ratio ever reached. The results of this work open up perspectives for transdisciplinary research, particularly in the field of biology.
The originality of the work carried out by the team lies in the double-pulse experimental configuration of a femtosecond laser, which has permitted to obtain nano-peaks reaching a height of 100 nanometers for a width of 20 nanometers. The temporal shaping of laser beams with polarization control on a nickel monocrystal substrate also allows a regular and densely compact distribution of the created nanostructures on large surfaces.
This method constitutes a significant improvement in current laser surface treatment processes. It lies indeed within a so far unexplored scientific field where the coupling of light and the hydrodynamic effects act in a coherent and synergistic way at the nanometric scale, allowing to create self-organized metastructures. This study also establishes the ultrafast laser technology as a very promising non-contact process capable of rationally and rapidly fabricating complex nanostructures with innovative surface functions.
The work has already caught the attention of the biologists' community, who can see in these results prospects for improving the antibacterial properties of certain materials. Indeed, it has been previously demonstrated that the lethal mechanical forces causing the death of bacterial cells require pointed geometries combined with a very high aspect ratio. This is the case, for example, of the mechano-bactericidal nanostructures of cicada wings, which can inflict critical membrane damage to microorganisms perched onto them, leading to their death.
"The diameter of most viruses being greater than that of our nanopeaks, we can envisage the opening of this work onto a search for possible viricidal properties of these nanostructures", says Anthony Nakhoul, co-author of the article.

The team is also considering possible innovative applications of these results in different fields of metaphotonics, such as optical communications, solar energy, optical light guidance or even display and sensor technologies.



Above: Schematic illustration of the ultrafast laser irradiation process on a Nickel layer, and microscopic view of the generated high peaks' regular and self-organized structure.

Advanced Science, 9 (21) (2022)

Nature Photonics

Hard X-ray helical dichroism of disordered molecular media

Jérémy R. Rouxel, Benedikt Rösner, Dmitry Karpov, Camila Bacellar, Giulia F. Mancini,Francesco Zinna, Dominik Kinschel, Oliviero Cannelli, Malte Oppermann, Cris Svetina, Ana Diaz, Jérôme Lacour, Christian David and Majed Chergui.

In July 2022, member of our Laser Matter Interaction team Jérémy Rouxel was first author of an article published in Nature Photonics, a monthly journal dedicated to top-quality research from all areas of light generation, manipulation and detection.
The research work was done in strong collaboration with the EPFL, Switzerland (Laboratory of Ultrafast Spectroscopy), and at the Free Electron Laser SwissFEL (Paul Scherrer Institute).

Certain molecules may be found in two forms that are physically similar yet mirror reflections of one another - these are called "chiral molecules", whilst "enantiomer" is the name given to their two mirror images. In this article, the team presents an innovative technique allowing an easier identification and an improved separation of these enantiomers, with potential implications in drug development, biochemistry and toxicology.
Separating enantiomers from one another is crucial in these fields in order to, for example, ensure that only the desired version enters a drug. Circular dichroism (CD) is the currently used technique to distinguish between enantiomers, sending circularly-polarized light through a sample. Chiral molecules, shown in Figure 1, will absorb more such light than their mirror image, producing a tell-tale difference in the transmitted light. This circular dichroism method is routinely employed in analytical chemistry, biochemistry and in the pharmaceutical, cosmetic and food industries. However, the signals produced are very weak, and the sample ideally needs to be in the gas phase. This can be a problem for chemistry and biochemistry experiments that are mainly carried out in aqueous solutions. The new method overcomes these problems as it works using a different form of dichroism that involves the shape of light rather than its polarization, the setup being shown in Figure 2. The effect that underlies this phenomenon is the use of a helical form for the beam wavefront. “One can imagine an optical vortex as a light beam, where the wavefront is twisted like a screw along the propagation direction,” says Jérémy Rouxel. “Just like a screw, the direction of this wavefront can go in one direction or another, comparable to a left- and a right-handed thread.”
Whilst Circular dichroism (CD) is strongly limited by the fact that light can only be left- or right-polarized, this new "Helical dichroism" (HD) technique uses optical vortices that can twist multiple times within one wavelength of the used light. This can strongly enhance the dichroic signal and also be used to determine the degree of chirality of a molecule.

In a new exciting direction, the team has also theoretically shown that twisted beams can be used in an ultrafast X-ray diffraction configuration to probe quantum coherences in molecules. This demonstration has been published in Physical Review Letters and will be the target of future experimental realizations.

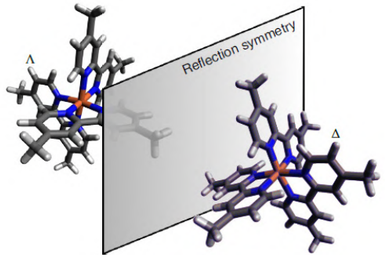


Figure 1:
Δ (right) and Λ (left) enantiomers of chiral Iron tris-dimethyl-bipyridine used in the experiment.

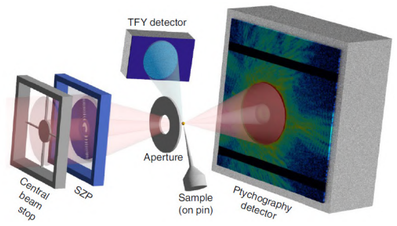


Figure 2:
Illustration of the experimental setup.
The OAM-carrying beam are generated using a spiral Fresnel zoneplate.

Nat. Photon., 16 (2022), 570–574

Carbon Trends

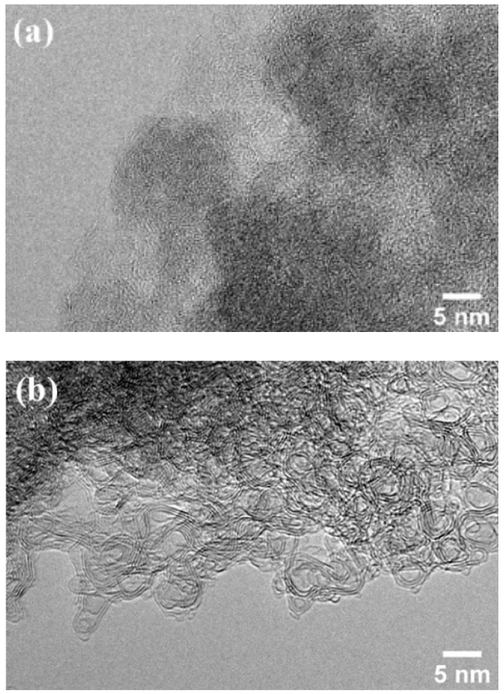
Discrimination of different amorphous carbon by low fluence laser irradiation

Hatem Diaf, Antonio Pereira, Patrice Melinon, Nicholas Blanchard, Florent Bourquard, Florence Garrelie and Christophe Donnet.

An article written by our Laser Matter Interaction team in collaboration with the ILM (Institut Lumière Matière) was published last year in Carbon Trends, a journal offering an open access platform to communicate progress in the field of carbon materials science.

Carbon is probably one of the most fascinating elements of the universe. It is the building block of life and, at the nanometric scale, presents various allotropic and hybridization forms: graphite, graphene, diamond-like, glassy, fullerene, onion-like, nanotubes, nanocones, etc., with a wide dispersion of physical and chemical properties. Discriminating these various forms of nanostructures by spectroscopic and microscopic investigations is quite challenging.
In this proof, a new way of carbon nano-structure synthesis and exploration is achieved by combining femtosecond pulsed laser deposition (fs-PLD) of two distinct sp2 carbon targets (crystallized HOPG and Glassy Carbon) with subsequent low fluence femtosecond laser irradiations. This process allows to control and discriminate amorphous carbon films with similar carbon hybridizations but different sp2-like carbon clusters.
Whatever the initial PLD target (HOPG or GC) is, the as-deposited film consists in a similar carbon sp3-like network with randomly dispersed carbon sp2 clusters. Subsequent low fluence femtosecond laser irradiation transforms the as-deposited film into a nanostructure with various discriminable forms of sp2-like clusters in a controlled and reproducible way (see Figure). Adding a partial pressure of helium gas during the initial deposition emphasizes the effect of the post-deposition laser irradiation, showing that it is not possible to transform amorphous carbon films deposited in helium atmosphere into glassy carbon. Indeed, helium cools and confines the ablation plasma, promoting the formation of sp2-like clusters which are different to deposition in vacuum. Such a difference is attributed to nuclei specific to the initial carbon target. When helium is introduced during deposition, the nuclei prevent the transition to glassy carbon during laser irradiation of the films. These investigations also demonstrate that some usual RAMAN bands are not related to the degree of carbon disorder but mainly to the nature of the carbon sp2 clusters.

Figures right:
High resolution transmission electron microscopy (HRTEM) of an amorphous carbon film deposited by femtoosecond PLD,
(a) before and
(b) after low fluence femtosecond laser irradiation.
Before irradiation, the film exhibits a typical amorphous structure, transformed in a glassy carbon structure by irradiation.



Carbon Trends, Volume 9 (2022), 100195

Applied Optics

Waveguide scattering antennas made by direct laser writing in bulk glass for spectrometry applications in the short-wave IR

M. Callejo, Myriam Bonduelle, A. Morand, Guodong Zhang, Jing Lv, Guanghua Cheng, Ciro D'Amico, Razvan Stoian and G. Martin.

Last year, members of our Laser Matter Interaction team published an article in Applied Optics, a journal covering the latest research in optical technology, photonics, lasers, information processing, sensing and environmental optics.
The paper offers a novel approach to the sampling of optical signals guided in bulk waveguides, using ultrafast direct laser written buried voxels and waveguides in bulk glasses. By using the same direct laser writing technology and spatial beam engineering, the team created 3D hybrid photonic structures made by waveguides and high aspect ratio void structures. The elongated void structures, photo-written transversally at the vicinity of the waveguide, convert the evanescent field of the guided light into scattered light propagated in the glass wafer towards a detector. It is demonstrated that each scattering center, made by a group of parallel and periodic elongated nanovoids (an antenna), is able to transversally radiate a high directional signal, which is proportional to the integrated optic stationary wave inside the waveguide at a given discrete position from the end mirror (positioned at the output of the waveguide in order to form the stationary wave inside). Scanning the wavelength of a guided monochromatic signal generates an oscillation of the signal intensity radiated by an antenna. The oscillation period is correlated to the distance between the considered antenna and the mirror positioned at the end of the waveguide, and this characteristic can be used to calibrate the detector and implement a compact integrated wavelength-meter. More generally, this new approach will enable to reduce cross-talk problems and therefore improve the resolution and performance of the next generation of compact detectors embedded in a bulk glass chip. This work is the result of a collaboration between the Hubert Curien Lab (for the realization of the 3D hybrid photonic structures in bulk fused silica), the Institut de Microélectronique Electromagnétisme et Photonique et LAboratoire d'Hyperfréquences et de Caractérisation - IMEP-LAHC (for the CCD added on the top of the prototype and characterization) and the "Institut de Planétologie et d'Astrophysique de Grenoble - IPAG" (for the conception of the prototype's design and characterization).

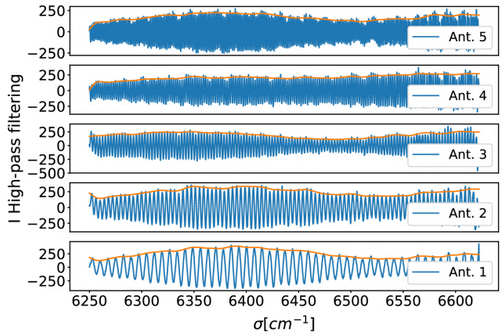
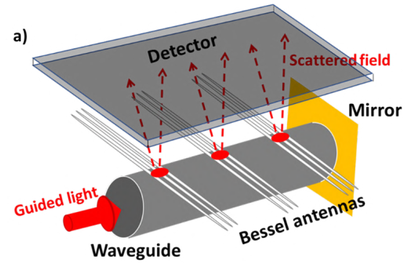
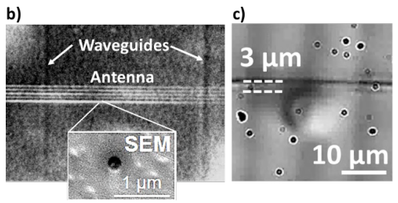


Figure above:
Oscillations of the intensity of the signal scattered by the antennas when the wavelength of the light guided in the waveguide is scanned. The response of several antennas (different distance from the end mirror) is shown. As can be seen the oscillation period depends on the distance from the mirror. This allow calibrating the detector, and implementing a wavelength-meter.

Figures below:
a) Schematic of the signal extraction concept using antennas.
b) and c) Waveguides and a group of periodic elongated Bessel nanovoids (an antenna) photo-written in fused silica by UDLW, in top-view (b) and in front-view (c), observed to the microscope. The inset in b) shows the nanosize cross-section of an elongated nanovoid forming an antenna, observed by scanning electron microscopy.





Applied optics, 61 (24) (2022), pp.7173-7180.

Physical Review Materials

Molecular dynamics simulation of structural evolution in crystalline and amorphous CuZr alloys upon ultrafast laser irradiation

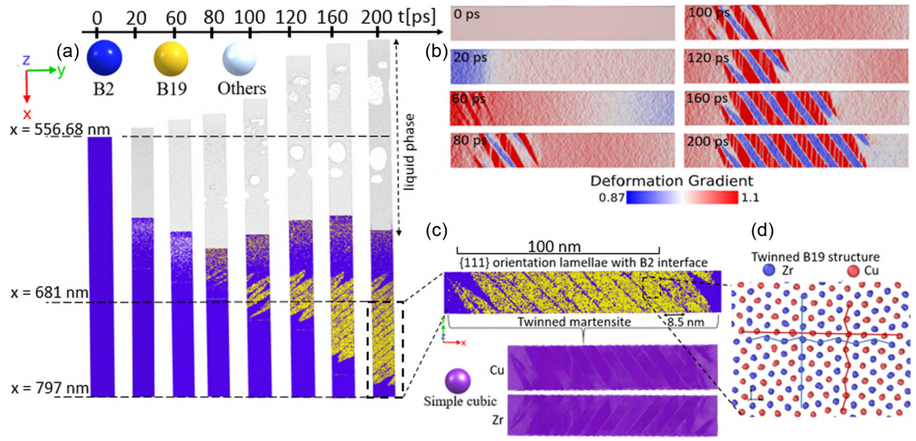
Djafar Iabbaden, Jonathan Amodeo, Claudio Fusco, Florence Garrelie and Jean-Philippe Colombier.

Physical Review Materials is a journal specialised in the publication of research on materials, responding to the increasing trend of this domain in breaking conventional subject boundaries. As such, the journal provides a publication and reference venue to the expanding community of physicists, materials scientists, chemists, engineers, and scientists in related disciplines, carrying out high-quality theoretical and experimental research in materials science. An article by our Laser Matter Interaction team was featured in one of their latest 2022 editions.

The article discusses laser-induced structural transformations in Zr-based alloys for crystalline and glassy states, for the manufacturing of emergent metamaterials. The study presents a hybrid simulation approach (TTM-MD – Two Temperature Model coupled with Molecular Dynamics) to simulate ultrafast laser matter interaction at the mesoscale and capture the phenomenon occurring at a picosecond time scale.

The authors look at how mechanical stress induced by shock waves affects certain compositions' structural features and stability, by comparing the ultrafast thermomechanical response between stable crystalline structures and amorphous structures in Cu-Zr alloys. In its amorphous state, this specific metallic glass (MG) plays indeed a fundamental role in advanced material engineering, from biomedical applications for antimicrobial properties to metallurgy and anticorrosion properties.
The results indicate that phase stability and microstructural transformations depend on the initial crystallographic structure. It also shows that a martensite phase transition occurs in B2 crystalline alloys, that defects are induced in the irradiated C11b phase whilst the amorphous state of photoexcited metallic glasses remains preserved.

Figure below:
Snapshots of the atomic configurations evolution in:
(a) at several times: 0 ps, 20 ps, 60 ps, 80 ps, 100 ps, 120 ps, 160 ps, and 200 ps in B_2–$Cu_{50}Zr_{50}$ target during ultrafast laser irradiation of τ = 100 fs pulse duration and F_{abs} = 160mJ/cm2 absorbed fluence. The atoms are colored according to their local atomic structure of the binary alloy, the double-dashed arrow in the upper part of targe shows the liquefied surface.
(b) Deformation gradient in the transformed zone following the x direction at different times.
(c) Zoom on the dashed region showing twinned martensite transformation.
(d) Enlarged view of the chemical species of the new twinned-B19 phase emergence after the irradiation.



Phys. Rev. Materials, 6 (2022), 126001

Scientific Reports

Deep Learning detection of nanoparticles and multiple object tracking of their dynamic evolution during in situ ETEM studies

Khuram Faraz, Thomas Grenier, Christophe Ducottet and Thierry Epicier.

An article by the Hubert Curien Lab's Image Science and Computer Vision team regarding multiple object tracking was published last year in the multi-disciplinary journal Scientific Reports, from the publishers of Nature.

This work is the result of a collaboration with the MATEIS, CREATIS and IR-CELYON laboratories, and presents an approach combining deep learning and computer vision for the detection and in-situ monitoring of nano-objects' populations. This approach allows the extraction of small objects' complex trajectories on a noisy and non-uniform background. Its application to the analysis of palladium nanoparticles on an alumina substrate during their calcination under oxygen by ETEM electron microscopy has provided an opportunity to highlight coalescence and fusion phenomena, which are very important for catalytic properties.

This study has benefited from the support of the CNRS IngéLySE Federation's scientific program and the EUR Manutech-SLEIGHT (University of Lyon - St-Etienne).

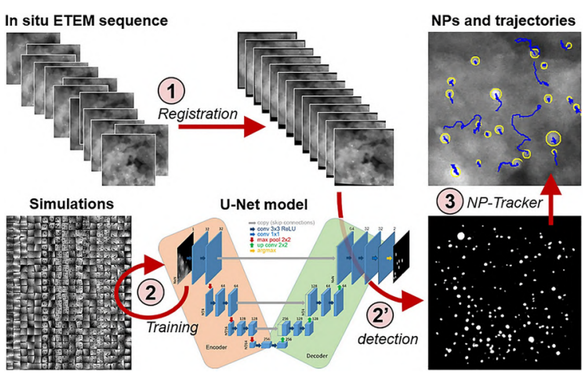


Illustration:
Synopsis of the algorithm.
(1) Registration of the real input sequence,
(2) training of a U-Net model with simulated images,
(2') detection and segmentation of particles in each frame using the model,
(3) determination of trajectories using the dedicated NP-Tracker algorithm.

Sci Rep, 12 (2022), 2484

Applied Optics

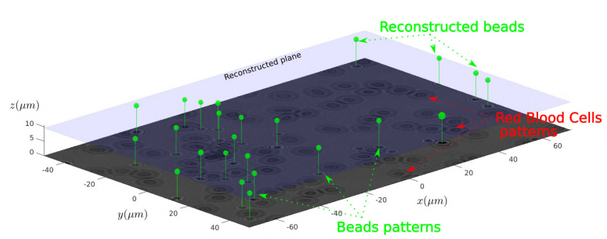
Automatic numerical focus plane estimation in digital holographic microscopy using calibration beads

Dylan Brault, Corinne Fournier, Thomas Olivier, Nicolas Faure, Sophie Dixneuf, Louis Thibon, Loïc Mees and Loïc Denis.

In February 2022, the Hubert Curien Lab's Image Science and Computer Vision team published one of their research studies on digital holographic microscopy. The article was published in Applied Optics, a journal covering the latest research in optical technology, photonics, lasers, information processing, sensing and environmental optics.

Microscopy is routinely used in medical diagnosis in the context of infectious diseases detection and/or characterization, blood components, morphological analysis and counting. Accurate and repeatable autofocusing is one of the first requirements for the automatic classification of biological component, for example involving Artificial Intelligence. The team suggests to use in-line digital holographic microscopy and numerical reconstruction of beads embedded in the sample, as it allows to estimate the axial position of the slide with more accuracy and repeatability than state-of-the-art image-based autofocusing methods. This work also led to a patent filed with bioMerieux, a multinational biotechnology company that provides medical diagnostic solutions.

Illustration below:
Bead reconstruction from one hologram.
For visualization purposes, the size of the beads is doubled.



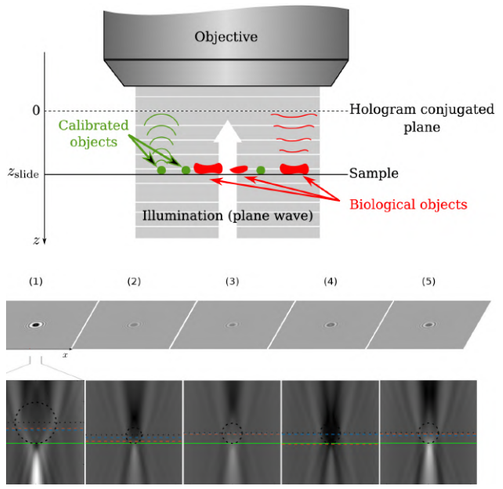


Illustration left:
Example of an in-line digital holographic upright microscope with calibrated objects inserted in the biological sample.

Left: Illustration of the need for an object independent reference plane:
(a) synthetic in-line holograms of various beads,
(b) amplitude profiles of the holograms back propagated : the green line represents the slide plane, the black line and black circles represent the bead centre planes and bead edges, and orange and blue lines represent the focus plane estimated using two state-of-the-art focusing criteria.

Appl. Opt., 61 (2022), B345-B355

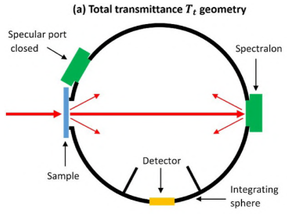
Solar Energy Materials and Solar Cells

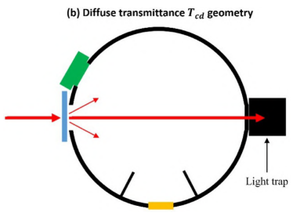
Characterization of UV–Vis–NIR optical constants of encapsulant for accurate determination of absorption and backscattering losses in photovoltaics modules

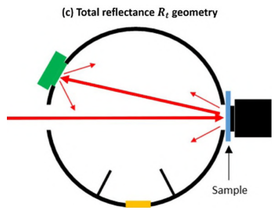
Julien Eymard, Raphael Clerc, Vincent Duveiller, Benjamin Commault and Mathieu Hebert.

In June 2022, an article by the Hubert Curien Lab's Image Science and Computer Vision team was published in Solar Energy Materials and Solar Cells, a journal dedicated to the dissemination of research results on materials science and technology related to photovoltaic, photothermal and photoelectrochemical solar energy conversion.

Photovoltaic cells are made of various clear or absorbing layers that must all be accurately characterized in order to properly estimate the amount of light that will be absorbed by the cell, and converted into electrical energy. This process therefore allows to optimize the electrical performance of the photovoltaic module. For certain types of cells, a small quantity of light is being scattered by the protection layers which have a translucent aspect and which characterization is more challenging than perfectly transparent or opaque layers. However, the propagation of light into these layers can be accurately described thanks to a 4-flux model, that can distinguish the amount of light that is being scattered. Four measurements with an integrating sphere spectrophotometer, as featured in the illustration below, are necessary to determine the four parameters of the model. Only the 4-flux model developed in this study provides consistent spectral values for the four parameters, compared with the values available in the literature for these materials. This scattering model and the corresponding characterization method can also be used in many other domains where light is weakly scattered: polymers, human or vegetal tissues, dental materials, etc.







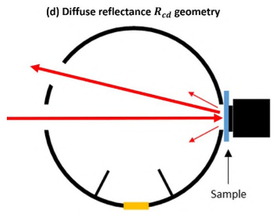


Illustration:
The characterization of translucent layers scattering little light, by using an integrating sphere spectrophotometer, is based on four measurements, two in reflection, two others in transmission, according to the four configurations presented in this figure. They allow to estimate the proportions of radiations which are scattered or propagate in straight line in the layer.

Solar Energy Materials and Solar Cells, Volume 240 (2022), 111717.

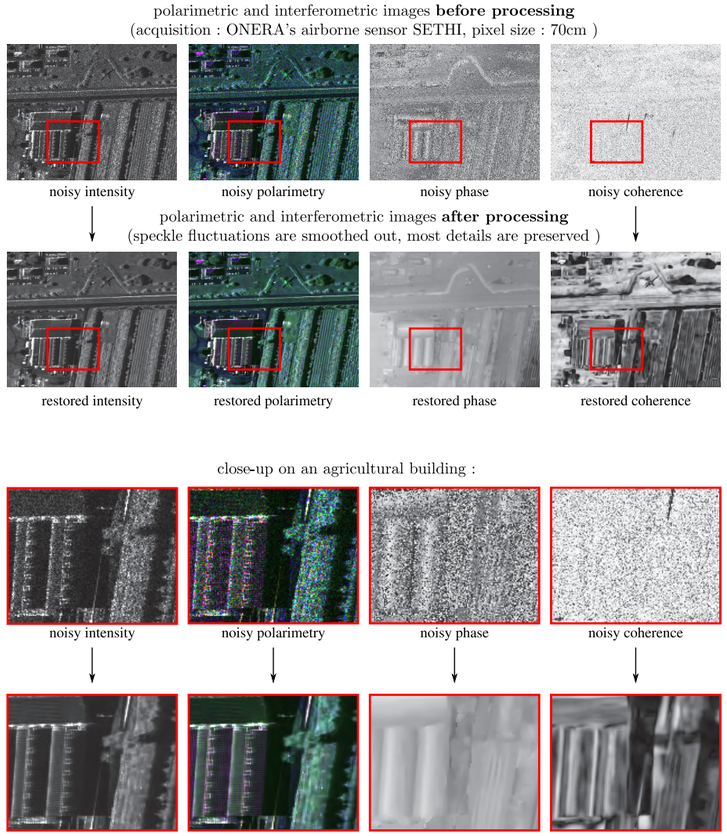
Journal of Mathematical Imaging and Vision

Speckle Reduction in Matrix-Log Domain for Synthetic Aperture Radar Imaging

Charles-Alban Deledalle, Loïc Denis and Florence Tupin

Last year, the Hubert Curien Lab's Image Science and Computer Vision team published an article in Journal of Mathematical Imaging and Vision. Emphasizing the role of mathematics as a rigorous basis for imaging science, this journal details innovative or established mathematical techniques applied to vision and imaging problems in a novel way.

This paper is the result of a long-term collaboration between the Optical Design and Image Reconstruction project team (ODIR), which is part of our lab's Image Science & Computer Vision team, and the Information Processing and Communications Laboratory (LTCI) at Télécom Paris. First author and research scientist Charles Deledalle is currently leading an AI team at Brain Corp in California, a global leading company specialised in robotic AI software. Synthetic Aperture Radar (SAR) imaging is a multi-disciplinary domain requiring to combine physical models, advanced image processing and IA techniques, as well as applied maths. This work is illustrative of the research led by the ODIR project team.

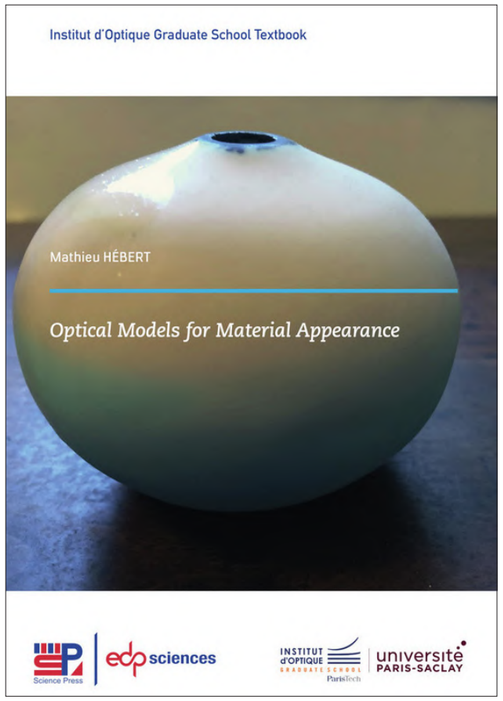


Left: An illustration of the speckle noise reduction achieved by the algorithm proposed in the paper.

Journal of Mathematical Imaging and Vision, 64 (2022), pp.298-320

Optical Models for Material Appearance

A new book by Mathieu Hébert



Professor Mathieu Hébert, from our Image Science & Computer Vision team, specialises on the subject of materials appearance. His many years of research work, together with his teaching activities and his role as coordinator of the OIVM master's AIMA track - Advanced Imaging and Material Appearance: Metrology & Modelling - have led Mathieu to write and publish a 260 pages book on «Optical Models for Material Appearance». The book isn't only addressed to students, but also to any researcher in optics involved in the interactions of light with matter or any professionals dealing with the visual appearance of materials and surfaces.

A word from the author: «Material appearance has emerged as a scientific topic in its own right rather recently and an increasing number of professionals concerned by this topic, belonging to various application areas, are entering this vast field. Thanks to the rise of imaging systems and visual rendering software, and the rapid development of accessible devices for color and gloss analysis, non-expert people can now check, for example, the compliance of a product with an appearance standard, or create a realistic virtual prototype. Most of these tools are based on optical concepts which are generally not in the forefront at an elementary level usage, but which are necessary for a consistent analysis of the specific cases studied. The objective of this book is precisely to introduce the fundamental notions of optics allowing the readers to understand the radiometric quantities measured with common devices, to learn how to analyze them, and to review some classical optics-based predictive models for various types of materials and structures. We have chosen to illustrate the theoretical notions with numerous examples and corrected exercises, easily transposable to a variety of materials: glass plates, polymer films, pigment layers, metals, papers and printed surfaces, coatings, etc.»
As explained by former professor at the Institut d'Optique Graduate School Jean-Louis Meyzonnette in his preface of the book: «One will particularly appreciate the didactic approach of the author [...] It presents the optical tools that one should master in order to compute the spectral, spatial and angular behavior of the visible radiation which, after reflection or scattering by the object of interest converges towards the observer's eyes and forms the retinal image. »

The book, published last August and available in English as printed and electronic versions, opens a new collection of scientific books from the Institut d'Optique Graduate School - 'Institut d'Optique Graduate School Textbook' - published by EDP Sciences.

EAN13 (paper) : 9782987526476

Journal of Imaging

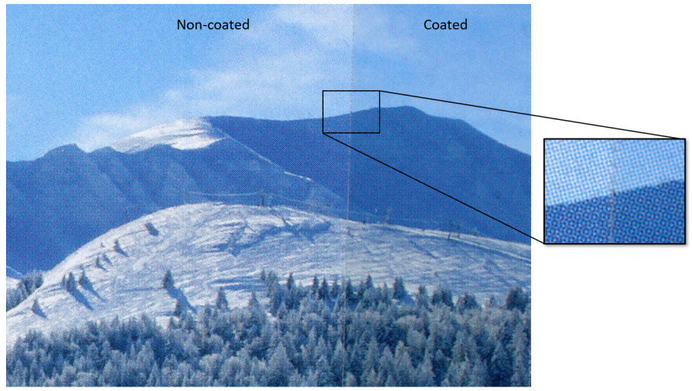
Use of Multispectral Microscopy in the Prediction of Coated Halftone Reflectance

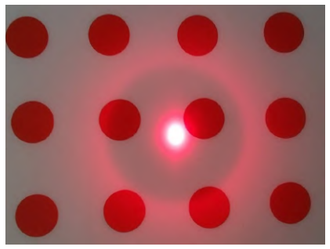
Fanny Dailliez, Mathieu Hébert, Lionel Chagas, Thierry Fournel and Anne Blayo.

An article by the Hubert Curien Lab's Image Science and Computer Vision team was published early September in Journal of Imaging. This international journal specialises in the publication of reviews, original research papers, communications, case reports, letters, and short notes in all fields of imaging research.

Book covers are often coated with a transparent layer to enhance the colors of the front page. This appealing color change can come from light propagation inside the transparent coating layer. Indeed, internal reflections inside the coating layer increase the probability for light to be absorbed by the ink dots composing the print. This light propagation has a very specific halo shape which was modelled to predict the appearance of coated prints. The prediction was based on experimental reflectances of non-coated prints measured with a custom multispectral microscope. The prediction and experimental results showed a rather good agreement both on the spectral and on the spatial dimensions. The results, obtained at the microscopic scale, were consistent with measurements at the macroscopic scale, which makes this method relevant for color management in the printing industry.

Illustrations below:
Left: Scanned picture from a printed magazine, "Alpes Is Here" #9 p35 Copyright "Images et Rêves",
the right part was coated with a tape layer. The colors of the coated area are darker and more saturated than the non-coated area.
Right: Halo shaped light propagation inside a coating layer, visible with a punctual light source.





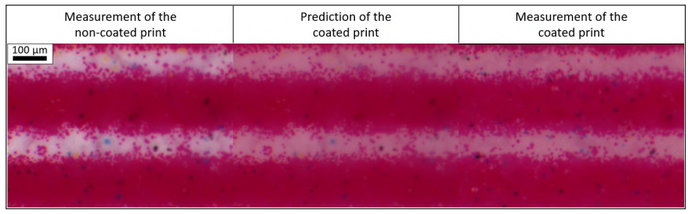


Figure left:
Microscope sRGB pictures of a magenta line halftone of period 0.252 mm. The middle picture was obtained by modelling the effect of a coating layer on the reflectance of the non-coated print, presented on the left. The prediction can be visually compared to the measurement of the coated print, displayed on the right. Light propagation in the coating changes the color of the non-inked lines, which can be rather well predicted by our multi-convolutive model.

J. Imaging, 8 (2022), 243

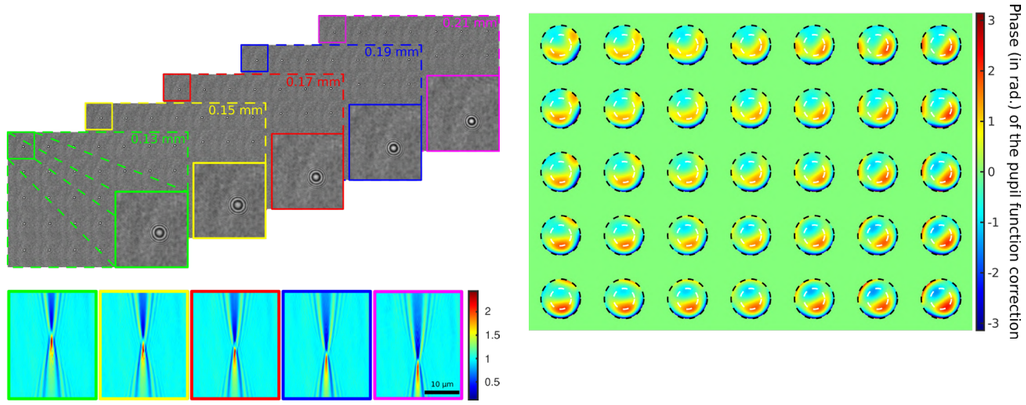
Optics Express

Accurate unsupervised estimation of aberrations in digital holographic microscopy for improved quantitative reconstruction

Dylan Brault, Thomas Olivier, Ferréol Soulez, Sachin Joshi, Nicolas Faure and Corinne Fournier.

The Hubert Curien Lab's Image Science and Computer Vision team has published last year an article in Optics Express, an open-access journal dedicated to scientific and technology innovations in all aspects of optics and photonics.

Optical microscopy can be used to extract several characteristics from a biological sample, such as morphological parameters or transmission. It can also be used to extract the phase shift introduced by the sample, which could bring some additional information in the context of medical diagnosis. In-line holography is an interferometric technique that aims at retrieving the transmission and phase shift introduced by the sample, using a numerical reconstruction. For a quantitative measurement of these properties, an accurate optical model which includes the characteristics of the optical system is required. When they are not taken into account, aberrations of the optical system may indeed bias the reconstructions. The team has here suggested to estimate them using a parametric inverse problems approach and calibrations beads (that may be embedded in the sample to self-calibrate the system), and to reconstruct the sample using a regularized inverse problems approach that considers these aberrations.



Figures above:
Left: In order to explore the aberrations changes in the field of view, a single polystyrene bead of 1µm was moved in 35 (7×5) different locations (top). Moreover, this was done for 5 different settings of the objective coverslip thickness correction collar, which induced various but controlled aberrations in the system (The values 0.13 to 0.21mm represent the supposed thickness of the coverslip, while it was actually 0.17mm thick). XZ-views of the hologram stacks reveals that the focus changes as well as the diffraction patterns (bottom).
Right: Evolution of the phase (in radians) of the pupil function correction in the field of view for a correction collar set at 0.17mm (that should be the lowest aberration situation) and for the 7×5 positions in the field where the aberrations were estimated.

Opt. Express, 30 (2022), 38383-38404

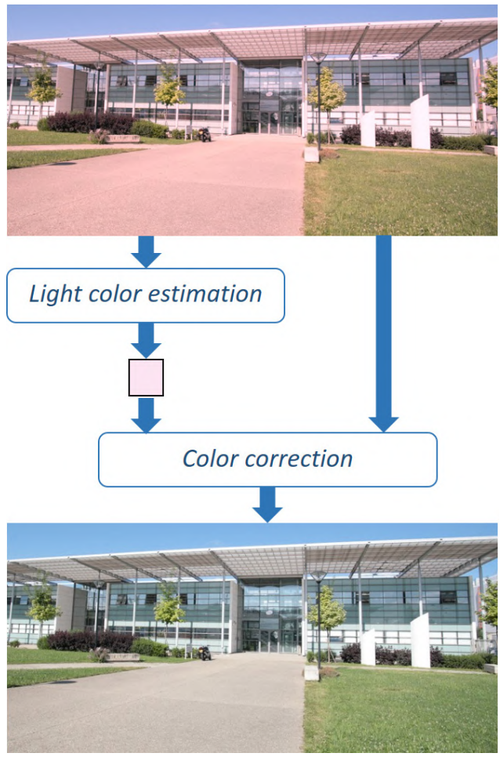
IEEE International Conference on Image Processing, ICIP 2022

Predicting the Colors of Reference Surfaces for Color Constancy

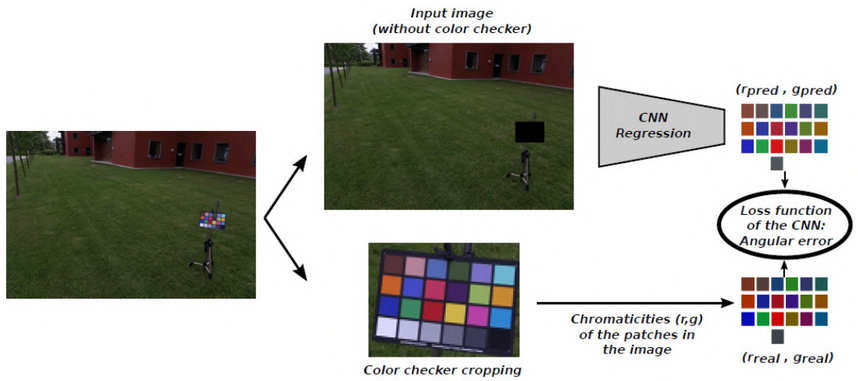
Isidore Dubuisson, Damien Muselet, Yanis Basso-Bert, Alain Tremeau and Robert Laganière.

The IEEE ICIP is the world's largest and most comprehensive technical conference focused on image and video processing and computer vision. Their latest event took place last October in Bordeaux and was an opportunity for members of our Image Science and Computer Vision team to present their most recent work on image color analysis.

Color constancy is the ability of the human visual system to perceive constant colors despite variations in illumination conditions. Computational color constancy tries to mimic this behaviour with computer vision systems. Given a digital image, the idea is first to estimate the color of the illumination and then remove the impact of this illumination from the pixel colors (Figure 1).
Classical approaches consist in characterizing the light color by measuring its impact on a grey surface. This solution allows correcting pixel colors only by scaling their red, green and blue components independently, known as white-balance. In this paper, the authors discuss the limits of such an approach and suggest to rather evaluate the impact of the light source on a set of reference surfaces. Thus, the team design and train a convolutional neural network that predicts the colors of these surfaces as if they were present in the image (Figure 2). With these predictions, the colors of the pixels can be corrected by using a full 3x3 matrix, and not only a diagonal matrix. The team show that they are able to better estimate the features of the light source and to better correct the pixel colors than the alternatives.



Right, Figure 1:
Classical computational color constancy
Below, Figure 2:
Deep color regression

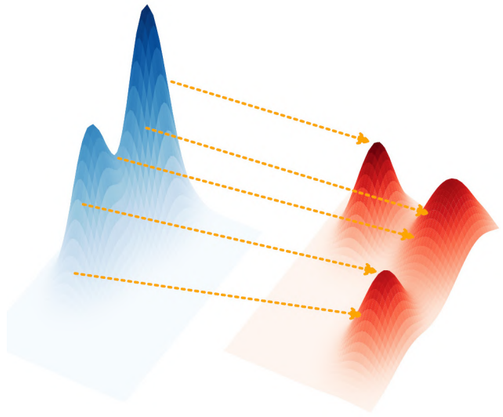


IEEE International Conference on Image Processing (ICIP), Bordeaux, France, (2022), pp. 1761-1765

AAAI'22 Conference on Artificial Intelligence

Optimal Tensor Transport

Tanguy Kerdoncuff, Michaël Perrot, Rémi Emonet and Marc Sebban.



An article by our Data Intelligence team was presented during the 2022 AAAI Conference on Artificial Intelligence, an annual event promoting theoretical and applied AI research as well as intellectual interchange among researchers and practitioners.

The optimal transport problem has recently found many applications at the core of machine learning, and especially in transfer learning. Tanguy Kerdoncuff's contribution to this subject, presented in his PhD. thesis, generalizes and unifies several existing formulations of optimal transport. The published article therefore explores a unified formulation, Optimal Tensor Transport (OTT), that includes a scalable stochastic optimization algorithm with convergence guarantees. This formulation also opens a whole range of new applications where datasets have more complex structures.

Illustration above:
The traditional optimal transport problem, here illustrated in 2D: the goal is to find the optimal transport plan (in orange) to reshape the blue mass into the red one. This optimal transport problem corresponds to OTT1 with F=2.

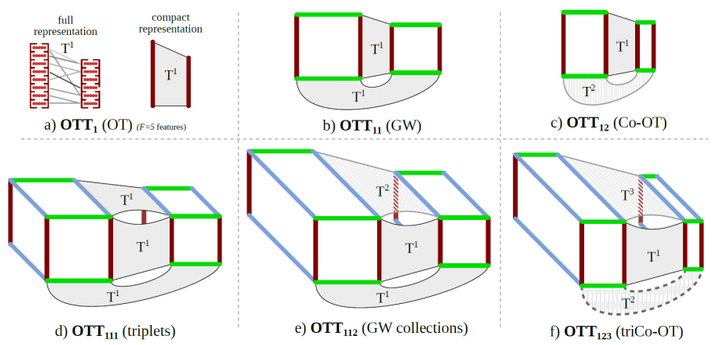


Illustration above:
Optimal Tensor Transport (OTT):
1st row: reformulation of 3 existing optimal transport formulations,
2nd row: some novel formulations, falling into the OTT generalization.

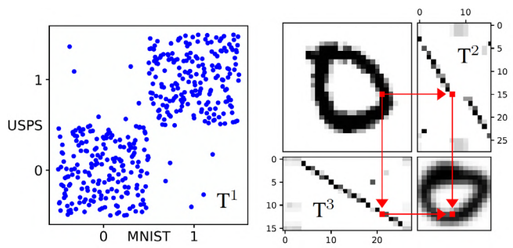


Illustration left:
Example of OTT123, a generalization of Co-Optimal Transport, where three transport plans are learned (T1 to map points, T2 for rows and T3 for columns) to align two digit-image datasets at different resolutions (MNIST and USPS).

Proceedings of the AAAI Conference on Artificial Intelligence, 36(7) (2022), 7124-7132

Annual Conference on Neural Information Processing Systems (NeurIPS 2021)

A PAC-Bayes Analysis of Adversarial Robustness

Paul Viallard, Guillaume Vidot, Amaury Habrard and Emilie Morvant

On the occasion of the Conference on Neural Information Processing Systems NeurIPS 2021, our Data Intelligence team presented the first PAC-Bayesian theoretical analysis for the adversarial robustness. It further allowed to obtain a new adversarial robustness method that is applied to image classification tasks. This paper is the result of a collaborative work between the Hubert Curien Laboratory, the CNRS, the Institut de Recherche en Informatique de Toulouse and Airbus Operation S.A.S.

In Artificial Intelligence (AI), and more specifically in machine learning, handwritten recognition is essential for many practical applications: automatically reading postal addresses, old scanned documents, etc. However, the quality of writing and the scan can compromise the AI which will here correspond to a digit classifier. Figure (1) shows an example where images are «clean» (first row), meaning that a human or an AI can easily recognise the digits, whilst others are "perturbed" by bad writing and scanning (second row), making them more difficult to recognise (even for a human). Therefore, the AI has to be trained with care to avoid errors on the "perturbed" images: it has to be more robust; the higher the robustness, the higher the correct recognition of "perturbed" images. More formally, the robustness is the probability $P(h_{AI}\,(x+\epsilon)=y)$ that the digit classifier h_{AI} produced by the AI correctly recognises an image x representing the digit y and perturbed by an additive noise ϵ.

Equation (1):

$$\textit{Robustness on new}\ \text{perturbed}\ \textit{images} \geq \textit{Robustness on images seen}\ \text{in}\ \textit{the training} - \frac{\textit{AI's complexity}}{f(\textit{Number of images})}.$$

In the literature, the AI's robustness is verified empirically by testing the recognition on "perturbed" images not seen during the training. In this contribution, the team derives a rigorous mathematical framework that provably shows how an AI can be robust to "perturbed" images. This framework allows to formalise new inequalities (namely, PAC-Bayes generalization bounds) that lower-bound the AI's robustness on the new images. The form of the inequality is illustrated in Equation (1) above. The robustness of the AI on the new images depends on (1) the robustness on training images and (2) the "complexity" of the AI (which is high when its definition or parameterization is "complex"). On the one hand, when there are few images (say one hundred), the AI must be "simple" to ensure good robustness on new images. On the other hand, when thousands of images are available, the AI can be "complex", robust, and potentially better suited to accomplish its task. More formally, the considered AI (a mathematical model) is a weighted sum of simple functions. Consequently, the AI's complexity is measured by the Kullback-Leibler divergence between the learned weights and some weights initialized randomly. That is to say, the higher the Kullback-Leibler divergence, the more "complex" the AI is. Finally, an algorithm can be derived from this generalization bound to robustify majority votes (by maximizing the right terms of the inequality). This work thus opens the way to the robustification of AI methods, an essential principle for improving the stability and safety of many applications.

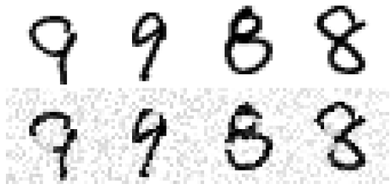


Figure (1):

1st row: The images are "clean": the digits 9 and 8 are easily recognisable.
2nd row: The images are noisy: the 9 and 8 digits can be read as 7, 4, 5 and 3.

(Credit *Towards Deep Learning Models Resistant to Adversarial Attacks*, [Madry et al., ICLR 2018])

Ref HAL: hal-03145332 , version 2

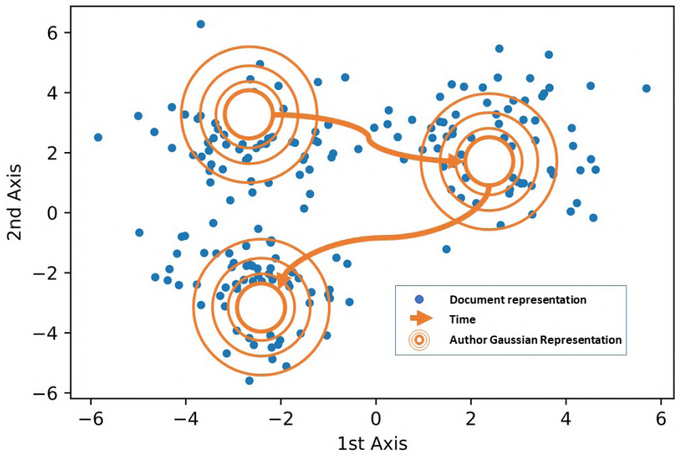
The ACM Web Conference 2022

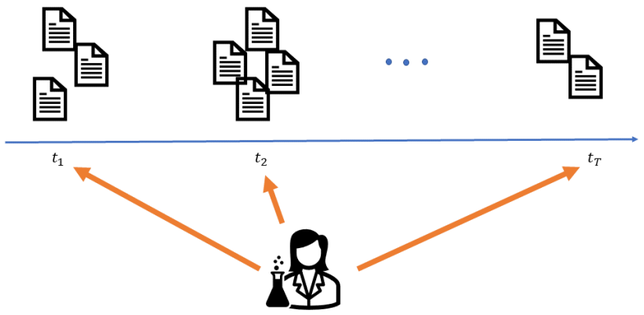
Dynamic Gaussian Embedding of Authors

Antoine Gourru, Julien Velcin, Christophe Gravier and Julien Jacques.

The Web Conference is a yearly international academic conference where the latest research progress, development, standards and applications related to the future direction of the World Wide Web are presented and discussed. The 2022 event was an occasion for our Data Intelligence team to present their latest work on representation learning.

Machine Learning methods for textual data rely on vectorial representations of text to solve common tasks, such as classification, clustering, generation, or recommendation. The similarity between the representations of words/documents should relate with their semantic proximity. In this article, the team propose a model that learns authors representations. The contributions are twofold: the representations evolve over time to capture the authors' shift of topic of interest over long periods (e.g., researcher's publications) and authors are represented as Gaussians instead of vectors, to obtain a measure of semantic uncertainty.





Illustrations:
Right: Output of DGEA - Illustration of the dynamic Gaussian embedding of an author (in orange) in the same semantic space than pre-trained document representation. Documents' representations are illustrated as dots (in blue). They are built using document encoders such as the Universal Sentence Encoder. The author's representations are Gaussian distributions that evolve over time (indicated as an orange arrow).

Right: The team relies on dynamic textual data organized in time bins. The representation of the author in the latent space should follow her/his evolution with regard to the content of its writings. For example, a researcher's topics of interest evolve over her/his carrier, along with the methods she/he uses.

Proceedings of the ACM Web Conference 2022, Pages 2109–2119

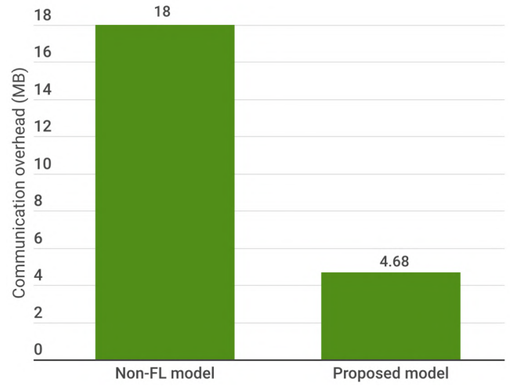
IEEE Transactions on Industrial Informatics

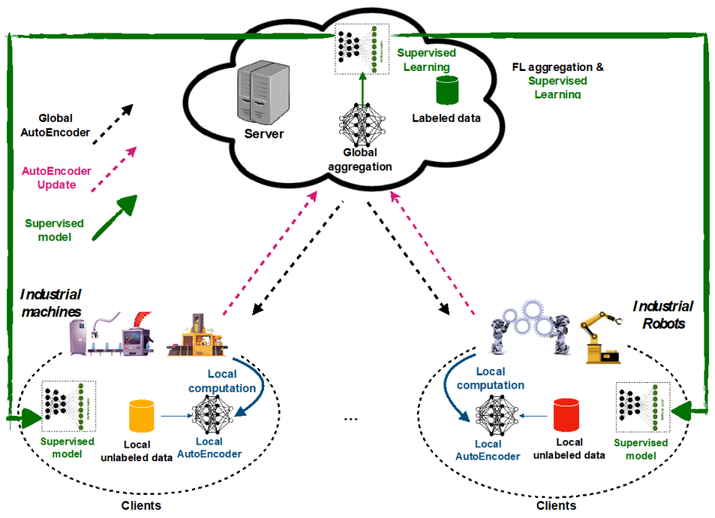
Federated Semi-Supervised Learning for Attack Detection in Industrial Internet of Things

Ons Aouedi, Kandaraj Piamrat, Guillaume Muller and Kamal Singh.

An article published in March 2022 by the Hubert Curien Lab's Data Intelligence team has appeared in IEEE Transactions on Industrial Informatics. This work was done in collaboration with the Laboratoire des Sciences du Numérique de Nantes (LS2N).

The paper addresses the challenges of implementing secure Industry 4.0 due to emerging cyber-security threats, and the difficulty of obtaining labeled data required for Deep Learning (DL) approaches to detect systems' intrusions. A novel, semi-supervised, federated learning scheme is proposed in this paper, which takes advantage of both unlabeled and labeled data in a federated way. This approach involves training an AutoEncoder (AE) on IIoT edge devices to learn representative and low-dimensional features using local/private data, then aggregating these models into a global AE using Federated Learning (FL). A supervised neural network is then composed and trained. The developed model has many advantages: it ensures that no local private data is exchanged, it detects attacks with high classification performance, works even with limited labeled data, and has low communication overhead.





Illustrations

Above: The team's proposal shows lower communication overhead as compared to another state of the art non-FL (non federated learning) scheme. Cyber attacks were detected in this dataset, which corresponds to the traffic of a water storage tank control system.

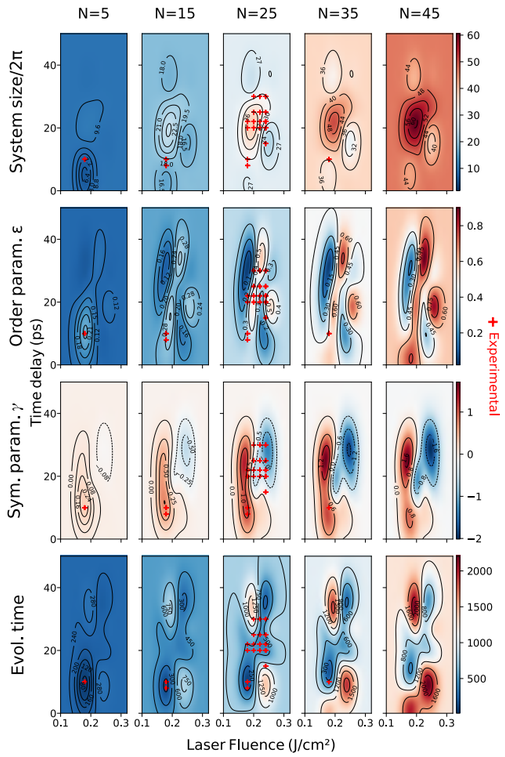
Left: The network architecture of the team's Federated semi-supervised proposal for Industrial Internet of Things.

IEEE Transactions on Industrial Informaticsn, Volume: 19, Issue: 1, (2023)

Entropy

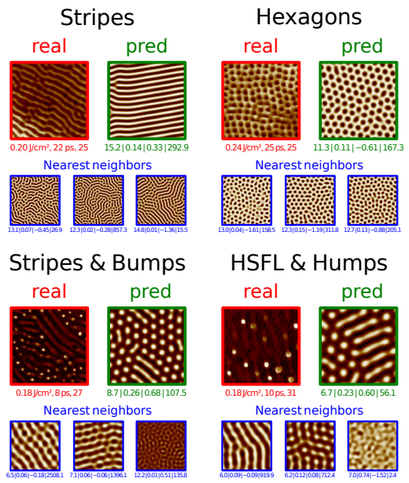
Learning PDE to Model Self-Organization of Matter

Eduardo Brandao, Jean-Philippe Colombier, Stefan Duffner, Rémi Emonet, Florence Garrelie, Amaury Habrard, François Jacquenet, Anthony Nakhoul and Marc Sebban.



Entropy is an international peer-reviewed open access journal covering research on all aspects of entropy and information theory. In August 2022, the journal published an article presenting the results of a collaborative research project between our Data Intelligence and Laser-Matter Interaction teams.

Self-organization governs the formation of many of the interesting structures that we observe in Nature, from the clouds of Jupiter to how the leopard got his spots. A self-organization process has recently been proposed to model the laser-induced formation of nanopatterns on nickel, which have many interesting - namely biomedical applications. In this paper, the team integrate the physical knowledge of this process in the form of the Swift-Hohenberg partial differential equation to guide the training of a machine learning model of the laser/matter interaction. This model predicts new patterns associated with different laser parameters and can be used to virtually explore laser parameter space. It is also shown that this method can be applied generally to learn self-organization processes, even with few data.



Illustrations:

Above: Each plot shows the predictions of the indirect model, trained on the full dataset, of a single Swift-Hohenberg parameter, as a heatmap (top to bottom: system size in multiples of 2π; order parameter ε; symmetry breaking parameter γ; solver evolution time) as a function of laser fluence, time delay, and number of pulses (respectively, x-axis and y-axis, and column). Experimental points are overlaid on each plot.

Right: Each group shows experimental SEM images (red, never seen by the model), model predicted images (green, trained on the «full» dataset using the indirect method), given the same laser parameters and three nearest neighbors of the former among solver generated images (blue).
Image labels, left to right: Fp, Δt, N (real images); l, ε, γ, t (other images).
All images are 224 by 224 pixels; for real images, 1μm ≈ 237 pixels.
Model's predictions are better than the nearest neighbor, since they integrate global information.

Entropy, 24 (2022), 1096

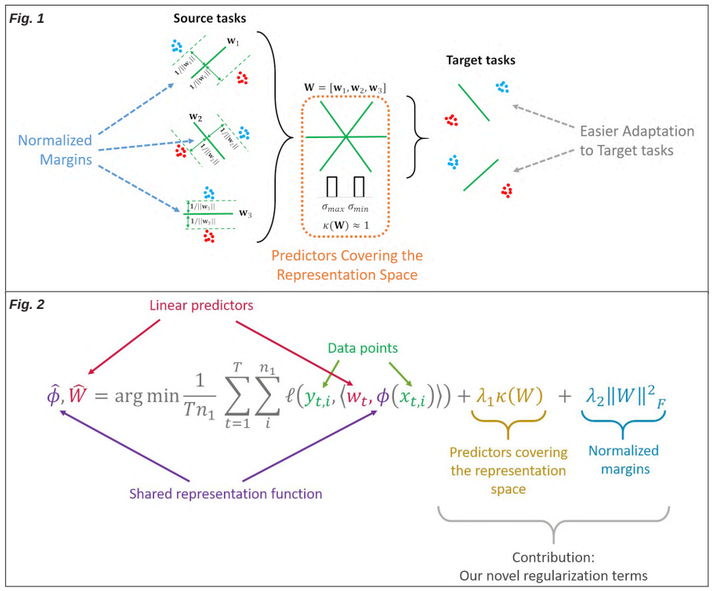
European Conference on Computer Vision (ECCV), 2022

Improving Few-Shot Learning through Multi-task Representation Learning Theory

Quentin Bouniot, Ievgen Redko, Romaric Audigier, Angélique Loesch and Amaury Habrard.

ECCV is a biennial research event considered to be one of the top conferences in computer vision. Its proceedings are published by Springer Science. The 2022 conference was an opportunity for our Data Intelligence team to present their latest work on Few-Shot Learning.

In this paper, the team is interested in Few-shot Learning problems, where only few amounts of labelled training data are available to solve a target task, whilst having access to a large labelled dataset to learn a generic representation. Popular approaches for tackling these types of problems are based on Meta-Learning, or Learning-to-learn, which aims to quickly adapt the general representation to the target task. Recent work in the theoretical literature of Few-Shot Learning has achieved a faster learning bound using novel assumptions and studying the problem in the Multi-Task Learning framework. In light of these recent results, the authors are putting theory into practice by analysing popular Meta-Learning algorithms in the Multi-Task Learning framework.



Illustrations:
Fig. 1: Illustration of the effect of the important assumptions derived from Multi-Task Learning theory.
Fig. 2: The proposed regularization terms introduced in the Meta-Learning optimization problem.

ECCV 2022. Lecture Notes in Computer Science, vol 13680.

IEEE Transactions on Cognitive Communications and Networking (TCCN)

Improving User Environment Detection Using Context-aware Multi-Task Deep Learning in Mobile Networks

Marie Line Alberi Morel, Illyyne Saffar, Kamal Singh, Sid Ali Hamideche and César Viho.

The TCCN publishes high-quality research related to cognitive communications (applications of perception, learning, reasoning, memory and adaptive approaches in the design of communication systems) and networking. An article by our Data Intelligence team is available since last September on the journal's website, summarizing a research work done within the framework of a CIFRE PhD thesis.

New 5G and beyond networks will bring new services and new technological advancements, as well as being increasingly human-centered. However, their growing levels of complexity and traffic volumes, combined with high diversity and big size, brings a new set of challenges for operators managing such networks. The team believes that networks should largely self-manage themselves and automatically deal with issues such as QoE, network optimisation, management of heterogeneous services. They should be able to automatically detect important context and quality information, and be able to automatically optimize the network and services for the users.

In this article, the authors address the problem of detecting user context. Their research question is: how can the knowledge of a mobile user behavior be automatically extracted and processed, in order to anticipate their preferences, their needs and as such optimize the networks? Knowing what/when/where/how a user consumes their mobile services can notably improve the self-adaptation and self-optimization capabilities of these networks and, in turn, ensure user satisfaction. User context has an important impact on user satisfaction and consumption of a service. Knowing user context can help a network anticipate user traffic and allocate appropriate network resources in advance. To achieve this, the team studies data driven techniques via multi-task learning (MTL) to detect a user environment - whether the user is indoors, at home, in a car, etc. - and mobility profile or at what speed the user is moving. Models using real-life radio signals data are built. Simulation results show that an efficient machine learning model can be trained to detect several environment classes using radio signals that arrive on the network side.

Illustrations:

Figure right: The team focuses on detecting the environment and mobility attributes of user context.

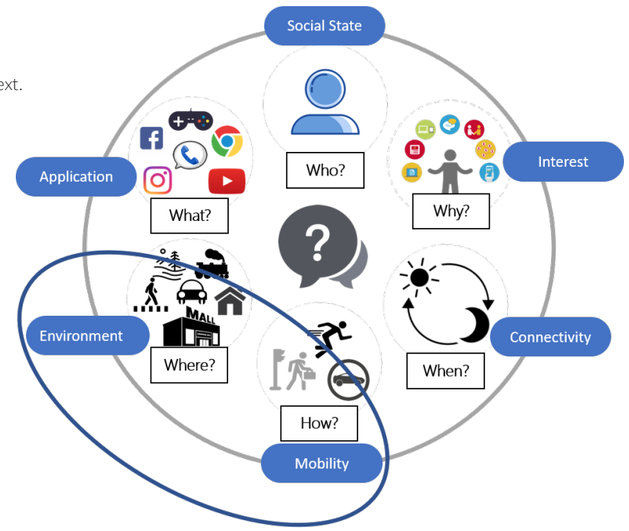


Table right: The authors obtain high values of Accuracy (Acc.) and F1-Score (F1-S.) using Multi-Task Learning model for different types of classifications. Here, different cases are shown, ranging from detection of only 2 classes up to 8 classes, as well as different speed ranges.

Environment (UED)	Mobility (MSP) kmph	Dataset 1	
		Acc.	F1-S.
Outdoor / Indoor	**{0,10,90}**	**99.12%**	**99.03%**
Pedestrian, Transport / Buildings, Home		**99.22%**	**98.23%**
Pedestrian, Transport / Buildings, Home, Mall		**98.92%**	**97.97%**
Pedestrian, Car, Bus, Train / Building, Home, Work, Mall		98.85%	97.90%

IEEE Transactions on Cognitive Communications and Networking, vol. 8, no. 4 (2022), pp. 1665-1676

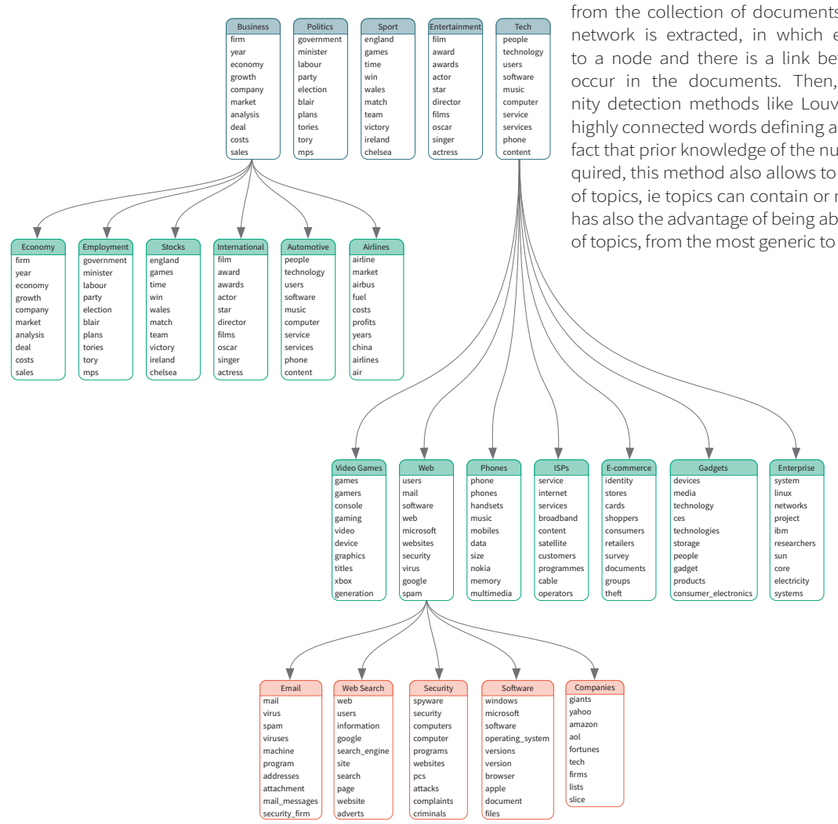
International Conference on Computational Linguistics (COLING 2022)

Community Topic: Topic model inference by consecutive word community discovery

Eric Austin, Osmar R. Zaïane and Christine Largeron

COLING is one of the premier conferences for the natural language processing and computational linguistics. Their 29th event was held between the 12th and 17th October 2022 in Gyeongju, Republic of Korea, and was an opportunity for our Data Intelligence team to present their latest work on topic modeling.

Topic modeling is an important task in natural language processing as well as in text mining and machine learning. It aims at discovering topics that appear in a collection of documents. Intuitively, the idea is that words having a similar meaning should appear frequently simultaneously and close together in the textual documents: this is the so-called “distributional hypothesis”. Latent semantic analysis (LSA) is one of the first statistical models introduced to solve the task. It allows to project words and documents in a common vector space which dimensions correspond to latent topics. The limits of LSA and derived methods are (i) the need to set a priori the number of topics and (ii) the lack of interpretability of these latent topics. To overcome these limits, the team suggests to combine text mining and social mining: from the collection of documents, a term co-occurrence network is extracted, in which each term corresponds to a node and there is a link between them if they co-occur in the documents. Then, by applying community detection methods like Louvain, the authors detect highly connected words defining a topic. In addition to the fact that prior knowledge of the number of topics is not required, this method also allows to control the overlapping of topics, ie topics can contain or not some same terms. It has also the advantage of being able to provide a hierarchy of topics, from the most generic to the most specific ones.



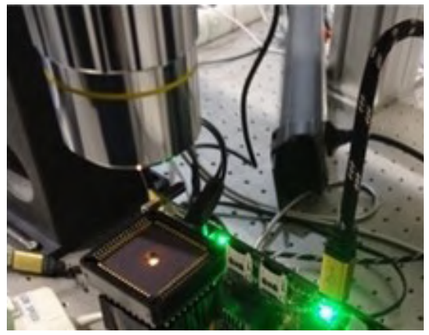
Proceedings of the 29th International Conference on Computational Linguistics, (2022), pages 971–983

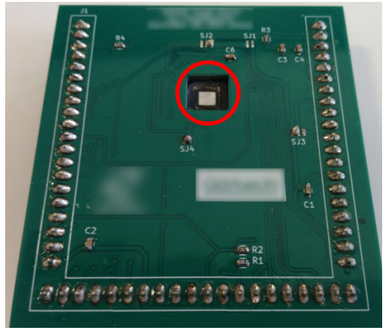
EUROCRYPT 2021 Conference on the Theory and Applications of Cryptographic Techniques

Message-Recovery Laser Fault Injection Attack on the Classic McEliece Cryptosystem

Pierre-Louis Cayrel, Brice Colombier, Vlad-Florin Dragoi, Alexandre Menu and Lilian Bossuet.

During the Eurocrypt 2021 conference, the Hubert Curien Lab's SESAM team presented one of their research studies on the security of code-based public-key cryptosystems.
In this article, the team present a laser-fault injection attack on a code-based cryptosystem, which is one of the finalists of the ongoing standardization competition organised by the NIST (National Institute of Standardization and Technology). The security of this cryptosystem relies on the hardness of a well-known problem, namely the «syndrome decoding problem over F2». Using laser-fault injection the authors flipped a bit on the memory, which allowed them to solve the hard problem by turning it into an easier one. The syndrome decoding problem over F2 was changed into the same problem, but over N, and specific algorithms were developed, which successfully solved this problem.
This article was written in collaboration with Brice Colombier (TIMA Laboratory, Université de Grenoble), Alexandre Menu (Ecole des Mines de Saint-Etienne - Gardanne site) and Vlad Dragoi (Arad University, Romania).





Illustrations above:
Left: An integrated circuit is placed under a 1064 nm laser to be disturbed during the execution of a cryptographic function such as a post-quantum encryption algorithm.
Right: In this article the team has targeted a 32-bit microcontroller which back side is accessible (here via a cutting of the PCB). This allows direct access to the silicon and optimal penetration of the photon beam from the laser. This board was prepared and lent to the team by the Ecole des Mines de Saint-Etienne (site of Gardanne).

International Conference on the Theory and Application of Cryptographic Techniques, 2021

IACR Transactions on Cryptographic Hardware and Embedded Systems (TCHES)

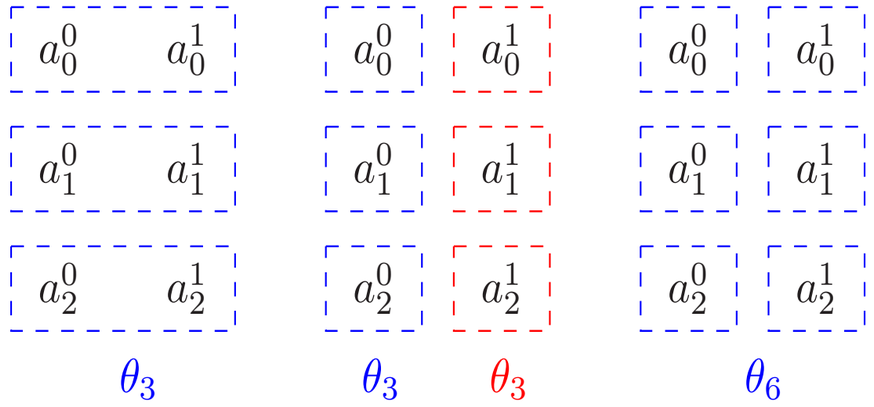
Bitslice Masking and Improved Shuffling: How and When to Mix Them in Software?

Melissa Azouaoui, Olivier Bronchain, Vincent Grosso, Kostas Papagiannopoulos and François-Xavier Standaert.

The Hubert Curien Lab's SESAM team has released an article in TCHES, a journal/conference hybrid publication model highlighting new results in the design and analysis of cryptographic hardware and software implementations. The journal is published by the Ruhr-University of Bochum.

Several countermeasures do exist to protect cryptographic implementations against side-channel attacks. Whilst the safety contribution of the various protections taken individually has been studied for several years, the impact of their combination is more complex.
In this article, the team puts forward a framework to combine different protections, and does a theoretical analysis of their security. In particular, a better compromise can be estimated, depending on the additional penalty cost they are ready to pay. This theoretical analysis is validated by tests on micro-controllers.

The figure below illustrates different shuffling and masking combination options:
On the left, the shuffling is applied to the shares;
In the centre, the shuffling is applied between the shares;
On the right, the shuffling is applied to each element.



IACR Transactions on Cryptographic Hardware and Embedded Systems, (2) (2022), 140–165

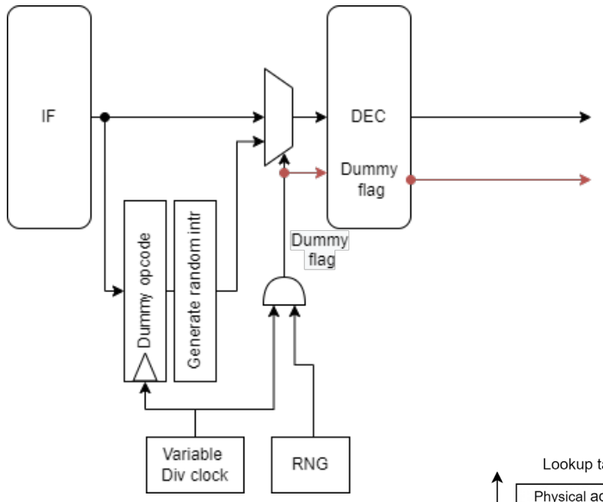
IEEE International Symposium on Hardware Oriented Security and Trust, HOST 2022

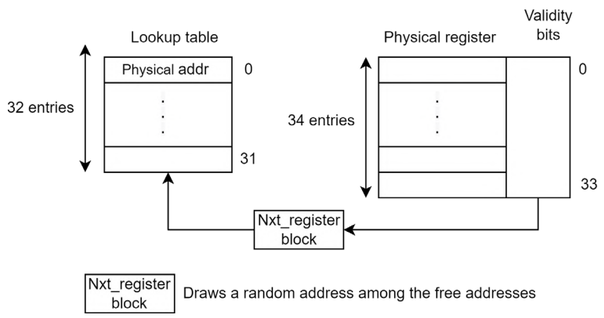
Insertion of random delay with context-aware dummy instructions generator in a RISC-V processor

Gaëtan Leplus, Olivier Savry and Lilian Bossuet.

The IEEE HOST Symposium is an international event that aims to facilitate the rapid growth of hardware-based security research and development. Last year's event was an opportunity for our SESAM team to present one of their research studies on hardware physical attacks.

In collaboration with the technology research institute CEA-Leti, the team has studied solutions to improve the security of the RISC-V processor architecture against physical attacks such as perturbation attacks (called “fault injection attacks”), and attacks by analysing the power consumption (called “side channel attacks”) of the circuit which embeds the processor. The security of RISC-V is a hot topic for both the academic and industrial communities, as this processor is increasingly used. It is indeed an open source processor, developed by the University of California at Berkeley, that is starting to replace proprietary solutions such as those proposed by British company ARM, market leader in embedded systems. As the architecture and instruction set of RISC-V are open, and because it is possible to modify the processor’s structure to make it more robust, it is particularly interesting to study security issues. This is what is suggested in this paper. The underlaying idea of the team’s approach is not new; it consists in adding false instructions (called “dummy instructions”) during the execution of a program. These instructions do not change the functionalities of the software application executed by the processor, however they hinder the work of an attacker. What is new in this contribution relies on the method used to add these instructions automatically and at the architecture level (i.e. without modifying the code at compilation time). Ultimately, this solution proves very efficient in increasing the security level of the processor with a low overhead.





Illustrations:
Above:
Architecture dummy instruction insertion.

Right:
Dynamic register bank.

IEEE International Symposium on Hardware Oriented Security and Trust (HOST), (2022), pp. 81-84

Smart Card Research and Advanced Application Conference, CARDIS 2022

An evaluation procedure for comparing clock jitter measurements methods

Arturo Mollinedo Garay, Florent Bernard, Viktor Fischer, Patrick Haddad and Ugo Mureddu

As smart cards are playing an increasingly role in our daily lives through their use in banking cards, SIM cards, electronic passports and IoT devices, it is particularly important to understand their security features and develop sound protocols and countermeasures whilst maintaining reasonable performances. In this respect, CARDIS conferences gather experts aiming to make steps forward in the field of embedded security. Our SESAM team’s latest research work on True Random Number Generators was presented at their 2022 event, held last November in Birminghmam, UK.
The security of cryptographic systems relies on the statistical quality and unpredictability of random generated numbers. An evaluation of random number generation mechanisms is therefore essential to the security validation procedures required by security standards. True Random Number Generators (TRNGs) need some analog physical phenomena that can be exploited as a nonmanipulable source of randomness.

The most common source of randomness in logic devices is clock jitter, which is a progressive fluctuation of the rising and falling edges of the clock signal. This analog source is used by a TRNG to produce random numbers. The security evaluation of a TRNG using jitter as a source of randomness depends on an accurate measurement of the jitter component caused by thermal noise. Several jitter measurement methods that can be embedded in cryptographic systems have been published over the last decade, but only a few are suitable for evaluation of jitter caused only by thermal noise. Paradoxically, no objective methodology for the analysis and comparison of their precision linked with their input parameters is currently available. However, such methodologies would be useful when deciding whether a particular jitter measurement method deserves to be implemented in hardware, or when assessing its limits in terms of precision and exploration space, i.e. the space of possible input values. The team suggests a new objective procedure for the evaluation of jitter measurement methods, based on the simulation of a given method using its own analytical model. The methods analyzed in this paper are shown to be only sufficiently accurate in certain conditions. This paper therefore demonstrates the necessity of defining the parameters ensuring the accuracy of a jitter measurement method.

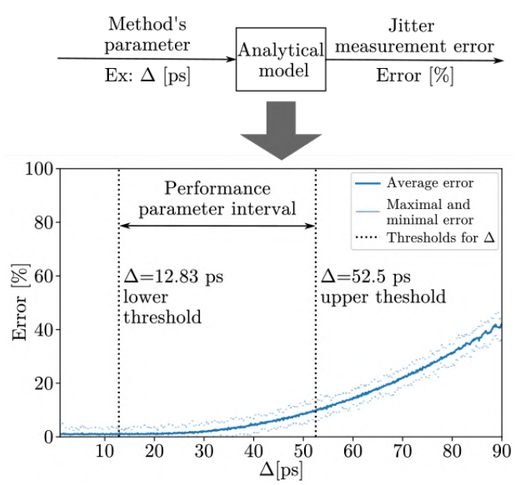


Figure left:
Example of our methodology applied to a jitter measurement method, showing the identified range of performance.

CARDIS 2022. Lecture Notes in Computer Science, vol 13820.

TRAINING
RESEARCH
INNOVATION

The laboratory has built an exceptional environment around the Training / Research / Innovation articulation, a principle at the core of the Graduate School that it coordinates. This section details out our program of Masters degrees, presents the activities of the Manutech-SLEIGHT Graduate School and introduces the joint laboratories we have launched in partnership with 2 private companies.

Our related Master's Degrees

The laboratory's researchers manage 9 master tracks as part of 2 master degrees of the University Jean Monnet, including 4 Erasmus+ and several international courses. The programmes developed within these degrees cover all scientific thematics of the lab's research activities. Our local partners include the Manutech SLEIGHT Graduate School, the Institut d'Optique Graduate School, the Ecole Centrale de Lyon, the Université de Lyon and the Ecole des Mines de Saint-Etienne.

Master Degree in Optics, Image, Vision, Multimedia (OIVM) - Head: Nathalie Destouches

The MSc in Optics, Image, Vision, Multimedia (OIVM) is a unique master programme offering 6 specialisation tracks including 4 Erasmus Mundus Joint Master Degrees - EMJMD. This master program intends to shape the future of industrial and academic experts in optics, photonics, surface engineering, image, material appearance, imaging technologies, spectral imaging, security, reliability, safety and radiation effects. All courses are taught in English.

PSRS - Photonics for Security, Reliability and Safety (EMJMD)
Coordinator: Nathalie Destouches
PSRS aims at training the next generation of highly-skilled experts in advanced imaging technologies, cutting-edge image processing, computational imaging, artificial intelligence technologies, biometrics, pattern recognition, behavioral analysis, spectrometry methodologies, photonic-based sensors, micro-nano-technologies, laser processing and surface functionalization to address the current and future societal challenges related to security and safety of people, goods and environment.

RADMEP - Radiation and its Effects on Micro Electronics and Photonics Technologies (EMJMD)
Coordinator: Sylvain Girard
The multidisciplinary and innovative programme of RADMEP covers the interactions between Radiation and MicroElectronics and Photonics, two Key Enabling Technologies for the future of Europe. RADMEP's objective is to educate students in those advanced technologies, providing methodologies and introducing practical applications for their implementation in a variety of natural or man-made radiation-rich environments.

COSI - Computational Colour and Spectral Imaging (EMJMD)
Local coordinator: Alain Trémeau
This master course aims at training the next generation of highly-skilled industrial experts in applied colour science, in various cutting-edge industries (photonics, optics, spectral imaging, multimedia technologies, computer graphics and vision) and in a diverse range of sectors (including multimedia, health care, cosmetic, automotive, agro-food). The two areas of focus are spectral technologies and applied colour imaging.

IMLEX - Imaging and Light in Extended Reality (EMJMD)
Local coordinator: Philippe Colantoni
This multidisciplinary programme combines the topics of image conversion, lighting and computer science. The objective of this degree is to train future experts who, in addition to acquiring a solid theoretical understanding of virtual reality, will also develop strong practical skills for virtual reality applications. IMLEX students benefit from a combined European and Japanese expertise in research related to virtual reality and robotics.

AIMA - Advanced Imaging and Materials Appearance: Metrology and modelling (International track)
Coordinator: Mathieu Hébert
The Advanced Imaging and Material Appearance: Metrology & Modelling - AIMA track focuses on imaging. It encompasses physical principles of image formation, imaging technologies, image analysis, digital image processing and image reproduction by printing. It also includes the appearance of materials and other specific imaging applications such as document security. The aim of the programme is to provide sufficient knowledge and skills to start a career as an engineer or a researcher in these fields.

PE - Photonics Engineering (International track)
Coordinator: Emmanuel Marin
The programme of Photonics Engineering is based on fundamental, practical and in-depth courses at the interface between optics, photonics and computer science. It provides a progressive specialisation training enabling future professionals to develop a research-engineering activity in the sectors related to applied physics, optics, photonics, fiber optic sensors, surface structuring by laser at micro & nanometric scales, modelling & optical, physical & mathematical characterisation of surfaces, structured interfaces, etc.

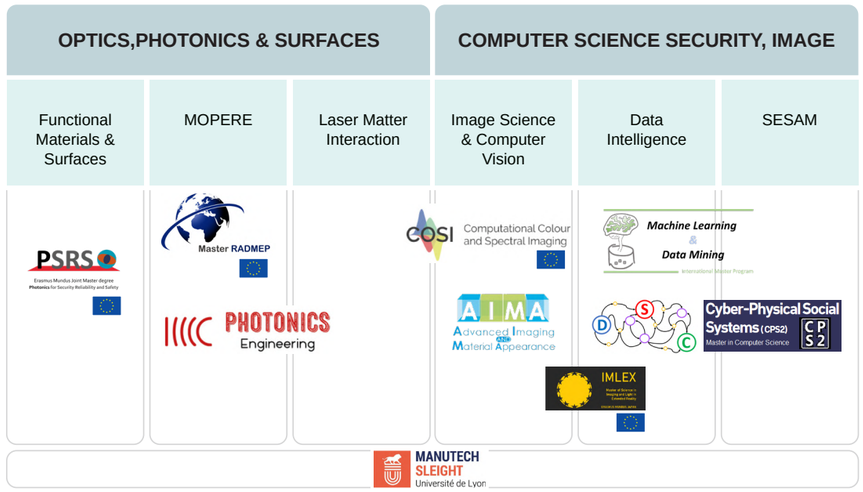
Master Degree in Computer science - Head: Amaury Habrard

The MSc in Computer Science is a programme offering 3 specialisation tracks mainly taught in English. The programmes are designed to train students specialised in artificial intelligence and IT, and prepare them for careers in both academic research and R&D for private companies.

MLDM - Machine Learning Data Mining (International track)
Coordinators: Amaury Habrard & Marc Sebban
MLDM occupies a unique scientific position in Europe on problems related to machine learning, big data, pattern recognition, classification, modelling, knowledge extraction and data mining. These issues have a strong employability potential for students trained in the fields of data science, prediction, data analysis or decision support, as well as in the area of the Web, image and video processing, health informatics, fraud and anomaly detection, etc.

CPS2 - Cyber-Physical Social Systems (International track)
Coordinator: Pierre Maret
The aim of this program is to provide students with a triple expertise on technologies and methods to design and integrate intelligent cyber-physical systems at the interface of the physical, social and digital dimensions of our environments (Technological, Functional, Scientific). Topics taught in CPS2 are related to the Internet of Things, Web and mobile applications, Artificial Intelligence, Cloud and Edge Infrastructures, Digital Twins, Cyber-security, Scientific Writing. Application domains include Industry 4.0, Smart Cities, Smart Buildings, Intelligent Transport Systems.

DCS - Data and Connected Systems (national track 50% French 50% English)
Coordinators: François Jacquenet (1st year), Baptiste Jeudy & Antoine Zimmerman (2nd year)
The objective of the DSC track is to train specialists capable of responding to the problems of data massification and the interconnection of computer systems and communicating objects linked to the current digital metamorphosis (web, Internet of Things, big data) by mastering the processing chain from raw data to its analysis, as well as its use in interconnected intelligent systems. Mainly aiming to train computer scientists, part of the teachingoffers advanced courses in algorithms, programming and project management.



The Manutech SLEIGHT Graduate School

The Manutech-SLEIGHT Graduate School provides an attractive research-integrated graduate program, offering a unique environment for training and for cross-disciplinary research in the domain of Surfaces Light EngIneerinG Health and socieTy (SLEIGHT). The School is coordinated by the Université de Lyon and managed by our lab. Resulting from our pioneering work on ultrafast laser surface texturing for the mechanical components in competition engines with the company HEF, the Manutech brand partnership was founded in the 2000s. With a fast dynamic of research and development activities, the consortium was strengthened in 2010, with 7 partners from the Saint-Étienne/Lyon area and through the creation in 2011 of the Equipment of Excellence EquipEx Manutech-USD and the Laboratory of Excellence - LabEx Manutech-SISE. A total of 32 research projects have been so far funded by Manutech-SLEIGHT, including 17 PhDs, for works at the interface of Surface (material physics, mechanics), Light (optics-photonics), Image & Data Sciences (machine learning, data mining), Biology/Medecine, Scientific & technical facilities. The Graduate School also supports the international mobility of researchers and students.

© Jean Monnet University

Twice a year, the School organises the SLEIGHT Science Events (SSE). During these, scientists and students can meet, interact, discuss their progress as well as their ambitions and challenges. The events include lectures from international guests, workshops, pitch and posters presentations, PhD and post-doc sessions, thesis defenses and social events.

Scientific excellence

The ambitious scientific program is structured around 3 scientific objectives:

- Predict and experiment light-induced surface modification processes
- Extract full information and meaning from surface imaging through an integrated chain of skills
- Foster a decisive technological leap in engineering and control of light-induced or light-monitored surface modification effects

The Graduate School offers a unique environment for researchers who wish to undertake ambitious & transdisciplinary research projects, responding to major societal issues of the 21th century.

Top-level training

Manutech-SLEIGHT offers graduate programs promoting interdisciplinary cross fertilisation (international master programmes, engineering schools and PhD programs) within a very pleasant learning environment.

3 MASTER'S DEGREES / 9 MASTER TRACKS
2 ENGINEERING SCHOOLS' RESEARCH TRACKS
2 DOCTORAL SCHOOLS
«Science, Engineering, Health» Doctoral School (ED 488 SIS)
«Mechanics, Energetics, Civil engineering, Accoustics» Doctoral School (ED 162 MEGA)

TOPICS
Surface Engineering, Optics-Photonics, Material physics & Mechanics, Image & data Science, Bio-engineering

Over 300 students involved in graduate programs including 50% of international students

190 scientists
100 PhD students involved

3 Master programs with 9 tracks including
4 Erasmus Mundus Joint Master Degrees
"Research tracks" of 2 Engineering schools
2 PhD Schools

A multidisciplinary consortium of 8 research labs working on Light - Surfaces Engineering

A DYNAMIC ECOSYSTEM
The innovation clusters Minalogic, CIMES & Novéka
The FrenchTech ONE LYON ST ETIENNE
PULSALYS (Technology Transfer Office)

The Manutech-SLEIGHT Graduate School brings together a consortium of 12 public and private partners located in the Lyon/Saint-Étienne area, including 7 academic institutions (Universities, Engineering Schools), 2 national research organisations and 3 economic stakeholders, with the main goal to weave links between education and research.

Manutech SLEIGHT Science Event #7

10th to 14th January 2022

The Manutech SLEIGHT Graduate School's 7th scientific event, took place from 10th to 14th January 2022, bringing together more than 260 participants - online and onsite - around the themes of light-surface engineering. The objectives of this week were to foster interactions between graduate students & researchers, bring together researchers from different disciplines, thus strengthening the links between education and research.
The Manutech SLEIGHT's scientific axes are traditionally the subject of 3 workshops during the event, during which actors of projects funded by the Graduate School (4 PhD students that year) present their research. Peter Wiecha (LAAS, Toulouse), Pierre Delullier / Guillaume Druart (ONERA) and Daniel Turover (SILSEF Company), were invited to participate in these working groups.

Nicolas Dalloz's viva took place during the event. His PhD thesis was done under the supervision of Nathalie Destouches, Mathieu Hébert and the company HID Global CID on laser image multiplexing, a cutting-edge technique developed for the security of identity documents.
The «Pitch session Prize» was won by Adrien Girardot and François Leroux, engineering students from the Institut d'Optique Graduate School and the Master OIVM (AIMA-Advanced Imaging and Material Appearance) degree programmes, for their work on the appearance of dental repairs.
The «Pulsalys Prize» was won by Émilie Laffont, doctoral student at the Hubert Curien Laboratory and Centre for Research in Photonics (Ottawa, Canada).
The «Manutech SLEIGHT Prize» was won by Arnaud Valour, a young doctor at the Hubert Curien Laboratory.

The 8 guest speakers of this 7th edition were:

- Laura Na Liu, Director of the 2nd Physics Institute at the University of Stuttgart, Germany (nanoplasmonics)
- Kevin Vynck, CNRS researcher at the Institut Lumière Matière, Villeurbanne (optics and nanostructures)
- Gwenn Pallier, product line manager at Cailabs, Rennes (optics for industry)
- Bernard Kress, Director of hardware at Google, California, USA (virtual reality)
- Florian Banhart, Professor at IPCMS, University of Strasbourg (ultrafast electron microscopy)
- Dmitry Ivanov, researcher at the University of Kassel, Germany (Laser interaction)
- Patrick Gallinari, researcher at LIP6 laboratory at Sorbonne Université, Paris (physics and machine learning)
- Françoise Peyrin, Director of research at INSERM in Laboratoire CREATIS, Villeurbanne (bone imaging).

They addressed the design of systems for laser machining, the dynamics of ultrafast laser-surface interaction processes, diagnosis by time-resolved electron microscopy, diffractive optics, micro-optics and nanophotonics, metamaterials applied to chemistry and biology, as well as the use of machine learning approaches in physics, and the use of synchrotron radiation to explore osteocyte processes.

The Manutech SLEIGHT Graduate School

Manutech SLEIGHT Science Event #8

4h to 8h July 2022

The 8th edition of the Manutech SLEIGHT Graduate School Science Event took place in July 2022, with a programme dedicated to the theme of «Photonics for Health». The event included one day dedicated to photonics applications in the space sector. No less than 19 internationally renowned guest speakers presented their research progress on medical imaging, transparency and bio-fabrication of living tissues, corneal bioengineering, biosensors, phototunable biomaterials, observation of tissues and cells by Brillouin microscopy, imaging techniques for dermatology, the effects of space conditions on the skeleton and optics for space, including the presentation of the Lumina Project. Specific sessions were dedicated to presentations by Master students, PhD students and Post-doctoral fellows (Pitch session and Junior Scientists session), and by all members of the SLEIGHT community (Poster session). Competivity cluster Minalogic and medical technologies association Novéka invited local companies to come and talk about photonics with biomedical applications during the «Industrial applications» session.

The 19 guest speakers of this summer edition were:

- Sugawara Ko - Institut de Génomique Fonctionnelle de Lyon.
- Nicolas Renier - Laboratory of Structural Plasticity, Brain Institute, Paris.
- Lucie Sancey - Institute for Advanced Biosciences, Grenoble.
- Charles Handschin - ART BioPrint, Bordeaux.
- Olfa Ben Moussa - BiiO Lab, Saint-Etienne
- Norbert Danz - Fraunhofer Institute for Applied Optics and Precision Engineering, Germany.
- Émilie Laffont - Hubert Curien Lab, Saint-Etienne.
- David Eglin - Laboratoire SAINBIOSE, Saint-Etienne
- Carlo Bevilacqua - European Molecular Biology Laboratory, Germany.
- Elisa Cinotti - Department of Medecine, surgery & neurosciences, University of Siena.
- Jean-Luc Morel - Institut de Neurosciences Cognitives et Intégratives, Bordeaux.
- Laurence Vico - Laboratoire SAINBIOSE, Saint-Etienne.
- Alain Guignandon - Laboratoire SAINBIOSE, Saint-Etienne.
- Sylvain Girard - Hubert Curien Lab, Saint-Etienne
- Florence Clément - Cadmos, CNES, Toulouse.
- Nicolas Balcon - CNES, Toulouse.
- Nicolas Foray - Laboratoire "Radiations : Défense, Santé, Environnement", Lyon.
- Valérian Lalucaa - CNES, Toulouse.
- Philippe Adell - NASA / JPL, USA.

The «Best PhD presentation prize» was jointly awarded to Sylvain FOURNIER, PhD student at MatéIS lab and Anthony NAKHOUL, PhD student at the Hubert Curien Laboratory. The «Best poster prize» was won by PhD students Olfa BEN MOUSSA and Steve PAPA, from the BiiO and SAINBIOSE labs, respectively. The «Best pitch session Prize» was awarded to second year Machine Learning and Data Mining (MLDM) master student Thibaud LETENO.

Télécom Saint-Etienne
The University's Engineering School

Télécom Saint-Etienne is a public engineering school specializing in digital technology. Educating each year over 725 students, it is part of the Jean Monnet University and is affiliated with the Mines Telecom Institute. The majority of its students come from its integrated CITISE preparatory class (conducted in partnership with the Faculty of Science & Technology and the IUT of Saint-Etienne), as well as from preparatory classes to the "grandes écoles" (French higher education schools outside the university system), recruited through the Mines-Télécom competition. Télécom Saint-Etienne and the Hubert Curien laboratory are part of the local entity Télécom and Digital Society Carnot Institute, for their high-quality training in innovation and partnership-based research in engineering. Teaching and research staff at Télécom Saint-Etienne come from its 3 supporting laboratories: Hubert Curien, Elico and the Camille Jordan Institute. Télécom Saint-Etienne manages the Jean Monnet University's Use'In incubator, located at the Centre des Savoirs pour l'Innovation on the Manufacture campus.

The "Engineering training under student status" program

Télécom Saint-Etienne trains engineers in the field of digital technology, particularly in the scientific and technological areas of photonics, electronics, networks & telecommunications, imaging, and computer science. After a common core year, the 360 students of this program are offered training in at least 2 of these domains (mono-thematic paths do not exist). Nearly 160 different companies interact annually with engineering students through internships, projects, conferences, and events organized at the school.

INSTITUT CARNOT
Télécom & Société numérique

The «Engineering training under apprentice status» program

Télécom Saint-Etienne offers 2 apprenticeship engineering programs over the course of a student's three years of training:

- The «Image & Photonics, Smart-Industry» apprenticeship engineering program, which has been training engineers in photonics and imaging for industrial applications for over 20 years (approximately 60 apprentices each year).
- The «Data Engineering» program, which meets the growing needs of industry in the data processing field, from capture to visualization, including software architectures, connected objects, and artificial intelligence (approximately 75 apprentices each year).

Upstream research for applied solutions

KEY FIGURES

14 granted patents between 2019 & 2022, including:
12 worldwide term extensions
7 patents granted in 2022 alone

5 patent applications filed in 2022

3 startups created

Keranova (incl. granted patent)
The QA Company
Dfinder

8 companies using and/or developping our work

Keranova
https://www.keranova.fr/

The QA Company
https://the-qa-company.com/

Dfinder
https://dfinder.eu/

Newclin (incl. granted patent)
https://www.newclin.com

Aitenders
https://aitenders.com/

TravelAssist
https://www.travelassist.io/

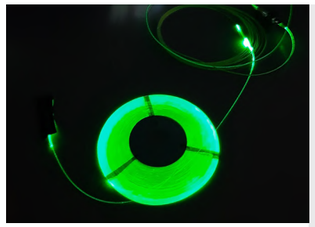
Kejako
https://www.kejako.com

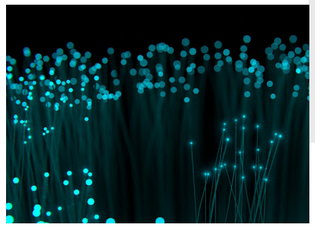
Safehear
https://www.safehear.fr/

2 joint labs

LabH6, with company Exail (ex-iXblue)
https://www.exail.com/

LAMCID, with company HID Global CID
https://www.hidglobal.com/





Our Materials for Optics and Photonics in Extreme Radiation Environments (MOPERE) team and the company Exail (ex-IxBlue), designer and manufacturer of photonic devices, had been collaborating for many years before launching «LabH6», their joint research laboratory, in 2018. The objective was for this new framework to enable the industrial valorization of the research conducted by both parties. Owing to a strong complementarity of skills, the team has made significant progress on the study of special optic fibres in harsh environments with potential applications in the nuclear, space and health sectors. The successful collaboration has so far resulted in no less than 20 joint publications in international journals and 1 granted patent. LabH6 notably participated in the «Lumina project», developed under the CNES leadership and in partnership with the CERN, which has led to the development of a fiber optic dosimeter that was sent in 2021 on board the International Space Station as part of the European Space Agency (ESA) ALPHA mission. The LabH6 contract is up for renewal this year.

exail

labH6

LABORATOIRE HUBERT CURIEN
UMR • CNRS • 5516 • SAINT-ETIENNE

LAMCID

HID

The creation of the LAMCID joint lab in 2022 came to seal a long-term collaboration between our Functional Materials and Surfaces team and HID Global CID, a company specialised in the development and manufacture of ID documents. The partnership involves combining the Hubert Curien Lab's knowledge and expertise in various disciplines (laser- matter interaction, plasmonics, sol-gel, materials' appearance, science of colour, secure images, machine learning, laser micronanostructuring) with HID's industrial expertise in ID documents manufacturing, in order to secure their authenticity. The team is looking to further develop techniques for laser inscription of images on and inside polycarbonate substrates, exploring the implementation of multiplexed images printing as well as the non-multiplexed inscription of color images to create special visual effects.

Our LabH6 and LAMCID joint labs illustrate the way structured partnerships between academia and industry can drive innovation and advance technology. (see special highlight page 17)

EVENTS &CONFERENCES

Our researchers are actively participating in various scientific manifestations, including conferences, workshops, seminars and other public events. As attendees or organisors they are often out and about, sharing and discussing their knowledge and latest research results. The following pages present a selection of these contributions, made over the year 2022.

SPIE Photonics Europe 2022

3rd to 7th April 2022

This international cross-disciplinary event highlighting compelling optics and photonics technologies, from digital optics to quantum technologies to optical imaging, sensing, and metrology, last took place in April 2022 in Strasbourg, France. Several of our teams (Functional Material & Surfaces, Image Science & Computer Vision, MOPERE) were represented at the event in the following sessions:

CONFERENCE - Clinical Biophotonics II
Session Fluorescence-Guided Surgery
"Robust estimation of 5-ALA-induced PpIX contributions in multiple-wavelength excitation fluorescence spectroscopy in guided neurosurgery for improving glioma classification"; incl. Mathieu Hébert.

CONFERENCE - Nanophotonics IX
Session Plasmonics II
"Surface plasmons propagation along metallic rough diffraction gratings".
incl. Olivier Parriaux, Colette Veillas, Stéphanie Reynaud, Yves Jourlin.

Session Surfaces
"Metallic nanoparticle reshaping by multipulse femtosecond laser irradiation" (Invited Paper)
incl. Balint Eles, Christophe Hubert, Nathalie Destouches.

Posters
"Development of chirp reduction technique for spherical beams interference lithography"
incl. Ratish Rao Nagaraj Rao, Thomas Kämpfe, Frederic Celle, Emilie Gamet, Yves Jourlin.

CONFERENCE - Unconventional Optical Imaging III
Program Committee incl. Pierre Chavel, Corinne Fournier.

Session Advanced Methods: Digital Holography I
"Effects of some model approximations in the reconstructions of digital in-line holograms: simulations, experiments on calibrated objects and model refinement assessment".
incl. Thomas Olivier, Dylan Brault, Sachin Joshi, Thomas Brard, Alexey Brodoline, Corinne Fournier.

Session Advanced Methods: Digital Holography II
"Focus plane estimation in digital holographic " (Invited Paper).
incl. Corinne Fournier, Dylan Brault, Thomas Olivier, Loïc Denis.

Session Advanced Methods: Light Scattering
"Unsupervised regularized inverse method for 3D reconstruction in tomographic diffractive microscopy".
incl. Laurence Denneulin, Fabien Momey.

CONFERENCE - Photosensitive Materials and their Applications II
Session Sol-Gel, Perovskites, and Metal Oxide Materials
"Microstructuration of luminescent sol gel coating by nanoimprint".
incl. Léa Marichez, Emilie Gamet, Isabelle Verrier, Yves Jourlin.

CLEO 2022 Conference, Lasers & Electro-Optics

15th to 20th May 2022

CLEO is the world's premier international forum dedicated to innovative advances, research and new technologies from the laser science industry. The event brings together all aspects of electro-optic technologies, with a program showcasing leading research and applications in a number of fields including biophotonics, advanced manufacturing, telecommunications or autonomous vehicles industry. Professor Jean-Philippe Colombier, from the Hubert Curien Lab's Laser-Matter Interaction team, gave a highlighted talk as part of the "Laser Induced Surface Effects" session, for this conference that took place in San Jose, California. Jean-Philippe presented his paper titled "Topographical, Structural and Chemical Nanopatterning of Ultrafast Laser Irradiated Surfaces", co-authored with our lab's colleagues Mathilde Prudent, Anthony Nakhoul, Djafar Iabbaden, Florent Bourquard and Florence Garrelie, in collaboration with Anton Rudenko from the University of Arizona.

LearnAut 2022 Workshop

4th July 2022

The 4th edition of the «Learning and Automata» workshop was held during the latest European Association for Theoretical Computer Science International Colloquium on Automata, Languages and Programming (ICALP).

The goal of the workshop was to bring together experts on logic - who could benefit from grammatical inference tools - and researchers in grammatical inference - who could find in logic and verification new potential applications for their methods.

Senior lecturer and researcher Rémi Eyraud, from our Data Intelligence team, was part of the workshop's organising committee and joined PhD student Volodimir Mitarchuk for his talk "On the limit of gradient descent for Simple Recurrent Neural Networks with finite precision".

SERESSA 2022

5th to 9h December 2022

The 18th edition of the International School on the Effects of Radiation on Embedded Systems for Space Applications took place at the CERN in Geneva between 5th and 9th December 2022.

Since 2005, the annual SERESSA event gathers academic, government and industrial communities working in the area of radiation effects on embedded systems. Topics covered by the school include: radiation environment, spacecraft anomalies, single-event effects (SEE), total dose effects (TID), radiation effects in power systems, radiation effects in solar cells, architecture hardening in analog, and digital circuits and in memories, software hardening, effects in FPGAs, hardness assurance, rate prediction, radiation testing, laser testing and remote testing experiments. For this event, member of our MOPERE team Matteo Ferrari was invited to give a talk on Radiation to Materials, whilst Luca Weninger presented a poster on " Gamma ray effects on the efficiency of COTS multicolor LEDs at MGy levels".
The event was an opportunity for 11 RADMEP master students - supervised by Sylvain Girard - to visit the largest particle physics lab in the world. The 2-year European Master in Radiation and its Effects on MicroElectronics and Photonics Technologies (RADMEP) provides a multidisciplinary and innovative programme covering the interactions between Radiation and MicroElectronics and Photonics. Each semester is spent consecutively at the JYU University of Jyväskylän in Finland, KUL Catholic University of Leuven in Belgium, and then in France either at the UM University of Montpellier or the University Jean Monnet, Saint-Etienne.

ECML-PKDD 2022

19th to 23rd September 2022

Last year's European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases was held in Grenoble from 19th to 23rd September 2022. The ECML-PKDD is Europe's top machine learning and data mining conference, with over 20 years of successful events and conferences across the continent.

For this event, Data Intelligence team members Emile Morvant and Charlotte Laclau were part of the organising committee, as Publicity Chair and Workshop & Tutorials Chair, respectively.

Charlotte Laclau also presented her paper «Understanding the Benefits of Forgetting when Learning on Dynamic Graphs», during a «Networks & Graphs» conference session.

Graph-Quality Workshop

23rd September 2022

As part of the ECML-PKDD conference, a half-day workshop was held on the subject of «Data & Model Quality for Mining & Learning with Graphs: Methods & Open Challenges».

The workshop aimed to explore the theoretical and practical aspects of quality of data, models and evaluation in the context of graph-based data mining and machine learning. The topic of the session was research and methods for:

- The assessment, quantification and identification of data and model quality problems on graphs.
- The interplay between problems in data and model quality.
- The (semi-)automatically improvement of data and model quality.

The Graph-Quality workshop seeks to connect researchers working on this topic, and provide a platform for the presentation of new methods' latest developments.
Christine Largeron, from our Data Intelligence team, was co-organising the event. She was also joined by Manvi Choudhary, Antoine Gourru and Charlotte Laclau for a presentation of their paper on «Learning Fair Variational Embedding with Graph Neural Networks».

RADECS 2022

3rd to 7th October 2022

The RADiation and its Effects on Components and Systems Conference (RADECS) is an annual European even organised by the RADECS Association since 1989. This scientific and industrial forum on radiation and its effects on electronics and photonic materials, devices, circuits, sensors and systems took place last year on Lido Island in Venice. Several members of our MOPERE team were represented at the event through the following talks and posters:

CONFERENCE SESSION
Photonics, Optoelectronics, and Sensors

- "Radiation Effects on Si-Photonics Integrated Passive Devices: Post Irradiation Measurements";
  incl. Sylvain Girard and Adriana Morana.
- "Radiation Induced Attenuation and Luminescence study in Radioluminescent Optical Fibres";
  incl. Adriana Morana, Youcef Ouerdane, Aziz Boukenter, Emmanuel Marin and Sylvain Girard.
- "Combined Photobleaching and Temperature Effects on 1550 nm Radiation-Induced Attenuation of Germanosilicate Optical Fiber";
  incl. Martin Roche, Adriana Morana, Marine Aubry, Aziz Boukenter, Cosimo Campanella, Youcef Ouerdane, Emmanuel Marin and Sylvain Girard.

CONFERENCE SESSION
Radiation Environments

- "Analysis of the radiation field generated by 205-MeV electrons on a target at the CLEAR accelerator at CERN";
  incl. Kacper Bilko.

POSTERS

- "Reproducibility of Dose Rate Measurements with Radioluminescent Nitrogen-doped Optical Fibers";
  incl. Fiammetta Fricano, Hugo Boiron, Adriana Morana, Luca Weninger, Cosimo Campanella, Emmanuel Marin, Aziz Boukenter, Youcef Ouerdane and Sylvain Girard.
- "Calibration in the Visible and Infrared Domains of Multimode Phosphosilicate Optical Fibers for Dosimetry Applications";
  incl. Luca Weninger, Cosimo Campanella, Adriana Morana, Fiammetta Fricano, Emmanuel Marin, Youcef Ouerdane, Aziz Boukenter and Sylvain Girard.
- "Proton dosimetry using radiation-induced luminescence in micrometer-core germanosilicate optical fibers";
  incl. Adriana Morana and Sylvain Girard.
- "Simulation of Radioluminescence Processes in Cerium-doped silica glasses;
  incl. Youcef Ouerdane, Adriana Morana, Sylvain Girard and Aziz Boukenter.
- "CERN SPS Radiation Environment and related RHA implications";
  incl. Kacper Bilko, Sylvain Girard and Marc Sebban.
- "The RADNEXT irradiation facility network";
  incl. Kacper Bilko and Sylvain Girard.

Journées Imagerie Optique Non-Conventionnelle

17th & 18th March 2022

For the last 17 years, the «JIONC» (Unconventional Optical Imaging Days) have brought together researchers and engineers involved in optical design, image physics and signal processing, in order to discuss the latest developments of systems or treatments in unconventional imaging, and assess their potential applications. These annual meetings promote scientific interaction between the optics and image processing communities, allowing their contributors to present recent advances at the crossroads of these fields. Corinne Fournier, from our Image Science and Computer Vision team, was once again part of the organising committee, and several members of our lab took part in the event co-organised by 3 GDRs: ISIS, Ondes and ImaBio.

Session - Problèmes inverses

- «Reconstructions multisprectrales d'échantillons biologiques avec auto-calibration des aberrations chromatiques», Dylan Brault, Thomas Olivier.
- «Approche inverse régularisée non supervisée pour la reconstruction 3D en microscopie tomographique diffractive», Laurence Denneulin, Fabien Momey, Dylan Brault.

Session - Problèmes ouverts en imagerie pour la biologie

- «Estimation of Fluorescence Contributions using Multiple-Wavelength Excitation: the example of PpIX for improving Glioma Classification», Arthur Gautheron, Mathieu Hébert.

Posters

- «Autofocus numérique en microscopie holographique», Dylan Brault, Corinne Fournier, Thomas Olivier, Louis Thibon, Loïc Denis.
- «Etude de dispositions non coplanaires de miroirs freeform pour la gestion de contraintes opto-mécaniques», Clément Freslier, Louis Duveau, Thierry Lépine.

CryptArchi 2022 Workshop

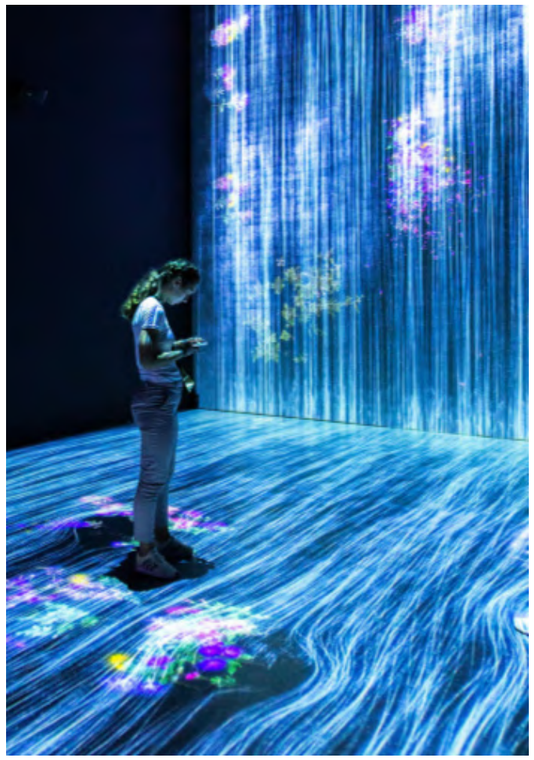
29th May - 1st June 2022

The Hubert Curien Lab's SESAM team has organised the 18th CryptArchi Workshop, an event that saw 53 participants gather on the ferry-accessible Porquerolles island, in the French Provence-Alpes-Côte d'Azur region. The main topic of this workshop was related to security aspects of modern logic devices' use in cryptography.
The objectives of the event were:

1. For participants to present their research activities progress.
2. Discuss problems related to embedding of cryptographic functions in modern logic devices (control and security aspects, architectural aspects, protocol-related aspects, key generation and key management aspects, attacks against implementations and countermeasures against attacks, neural networks and deep learning approach applied to DPA).
3. Propose a structure of the future logic devices or systems aimed at cryptographic applications.
4. Initiate new partnerships and collaborations.

Arqus workshop - Artificial Intelligence and Digitalisation

1st to 3rd June 2022



Arqus is a multilateral alliance of internationalised institutions that share academic, scientific and cultural objectives, a common vision of research and higher education's roles, and have mutual fields of interest. It brings together the universities of Bergen, Granada, Graz, Leipzig, Lyon/Saint-Etienne, Minho, Padua, Vilnius and Wroclaw.
Within the framework of the Arqus R&I project, which aims to address current global societal challenges through intensified joint research, the Universities of Lyon 1, Lyon 3 and Saint-Étienne have organised their first workshop on AI and digitalisation.
The advances of Artificial Intelligence (AI) have led to a considerable growth in many domains: research, economics, health, ethics and law. This implies some significant transformations in the technologies based on AI systems but also numerous societal impacts. The objective of this workshop was to promote exchanges on various aspects of AI, by discussing advances in core AI methods technologies such as Machine Learning, Robotics, Trustworthy AI, Neuro-symbolic AI, Hybrid AI, AI & ethics. The workshop also intended to cover some applications and associated societal impact, including AI & Health, AI & Environment, AI & Transport, AI & Society, AI & Energy, Responsible AI, AI & law. Amaury Habrard, from our Data Intelligence team, was co-chair of the workshop's scientific committee and moderated three «Core AI» sessions.

GDR 2044 APPAMAT

Several scientific events were organised last year under the guidance of the GDR 2044 APPAMAT, coordinated by Mathieu Hébert from our Image Science & Computer Vision team. Established in 2019 by the CNRS, this research group aims to organize and develop the scientific community around the appearance of materials, surfaces and objects.

Computational Color Imaging - Conference

09th June 2022

Created in 2007 by Alain Trémeau (Hubert Curien Lab), Raimondo Schettini (Università di Minalo – Bicocca) and Shoji Tominaga (Chiba University), this international workshop covers various topics around color and imaging techniques.
Sixteen speakers, among which many young researchers, participated last year in the online edition organized by Mathieu Hébert. The laboratory was represented by 3 speakers: Thierry Fournel, Nicolas Dalloz and Fanny Dailliez. The Best young researcher presentation prize was awarded to Morgane Gerardin, former IOGS and AIMA student (graduated in 2018), for her work on color prediction models for hematite pigments in parietal paintings.

La photométrie aujourd'hui - Conference

20th May 2022

On the occasion of last year's World Metrology Day and the re-edition of the optical essay on the gradation of light by Pierre Bouguer, the Association Française de l'Eclairage (AFE), the GDR Appamat and Light Zoom Lumière offered a day conference on current developments in photometry in different disciplinary fields. This "light metrology", born with Bouguer's Essay in the 18th century, is the basis of fields such as lighting, remote sensing, astronomy, photorealistic renderings in image synthesis. Among the speakers, Thierry Lépine and Mathieu Hébert developed the most recent applications of photometry in astronomy and material appearance, respectively.

Apparence visuelle de milieux nanostructurés
NanoApp 2022 Conference

16th & 17th November 2022

Nature provides us with beautiful visual appearances. The most resplendent of them are mainly the result of interference effects created by nanostructures. The last decades have seen the emergence of new multidisciplinary research themes aimed at understanding the microscopic origin of these natural visual effects, seeking to reproduce them by artificially structuring matter, or trying to create new ones for new applications (with no equivalent in the natural state). The design of visual appearance is nowadays a major challenge in many industrial sectors. The conference was gathering researchers and engineers working in various fields - including structural colouring in the living world, biomimicry in optics, surface engineering, colloidal chemistry, wave physics in complex media, nanophotonics, image synthesis and visual perception - around the theme of nanostructured media appearance.

Laser Processing for Industry Conference

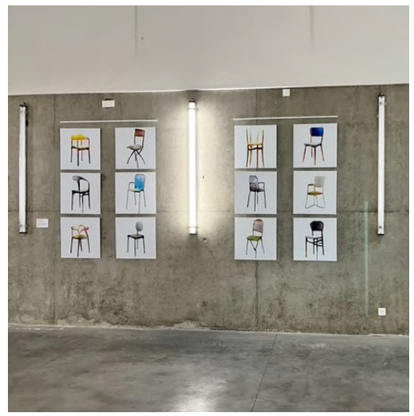
28th & 29th June 2022

The PLI Conferences are special occasions for the French laser community as they offer an overview of the latest innovations in the field of industrial laser processing. During 2 days filled with talk sessions, exhibitions and site visits, more than 110 attendees, mostly from industrial background, gathered in Saint-Etienne Centre des Congrés for this event organized by the Club Laser & Procédés (CPL).
The following topics were discussed during the various conference sessions: Surface engineering, Design, Decoration, Welding and Additive manufacturing.
Members of our Laser Matter Interaction team were actively involved in this conference, alongside CETIM and Manutech-USD. Razvan Stoian gave an invited presentation on «Non-diffractive ultrafast beams; new opportunities for material processing» during the closing session. Xxx Sedao's talk on «Ultrafast laser modification of crystalline lens for ophthalmological applications» was part of a session dedicated to «Transparent Materials Processing».
A tour of the Hubert Curien Laboratory and its experimental rooms was also organised for a number of visitors from both academia and industry, participants at the conference.

Biennale Internationale Design Saint-Etienne 2022

«Entre deux chaises»

The 12th edition of the Biennale Internationale Design Saint-Etienne took place from April to July 2022. The biennale is a major cultural event in France and Europe that involves designers, researchers, economic stakeholders, intellectuals and students questioning the practice of design and experimenting with its methods.
The University Jean Monnet has actively engaged in last year's event, submitting an ambitious cultural program of exhibitions and workshops highlighting its scientific research. For a week at the beginning of April, the exhibition "Explorations Arts/Sciences: des recherches en partage" presented a collaborative project involving two researchers from our Data Intelligence team: Charlotte Laclau and Ievgen Redko. The exhibition, called "Entre deux chaises", explored the links between the domains of Product Design and Deep Learning. The researchers' field of study "is based on the connectionist model which, using simple network connected calculations in very large numbers, allows a computer system to simulate intelligent behavior". One of the most emblematic object of study and experimentation for designers, the chair, was explored here to investigate the design process using Generative Adversarial Networks (GANs).



GIE Manutech-USD - 10 years of excellence

8th September 2022

Above: An example of the amazing work that can be done with the Equipex. Here an egg textured with a femtosecond laser, stripped down to a few microns, cut by femtosecond laser pulses generating extreme but very localised pressures on an extremely fragile object.

The GIE Manutech-USD (Ultrafast Surface Design) is an Economic Interest Group that has, for the last 10 years, been gathering members from public research and industry around an Equipex (Equipment of Excellence from the Future Investment Program obtained in 2011). It aims at exploring and exploiting scientific and industrial potentials offered by femtosecond lasers.
In 2022, the GIE Manutech-USD celebrated its 10 years of innovation, science and great successes!
The purpose of the GIE is to design and develop a technological platform for the functionalization of surfaces by ultrafast laser and the characterization of surfaces. The GIE is currently composed of 6 members: University Jean Monnet, Ecole Centrale de Lyon (ECL-ENISE), Ecole des Mines St Etienne, Cetim, IREIS (HEF group) and WeAre Tech.
The University Jean Monnet has contributed to this group through our Laser-Matter Interaction team's technical and scientific skills in the field of ultrashort-laser matter interaction and laser beam shaping techniques.
The GIE was created in 2012, subsequently to obtaining the eponymous EquipEx coordinated by Florent Pigeon until 2014, then by Florence Garrelie until its closure in 2021. Since then, several members of our laboratory have been heavily involved in the GIE Manutech-USD, in particular Cyril Mauclair for the development of ultrashort laser beams shaping techniques, Stéphanie Reynaud for the use of FIB, and especially X. Sedao who has been setting up new projects in connection with our Laboratory (e.i. Booster Region project, European EIC LaserImplant project, FUI project, Labex Manutech-SISE projects or EUR Manutech-SLEIGHT projects). Many other colleagues in our lab have developed or are developing activities around the Manutech-USD platform (Razvan Stoian, Jean-Philippe Colombier, Yves Jourlin, Christine Largeron, etc.).

Laser AP

10h to 14th October 2022

The latest LaserAP-Laser Applications seminar was held in the Bourgogne-Franche-Comté region from October 10th to 14th 2022. The purpose of this seminar is to provide extended training to doctoral students and members of the industry on the physics of laser processes, and on the most recent applications' developments. It is also a platform for all actors of the field to discuss their activities, needs, scientific and technical difficulties, whether regarding a specific research theme or an industrial application.
Members of our Laser-Matter Interaction team Florence Garrelie and Tatiana Itina were part of the event's scientific committee, whilst the following seminars were held by members of the lab:
Jean Philippe Colombier:

- Modélisation des interactions laser-matière : état de l'art
- Structuration de surface par laser : de l'excitation à son auto-organisation

Razvan Stoïan:

- Fs laser Writing in dielectrics (also using shaped fs and pulse train pulses

X. Sedao:

- Structuration de surfaces pour le biomédical
- Mise en forme spatiale reconfigurable de faisceau laser femtoseconde, défis et optimisations.

French Photonics Days, Saint-Etienne

20th and 21th October 2022

The latest edition of the French Photonics Days event took place at the Saint-Etienne Centre des Congrès on the 20th and 21st October 2022. The meeting was co-organised with Minalogic and Cluster Lumière, in partnership with the Manutech SLEIGHT Graduate School and the Institut d'Optique Graduate School.
The two-day program aimed to present the photonics perspectives within three main areas: display, lighting and manufacturing, covering both technological advances and market forecast. It was also an opportunity to address the difficult subjects of training and strategy of the French photonics sector, in order to meet the needs of stakeholders in terms of professions and skills. Several members of the Hubert Curien Laboratory contributed to the successful event: Jean-Philippe Colombier and Nathalie Destouches took part in the "Photonics and Surfaces" Technical Session, with their respective talks on "Structuration des surfaces par laser à des échelles extrêmes" and "Impression d'images sécurisées par laser". As part of the "Employment and training in Photonics" session, Raphaël Clerc, Hubert Konik, Nicolas Crespo Monteiro and Emmanuel Marin gave an overview of the Master OIVM, Télécom Saint-Etienne, the Manutech Sleight and Institut d'Optique Graduate Schools. Doctoral students Daiwei Zhang, Vincent Duveiller, Anthony Nakhoul and Eduardo Brandao presented their research work during the event's poster session.

AWARDS & DISTINCTIONS

Researchers are rarely motivated by the pursuit of distinctions, but they are certainly never disappointed to earn marks of recognition from their peers! Last year, many members of our laboratory received various prizes and accolades. We congratulate all our laureates, may they be doctoral students or already experienced scientists.

Amaury Habrard

new senior member of the IUF

The mission of the IUF is to promote the development of high-level research in public education establishments under the responsibility of the Ministry of Higher Education. It also aims at strengthening interdisciplinarity, by pursuing three objectives:

- Encourage establishments and researchers to excel in fundamental research, innovation and scientific mediation with the positive outcome that can be expected on teaching, the training of young researchers and more generally the dissemination of knowledge to society;
- Contribute to the feminization of the research sector;
- Contribute to a balanced distribution of university research in France, and therefore to a policy of scientific networking.

Each year, the IUF appoints a small number of university professors for a period of 5 years. Hubert Curien Lab's member Amaury Habrard was a laureate of the 2022 selection.
After defending his PhD at the University Jean Monnet in 2004, Amaury spent 7 years as assistant professor at the University Aix-Marseille and member of the Fundamental Computer Science Lab (today LIS - Laboratoire d'Informatique et Systèmes). Amaury joined the Hubert Curien Laboratoiry in 2011 and is now Head of our Data Intelligence team. This group explores two main aspects of Data Intelligence: Machine Learning (from a statistical theory point of view) and Complex data analysis.
In 2017 Amaury took part in the creation of the Machine Learning French Speaking Academic Society (SSFAM - Societe Savante Francophone d'Apprentissage Machine), aiming at disseminating machine learning knowledge among the public, promoting exchanges between researchers and users, establishing itself as a source of information for ministries, the media, industries and the public, and initiating reflections on scientific challenges and societal issues related to machine learning. Amaury is head of the University Jean Monnet's Computer Science Master, and co-coordinator of the international Machine Learning and Data Mining (MLDM) track. Amaury is strongly involved in many research projects, including European, ANR and industrial projects.
During their delegation, appointed members of the IUF are discharged of their teaching duties, allowing them to focus on their research project. Amaury will therefore dedicate the next 5 years to his IUF approved project: "Advanced Machine Learning for Intelligent Surface Engineering".
Only 100 senior laureates are designated each year by the institution.
We therefore congratulate Prof. Habrard for this remarkable achievement!

Nathalie Bochard

new member of the ANSSI's scientific council

Nathalie Bochard, Research Engineer for our laboratory and part of its SESAM team, has recently been appointed as a member of the ANSSI's scientific council.
Three years ago, the Agence Nationale de Sécurité des Systèmes d'Information has established a scientific council that acts as an advisory board. The objective is to steer and distribute all efforts and resources towards its research activities in the best possible manner. The Scientific Council is a consultative body that suggests research topics, expresses its opinion on the agency's scientific programme and on its outreach and collaboration policy. Appointed for 3 years, the 16 recognised academics and members of the council are selected intuitu personae for their skills and knowledge in relation to the topics covered by the ANSSI.
Nathalie owes her nomination to her great knowledge of hardware security, and in particular her expertise in electronics and specialisation in random number generation within integrated circuits. Having joined our lab in 2001, she started a specialisation in Cryptology in 2003 as part of the newly founded SESAM team. She undertakes a major role in the organisation of CryptArchi, an international annual workshop on embedded cryptographic architectures, therefore contributing to the advance of knowledge and collaboration in the field. Nathalie is the recipient of the 2019 CNRS crystal medal.
We congratulate Nathalie for this nomination!

ANSSI
Agence nationale de la sécurité des systèmes d'information

Loïc Denis

new Associate Editor of IEEE

IEEE Signal Processing Society

Loïc Denis, from the Hubert Curien Lab's Image Science and Computer Vision team, joined last year the Editorial Board of the IEEE Transactions on Image Processing, the flagship journal in image processing, to serve as an Associate Editor.
Loïc's research activities focus on the development of image restoration and image reconstruction methodologies. A notable aspect of his work is its pluridisciplinarity, covering areas such as physics of image formation (optical modeling of the instrument and of the medium under study, speckle phenomenon, polarimetry and interferometry in radar imaging), signal processing (detection of weak signals, estimation), image processing (patch-based models, deconvolution), applied maths (inverse problems, discrete or continuous optimization of non-convex and/or non-smooth criteria) or machine learning (deep neural networks). His work has found many applications, especially in the fields of microscopy, remote sensing and astronomy.

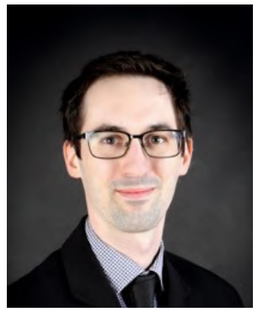
Sylvain Girard

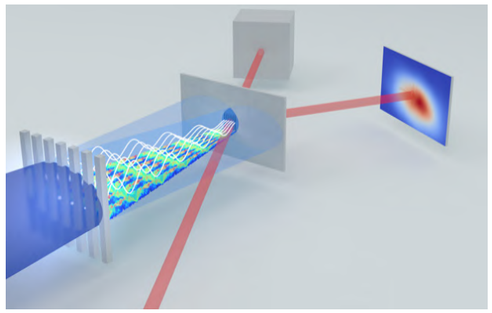
2021 iXcore-iXlife-iXblue Foundation Research Award

Last year, the iXcore-iXlife-iXblue Foundation announced that its jury, chaired by Alain Aspect, would award its 2021 Research Prize to Professor Sylvain Girard, head of our MOPERE team. The Foundation aims to facilitate the conditions under which researchers carry out their activities, enabling greater responsiveness. Through its annual Research Award, the Foundation recognizes exceptional scientific researchers for the quality of their work.
After obtaining his PhD in 2003, Sylvain Girard joined the Centre d'Energie Atomique - CEA - as an Engineer. He started his teaching and research career at the Jean Monnet University in 2012, as part of the Physics Department and member of the Hubert Curien Lab. His expertise lies in the development of optical materials, photonics and optoelectronics technologies for operations in radiation-rich environments. He currently coordinates the Erasmus Mundus Joint Master Degree - EMJMD RADMEP (see page 80), and is the local coordinator of the SWISSMODICS, MODATS, PHOTONHUB and RADNEXT collaborative European projects (see page 23). Sylvain has authored or co-authored over 280 articles in peer-reviewed journals, and has filed 6 patents.

Jérémy Rouxel

FELs of Europe Award





The FELs of Europe Award 2022 in "Development or innovative use of advanced instrumentation in the field of FELs" for young researchers has been awarded to Jérémy Rouxel, from the Hubert Curien Laboratory. FELs of Europe is a collaboration of all free electron laser (FEL) facilities in Europe, with the goal to meet the technological and scientific challenges of these novel and rapidly developing technologies. It enables the exploitation of the full scientific potential of these unique accelerators based short-pulse light sources.
The prize recognizes Jérémy's "outstanding achievements in non-linear X-ray science, and in particular the demonstration of ultrafast hard X-ray transient grating spectroscopy ". This work, carried out with the SwissFEL free electron laser, is the result of a collaboration between the Hubert Curien Laboratory's Laser-Matter Interaction team, the Paul Scherrer Institute's teams (Cris Svetina, Bernina experimental station's team and the LMN team) and the Ecole Polytechnique Fédérale de Lasanne's LSU team (Majed Chergui). The technique uses an X-ray pump beam that generates a transient grating of excitation in matter which is then probed by diffracting an optical laser pulse from it. The implementation of this technique in the field of X-rays makes it possible to probe the transport of photoexcited electrons at nanometric scales and ultrashort durations.

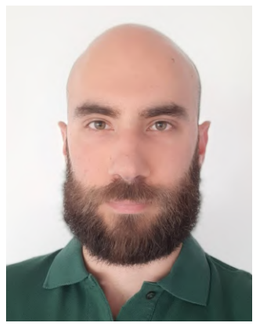
Vincenzo De Michele

Best USTV 2021 PhD thesis award

Vincenzo De Michele is the recipient of the 2021 best thesis award from the "Union pour la Science et la Technologie Verrières" (USTV). The prize awarded Vincenzo's doctoral work addressing the science and technology of glass. The purpose of the USTV is to develop and disseminate knowledge in the fields of science, glass technology and glass products.
Vincenzo is a 2016 graduate from the University of Palermo. As a Ph.D. student within the Hubert Curien Lab's MOPERE team, he was working under the supervision of Prof. Youcef Ouerdane and Prof. Sylvain Girard, together with Prof. Marco Cannas from the University of Palermo. In his thesis, Vincenzo studied the transient optical phenomena related to point defects in pure and doped silica, on different classes of samples such as pure & doped optical fibers and bulk silica. His PhD was defended in April 2021. Since beginning his research work on amorphous silica, Vincenzo has authored or co-authored more than 20 publications in international journals, and attended several international conferences. Vicenzo received his prize during the «Journées Verre 2022» which took place in Nice & Biot from 21st to 23rd September 2022. Vincenzo has recently been appointed as a lecturer of the University Jean Monnet, and permanent member of our lab.

Cosimo Campanella

IEEE NPSS Paul Phelps 2022 award



Cosimo Campanella is the recipient of the 2022 Paul Phelps Award of the IEEE Nuclear and Plasma Sciences Society (NPSS), that recognizes "exceptional promise as a student, postdoc or research associate in any of the fields of NPSS, or exceptional work in those fields". The IEEE NPSS is the premier professional association for the advancement of the nuclear and plasma sciences, sponsoring seven technical conferences and three peer-reviewed journals.
Cosimo is a graduate of Politecnico di Bari. After doing his master internship on radiation effects on optical amplifiers in 2018 within the Hubert Curien Lab's MOPERE team, Cosimo remained with us to work on his doctorate under the supervision of Professors Aziz Boukenter (Hubert Curien Lab) and Franck Mady (INPHYNI lab, Nice). He was studying the combined effects of radiation, hydrogen and temperature effects on the various types of passive optical fibers, from radiation hardened ones to sensitive ones. During his PhD, Cosimo authored and co-authored no less than 18 publications in scientific journals. His thesis was funded by the PIA-ANR project CERTYF, led by the University Jean Monnet in close collaboration with ANDRA (Agence nationale pour la gestion des déchets radioactifs), IRSN (Institut de radioprotection et de sûreté nucléaire) and the Université de Côte d'Azur. Cosimo is currently a post-doc fellow in our laboratory.
This is the 4th time that the IEEE prize is awarded to a member of our lab, after Adriana Morana in 2017, Imene Reghouia in 2018 and Marine Aubry in 2021.

Ana Florencia Juarez Saborio

Best poster presentation award

During its 2022 conference, the Société Francophone d'Étude des Carbones (SFEC) has awarded its best poster presentation prize to Ana Florencia Juarez Saborio, a young doctoral student from our Laser Matter Interaction team.

The SFEC conference is the annual meeting of French- speaking researchers and engineers working on the development, characterisation, modelling or industrialisation of diverse carbonaceous materials. The 2022 conference was held in Nouan-le-Fuzelier from 4th to 7th April.
Ana Florencia is a Mexican-born student currently pursuing a doctorate in our lab, on the subject of «Periodic Van der Waals graphene origamis by ultrafast laser nanotexturing». After obtaining her Baccalaureate in the US, Ana Florencia pursued her higher education in various countries including France, Spain and Canada. She works under the supervision of Florent Bourquard and Florence Garrelie, together with Alfonso San Miguel of the Institut Lumière-Matière (Univ Lyon1, CNRS).

Hugo Boiron

IEEE INERTIAL 2022 Best student poster award

Doctoral student Hugo Boiron, from our MOPERE team, has won the best student poster award at the IEEE INERTIAL 2022 conference, the exclusive international Symposium on Inertial Sensors and Systems. The conference was held at the Palais des Papes in Avignon, France, from 8th to 11th May 2022.

In 2019 and just after obtaining his engineering diploma from the Institut d'Optique Graduate School, Hugo joined our MOPERE team as an intern, to study the thermomechanical strain in fibers by the analysis of the Rayleigh scattering. Hugo then remained in the same team to work on his Exail (ex-iXblue) funded doctorate, under the supervision of Prof. Emmanuel Marin (Hubert Curien Lab) and Emmanuelle Peters & Maxime Rattier (Exail). The subject of his thesis is the Thermomechanical analysis of optical fiber coils by the study of their Rayleigh backscatter.

Emanuele Dalsasso, Inès Meraoumia, Loïc Denis and Florence Tupin

IEEE GRSS SYMPOSIUM Prize paper award

Our Image Science & Computer team have received the 2021 IEEE GRSS Symposium Prize Paper Award during the latest IEEE IGARSS conference, for their paper «Exploiting multi-temporal information for improved speckle reduction of Sentinel-1 SAR images by deep learning» (IEEEXplore link, ArXiV version).

According to the Geoscience and Remote Sensing Society (GRSS), «the GRSS Symposium Prize Paper Award was established to recognize the author(s) who presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS) an exceptional paper in terms of content and impact on the geoscience and remote sensing community». The team's paper was selected among the 2000+ research works presented at the conference. It describes an approach to extend deep neural networks trained for single-image despeckling in order to process multi-temporal stacks of radar images. This work is a product of a long-standing collaboration between Télécom Paris laboratory LTCI and the Hubert Curien Lab on the topic of synthetic aperture radar imaging.

Kamal Singh and Guillaume Muller

IEEE ICC 2022 Best paper award

Kamal Singh and Guillaume Muller, from our Data Intelligence team, have received the best paper award for their article titled «Intrusion detection for Softwarized Networks with Semi-supervised Federated Learning», presented during the 2022 IEEE International Conference on Communications. Every year, this conference brings together audiences from both industry and academia to learn about the latest research and innovations in communications and networking technology, to share ideas and best practices, and collaborate on future projects. The event saw nearly 2000 participants from 70 countries gather in Seoul, Korea, between the 16th and 20th May 2022. A total of 16 papers were selected by the Award committee amongst nearly 2,500 submissions! The Communication Software & Multimedia category prize was shared with co-authors Ons Aouedi and Kandaraj Piamrat, from the Laboratoire des Sciences du Numérique de Nantes's STACK research group.

Fondation de l'Université Jean Monnet - Awards night

8th December 2022

FONDATION UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE

On Thursday 8th December 2022, the Fondation de l'Université Jean Monnet held its research evening, a first major event celebrating the winners of their 2023 Funds for research projects. The event was attended by more than 150 academics and partners from the public and private sectors.
Created in 2011, the Fondation constitutes an active bridge between socio-economic and academic players in our region. In the last ten years, it has identified actions to be carried out and projects to be funded, with the aim of highlighting the scientific research emerging from our University, and the attractiveness of the territory. The Fondation awards Mobility ambassador grants to support students who wish to go abroad during their academic career, and delivers Excellence Awards rewarding the best students of the University. It also contributes to the emergence of innovative initiatives through the funding of projects submitted by either students or researchers.
Last year, 2 out the 8 awarded projects have been submitted by members of our lab. Laure Bsawmaii, from our Functional Materials & Surfaces team, was awarded 15 k€ euros to help finance her project on the development of micro-structured surfaces. The project will consist in exalting a chiro-optic signal through sensors, combining a photo nanostructure and a magneto-optic material. These revolutionary biosensors will allow the detection at low cost of chiral molecules.
For his project related to real-time processing of spectral image video stream, member of our Image Science & Computer Vision team Philippe Colantoni was awarded 20 k€ euros towards the acquisition of a new type of spectral camera based on the Spectral Filter Arrays (SFA) technology. It will allow to develop, within the Imaging and eXtended Reality (IXR) platform, research projects on real time spectral imaging for various application fields such as material appearance, health, waste sorting, military, plant analysis, pollution analysis and detection, cosmetics or art analysis.

MEMBERS NEWS

As with any other academic institution, we are proud to see each year our students graduate and our permanent members advance in their careers. In this section, we have listed out our new doctors and HDRs, as well as all personnel who joined our lab in the past year.

Our new HDRs

Kamal SINGH

Last year, Associate Professor Kamal Singh successfully defending his Habilitation thesis (HDR), with a presentation on «Towards Data Driven Intelligent Networks». Having secured a position at the University Jean Monnet in 2014, Kamal joined our Data Intelligence team to carry out research work on AI, the Internet of Things, mobile networks, edge computing and software-defined networking. Since his arrival, Kamal has been involved in several collaborative projects, the latest of which - the ANR funded CoSWoT project - aims to build a software architecture prototype allowing the construction and execution of intelligent and decentralized WoT applications. His HDR work was focussing on AI and optimization approaches for improving network performance and advancing towards intelligent networks.

Ievgen REDKO

Associate Professor Ievgen Redko has recently left our university to pursue a new career in the private sector. Ievgen joined our lab's Data Intelligence team in September 2018 to work on various fundamental and applied machine learning subjects. In July 2022, Ievgen defended his Habilitation thesis (HDR), covering recent research in transfer learning, optimal transport and some game-theoretical contributions to statistical learning theory. With his strong record of top-level publications, scientific excellence rewards, numerous successful grant applications, we thank Ievgen for his contribution to our lab and wish him the best in his new adventure!

Our new doctors

Nicolas Dalloz
Functional Materials & Surfaces
+ Image Science & Computer Vision
January 12th, 2022

Printed image multiplexing by laser processing and its application to security and identity document

Thesis supervisors

Nathalie Destouches
Hubert Curien Lab, Supervisor

Mathieu Hébert
Hubert Curien Lab, Co-Supervisor

Jules Rio
Image Science & Computer Vision
January 18th, 2022

Deep Learning methodologies for denoising periodic signals

Thesis supervisors

Olivier ALATA
Hubert Curien Lab, Supervisor

Christophe DUCOTTET
Hubert Curien Lab, Co-Supervisor

Fabien MOMEY
Hubert Curien Lab, Co-Supervisor

Damien Robissout
SESAM
+Data Intelligence
February 10th, 2022

Security of cryptographic implementations against side-channel attacks based on deep learning techniques

Thesis supervisors

Lilian Bossuet
Hubert Curien Lab, Supervisor

Amaury Habrard
Hubert Curien Lab, Co-Supervisor

Marine Aubry
MOPERE
March 18th, 2022

Experimental and theoretical study of the combined effects of radiation and temperature on fiber optic amplifiers

Thesis supervisors

Sylvain Girard
Hubert Curien Lab, Supervisor

Emmanuel Marin
Hubert Curien Lab, Co-Supervisor

Luciano Mescia
Politecnico di Bari, Co-Supervisor

Our new doctors

Maria Alejandra Usuga Higuita
Functional Materials & Surfaces
May 30th, 2022

Elaboration of micro-nanostructured layers of titanium nitride (TiN) obtained by the process of nitriding sol-gel layers TiO_2

Thesis supervisors

Yves JOURLIN
Hubert Curien Lab, Supervisor

Francis VOCANSON
Hubert Curien Lab, Co-Supervisor

Rémi Viola
Data Intelligence
June 24th, 2022

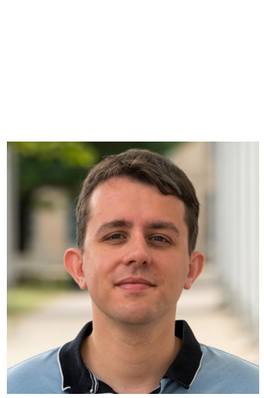
Highly Imbalanced Learning, Application to Fraud Detection

Thesis supervisors

Marc Sebban
Hubert Curien Lab, Supervisor

Amaury Habrard
Hubert Curien Lab, Co-Supervisor

Haicheng Tao
DGFip, Co-Supervisor



Yoann Boussit
Image Science & Computer Vision
June 27th, 2022

High-resolution multi-scale segmentation of objects by CNN approaches: Application to the assembly control of car body parts

Thesis supervisors

Virginie Fresse
Hubert Curien Lab, Supervisor

Hubert Konik
Hubert Curien Lab, Co-Supervisor

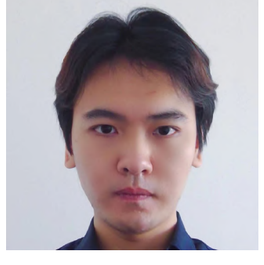
Louis Duveau
Image Science & Computer Vision
July 4th, 2022

Freeform mirror designs for aerospatial multi spectral band imaging systems

Thesis supervisors

Thierry Lépine
Univ Paris-Saclay/IOGS/Hubert Curien Lab, Supervisor

Guillaume Druart
ONERA, Co-Supervisor



Guoqin Zan
Image Science & Computer Vision
July 11th, 2022

Study, Design, and Realization of an Extended Automotive Signalization

Thesis supervisors

Mathieu Hébert
Hubert Curien Lab, Supervisor

Sheherazade Azouigui
Huawei, Co-supervisor

Sébastien Saudrais
ESTACA Engineering School, Co-supervisor

Mathilde Prudent
Laser Matter Interaction
July 12th, 2022

Functionalization of thin film metallic glasses by femtosecond laser irradiation

Thesis supervisors

Jean-Philippe Colombier
Hubert Curien Lab, Supervisor

Florent Bourquard
Hubert Curien Lab, Co-Supervisor

José M. Giménez-García
Data intelligence
July 18th, 2022

Formalising, capturing and mananging the context of statements in the semantic web

Thesis supervisors

Pierre Maret
Hubert Curien Lab, Supervisor

Antoine Zimmermann
Ecole des Mines SE, Co-Supervisor

Balint Eles
Functional Materials & Surfaces
July 18th, 2022

Energy relaxation mechanisms in plasmonic nanocomposite materials under femtosecond laser excitation

Thesis supervisors

Nathalie Destouches
Hubert Curien Lab, Supervisor

Christophe Hubert
Hubert Curien Lab, Co-Supervisor

Our new doctors

Cosimo Campanella
MOPERE
October 27th, 2022

Combined effects of radiation and temperature on silica-based optical fibers

Thesis supervisors

Aziz Boukenter
Hubert Curien Lab, Supervisor

Frank Mady
INPHYNI, Université Côte d'Azur, Co-supervisor

Anthony Nakhoul
Laser Matter Interaction
November 29th, 2022

Surface Morphology at Nanometric Scale by Temporal and Polarization Control of Ultrashort Laser Pulses

Thesis supervisors

Jean-Philippe Colombier
Hubert Curien Lab, Supervisor

Claire Maurice
Laboratoire Georges Friedel, Co-Supervisor

Ratish Rao
Functional Materials & Surfaces
December 8th, 2022

Fabrication of grating waveguide structures for spectral (and linear polarization) stabilization and wavelength multiplexing for 976 nm, 1030 nm, and 2000 nm wavelength range

Thesis supervisors

Yves Jourlin
Hubert Curien Lab, Supervisor

Emilie Gamet
Hubert Curien Lab, Co-Supervisor

Gaetano Li Vecchi
MOPERE
December 16th, 2022

Potential of radiation sensitive silica based optical fibers for dosimetry and regeneration techniques

Thesis supervisors

Sylvain Girard
Hubert Curien Lab, Supervisor

Yacine Kadi
CERN, Co-Supervisor

Jeoffray Vidalot
MOPERE
December 1st, 2022

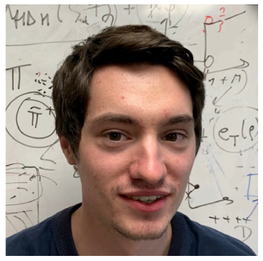
Optical fiber based dosimetry dedicated to irradiation facility monitoring

Thesis supervisors

Sylvain Girard
Hubert Curien Lab, Supervisor

Philippe Paillet
CEA DAM, Co-Supervisor

Adriana Morana
Hubert Curien Lab, Co-Supervisor



Paul Viallard
Data Intelligence
December 7th, 2022

PAC-Bayesian bounds and beyond: Self-bounding algorithms and new perspectives on generalization in machine learning

Thesis supervisors

Amaury Habrard
Hubert Curien Lab, Supervisor

Pascal Germain
Université Laval, Québec, Co-Supervisor

Emilie Morvant
Hubert Curien Lab, Co-Supervisor

Alexis Dufour
Functional Materials & Surfaces
December 16th, 2022

Magneto-optical functionalization of a microstructured optical fiber by a sol-gel nanocomposite

Thesis supervisors

Emmanuel Marin
Hubert Curien Lab, Supervisor

Damien Jamon
Hubert Curien Lab, Co-Supervisor

Dylan Brault
Image Science & Computer Vision
December 19th, 2022

Inverse problems approaches in digital holographic microscopy for unsupervised and quantitative recosntructions of microbiological samples

Thesis supervisors

Corinne Fournier
Hubert Curien Lab, Supervisor

Ferréol Soulez
CNRS, Observatoire de Lyon, Co-Supervisor

Thomas Olivier
Hubert Curien Lab, Co-Supervisor

Fabien Momey
Hubert Curien Lab, Co-Supervisor

New recruits

Vincenzo De MICHELE

A previous doctoral student in our lab, Vincenzo has returned to the University Jean Monnet as a lecturer and member of our Laser-Matter Interaction team.

Jordan FRECON-DELOIRE

Jordan is a newly appointed Lecturer for the University Jean Monnet. He is carrying his research work on Machine Learning as part of our Data Intelligence team.

Brice COLOMBIER

After 2 years spent at the University of Grenoble, Brice has returned to our lab as a lecturer for the University Jean Monnet and researcher for our SESAM team.

Maxime ROYON

Maxime is a newly appointed Lecturer for the University Jean Monnet. He is continuing his research work on the subject of Functional Materials & Surfaces, a team he joined in September 2018.

Antoine GOURRU

Antoine has recently converted his existing ATER position into a lectureship for the University Jean Monnet. He is pursuing his research work on Machine Learning, as part of our Data Intelligence team.

Izdine MMADI

has recently joined our Admin team. He is working as a financial administrator for several of our lab teams and one platform.

Elisabeth REBY

has joined the lab in January 2022 and is working as a PA and communication manager.

Mathieu HEBERT

Mathieu, a member of our Image Science & Computer Vision team, was granted a Professorship last year after many years of lecturing at the Institut d'Optique Graduate School and research activities within our lab. Since 2015, he has been coordinating the AIMA track - Advanced Imaging and Material Appearance: Metrology & Modelling - of the Jean Monnet University's OIVM master's program. He is currently leading the CNRS 'APPAMAT' research network, which is dedicated to material appearance sciences. He recently authored a book titled «Optical Models for Material Appearance», which is aimed at students, researchers in optics, and professionals dealing with the visual appearance of materials and surfaces (see page 62).

Loic DENIS

Loic was last year promoted to the rank of Professor, having joined the Jean Monnet University in 2011 as a Lecturer and researcher in our lab's Image Science & Computer Vision team. In October 2018, Loic defended his Habilitation thesis (HDR), with a presentation on «A few methodological contributions to image reconstruction».
Now holding a professorship, Loic is working on the development of artificial intelligence and image processing techniques with a special focus on applications in physics: Earth observation (synthetic aperture radar), astrophysics (especially exoplanets detection & characterization), microscopy for surface and biological sample imaging.

Matteo FERRARI, new Junior Professor

Matteo has joined our MOPERE team in September 2022, having gained a Junior Professorship (Chaire Professeur Junior) in «Photonics, Optoelectronics & Microelectronics in extreme Radiation environment» at the Jean Monnet University. He comes with a multidisciplinary expertise that includes radiation effects, dosimetry, simulations and medical physics. After completing a Master in Physics at UniPv (Italy) and a Ph.D. in Mechanical Engineering (UniBs,Italy / ESS project, Sweden), Matteo's work focused on radiation effects in lubricants and elastomers, before developing 'Radiation to materials' activities during a fellowship at CERN (R2E Project).
Focusing on a better understanding of materials degradation's mechanisms for optics and photonics in a harsh environment, Matteo is now working on the development of tools that will enable the team to expand its studies onto the fields of optoelectronics and microelectronics. He intends to identify areas of interest not yet covered in France and Europe, to then set up new theoretical and experimental tools in order to develop them. Matteo will also work on the miniaturization of embedded photonic solutions for space applications, and will expand the application of his research to more demanding environments such as those associated with modular reactors or dismantling operations.
The objective of this new Junior Professorship position is to strengthen and develop existing collaborations between our MOPERE team and the main actors in the field, as well as consolidate the actions carried out so far with the team's industrial partner Exail (ex-iXblue) within the framework of the LabH6 joint laboratory. Being linked to the European master's degree RADMEP (Radiation and its Effects on MicroElectronics and Photonics Technologies), this new Junior Professor position fits perfectly into the training / research / innovation strategy set by the Hubert Curien Laboratory.

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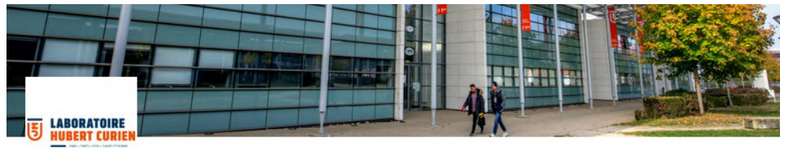

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