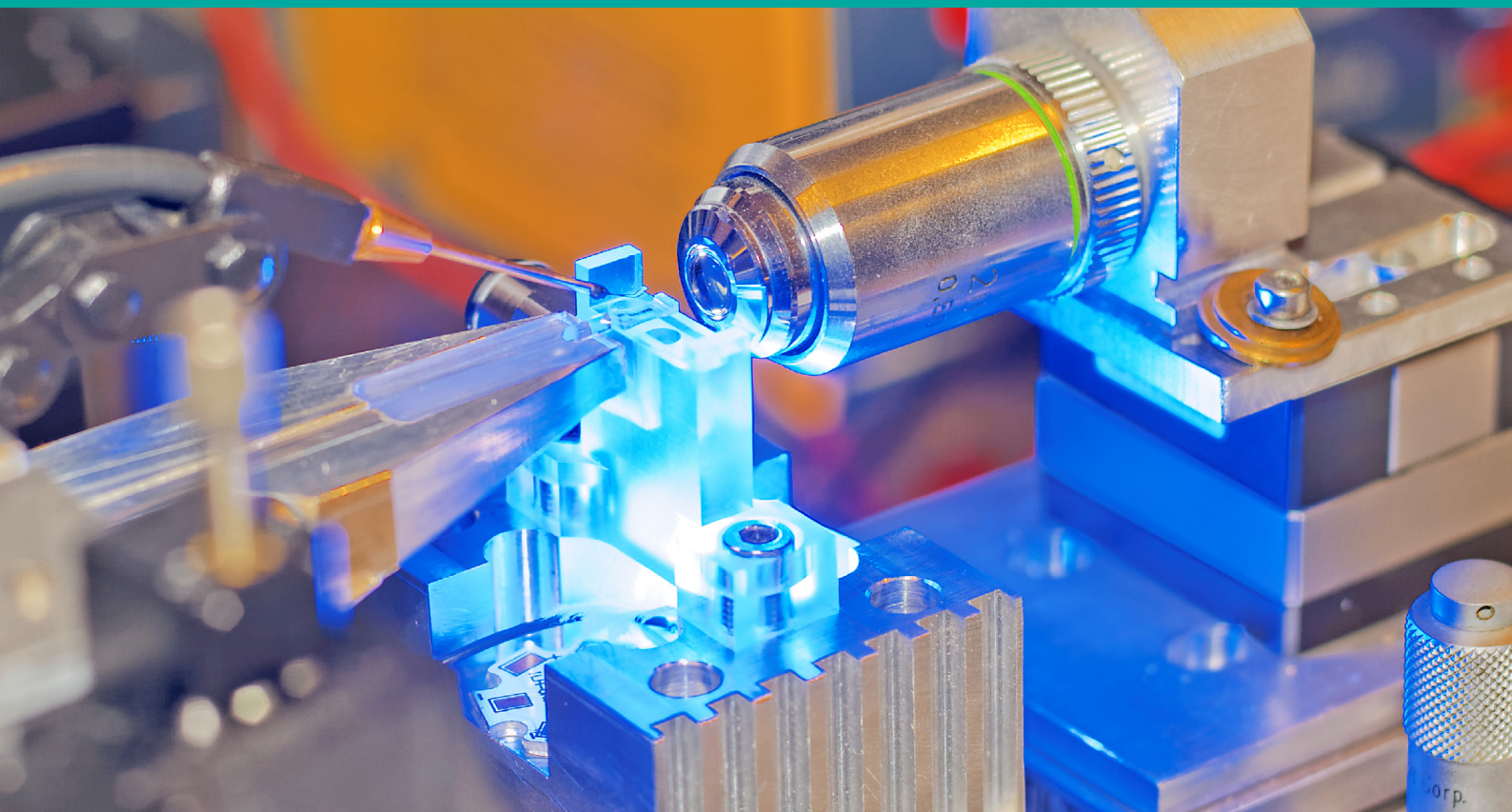
femto-st
SCIENCES &
TECHNOLOGIES

2024
Annual Report



Cover

Sensitive e-field probe using a microstructured EO lithium niobate waveguide

@Remi Meyer

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FOREWORD

Exploring Science and Innovation, from basic research to industries and spin-offs, from theory to experiments through high technology facilities, developing micro and nanotechnologies, increasing the density of functions and integrating intelligence for the engineering of components and systems with optimized performances, contributing to the future of a knowledge-based improved society.

FEMTO-ST is a joint laboratory between the Centre National de la Recherche Scientifique (CNRS) and the faculties of Université Marie et Louis Pasteur (UMLP). We are focused on Science and Technology (ST) and work in a variety of areas along five strategic axes: healthcare, ecological transition, micro and nano ST, Information ST, and Quantum ST. With 282 faculty members and 700 employees, we are one of the largest CNRS laboratories in France working in engineering and the information sciences.

In the annual report for 2024, you will discover highlights of the broad range of our scientific activities. You will also see that FEMTO-ST invests in new talent. In 2024, we added 14 faculty members to help build the future of our institute. 2024 further confirmed our involvement internationally. We worked with 65 different universities from 28 countries, and launched 12 European projects. FEMTO-ST continues to invest in technological facilities to provide its members with a unique environment for research in advanced technologies.

We hope that readers of the 2024 FEMTO-ST Annual Report will gain a deeper understanding of the remarkable work carried out by our talented researchers and staff. We also hope this report will lead to new opportunities for collaboration and inspire talented individuals to join our community. Finally, we would like to extend our sincere thanks to all FEMTO-ST members for their dedication to our shared scientific mission: this is your report.

Michaël Gauthier, Director

Thérèse Leblois, Deputy Director

Marie-Ange Manier, Deputy Director

FEMTO-ST

IN FIGURE

723

WHO WE ARE

248 Professors & Associate Professors
31 CNRS Researchers
256 PhD Students
51 Postdocs
137 Engineers/Technicians

MORE THAN

100

WORLD WIDE INSTITUTIONAL ACADEMIC PARTNERS

7 RESEARCH DEPARTMENTS

12 STARTUPS IN 11 YEARS

830

SCIENTIFIC ARTICLES IN 2024

1 INNOVATION TRANSFER UNIT (FEMTO ENGINEERING)

1 MICRO-NANO TECHNOLOGY CENTRE (MIMENTO)

10 RESEARCH FACILITIES

35M€

ANNUAL BUDGET

101

RESEARCH CONTRACTS IN 2024

CONTENTS

A BROAD RANGE OF SCIENTIFIC EXPERTISE

FEMTO-ST INSTITUTE includes 7 departments that are encouraged to perform research collaboratively.
Multidisciplinary research is carried out along the transverse axe BIOM'@X and the team RECITS.

APPLIED MECHANICS

- Materials, surfaces, processes, structures
- Micromechanics, microfabrication
- Functionalization, smart structures
- Sustainability, reliability, bio-compatibility

TIME & FREQUENCY (TF)

- Oscillators/ resonators
- Time & Frequency metrology
- Microwave systems and sensors

ENERGY

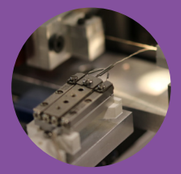
- Hydrogen-energy
- Electromagnetic converters
- Thermal machines
- Metrology and energy management

OPTICS

- Nonlinear photonics
- Complex optoelectronic systems
- Nano-photonics

BIOM'@X

- Towards a technological, translational medicine



ROBOTICS & AUTOMATION (AS2M)

- Microrobotics, mechatronics
- Automation
- Prognostic & Health Management (PHM)

COMPUTER SCIENCE (DISC)

- Parallel and distributed computing
- Formal methods for software engineering
- High performance computing
- Distributed smart microsystemsrs

MICRO-NANOSCIENCES & SYSTEMS (MN2S)

- Nanosciences and nano-structured materials
- Multimodal qualification of biological objects
- Bio-microsystems
- Phononic and Microscopy

RECITS

- Research and Study of the Evolution of Industry, Technology, and Society

RESEARCH

NEW MEMBERS

DISC

Jad Bassil

Associate professor

Jad Bassil is an Associate Professor in Computer Science at Université Marie et Louis Pasteur and a member of the OMNI team in the DISC Department at FEMTO-ST Institute. He earned his PhD in Computer Science from the University of Bourgogne- Franche-Comté in 2023, focusing on distributed algorithms for self-reconfigurable modular robots. In 2023-2024, as a postdoctoral fellow in the DISC Department, he worked on deep learning for dust detection on solar panels. His interests center on distributed planning and coordination with a view to enabling autonomous, adaptive, and scalable reconfigurations. He is currently involved in a project on programmable matter that aims to replace particles with tiny robotic modules that can communicate with each other and self-configure into different shapes.

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MN2S

Aurélien Besnard

Associate professor

After earning an engineering degree from Supmicrotech, Aurélien Besnard was awarded a PhD in 2010 by the University of Bourgogne-Franche-Comté. That same year, he served as an assistant professor at Arts et Métiers Institute of Technology where he was promoted to associate professor in 2011. In 2019, he was a visiting professor at the University of Namur (Belgium). In September 2024, while an associate professor at Supmicrotech, he carried out research at FEMTO-ST Institute. His research activities focus on the synthesis and characterization of ceramic and metallic thin films deposited by cathodic sputtering, using an approach that combines process simulation and experimentation (synthesis and characterization). He has long worked on oblique angle deposition (OAD) to obtain nanostructured thin films with highly specific properties.

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DISC

Frédéric Lassabe

Associate professor

After earning his PhD in 2009 from the Computer Science Laboratory at the University of Bourgogne-Franche-Comté, Frédéric Lassabe was an Assistant Professor at the University of Technology Belfort-Montbéliard until August 2024, conducting research in the SeT, OPERA, and FEMTO-ST/DISC laboratories. His work finds application in network-related topics in the area of large-scale modular robotics as well as in areas of mobility, energy transition, and telecommunications. He is co-holder of the Guinness World Record for the “largest autonomous light block structure.”

Frédéric’s research primarily focuses on combinatorial optimization, distributed systems, protocols and algorithms, and artificial intelligence, all of which are generally applied to trending topics such as the electrification of mobility, mobile network optimization, mobility analysis, modular robotics, and indoor positioning systems.

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DISC

Anthony Dugois

Associate professor

Anthony Dugois is an Associate Professor at Université Marie et Louis Pasteur where he teaches various topics in Computer Science such as mobile programming, software engineering, and distributed systems. He earned his PhD from the École Normale Supérieure in Lyon in 2023.
His research interests include scheduling algorithms, the optimization of parallel computing, and distributed systems, as well as approximation theory and the analysis of algorithms. His work centers on the combinatorial optimization of distributed systems (supercomputers, databases, etc.) with an aim towards obtaining performance guarantees through the use of algorithm analysis and operational research. More specifically, his research focuses on developing various theoretical and practical tools to help understand and manage these complex systems.

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NEW MEMBERS

OPTICS

Benjamin Rousseaux

Associate professor

Benjamin Rousseaux earned his PhD from the University of Burgundy Franche-Comté in 2016, following which he worked as a post-doctoral fellow at Chalmers University of Technology in Gothenburg, Sweden (2017- 2020), the Physics Laboratory at the École Normale Supérieure in Paris (2020-2021), and the Optics Institute in Bordeaux (2022-2024). He is currently an Assistant Professor in the nano-optics group at FEMTO-ST Institute.

Benjamin has done extensive work in the theory and modeling of quantum light-matter interactions in nanoscale objects. His research focuses on nanophotonic systems, cavity quantum electrodynamics, plasmonics, quantum devices such as single-photon sources, and electromagnetic modelling. He is currently developing models to help understand the dissipative interactions between photons and quantum emitters at the nanoscale.

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ENERGY

Halima Ikaouassen

Associate professor

Halima Ikaouassen earned a degree in Electromechanical Engineering from ENSAM Meknès before obtaining a PhD in Electrical Engineering from Mohammed V University in Rabat in 2020.

She is currently an Associate Professor at the Université Marie et Louis Pasteur in Belfort, and works with the SHARPAC team at FEMTO-ST Institute.

Her research focuses on the modelling and control of electrical micro-grids that integrate solar renewable energies, energy management strategies, grid-connected and non-interconnected power systems, non-linear control algorithms for power electronic converters, sustainable and intelligent charging systems for electric vehicles, and Energetic Macroscopic Representation formalism.

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APPLIED MECHANICS

Julien Monnet

Associate professor

Julien Monnet started teaching mechanical engineering at the University of Bourgogne- Franche-Comté in 2011. In 2019 he received his PhD with a thesis on the realization and characterization of micro-mechanical components in ceramics and tungsten carbide. Specifically, he studied the micro milling process through the use of electro discharge machining and the fracture toughness of the components produced.

His research focuses on small-scale compliant system design. It aims to create design tools that take into account the constraints imposed by materials and manufacturing protocols (micromechanical processes and cleanroom procedures).

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OPTICS

Simon Neves

Associate professor

After earning a PhD, Simon Neves worked with the Quantum Information team at the Sorbonne University in Paris, creating a variety of sources of photonic quantum entanglement and thereby demonstrating the capabilities of new quantum network protocols. As a post-doctoral fellow at the University of Geneva, he studied novel ways to apply entangled photons to quantum sensing, producing the first open-path analysis of organic vapors via quantum infrared spectroscopy. He currently works in the Optics Department at FEMTO-ST Institute where he has been carrying out research on photonic entanglement for the study of quantum sensing and communications. He hopes to create novel entangled-photon sources that rely on 2nd and 3rd order non-linear effects for quantum sensing in the infrared region of the spectrum. His goal is to demonstrate the advantages of quantum sensing, both on a fundamental level via the study of energy-time entanglement and in its practical application to matters of health and the environment.

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NEW MEMBERS

AS2M

Lefevre Alexis

Associate professor

After earning an engineering degree in mechatronics in 2017, Alexis Lefevre began work on the contactless manipulation of micro-objects as a research engineer at FEMTO-ST Institute. He earned his PhD in November 2023 for his work on the use of electric fields to control the trajectory of biological cells in microfluidic devices.

He is currently an Associate Professor in the AS2M Department at FEMTO-ST Institute

where he is working on the use of force fields within the Hamiltonian framework to model and control micro-robots.

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OPTICS

Mayeul Chipaux

Junior Professor Chair

Mayeul Chipaux studied at both the Industrial Physics and Chemistry Institute (ESPCI – PSL) and the Institute of Optics in Paris. He earned a PhD in wide field magnetometry from the Thales Group's graduate program in 2014 after which he did post-doctoral work at the university hospital in Groningen, where he monitored the metabolism of living cells. From 2020 to 2024, at the Swiss Federal Technology Institute in Lausanne, he successfully completed an independent project on nanoscale quantum controls using a scanning electron microscope.

He joined FEMTO-ST Institute in November 2024 to work on solid state quantum technologies. Using the nitrogen-vacancy centers in diamonds as quantum sensors or qubits he has been exploring novel ways in which to improve nanoscale quantum controls and prepare and apply large-scale entangled states.

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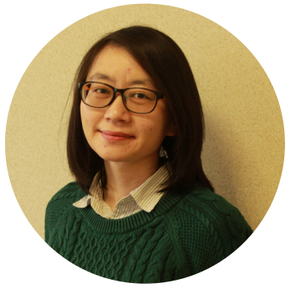

ENERGY

Zhixue Zheng

Associate professor

Zhixue Zheng has been an Associate Professor at Université Marie et Louis Pasteur since September 2024. She carries out her research in the Department of Energy at the FEMTO-ST Institute while teaching in the Electrical Engineering and Industrial Computing Department of the University Institute of Technology (IUT) Nord Franche-Comté.

From 2018 to 2024, she was an Associate Professor at the University of Lorraine where she worked at the optics, photonics and systems laboratory (LMOPS) while teaching at the IUT Thionville-Yutz. Her research interests include the diagnosis, prognosis, and modeling of hydrogen systems including fuel cells and electrolysers, energy and health management of renewable energy sources, and the application of artificial intelligence methods to energy fields.

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NEW MEMBERS

AS2M

Freddy Romero Leiro

Associate Professor

In 2023, Freddy Romero Leiro was awarded a PhD in Robotics and Automation from the Sorbonne for his work at the Intelligent Systems and Robotics Institute where he remained, following his degree, as a post-doctoral fellow until July 2024. His thesis explored the development of correlative AFM-in-SEM microscopy techniques with rotational degrees of freedom. Earlier, from 2016 to 2020, he worked as a robotics research engineer at ENSAM Lille, developing classical and collaborative robotic solutions to industrial clients' problems.

Through his study of robotic calibration at the micro-scale, he hopes to improve the precision and capabilities of robotic micromanipulators, micro-robot/micro-mechanism design and fabrication, micro-force measurements, and their applications to atomic force microscopy. These tools can be made user-friendly by automating them through the use of hybrid system controls.

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APPLIED MECHANICS

Fabrice Lallemand

Professor

Fabrice Lallemand has been a professor at Université Marie et Louis Pasteur since 2010. He teaches surface treatment and organic chemistry at the IUT Besançon. He has served as head of the Chemistry Department and Vice President of the University of Bourgogne-Franche-Comté. From 2016 to 2022, he was co-founder and CEO of the start-up AFULudine. He has been working in the Applied Mechanics Department at FEMTO ST Institute since 2024, focusing on the replacement of petroleum oils in the metal processing industry.

His research aims to functionalize surfaces by giving them specific properties, for example to reduce corrosion, wear, or friction. The coatings are developed by chemical or electrochemical means and can be metallic or organic.

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APPLIED MECHANICS

Valentin Calisti

Associate professor

Valentin Calisti earned his PhD from the Élie Cartan Institute of Lorraine, in Nancy in 2021 and worked as a post-doctoral fellow at the Institute of Mathematics at the Czech Academy of Sciences in Prague from 2022 to 2024. He joined the faculty at FEMTO-ST in September 2024. His research focuses on theoretical and numerical shape optimization (topological optimization) applied to solid and fluid mechanics (periodic metamaterials, fluid-structure interactions, non-Newtonian fluids).

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AWARDS

I NOVE YOU™ 2024
FIRST PRIZE ALL CATEGORIES

APPLIED MECHANICS

Scott Cogan, David Renault

I Nove You™ is Alstom's annual program designed to reward the creativity of its personnel company-wide. HELIOS, the software platform for the virtual homologation of railway vehicles developed by the D.SMART Team in the Department of Applied Mechanics at FEMTO-ST, won the award for best overall innovation in 2023-2024. It was one of 1518 submissions from 101 sites and 36 countries.

A digital twin paradigm implemented for testing and multibody simulations allows the application of multi-query approaches for model validation and design decision support in cases of uncertainty. ALSTOM estimates that HELIOS, which is owned and distributed by the CNRS, will reduce virtual homologation costs by 50% per mainline project.

Website:

https://www.alstom.com/ alstom-innovation-awards

References:

https://www.femto-st.fr/fr/Departements-de-recherche/MECANIQUE-APPLIQUEE/Themes-de-recherche/D.SMART

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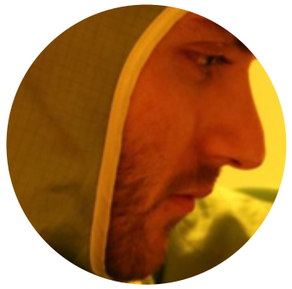

RENATECH 2024 THESIS AWARD

OPTICS

Adria Grabulosa

The RENATECH Technology Prize rewards students for outstanding work in micro-nano fabrication done in the context of their PhD thesis. Adria Grabulosa won the award in 2024 for developing a 3D photonic integration technique leveraging high-resolution additive manufacturing.

His approach enables the efficient integration of photonic devices with one order of magnitude reduced fabrication times, which will improve future large-scale 3D photonic circuits, for example those used for integrating optical neural network processors. Using this flash-TPP technique, he demonstrated the increased capabilities of numerous integrated optical components including waveguides, broadband adiabatic optical splitters, and bends with a few micrometer bending radii.

Additionally, by printing these structures on semiconductor and silicon platforms he showed that they are CMOS-compatible, thereby enhancing integration for future photonic and opto-electronic systems.

Facility: MIMENTO

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FONDATION DE WENDEL RESEARCH GRANT

RECITS

Fanny Crozet

In January 2025, Fanny Crozet was awarded a research grant from the Fondation de Wendel to support her doctoral research, which she is due to complete in October 2026. Her thesis examines the production methods and applications of 19th-century puddled iron, shedding light on its role in the development of industrial architecture. The puddling process, developed by Henry Cort in the late 18th century, enabled the large-scale production of high-quality iron, which was widely employed in iconic structures such as the Eiffel Tower and Parisian train stations.

However, with the advent of steel construction in the early 20th century, puddled iron fell into disuse and much of the associated technical knowledge was lost, posing major challenges for the maintenance and reuse of heritage structures today. Crozet's research seeks to reconstruct this lost technical knowledge through an interdisciplinary approach that combines the history of techniques and the laboratory analysis of structural samples. The aim is to improve our understanding of puddled iron in the context of reuse and energy transition, thereby reinforcing the link between technical heritage and contemporary environmental imperatives.

References:

F. Crozet, « Le fer puddlé: histoire d'un matériau disparu au service du patrimoine industriel et ferroviaire » (2024), Les Cahiers de RECITS, [À paraître]

F.Crozet, « Reconstruire des châteaux au xxe siècle ? » (2023), In Situ [En ligne], 51 |, mis en ligne le 26 septembre 2023 DOI: https://doi.org/10.4000/insitu.39144

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FEMALE SCIENCE TALENTS 2024

AS2M

Mayra Yucely Beb Caal

The Berlin-based Female Science Talents program promotes female leadership in science, business, and society, offering year-long support and networking opportunities.

In 2024, Yucely Beb Caal was selected for the program's Female Science Talents – Intensive Track, joining 19 other outstanding early-career scientists from 15 countries.

Originally from Guatemala, Yucely earned a PhD in Automation from Bourgogne- Franche-Comté University in 2024. She was a member of the Micro and Nano Robotics team at the FEMTO-ST Institute where she worked on computer vision at the micro- and nanoscale.

She was selected for her leadership potential, her research achievements, and her work on 3D surface reconstructions using scanning electron microscopy (SEM), a technique widely used in engineering, biology, and geology but which inherently provides only 2D images.

References:

https://falling-walls.com/foundation/people/mayra-yucely-beb-caal

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AWARDS

AMAC PHD THESIS AWARD (FRENCH ASSOCIATION FOR COMPOSITE MATERIALS)

APPLIED MECHANICS / AS2M

Jason Govilas

This annual, national award promotes research advancements in composite materials by recognizing outstanding doctoral work. Jason Govilas received the award in 2024 for his PhD thesis, defended in 2023. His research was carried out at the EIPHI Graduate School and as part of the Era-Net project NETFIB, which co-funded his work.

The thesis was co-supervised by the Departments of Applied Mechanics and Automatic Control at FEMTO-ST. Two breakthrough approaches were developed to address the challenges of testing the mechanical behavior of plant fibers at the microscale. Two high-precision micro-mechatronic experimental platforms were designed, enabling, for the first time, the characterization of single-fiber transverse compression behavior and the measurement of adhesion forces between individual fibers.

Facilities:

CMNR, MIMENTO, AMETISTE

References:

J. Govilas. Plant fiber mechanical characterization with high precision micro-mechatronic means: investigation of single fiber transverse behavior and inter-fiber adhesion. PhD Thesis Université Franche-Comté, 2023.

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GOLD MEDAL OF THE SOCIÉTÉ D'ENCOURAGEMENT AU PROGRÈS

ENERGY

Daniel Hissel

Daniel Hissel is a Professor at Université Marie et Louis Pasteur, head of the SHARPAC research team in the Energy Department at FEMTO-ST, and current holder of a Senior Innovation Chair at the Institut Universitaire de France. He has been working on hydrogen-energy research and innovation for more than 25 years.

The Gold Medal awarded by the Société d'Encouragement au Progrès (SEP) is different from most prizes and national awards in that the SEP honors exceptional service rendered to further the cause of progress. The medal has been awarded annually since 1908 and is traditionally presented to recipients in France's Senate. Prof. Hissel won the award in 2024 for his contributions in research and innovation, the numerous industrial applications of his research, and more generally for the influential role he has played as an ambassador for hydrogen technology.

References:

https://www.sep-france.org/gd_medaille.php

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AWARDS IN VIBRATION AND ACOUSTICS

APPLIED MECHANICS

Fanny Pelisson & Rafael Raqueti

The 14th gathering of the Young Researchers in Acoustics, Vibration and Noise Conference was held at the ISAE-SUPMECA in Saint-Ouen in November 2024. Fanny Pelisson and Rafael Raqueti, both FEMTO-ST PhD students, shared the prize for best 3-minute flash presentation.

Fanny focused on the dynamic response of plant fibers, on how piezoelectric excitation and high-speed imaging allow her to determine properties such as loss factor and storage modulus. Controlled tests are carried out to assess environmental influences, thereby increasing our understanding of fiber damping with the aim of improving the design of sustainable, bio-based composite materials.

Rafael presented a self-adaptive sandwich structure for vibration control, which incorporates embedded instrumentation and operates by thermally driving its smart material core. Self-adaptation is achieved by identifying the dominant vibration mode and, to enhance damping, applying an optimized temperature field determined by an advanced equivalent plate modelling strategy.

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AWARDS

BEST PRESENTATION AWARD PHOTONICS WEST

OPTICS

Mathilde Hary

Every year, Photonics West, held in San Francisco, is the must-attend event for the optics-photonics industry, drawing 20,000 participants from all over the world.

In 2024, Mathilde Hary, who recently completed a PhD co-supervised by FEMTO-ST's Optics Department and the University of Tampere (Finland), was the recipient of one of 5 awards out of some 4,666 entrants for best oral presentation. The Best Paper recognized her work on applying autoencoders to compressive sampling in a high-dimensional, ultrafast optical system.

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BEST PAPER AWARD BIOSTEC 2024

AS2M

Raniya Ketfi, Zeina Al Masry, Noureddine Zerhouni

BIOSTEC is an annual conference that brings together researchers and practitioners from various fields in the sciences. It focuses on both theoretical advances and applications of information systems, artificial intelligence, signal processing, electronics, and other engineering tools in knowledge areas related to biology and medicine. At the conference held in Italy in February 2024, Zeina Al Masry, Raniya Ketfi, and Noureddine Zerhouni won the prize for best paper for research focusing on design, data collection methods, and classification techniques that innovatively explores the potential of accessible, non-radiative, and non-invasive thermography as applied to smart, wearable devices designed for the early detection of breast cancer. The paper highlights the ways these devices can enhance early detection and potentially revolutionize breast cancer prevention.

Website:

https://biostec.scitevents.org

Reference:

Ketfi R, Al Masry Z, Zerhouni N, Gay C, Devalland C. Breast Cancer Detection Using Smart Wearable Devices with Thermal Sensors. BIOSTEC (1). 2024:23-33. https://www.scitepress.org/Link.aspx?doi=10.5220/0012309400003657

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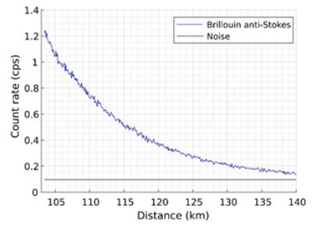
OPTO SUSTAINABILITY BEST PAPER AWARD

OPTICS

Maxime Romanet

The SPIE OPTO Sustainability Best Paper Award promotes the use of optics and photonics for renewable energy, natural resource management, sustainable manufacturing, and greenhouse gas mitigation in accordance with the Sustainable Development Goals of the United Nations.

The award I received in 2024 recognized work developing a distributed fiber-optic sensor for measuring temperatures over long distances. One of its principal applications is monitoring the temperature of underwater cables carrying electricity from off-shore wind turbines to installations on land, to alert us to the possibility of overheating and prevent the cables from deteriorating or breaking. The research was funded by the INTERREG VI program and carried out using AUREA Technology detectors.



Measurement of Brillouin anti-Stokes count rate as a function of distance. The attenuation is due to optical fiber loss.

Website:

https://spie.org/conferences-and-exhibitions/photonics-west/program/conferences/awards#_=_

Reference:

Maxime Romanet, Étienne Rochat, Kien Phan Huy, Jean-Charles Beugnot "140 km Brillouin optical time domain reflectometry based on single-photon detector," Vol. 12893 p. 121-126 (2024).

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AWARDS

EFTF AWARD 2024

TF

Vincent Giordano

The European Frequency and Time Award honors outstanding contributions in a variety of fields of scientific research and industrial development. In 2024, at the EFTF conference held in Neuchâtel, Switzerland, Vincent Giordano, a senior scientist at the CNRS, received the award in recognition of his more than 35 years of intense research in frequency metrology, including the development of cryogenic sapphire oscillators (CSOs), optically-pumped Cs beam clocks, CPT-based atomic clocks, and phase noise metrology.

The CSOs developed by Vincent Giordano have been commercialized by FEMTO-Engineering and installed in several national metrology institutes and government agencies worldwide. They are generally used as interrogation oscillators for atomic fountains and have demonstrated exceptional fractional frequency stability levels.

References:

C. Fluhr et al., Appl. Phys. Lett. 123, 044107 (2023).

Website:

https://www.eftf.org/awards

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BEST PAPER AWARD 2024 WORLD CONGRESS ON INTERNAL COMBUSTION ENGINES (WICE)

ENERGY

Meryem Benzine

Meryem Benzine completed her PhD in December 2024. That same year, she won the T10 Best Paper award at the World Congress on Internal Combustion Engines (WICE) held in Tianjin, China for her work on the interaction between fuel cells and DC to DC converters.

Fuel cell systems generally require a DC to DC boost converter to harmonize the varying voltage levels of fuel cell output with the constant voltage levels in electric systems. These converters have to be designed in a way that inhibits the fuel cell degradation caused by ripple current. In her paper, Meryem explored the possibility of solving the problem through the use of interleaved boost converters with coupled inductors.

Website:

https://wice.csice.org.cn/U/

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THE EUROPEAN PHYSICAL SOCIETY PRIZE FOR RESEARCH INTO THE SCIENCE OF LIGHT

OPTICS

John Dudley

In 2024, John Dudley was nominated as a Senior Member of the Institut Universitaire de France, and was also awarded the European Physical Society Prize for Research in the Science of Light. Appointment to the IUF is a highly selective national distinction that enables its laureates to develop an ambitious research program over a five-year period. The EPS Prize is a major international award recognizing high impact achievements in the understanding of light. Both IUF and EPS distinctions recognize his pioneering contributions to ultrafast nonlinear fiber optics, which have opened new frontiers in the study of supercontinuum light. Other accomplishments recognized include the discovery in optics of a special class of extreme nonlinear wave equivalent to the rogue waves observed on the surface of the ocean. Note that the EPS prize was jointly awarded to Prof. Goery Genty from Tampere University (Finland), with whom Prof. Dudley has worked for more than 15 years, including in the context of joint PhD student supervision.

References:

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RESEARCH HIGHLIGHTS

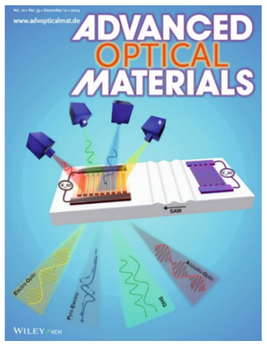
VERSATILE METAMATERIAL: EXPLORING THE RESONANCES OF SYMMETRY-PROTECTED MODES FOR MULTITASKING FUNCTIONALITY

OPTICS, MN2S

Souhaïla Boublouh, Miguel Suarez,

Abdelkrim Khelif, Fadi Baida

Enhancing light-matter interaction is a key factor in intensifying the optical response of a given structure, thereby improving its performance. An experimental study supported by numerical modeling highlighted the possibility of exciting continuum-bound states (SP-BIC) in a 1D silicon lattice built on a lithium niobate substrate to obtain a very high-quality factor resonance that can be controlled through illumination (here the angle of incidence). Working with both TE and TM polarization states, we were able to excite 4 quasi-Bound states in the Continuum (quasi-BIC) that exhibited distinct properties. We proposed four different applications, among them electro-optic and acousto-optic modulations that showed enhanced sensitivity (peak-to-peak drive voltage Vpp=0.7V for the EO modulator, for example) and a refractive index detection ability with a sensitivity of 2348°/RIU. Additionally, our experiments demonstrated temperature detection with a sensitivity of ST=0.81nm/°C, a state-of-the-art value we arrived at because of the significant electromagnetic field enhancement inside the lithium niobate. These findings pave the way for various applications, for example, in biological, electromagnetic, and temperature sensing, as well as for nonlinear applications such as second harmonic generation and electro- and acousto-optic modulation.



The inside front cover, shown here, of the paper in which this research was presented is a schematic rendering of the fabricated structure that allowed simultaneous detection (refractive index, electric field, temperature…), modulation (electro- and acousto-optic), and non-linear signal generation (SHG, for example).

Facility: MIMENTO

Website:

https://advanced.onlinelibrary.wiley.com/doi/full/10.1002/adom.202401558

Reference:

S. Boublouh et al., Advanced Optical Materials (2024). https://doi.org/10.1002/adom.202401558

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2024 OPTICA RESEARCH HIGHLIGHT

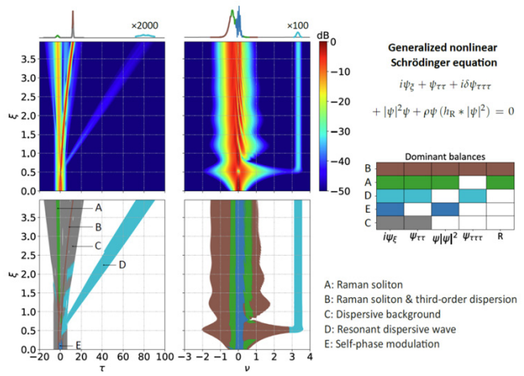
AUTOMATING PHYSICAL INTUITION IN NONLINEAR OPTICS

OPTICS

A. Ermolaev and J.M. Dudley

Every year, the international scientific society Optica publishes a collection of research highlights in its journal Optics & Photonics News, focusing particularly on breakthroughs of impact and interest to the broad optics community. That the work of Andrei Ermolaev and John Dudley was included in the journal in 2024 stands as prestigious recognition of the high quality of their research.

Machine learning is transforming both experimental and theoretical studies in photonics, both by uncovering new physical laws and providing new ways of understanding complex dynamics. Traditionally, modeling physical systems and interpreting the associated physics relied on human experience, but machine learning now allows intuition to be applied algorithmically. Specifically, research carried out at FEMTO-ST in the context of Andrei Ermolaev's PhD developed an unsupervised algorithm that can automatically detect the dominant physical processes that interact during fiber supercontinuum generation. This work has impact beyond nonlinear fiber optics, offering a powerful tool that can be applied broadly to all physical systems governed by differential equations.



Automated identification of different physical effects during the temporal (left) and spectral (right) evolution associated with fibre supercontinuum generation.

Reference:

Andrei V. Ermolaev, Christophe Finot, Goery Genty, John M. Dudley, Optics Letters 49, 4202-4205 (2024); Optics and Photonics News 35 (12), 46 (2024)

Contact:

john.dudley@femto-st.fr

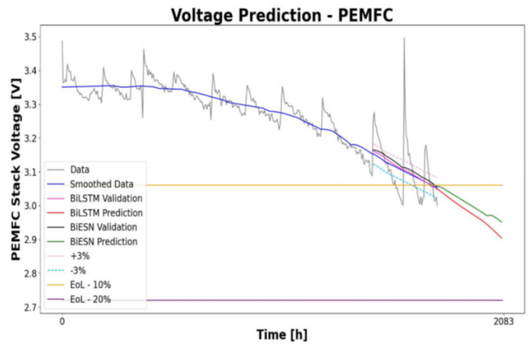
DIAGNOSTICS AND PROGNOSTICS FOR PRESCRIPTIVE MAINTENANCE AND CONTROL OF PEMFC SYSTEMS IN AN INDUSTRIAL CONTEXT

ENERGY

Gaultier Gibey, Elodie Pahon,

Noureddine Zerhouni, Daniel Hissel

Our research established a framework for the prescriptive maintenance of hydrogen-energy systems that takes into account the constraints of systems currently in use, with the aim of improving durability, availability, reliability, performance, safety, and operating costs. We studied different data-driven approaches for diagnostics and a variety of approaches for the prognostics of Remaining Useful Life (RUL) of Proton Exchange Membrane Fuel Cell (PEMFC) systems. By using measuring devices regularly available on systems we were able to validate the approach in an industrial context. We compared several diagnostic algorithms (classification and clustering) to find the best compromise between computation time and accuracy in an online diagnostic framework. The data set used for the prognosis for a PEMFC stack was obtained from experimental tests performed under steady load. It yielded a degradation trend for PEMFC stack voltage. To evaluate the robustness of the PEMFC voltage prediction for RUL estimation we tested and compared two well-known prediction algorithms, Bidirectional Echo State Network (BiESN) and Bidirectional Long-Short Term Memory network (BiLSTM). These diagnostic and prognostic approaches represent first steps towards future work on the prescriptive maintenance of hydrogen-energy systems (PEMFC, Proton Exchange Membrane Water Electrolyzer, and the hybridization of the two)..



Voltage prediction of a Proton Exchange Membrane Fuel Cell stack.

Reference:

G. Gibey, E. Pahon, N. Zerhouni, D. Hissel, Diagnostic and prognostic for prescriptive maintenance and control of PEMFC systems in an industrial framework, vol. 613, 234864, Journal of Power Sources, 2024.

Contact:

elodie.pahon@femto-st.fr

SELF-ASSEMBLED VIOLOGENS ON HOPG: SOLID-STATE NMR AND AFM UNRAVEL THE LOCATION OF THE ANIONS

MN2S

F. Cherioux, F Palmino, J. Jeannoutot

Organic materials are key candidates for the next generation of nanoelectronic devices. One promising approach involves depositing conductive ionic organic molecules, such as viologens, onto ultra-pure graphite, a process known as «organic doping.» However, visualizing these ionic species after adsorption is challenging due to complex interactions with the substrate, their mobility, and surface inhomogeneity. Conventional techniques, such as atomic force microscopy (AFM) and electron microscopy, often fail to provide a precise localization of these molecules.

To meet this challenge, we at FEMTO-ST, in collaboration with researchers from the Institut de Chimie in Strasbourg, have developed an innovative method combining solid-state nuclear magnetic resonance (NMR) and AFM. By using NMR to analyze atomic interactions between viologens and AFM to capture detailed surface images, they successfully mapped viologens on HOPG surfaces with sub-nanometer precision. This breakthrough could extend to other systems involving surface-deposited objects, such as chemical or biological sensors, molecular memory devices, and catalysts.

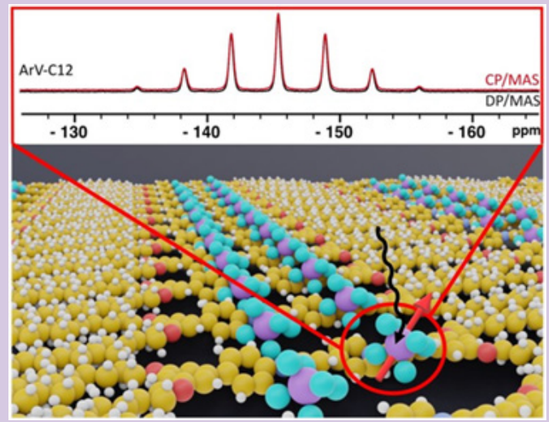


Illustration of the effectiveness of combining solid-state NMR and atomic force microscopy to determine the organization of ionic molecules on a surface.

Facility: Surface

Website:

https://www.inc.cnrs.fr/fr/cnrsinfo/electronique-moleculaire-un-nouveau-regard-sur-lorganisation-des-molecules-ioniques

Reference:

J. Joseph et al., Nanoscale (2024). www.doi.org/10.1039/D4NR00894D

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RESEARCH HIGHLIGHTS

FROM CONVENTIONAL TO PROGRAMMABLE MATTER SYSTEMS: A REVIEW OF DESIGN, MATERIALS, AND TECHNOLOGIES

DISC

Ahmed Amine Chafik, Jaafar Gaber,

Julien Bourgeois, Tarek El Ghazawi,

Programmable matter represents a system of elements whose interactions can be programmed to alter physical characteristics (e.g., color, shape) upon command. Researchers, engineers, and artists have shown particular interest in the development of smart modeling clay as a novel alternative to conventional matter and the classical means of prototyping. People can now do/undo/redo forms based on computed data (CAD) or interactions (sensors), which can help them unlock features and increase the functionality of their creations.

This promising technology presents many challenges, for programable matter relies on energy consumption, data transmission, stimuli control, and shape formation mechanisms. Our research focused on the basic operations required to create shapes. We studied various objects created by programmable matter's ability to alter form and the pertinent ways in which to classify them, and reviewed the associated challenges, among them those posed by the use of the same term for strategies aimed at controlling and modifying behavior.

References:

https://doi.org/10.1145/3653671. Impact Factor 23.8, classement de la revue 1/143 (Q1) dans le Computer Science Theory and Models Rank: https://dl.acm.org/journal/csur/indexing#impactranking.

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julien.bourgeois@femto-st.fr

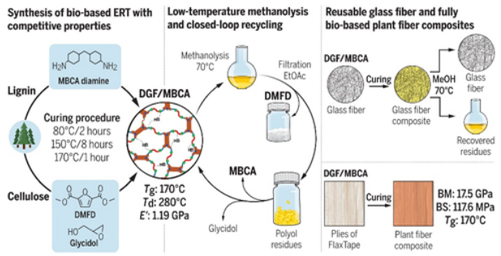
CLOSED-LOOP RECYCLABILITY OF A BIOMASS-DERIVED EPOXY-AMINE THERMOSET BY METHANOLYSIS

APPLIED MECHANICS

Vincent Placet

Thermoset epoxy resins constitute an important class of polymer materials. They have been used for many years in combination with glass or carbon fibers in the manufacturing of aircraft, trains, boats, and wind turbine components. These fiber-reinforced polymers exhibit excellent mechanical and thermal properties while being significantly lighter than metals, but because they are highly crosslinked they suffer from an inability to be recycled and have a devastating impact on the environment. There is clearly a need to design inherently recyclable epoxy resins made from renewable resources.

In our research, we were able to synthesize and recycle such a fully bio-based epoxy resin with excellent thermomechanical properties (glass transition temperature of 170°C and storage modulus at 25°C of 1.2 GPa). It was made from a combination of synthons derived from cellulose and lignin. We furthermore recovered all the bio-based synthons involved through simple methanolysis carried out in the absence of catalysts. These results represent a significant step toward integrating thermosetting materials into the circular and bio-based economy.



The design and closed-loop recycling of a fully biomass-derived epoxy resin thermoset and relevant applications.

Website:

https://www.science.org/doi/10.1126/science.adj9989

References:

Xianyuan Wu et al. Closed-loop recyclability of a biomass-derived epoxy-amine thermoset by methanolysis. Science384, eadj9989(2024).DOI:10.1126/science.adj9989

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vincent.placet@univ-fcomte.fr

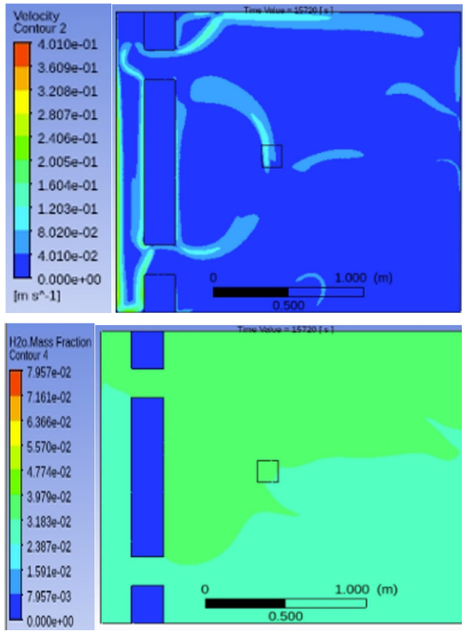
TRANSIENT HYGROTHERMAL CFD MODEL OF TROMBE WALL SYSTEM

ENERGY

Nour El Zein, Yacine Ait Oumeziane,

Philippe Désévaux, Sylvie Bégot, Valérie Lepiller

The building sector is responsible for a substantial part of energy consumption worldwide. To improve a building's energy performance and hygrothermal comfort it is essential to adopt renewable energy resources and environmentally friendly engineering solutions. Trombe walls are recognized as a cost-effective solution. Like other building facades, they are in constant interaction with their environment, generating highly dynamic systems involving the complex, interconnected phenomena of heat, air and moisture transfer. Our research focused on developing a transient CFD model that could capture these phenomena accurately, taking into account variable solar radiation as well as the presence of occupants and their activities, plotting temperature and velocity profiles at different locations, and monitoring the impact of moisture on hygrothermal behavior. The model showed that Trombe walls can ensure an occupant's thermal comfort from 11 am to 4 pm on an overcast winter's day.



Velocity profile and vapor mass fraction in a Trombe wall at noon

References:

El Zein, Nour and Ait Oumeziane, Yacine and Désévaux, Philippe and Bégot, Sylvie and Lepiller, Valérie, Transient thermo-hygrometric CFD model of Trombe wall system, 32ème Congrès Français de Thermique (SFT 2024),

Contact:

nour.elzein@femto-st.fr

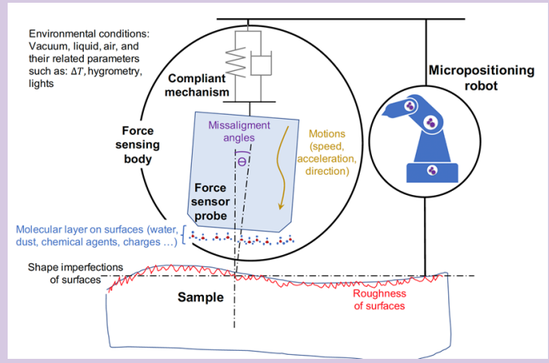
AN OVERVIEW OF MICROROBOTIC SYSTEMS FOR MICROFORCE SENSING

AS2M

Valentin Reynaud, Joel Agnus, Cédric Clévy

Microrobotic force-sensing systems allow humans to control the interactions between a robot and micrometer-size samples. In particular, they provide a highly versatile means for controlling speeds, dynamics, and approach angles, as well as for identifying the point of contact. It is extremely difficult for integrated microforce sensors to measure the forces that are generated during interactions because they are affected by environmental and system parameters.

Our research on the most recent microrobotic systems used for microforce sensing was carried out in collaboration with both the ISIR Institute in France and Purdue University in the US. It addressed all of these aspects. After presenting the basic principles of microrobotic microforce sensing, robotics, and control, we underscored the importance of microforce sensor calibration and active microforce-sensing techniques. We provided an overview of microrobotic microforce-sensing systems and their potential applications, including both tethered and untethered microrobotic approaches.



Principle scheme for microforce sensing with robots and related influential parameters.

Facility: CMNR

Website:

https://www.annualreviews.org/content/journals/10.1146/annurev-control-090623-115925

References:

Adam, G., Boudaoud, M., Reynaud, V., Agnus, J., Cappelleri, D. J., & Clévy, C. (2024). An overview of microrobotic systems for microforce sensing. Annual Review of Control, Robot-ics, and Autonomous Systems, 7.

https://doi.org/10.1146/annurev-control-090623-115925

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RESEARCH HIGHLIGHTS

TOWARDS A CONTROL THEORY OF SOCIAL INTERACTIONS

AS2M

Jean-Julien Aucouturier

Research carried out in collaboration with colleagues from the University of Glasgow led to a new software platform. Two people talk to each other in videoconference unaware that video filters are modifying their appearance in real time, giving the impression either that they are smiling or that they are not. Our research showed that the filters can modulate the perceived quality of a conversation and of each person's desire to meet the other again, by making, or not making, them smile at the same time. This methodological advance in signal processing opens the possibility for studying human communication as a system that can be modelled, identified, and controlled (in the sense of control theory), and for using this system to carry out vast scale experiments on consenting participants on the Internet.

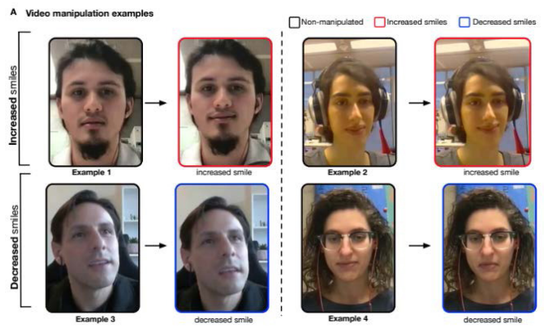

Illustration of real-time smile manipulation. Two people in video conference, each seeing the other as smiling more (top line) or smiling less (bottom line) than they actually are.

Website:

https://www.pnas.org/doi/10.1073/pnas.2400369121

References:

Arias-Sarah, Pablo, Bedoya, Daniel, Daube, Christoph, Aucouturier, JJ, Hall, L & Johansson, P. Aligning the smiles of dating dyads causally increases attraction. Proceedings of the National Academy of Sciences, 121(45), e2400369121.

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GROUND VIBRATION TESTS ON ECOPULSE AIRCRAFT: AN INTENSIVE WEEK FOR A UNIQUE EXPERIMENTAL ADVENTURE!

APPLIED MECHANICS

Emmanuel Foltête, Scott Cogan, Stani Carbillet,

Darian Fechner

The D-SMART group of the Applied Mechanics Department is heavily involved in the FLAM2 project in collaboration with DAHER AEROSPACE and VELICA. With the financial support of FRANCE 2030, these three partners have been working to establish advanced methods for predicting flutter on light aircraft by combining efficient experimental approaches and numerical robustness analysis.

A major milestone was reached in September 2024 when a series of Ground Vibration Tests were carried out on ECOPULSE aircraft, an innovative hybrid distributed propulsion demonstrator manufactured by DAHER, SAFRAN and AIRBUS. The testing required ten days of intensive work at DAHER's facilities in Tarbes using instrumentation from the AMETISTE platform. Four electrodynamic shakers and a set of 3D sensors allowed us to determine 1400 Frequency Response Functions for each of the 4 tested configurations. In-house developed pre- and post-processing software identified over 25 vibration modes in the frequency band of interest.

This exceptional work helped to improve the efficiency and reliability of Ground Vibration Testing, while generating an outstanding set of "real world" experimental data. The next steps will focus on the analysis of robustness, specifically, how to assess the absence of flutter despite the presence of uncertainties, variabilities, and lack of knowledge.

Setting up vibration tests on the ECOPULSE hybrid demonstrator.

Facility: AMETISTE

Contact:

Emmanuel.Foltete@femto-st.fr

ACTIVE PARTICIPATION AT THE MARSS CONFERENCE, THE REFERENCE IN THE DOMAIN FOR MICROMANIPULATION AND MICROROBOTICS

AS2M

The AS2M department at FEMTO-ST Institute is exploring innovative actuation strategies to control robots dedicated to the manipulation of micrometer-size objects. At these small scales, the effects of gravity become negligible compared to those of forces such as friction and adhesion, necessitating new designs and approaches. The latest work in this area carried out at FEMTO-ST Institute was presented in July in Delft (Netherlands), at the annual International Conference on Manipulation, Automation and Robotics at Small Scales (MARSS), the most well-known in the field. Many members of the department actively participated and made technical presentations. One of the papers from the AS2M and DMA departments was nominated for Best Student Paper (Anouk Chevallier et al). Our researchers also organized special sessions on force sensing and continuum robotics, and gave a plenary talk on non-contact actuation for microrobots. The five days were rich in scientific exchanges, and enabled us to showcase our most recent work and to initiate and strengthen collaboration with teams from all over the world.

Members of the AS2M Department during the international Annual MARSS conference in Delft, the reference in the field of micromanipulation and microrobotics.

Website:

https://www.femto-st.fr/en/Research-departments/AS2M/Presentation

References:

Chevallier, Anouk, et al. «Assessment of direct microrobotic gripping for single flax fibre tensile tests.» 2024 International Conference on Manipulation, Automation and Robotics at Small Scales (MARSS). IEEE, 2024.

David J. Cappelleri (Purdue Univ) and Cédric Clévy (UMLP/FEMTO-ST) "Special session on Microrobotic Force Sensing and Applications"

Kanty Rabenorosoa (UMLP/FEMTO-ST), "Special session on Advancements on continuum robotics for medicine"

RETHINKING THE MEANING OF DESIGN FOR ENGINEERING STUDENTS

RECITS

Laurent Heyberger, Nathalie Kroichvili, Bénédicte Rey,

Nicolas Simoncini, Mathieu Triclot

2024 saw the publication of a design manual we wrote for engineering students. It was the product of a long-term collective research effort stemming from discussions on the role of the humanities and social sciences in technological research that dated back to a weeklong symposium in Cerisy in 2019.

The book draws on contributions from various disciplines, including the philosophy and history of technology, earth sciences, life sciences, sociology, economics, and cognitive psychology and is largely informed by the experience researchers from the RECITS Department at FEMTO-ST had carrying out technological projects.

The manual is structured by the concept of the «technical milieu» and aims to provide resources for rethinking the meaning of the engineering profession, which serves as a guiding thread. It explores new concepts, such as living and zombie technologies, technodiversity, and care technology. Our hopes have now been fulfilled, as the book—available through open access—is used as the foundation for a course taught at the UTs in Compiègne and Belfort-Montbéliard.

The cover of the manual with the names of its 15 contributors.

Website:

https://materiologiques.com/fr/essais-2427-4933/388-prendre-soin-des-milieux-manuel-de-conception-technologique-9782373614473.html

References:

Mathieu Triclot (dir.), Prendre soin des milieux: Manuel de conception technologique, Éditions Matériologiques, 2024 (ISBN 978-2-37361-447-3)

Contact:

mathieu.triclot@pm.me

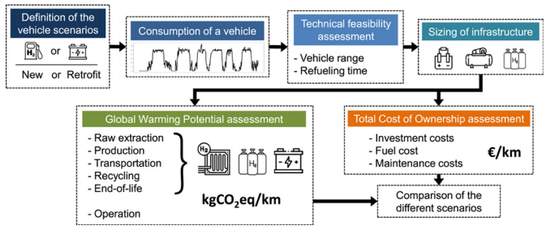
RESEARCH HIGHLIGHTS

INVESTIGATING THE USE OF HYDROGEN AND ELECTRIC BATTERY VEHICLES FOR PUBLIC TRANSPORTATION: A TECHNICAL, ECONOMICAL, AND ENVIRONMENTAL ASSESSMENT

ENERGIE, RECITS

Agnès François, Robin Roche, Nastasya Winckel

More and more public transportation systems are looking at alternatives to diesel to decarbonize their energy mix. Our research focused on bus fleets in Réunion. It was a collaborative effort involving the Energy-lab at the University there and our team at Energy-Récits. Working on the basis of technical, economic and environmental criteria, we analyzed the possibility of using electricity and hydrogen power sources, which are among the most popular alternatives. We estimated the consumption of hydrogen and electric powered vehicles and studied their feasibility in terms of range and recharging time. We also evaluated the total cost of ownership (TCO) and their global warming potential (GWP), taking into account the life cycle of the technologies they run on as well as a vehicle's operational life. We concluded that it would not be technically feasible to have a fleet exclusively composed of electric powered vehicles but that the TCO and GWP of one composed of hydrogen powered vehicles alone would be too high.



Website:

https://www.sciencedirect.com/science/article/abs/pii/S0306261924015265?via%3Dihub

Reference:

Agnès François, Robin Roche, Dominique Grondin, Nastasya Winckel, Michel Benne, « Investigating the use of hydrogen and battery electric vehicles for public transport: A technical, economical and environmental assessment ", Applied Energy, Volume 375, 2024, 124143,

ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2024.124143.

Contact

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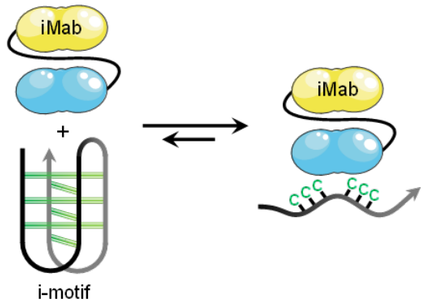
IMAB ANTIBODY BINDS SINGLE-STRANDED CYTOSINE-RICH SEQUENCES AND UNFOLDS DNA I-MOTIFS

MN2S

Jérôme Dejeu

i-Motifs (iMs) are non-canonical, four-stranded secondary structures formed by stacking hemi-protonated CH+·C base pairs in cytosine-rich DNA sequences, predominantly at pH < 7. The presence of iM structures in cells had been a matter of debate until the recent development of the iM-specific antibody, iMab, that has been a key element in several studies that suggest the existence of iMs in living cells and their biological role. We assessed the interaction of iMab with cytosine-rich oligonucleotides by using biolayer interferometry (BLI), pull-down assay, and bulk-FRET experiments. Our results suggest that the binding of iMab to DNA oligonucleotides is governed by the presence of runs of at least two consecutive cytosines and that it generally strengthens in acidic conditions, irrespective of a sequence's capacity, if any, for adopting an iM structure. Moreover, the results of the bulk-FRET experiments indicate that, even in acidic conditions, interaction with iMab leads to the unfolding of iM structures, similarly to what has been observed with hnRNP K, a well-studied single-stranded DNA binding protein. Our results strongly suggest that iMab actually binds to blocks of 2–3 cytosines in single-stranded DNA, which would seem to indicate the need for further interpretation of the results obtained in previous studies of this antibody.



Website:

https://www.femto-st.fr/fr/L-institut/actualite/la-structure-i-motif-de-ladn-existe-t-elle-dans-la-cellule

https://www.inc.cnrs.fr/fr/cnrsinfo/la-structure-i-motif-de-ladn-existe-t-elle-vraiment-dans-la-cellule

Reference:

J. Boisssieras et al., Nucleic Acid Research (2024). www.doi.org/10.1093/nar/gkae531

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A NEW TWIST OF ULTRAFAST LIGHT

OPTICS

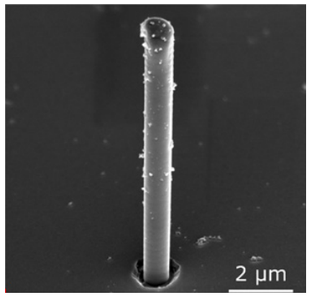
Valeria Viviana Belloni, Mostafa Hassan, Luca Furfaro,

Remo Giust, François Courvoisier

Femtosecond lasers are well-known for their ability to process materials with extreme precision. A team at FEMTO-ST has achieved a world first by creating a new use for these lasers.

Through a process we call laser-induced extrusion, a single laser pulse can generate high aspect ratio nanopillars on sapphire by moving a large volume of material from the inside to the surface. The approach uses tubular beams, also known as higher-order Bessel beams, to induce a cylindrical micro-explosion inside. Depending on the intensity of the laser, the micro-explosion can displace a nano-pillar from within the material (see illustration) or even create a nano-jet subject to hydrodynamic instabilities that re-crystallizes to form structures with a high aspect ratio and varied morphologies. These nano-pillars typically have a diameter of 800 nm and heights of up to 15 µm.

Interestingly, these nano-pillars are mono-crystalline, suggesting the possibility for applications in fields such as metamaterials, mechanics, health, sensors, photonics, or phonics. From a fundamental point of view, the results also demonstrate the ability to confine laser-matter interaction to scales of the order of fifty nanometers, even in extreme thermodynamic regimes.



Nano-pillar formed on the surface of a sapphire sample after illumination by a single femtosecond laser pulse.

Website:

https://www.insis.cnrs.fr/fr/cnrsinfo/des-nanopiliers-crees-par-une-seule-impulsion-laser-femtoseconde

V. V. Belloni, et al., Laser Photonics Rev, 18, 2300687 (2024) https://doi.org/10.1002/lpor.202300687 [open access]

Facility:

MIMENTO

Reference:

Belloni, V. V., Hassan, M., Furfaro, L., Giust, R., Seydoux-Guillaume, A. M., Sao-Joao, S., & Courvoisier, F. (2024). Single Shot Generation of High-Aspect-Ratio Nano-Rods from Sapphire by Ultrafast First Order Bessel Beam. Laser & Photonics Reviews, 18(3), 2300687.

Contact:

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RESEARCH HIGHLIGHTS

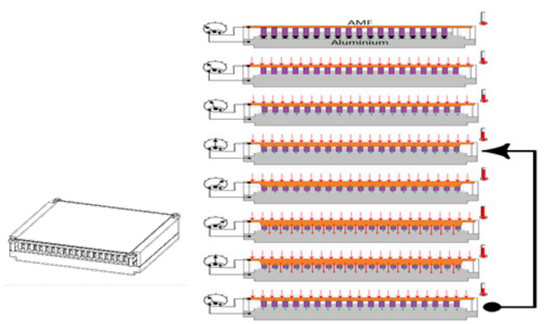
A UNIVERSAL DEVICE FOR HARVESTING ENERGY FROM MULTIPHYSICS EXCITATIONS

DISC

Jaafar Gaber

The present invention is a universal energy harvesting device that converts ambient noise and multiphysics excitations from multiple physical categories into electrical energy. It can be integrated into low-power electrical equipment, such as sensors and IoT devices.

The device can convert multiple types of excitations, including mechanical, vibrational, thermal, and photonic fluctuations. To perform these conversions, it incorporates SMA/SMP components that transform thermal fluctuations into mechanical excitations and piezoelectric materials that directly capture mechanical and vibrational excitations. The exposure of piezoelectric materials to mechanical and vibrational excitations generates electrical discharges that are collected by a charge controller powering a battery, ensuring a continuous power supply for electrical devices.



Modular universal energy harvesting device integrating AMF, PMF, and piezoelectric components for converting multiphysics excitations into electrical energy.

Website:

https://patent.ompic.ma/publication-server/document?PN=MA61005%20MA%2061005&iDocId=21219&iPosition=0&iFormat=0

Reference:

Tayane S., Ennaji M., Gaber J. Dispositif de récupération d'énergie universelle à partir de sollicitations multiphysiques, Moroccan Patent MA 61005 A1, 2024.

Contact:

gaber@utbm.fr

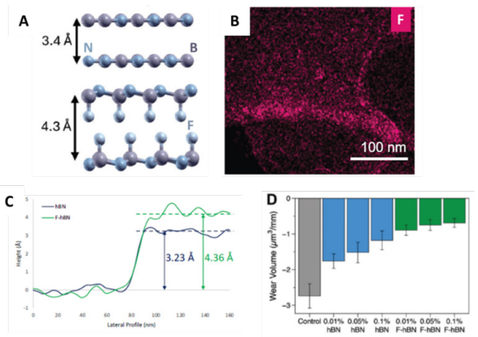
ENABLING MULTIFUNCTIONAL APPLICATIONS THROUGH THE FLUORINATION OF HEXAGONAL BORON NITRIDE

MN2S

Guillaume Colas

2D materials exhibit exceptional properties in comparison with their macroscopic counterparts, offering promising applications in nearly every area of science and technology. Functionalizing them chemically can generate powerful techniques for enabling the tunability of the known physical properties and potentially developing new ones.

2D h-BN is considered a promising lubricating, thermal management, and dielectric material, but its ability to achieve effective dispersion and exfoliation for macroscopic application has proven difficult. Researchers from Rice University (Houston, USA) took a first step in overcoming these difficulties when they developed an in-house, gas-phase fluorination technique for covalently functionalizing 2D materials using fluorine moieties and applied it to h-BN materials. In our collaboration with them and researchers from the University of Toronto (Canada), we demonstrated that fluorine atoms expand interlayer distance, which improves exfoliation and decreases interlayer coupling. Fluorination into F-h-BN significantly enhanced (i) di-electric properties, (ii) the anti-wear properties of lubrication and, (iii) dispersion in nano-fluids, while greatly improving thermal conductivity.



DFT calculation of F effect on h-BN structure (A) correlated with AFM measurement (C), F distribution on h-BN nanosheets (B), and wear volume following fluorination (D)

Facilities:

AMETISTE, MIMENTO

Reference:

D. Salpekar et al., Small (2024). www.doi.org/10.1002/smll.202311836

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GLOBAL WARMING RISK AND THE SOCIETAL AND GOVERNMENTAL IMPACT OF THE HYDROGEN ECOSYSTEM IN THE TRANSPORTATION SECTOR

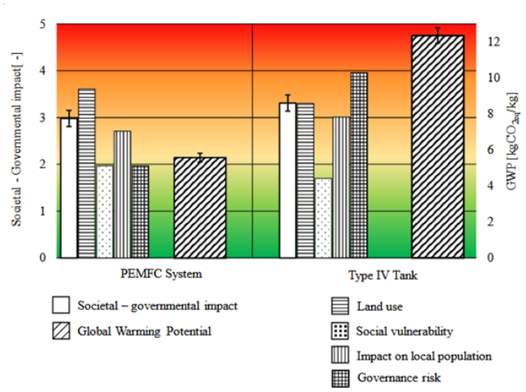
ENERGIE

Clotilde Robert, Alexandre Ravey, Daniel Hissel

The environmental and societal challenges of contemporary society have led us to reconsider our approaches to vehicle design. Our research involved gathering the essential knowledge needed to responsibly design a vehicle equipped with a hydrogen fuel cell system. We studied two pivotal aspects of hydrogen-electric powertrain eco-design.

First, the global warming risks associated with both PEMFC systems and Type IV hydrogen tanks, which deal with material extraction, production, and end-of-life considerations. (To facilitate data adaptation for each type our study did not include the usage phase.) PEMFC exhibits a global warming potential of about 29.2 kgCO2eq/kW while hydrogen tanks register 12.4 kgCO2eq/ kWh, a figure that takes transportation factors into account.

Secondly, the impact on society and government. Carbon-intensive hydrogen tanks present the most significant risks. In fact, on a scale of 1 to 5, with 5 representing the highest, the PEMFC system has a societal impact and governance risk of 2.98, and the Type IV tank a societal impact and governance risk of 3.31. While there remain uncertainties in our research, the values obtained provide an overview of the impact of the hydrogen ecosystem in the transportation sector. The next step will be determining, for the same usage, which of the two, hydrogen-electric or 100% battery, is more respectful of humans and the environment.



Comparison of the impact of a PEMFC system and a type IV hydrogen tank on society and government.

Website:

https://hal.science/hal-04584395/document

Reference:

DOI: 10.1016/j.ijhydene.2024.0

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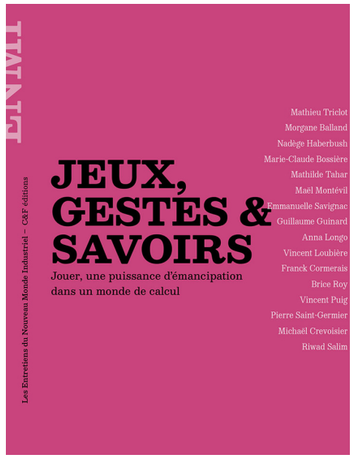
RESEARCH HIGHLIGHTS

JEUX, GESTES & SAVOIRS

RECITS

Mathieu Triclot



The book cover, with the names of its 16 contributors.

Jeux, Gestes & Savoirs, (Games, Gestures, and Knowledge) co-edited by Mathieu Triclot, Vincent Puig, and Franck Cormerais, is a compilation of papers given at the 17th Entretiens du Nouveau Monde Industriel (ENMI) colloquium held in Paris in 2023. The ENMI, which was founded by the philosopher of technology Bernard Stiegler, brings together policymakers, researchers, businessmen, engineering designers, and artists, allowing them to voice their theoretical and forward-looking views on the industrial and social experiments undertaken in various locales. It integrates theoretical contributions from the life sciences, psychology, economics, philosophy, and game studies, along with reports on experiments carried out in the field. It follows a broad trajectory from animal play to human play, focusing on play's ability to empower and educate at a time when computation, games, and game rules increasingly shape our thinking and our values.

Website:

https://cfeditions.com/jeux-gestes-savoirs/

Reference:

Mathieu Triclot, Vincent Puig & Franck Cormerais (dir.), Jeux, gestes & savoirs : Jouer, une puissance d'émancipation dans un monde de calcul, C&F Editions, 2024 (ISBN 978-2-37662-089-1)

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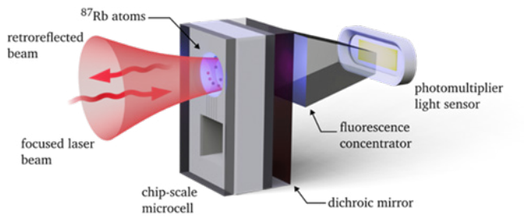
RB MICROCELL OPTICAL FREQUENCY REFERENCE WITH STABILITY IN THE LOW 10^{-13} RANGE AT 1 S

TF / MN2S

Martin Callejo, Aadrei Mursa, Rémy Vicarini, Emmanuel Klinger, Quentin Tanguy, Jacques Millo, Nicolas Passilly, Rodolphe Boudot

New generation miniaturized optical clocks rely on the stabilization of the frequency of a laser onto a narrow atomic transition, resonant in the optical domain (a few 100 THz) and detected in a microfabricated vapor cell. At FEMTO-ST, we have developed and characterized the short-term stability of an optical reference based on the spectroscopy of a two-photon transition at 778 nm of the rubidium atom. The short-term stability of the microcell frequency standard is $3.5 \times 10^{-13} \tau^{-1/2}$ until τ = 200 s (with _the integration time), which is about 1,000 times greater than commercial microwave chip-scale atomic clocks. These results are very encouraging and pave the way for ultra-high-stability miniaturized atomic clocks that would lose only a few nanoseconds per day, and are sure to have an impact on navigation, communications, and metrology.



Heart of the microcell-based optical frequency reference.

Facilities:

MIMENTO/OSC-IMP

Reference:

M. Callejo et al., Short-term stability of a microcell optical reference based on the Rb atom two-photon transition at 778 nm, Journal of Optical Society America B 42, 1, 151-159 (2025).

Website:

https://doi.org/10.1364/JOSAB.533904

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rodolphe.boudot@femto-st.fr

OPTICAL SPIN WAVES

OPTICS

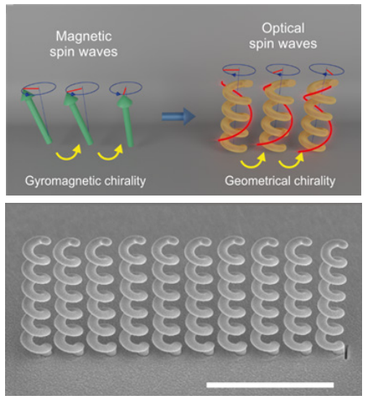
Vage Karakhanyan, Roland Salut, Miguel Suarez, Nicolas Martin, Thierry Grosjean

Ferromagnets have the ability to generate and propagate microscopic magnetic waves. These "spin waves" are quantized in the form of quasiparticles called magnons. They result from the precession (rotation) of micro-magnetizations within the material and from couplings between these rotating micro-magnetizations. Spin waves are currently at the center of intensive scientific research in the field of magnonics that could yield computer components that do not generate heat, making it a promising low-energy alternative to conventional electronics.

We have designed and created an optical equivalent of magnetic spin waves using chains of carbon nano-helices coated with a thin layer of gold. The optical excitation of such plasmonic structures triggers the propagation of optical spin waves through its periodic property. Each nano-helix generates a local twisted optical (plasmonic) phenomenon that, through successive couplings between adjacent nanostructures,

results in the formation of a new optical wave exhibiting strong similarities with magnetic spin waves. This approach exploits the geometric chirality of nanostructured matter as an optical counterpart to the gyromagnetic chirality responsible for the precessing micro-magnetizations that produce magnetic spin waves.

Optical spin waves open up unprecedented ways to control light at very small scales. In their fundamental forms, optical spin waves could lead to the concept of optical magnons, a new family of light quasiparticles transported through arrays of chiral nanostructures carrying twisted eigenmodes.



Top: Principle of optical spin waves, analogy with the magnetic spin waves (Real. B. Guichardaz). Bottom. Scanning electron microscope image of a nano-helix chain designed to support optical spin waves. Scale bars: 2 µm.

Facility: MIMENTO

Reference:

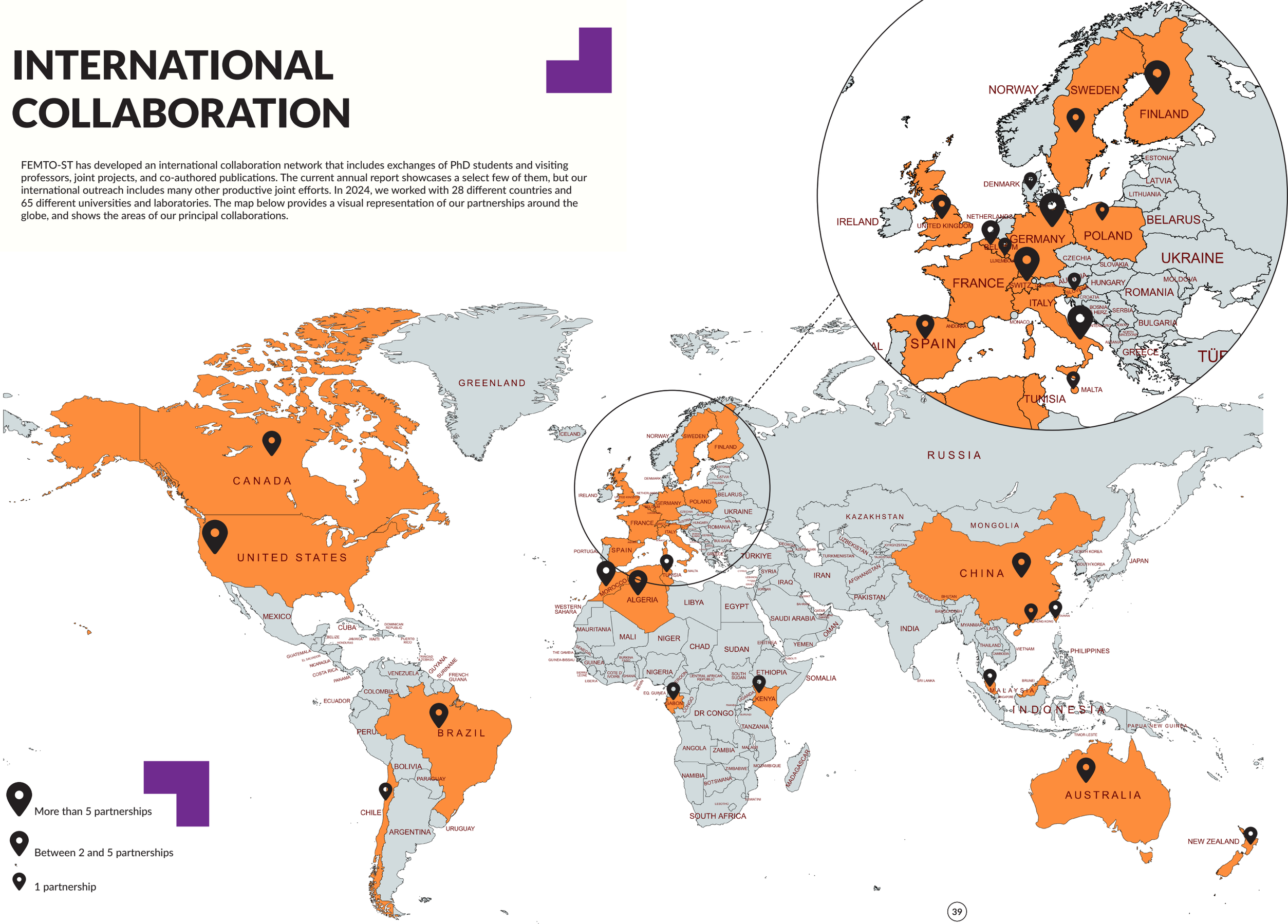
V. Karakhanyan, R. Salut, M.A. Suarez, N. Martin and T. Grosjean. Optical spin waves. Nano Lett., 24, 8296-8302 (2024).

Contact:

Thierry.grosjean@univ-fcomte.fr

INTERNATIONAL COLLABORATION

FEMTO-ST has developed an international collaboration network that includes exchanges of PhD students and visiting professors, joint projects, and co-authored publications. The current annual report showcases a select few of them, but our international outreach includes many other productive joint efforts. In 2024, we worked with 28 different countries and 65 different universities and laboratories. The map below provides a visual representation of our partnerships around the globe, and shows the areas of our principal collaborations.



INTERNATIONAL COLLABORATION

COLLABORATION WITH BRAZILIAN INSTITUTIONS

Rafael Teloli, Najib Kacem, Nouredine Bouhaddi, Gaël Chevallier, Morvan Ouisse / Paulo Varoto (EESC-USP), Samuel da Silva (UNESP), Leopoldo de Oliveira (EESC-USP), Daniel Castello (UFRJ), Marcela Machado (UnB).

The D-SMART team at FEMTO-ST has long maintained strong ties with Brazilian institutions, fostering joint research projects in structural dynamics. Their collaboration has recently expanded to include work in energy harvesting and physics-informed machine learning.

This year, joint efforts included research on data-driven approaches to energy harvesting (the Chaires Franco-Brésiliennes project), an invited professor position at ITA, numerous subsidized visits from researchers in Brazil at the USP, UFRJ, and UNESP (the Accueil de Chercheurs Invités program), a double degree PhD funded by FAPESP that explored wave propagation in phononic crystals, and short-term internships focusing on stochastic modeling and nonlinear system identification.

In the past two years alone, six Brazilian PhD students and two short-term interns carried out research at FEMTO-ST, and some ten master's students, one postdoctoral researcher, and four invited professors also came. The collaboration between the Institute and Brazil is supported by institutions such as the French Consulate in Brazil, Supmicrotech, CNPq and FAPESP.

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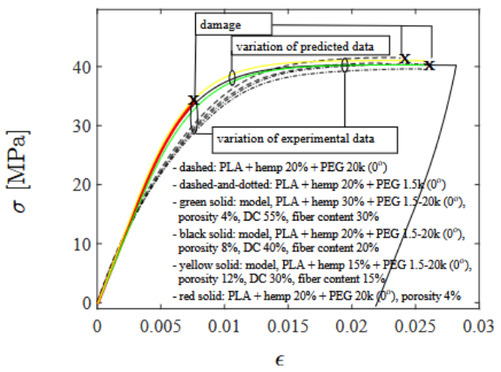
UNIVERSITY OF TAMPERE, TAU

Thierry Barrière, Vincent Placet

Sami Holopainen, Reijo Kouhia

The collaborative research undertaken with Sami Holopainen from Tampere University of Technology (Finland) deals with the computational mechanics of metal and polymer materials with a focus on computer-aided design and simulation for modeling mechanical deformation behavior of, and fatigue damage to metals (steels, glassy metals) and (bio)polymers.

Our collaboration has resulted in several peer-reviewed articles published jointly over the years in leading journals in the field, as well as one or two per year at international conferences. While at FEMTO-ST, Sami also obtained a degree as a Research Supervisor and co-directed a thesis with Vincent Placet and Thierry Barrière.



Measured stress vs. strain responses up to rupture and mathematical (physical) model predictions based on degrees of porosity, DC, and fiber content

Reference:

T. Barriere, S. Carbillet, X. Gabrion, and S. Holopainen. Prediction of short- to long-term cyclic deformation behavior and fatigue life of polymers. Polymers, 16:1640, (2024).

Contact:

thierry.barriere@univ-fcomte.fr

CREATION OF THE FRANCO-MOROCCAN RESEARCH CENTER (CRFM)

Nadia Yousfi Steiner

October 2024 saw the founding of the Franco-Moroccan Research Center (CRFM), an institute supported by the Université Marie et Louis Pasteur that brings together researchers from FEMTO-ST, the Sorbonne, the University of Lorraine, and the CNRS, as well as from the International University of Rabat, Mohammed V University, and Ibn Tofail University in Morocco. The center, the first of its kind on the African continent, is dedicated to teaching, research, and innovation in fields such as artificial intelligence, Big Data, cybersecurity, hydrogen, renewable energy, and societal issues. The CRFM has plans, in conjunction with the CNRS and the University of Lorraine, for the creation in the near future of an international research laboratory focusing on hydrogen energy.

References:

https://maroc-diplomatique.net/sm-le-roi-mohammed-vi-et-le- president-emmanuel-macron-president-la-ceremonie-de- signature-de-plusieurs-accords-entre-le-royaume-du-maroc-et- la-republique-francaise/

https://www.enseignementsup-recherche.gouv.fr/fr/ signature-d-une-declaration-d-intention-pour-le-renforcement-de-la-cooperation-franco-marocaine- dans-97781

https://factuel.univ-lorraine.fr/node/28027

Website:

www.uir.ac.ma/

Contact:

nadia.steiner@femto-st.fr

CRFM
Centre de Recherche
Franco-Marocain

EUROPEAN PROJECTS

RAIDO

RELIABLE AI AND DATA OPTIMIZATION

EU CALL: HORIZON-RIA- CL4-2023-HUMAN-01-01

Cédric Clévy - local coordinator for UMLP FEMTO-ST)

Vincent Placet

RAIDO's Vision is a comprehensive framework for trustworthy and green AI, offering comprehensive solutions for data and model-related aspects. The platform features automated data curation methods, data-efficient models, and tools for energy-efficient green AI. XAI methods, decentralized blockchain, feedback-based reinforcement learning, novel KPIs, and visualization techniques ensure the transparency, explainability, and soundness of optimized AI models and data handling processes. A novel AI orchestrator optimizes tasks and processes, reducing energy consumption and the environmental footprint. The integrated platform will be evaluated through four real-life demonstrators in key application domains, with FEMTO-ST responsible for the one in robotics, which is the product of a long-existing collaboration between the AS2M and Applied Mechanics departments. It will be entitled «Industry 5.0 & Bio-based Composites, AI Models for Plant Fiber Characterization»

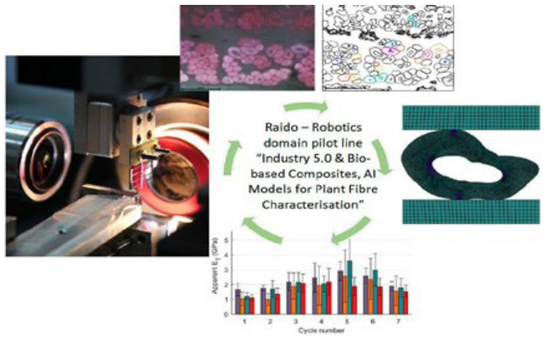
Consortium Partners: Inst. Joseph Stefan (Coordinator-SI), Ubitech (CY), Netcompany-Intrasoft (LU), Ayesa (ES), Fujitsu (LU), Metamind Innov. (EL), Trinity College London (IE), The Awareness Movement (CY), Krechnologies (BE), Chelenic Ntainamiks (UK), Vito (BE), Sidroco (CY), FEMTO-ST(FR), Eight Bells LTD (CY), Mathema (IT), CRT Hellas (EL), Cyberjab (IE), Dimosia (EL), Axon logic (EL), Adrestia (EL), Logos Ricerca (IT), Jessa (BE), TWI Ellas (EL).

Funding for FEMTO-ST:

450k€

Total funding:

9M€



Robotics domain pilot line to provide RAIDO experimental robotics data and mechanical numerical simulation data.

Website:

https://raido-project.eu/

Contact:

cclevy@femto-st.fr

POSTDIGITAL PLUS

EUROPEAN TRAINING NETWORK ON POST-DIGITAL COMPUTING +

EU CALL: HORIZON-MSCA-2023-DN-01

Daniel Brunner - local coordinator for CNRS - FEMTO- ST

Europe's future economic growth depends on engineers and researchers who can develop new information technologies to support data-driven transformations across various sectors. Current digital technologies, based on classical approaches, are reaching their physical limits, and their energy consumption is becoming unsustainable in the climate crisis. To address these challenges, academic and industrial research is exploring «unconventional,» nature-inspired, computing approaches that depart from traditional digital paradigms. The European Doctoral Network on POSTDIGITAL Plus unites leading teams from academia, research centers, and industry, including major companies and start-ups, to train doctoral candidates in emerging neuromorphic computational technologies. The aim is to create a new generation of scientific and industrial leaders who will enhance Europe's competitiveness in future digital and post-digital economies. The project brings together 13 partners, with the Universitat de les illes Balears (Spain) serving as coordinator.

Partners: Aston University (UK), agencia estatal consejo superior de investigaciones cientificas (Spain), CNRS (Fr), Universiteit Gent (Be), HP (Be), Université libre de Bruxelles (Be), VLC Photonics SL (Spain), Thalès (Fr), Akhetonics GMBH (Ge), IBM Research GMBH (CH), Université de Paris-Saclay (Fr), Nicodin (Fr).

Funding for FEMTO-ST:

565 k€

Total funding:

3,8M€

Contact:

daniel.brunner@femto-st.fr

RE-FIBRE

SMART DISASSEMBLY, FUNCTIONALIZATION AND REASSEMBLY OF PLANT FIBERS FOR FULLY RECYCLABLE BIO-BASED COMPOSITES

EU CALL: HORIZON-MSCA-2023-DN-01

Vincent Placet - local coordinator for UMLP

RE-Fibre is a doctoral network funded by Marie Skłodowska-Curie Actions (MSCA-DN) that aims to revolutionize the bio-fiber landscape by designing high-performance, fully renewable and recyclable wood and plant fiber composites, in full accordance with the principles of circular economy. RE-Fibre will train eleven doctoral candidates in the disciplines of green lignin chemistry, biobased material development, and environmental systems science, bringing together leading academic institutions and industry partners from across Europe who are known worldwide.

Funding for FEMTO-ST:

565 k€

Total funding:

2.44 M€

Coordinator:

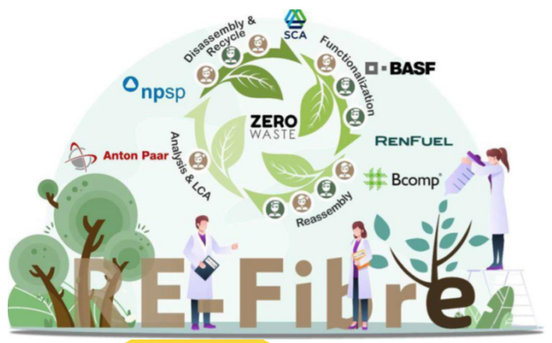
University of Graz

Website:

https://refibre-dn.eu/

Contact:

vincent.placet@univ-fcomte.fr



HINA

HYBRID INTEGRATION OF ALKALINE NIOBATE – TANTALATE FILMS FOR ADVANCED PHOTONIC AND PIEZOELECTRIC DEVICES

EU CALL: MSCA-2023-DN-101169557-HINA

Ausrine Bartasyte

HINA project proposes to consider the hybrid integration of alkaline niobate-tantalate thin films (materials with the highest known experimentally measured electro-optic, nonlinear, piezoelectric, elasto-optic coefficients) in photonic and acoustic devices for advanced semiconductor photonics platforms. HINA links world-leading research groups at Academia and Industry to give a combined, integrated approach of synthesis/fabrication, characterization, modeling/theory linked to concepts for materials integration in devices and systems.

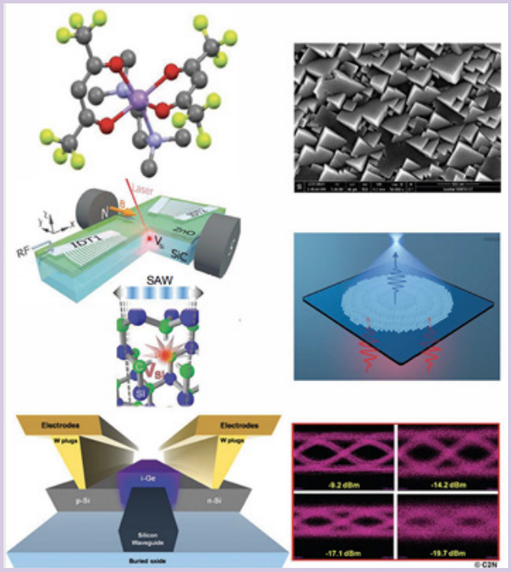
Coordinator: UMLP/FEMTO-ST

Beneficiaries: Univ. Lyon Claude Bernard/ CP2M, CNRS/C2N, Univ. Paris Cité /MPQ, Annealsys (FR), Leibniz-Institut für Kristallzüchtung, Paul-Drude-Institut für Festkôrperelektronik, Technische Universitaet Muenchen,AIXACCT (DE) Czech Academy of Sciences (CZR) Univ. Politecnica de Madrid (ES) Katholieke Universiteit Leuven (BE), PIEMACS, LUMIPHASE (CH), INSTM/ Univ. of Catania (IT)

Partner Organizations: ETHZ (CH), Air Liquide (FR), STMicroelectronics (FR & IT), Cristal Laser (FR), BREVALOR (CH)

Funds for UMLP:

750 k€



HINA Doctoral Network offers extended trainees to 19 PhD students within 20 partners from molecular chemistry to devices fabrication of KTN material.

Contact:

ausrine.bartasyte@femto-st.fr

EUROPEAN PROJECTS

SSUCHY-NEXT

DEVELOPING THE SUPPLY CHAINS FOR INDUSTRIAL HEMP FIBRE AND BIO-BASED RESINS TOWARDS HIGH PERFORMANCE CIRCULAR BIO-BASED COMPOSITES

EU CALL: HORIZON-JU-CBE-2023-IA-07

Vincent Placet - local coordinator for UMLP

SSUCHY-Next carries forward the work performed until 2022 by the European project SSUCHY. The aim is to bring different parts of the hemp fiber supply chain to TRL 7, through production at the scale of various fiber products, covering the complete value chain from field to composite. The consortium will increase hemp fiber production and develop new bio-based resins (bio-based acrylic polymer Elium® with a very high bio-content, fully bio-based benzoxazine, and fully bio-based epoxy) to create sustainable composite materials. These bio-based composites will serve as the basis for demonstrators developed within the framework of the project, including wind turbine blades, structural load-bearing elements, and façade panels. The recyclability of each developed product will be demonstrated and each stage will be monitored and adjusted through LCA.

Funding for FEMTO-ST:
523 k€

Total funding:
6.7 M€

Coordinator:
KU Leuven

Website:
https://ssuchy-next.eu/

Contact:
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LEEMONS

EU CALL: HORIZON-CL5-2024-D3-01-10

Samuel Queste - local coordinator for UMLP

The LEEMONS project aims to develop game-changing renewable energy technology by greatly improving the yield of solar panels without significantly changing current

manufacturing lines. Traditional solar cells suffer from loss of efficiency, notably through heat dissipation, that limits their yield to about 30%. LEEMONS will make

a proof-of-concept demonstration of a new technology that can overcome these fundamental thermalisation losses by converting high energy electrons into several lower energy electrons. This nanotechnology-driven innovation will be fully implemented in different types of industrial photovoltaic cells.

Coordinator: Segton Advanced Technology (Fr)

Partners: CEA (Fr), International solar energy research center Konstanz (Ge), CSEM Neuchatel (Switzerland), Roltec Spolka orgraniczona odpowiedzialnosci (Pl), Université Marie et Louis Pasteur (Fr)

Funding for FEMTO-ST:
171k€

Total funding:
2,6M€

Silicon tool created specifically for ion implantation, 15 µm wide through holes spaced 15 µm apart, 380 µm deep.

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PEPPER

PERFORMANT AND EFFICIENT PLANAR PROTON-CONDUCTING ELECTROLYSIS REACTOR

EU CALL: HORIZON-JTI-CLEANH2-2024

Pascal Briois - local coordinator for CNRS

The PEPPER project has made a major breakthrough in hydrogen production technology aimed at meeting the soaring global demand for green hydrogen with the development of a cutting-edge planar Proton Conducting Ceramic Electrolysis Cell (PCCEL) reactor. Operating optimally between 400°C and 600°C, PEPPER's PCCEL technology aligns seamlessly with industrial waste heat sources, maximizing the utilization of resources.

Partners: Deutsches zentrum fur Luft und Raumfahrt EV (DLR – Germany), AVL list GMBH (Austria), CEA (France), CNRS (IMN/ICGM/FEMTO-ST – France), Danmarks Tekniske Universitet (DTU – Denmark), Europaisches Institut Für Energie Forschung (EIFER – Germany), Aktsiaselts Elcogen (Estonia), Grant Garant (Czech Republic)

FEMTO-ST: Aubry Eric (characterization-coating), Bernal Monica (characterization) Billard Alain (PVD expert), Briois Pascal (Management, Scientific report).

Funding for FEMTO-ST:
100 k€

Total funding:
4 M€

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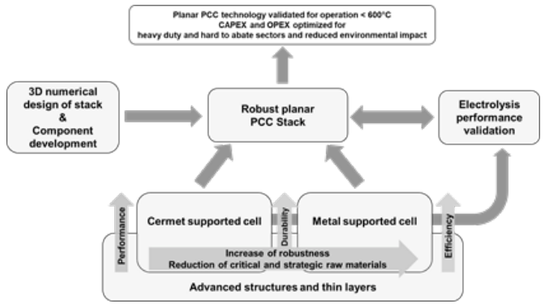


Overall project concept

PELVITRACK

PELVIC FLOOR EVALUATION LIVE TRACKING – REAL-TIME PREDICTION OF PERINEAL TRAUMA

EU CALL: HORIZON-EIC-2024-PATHFINDER

Emmanuelle Jacquet - local coordinator for UMLP

In a continuing effort to improve women's health and in particular to prevent severe perineal tears during childbirth, the PELVITRACK project looks to provide the means for earlier diagnosis, a more reliable prognosis, and more effective care. The project is funded as part of the EIC Pathfinder Open and is led by Anne-Sophie Car (IMT Mines Alès, France) and, at FEMTO-ST Institute, by the BiomecaT team (Biomechanics of Soft Tissues). It draws on the recent PhD theses of Marine Lallemant and Tiguida Kadiaké, who are both on the BiomecaT team. The aim is to design a solution for monitoring perineal tears during childbirth in a real-time medical environment. The project is based on a hybrid experimental, digital approach that includes tests on pigs and sheep, digital modeling of clinical situations, and a multicenter clinical study.

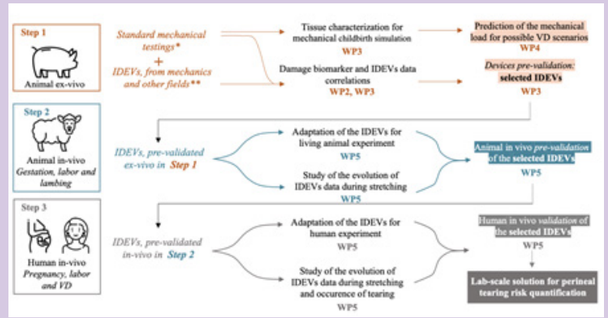
Coord: UMLP-CNRS (Emmanuelle Jacquet)

Project Initiator: Institut des Mines-Telecom (FR)

Participants: FEMTO-ST, LMGC (FR), LMA (FR), LamCUBE (FR), CHUs (FR), EPFL (Switzerland), University of Zaragoza (Spain), Polytechnic of Turin (Italy), University of Bohemia (Czech Republic), INEGI (Portugal), hospitals in Switzerland, and 2 private partners: Virtual Care and Superviseme (Switzerland).

Funding for FEMTO-ST:
138k€ - funds for CNRS :328k€

Total funding:
3658 k€



PELVITRACK conceptual approach

Contact:
emmanuelle.jacquet@univ-fcomte.fr

EUROPEAN PROJECTS

INTERLAB (2024-2027)

EU CALL: INTERREG VI FRANCE-SUISSE

Marjorie Barcella and Katy Cabaret

Interlab has proposed a collaborative approach to innovation to meet the challenges of transitions through the creation of a joint Franco-Swiss platform dedicated to supporting project leaders. The platform includes physical spaces on both sides of the border, a common virtual space made up of shared digital tools, and a shared methodology that brings together the tools of the Franco-Swiss actors in the consortium and allows them to pool their resources.

Coord. France: UTBM, Coord. Suisse: Basel Area; other partners: Haute Ecole Arc, Ville de Delémont, SACM (KM0, Mulhouse)

Total funding:

428 k€ for France (253 k€ for UTBM)

Website:

https://www.interreg-francesuisse.eu/les-projets-aides/interlab

Contact:

marjorie.barcella@utbm.fr

RASOL - RECYCLAGE D'ACIER SOLAIRE

EU CALL: INTERREG FRANCE - SUISSE

François Lanzetta, UMLP - coordinator France

Raymond Constantin - Haute Ecole Arc Ingénierie

(Switzerland)

The project aims to develop the complete process of making 1.4441 steel from 100% recycled waste using concentrated solar radiation as a heat source for fusion. The solar furnace operates in two main stages. First, it captures solar radiation using a heliostat composed of flat mirrors that follow the sun. Second, the captured rays are reflected back to a concentrator of concave mirrors that focuses the light like a magnifying glass and directs it to a solar reactor where the steel is melted in a crucible.

Industrial partners:

PANATERE (Suisse), SOCRATE Industrie (Suisse)

Funding for FEMTO-ST:

193 k€

Total funding:

1993 k€

Prototype of Concentrator

Website:

https://projects.femto-st.fr/rasol/fr

Contact:

francois.lanzetta@univ-fcomte.fr

UPWEARS

SUSTAINABLE SOLUTIONS FOR UPGRADED SMART WEARABLES AND EQUIPMENT IN SPORT

EU CALL: HORIZON-CL4-2023-RESILIENCE-01-32

Vincent Placet - local coordinator for UMLP

UPWEARS aims to promote structural resource efficiency and a sustainable economy by unlocking the potential of a new generation of biobased, hybrid fabrics. UPWEARS e-textile will feature high performance, cost-effective multi-functional fibers and yarns, biomimetic fabrics, embedded electronics, and pollution sensing. The project will minimize manufacturing waste through artificial intelligence automation and digital twin while also reducing the use of chemicals by incorporating green bleaching processes.

UPWEARS will present and demonstrate in real conditions an integrated solution (innovative e-textile and adapted manufacturing process): a smart, functional, protective, and sustainable cross-country biking suit. The goal is to develop a bioinspired end product that is abrasion-resistant, waterproof and/or water-repellent, stretchable, breathable, and tear resistant.

Funding for FEMTO-ST:

411 k€

Total funding:

7.5 M€

Coordinator:

INRAE

Website:

https://cordis.europa.eu/project/id/101130741

Contact:

vincent.placet@univ-fcomte.fr

jean-baptiste.sanchez@univ-fcomte.fr

PRE-QUALIFICATION OF A NOVEL MOS2-X DRY LUBRICANT, AN ALTERNATIVE TO MOS2

EU CALL: R&T DÉMONSTRATEUR CNES (FRANCE) IN COORDINATION WITH LUXIMPULSE (LUXEMBOURG)

Guillaume Colas (coordinator)

This joint project aims to bring to a Technology Readiness Level of between 7 and 8 a coating developed in 2022 that is based on the co-deposition of MoS2 and Ta. The coating aims to enhance the tribological properties of MoS2 in space application. The project is funded by the space agencies of France (CNES) and Luxembourg (LSA).

The coating can maintain a low friction coefficient over long periods of time after undergoing service during air to vacuum transition. The coating is now patented and the deposition process is moving from research deposition chamber to semi-industrial deposition chamber. These coatings will be fully characterized for composition, mechanics, and tribological properties on laboratory-scale pieces of equipment, after which a coated ball bearing demonstrator will be tested under relevant conditions in anticipation of space test validation.

Coordinator: Institut FEMTO-ST

LaMCoS (Lyon), Institut FEMTO-ST (Besançon), CNES (Toulouse), Luxembourg Institute of Technology LIST (Luxembourg), Luxembourg Space Agency LSA (Luxembourg), ESA (Noordwijk) acting as technical officer for LIST

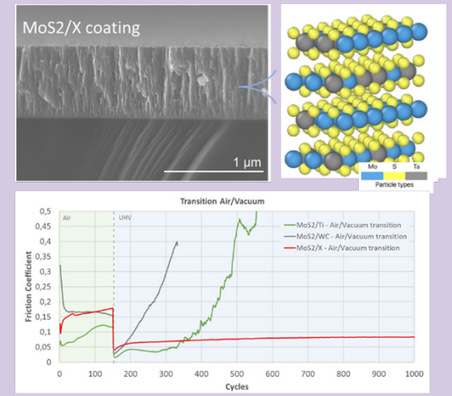
Partners: LaMCoS (Lyon), CNES (Fr), Luxembourg Institute of Technology LIST, Luxembourg Space Agency LSA, ESA (Noordwijk) acting as technical officer for LIST

Funding for FEMTO-ST:

210 k€

Total funding:

642 k€



Top: Cross section view of the MoS2-X coating and the molecular dynamic simulation of its microstructure. Bottom: friction coefficient evolution during air to vacuum transition.

Reference:

Brevet WO2022254130, Pre-qualification of a novel MoS2-X dry lubricant, an alternative to MoS2

Contact:

Guillaume.colas@femto-st.fr

FEDER PROJECTS

The three projects presented, SAMI, NEXT and BioImp, are emblematic of FEMTO-ST's strategic engagement in the areas of micromechanics, advanced micro-nanofabrication, and microtechnologies for healthcare. They also underscore FEMTO-ST's strong integration within the regional socio-economic landscape.

These initiatives make extensive use of the technological platforms Mephysto and MIMENTO, the latter being a member of the national RENATECH network.

COFINANCÉ PAR L'UNION EUROPÉENNE
RÉGION BOURGOGNE FRANCHE COMTE

SAMI - AUTONOMOUS SENSORS FOR INTELLIGENT MONITORING

EU CALL: FEDER-FSE + BOURGOGNE FRANCHE-COMTÉ ET MASSIF DU JURA 2021-2027

Sebastien Thibaud, Samuel Queste

SAMI is based on ChronoMEMS© technology developed by SilMach, which combines the principles of micromechanics and advanced manufacturing technologies to create intelligent, autonomous sensors. These free-energy sensors monitor structural deformations to detect and record mechanical events. Drawing on advances in the watchmaking industry, they offer low-cost, low-carbon solutions that can be transposed to various sectors: aeronautics, transport, infrastructure, energy, health, and many others.

Coordinator:
SILMACH
Partners:
SUPMICROTECH ENSMM with MIFHYSTO platform and Université Marie et Louis Pasteur with MIMENTO platform of FEMTO-ST

Old Generation CHRONOMEMS Sensor

Funding for FEMTO-ST:
1,2M€
Total funding:
6M€
Contact:
sebastien.thibaud@femto-st.fr
Samuel.queste@femto-st.fr

NEXT

NEW TECHNOLOGICAL AND AUXILIARY EQUIPMENT FOR MICRO- AND NANO-TECHNOLOGIES

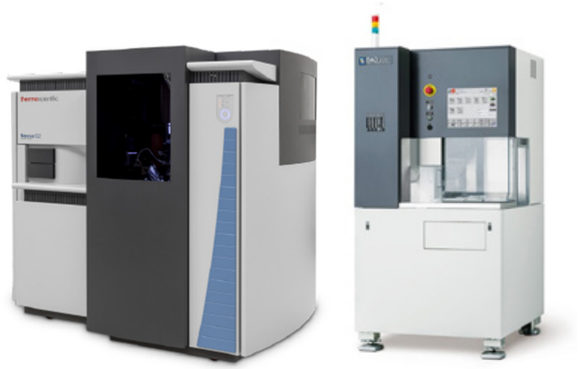
EU CALL: FEDER-FSE+ BOURGOGNE FRANCHE-COMTÉ AND JURA MASSIF PROGRAM 2021-2027

Thomas Baron

Priority: Developing an innovative and competitive regional economy
Objective: Improving research and innovation
Action: Supporting the structuring of research in connection with RIS3

The FEDER NEXT project has two objectives: first, to strengthen the MIMENTO cleanroom's core scientific areas and maintain state-of-the-art standards through investments, obtained in large part from the RENATECH Network, in particular from the national programs PEPR Electronique and the Equipex+ NanoFutur and, second, to upgrade the cleanroom infrastructure and incorporate energy efficiency, which is essential for the sustainability of the entire research platform.

Funding for FEMTO-ST:
4 098 913,00 € HT
Total funding:
2 691 860,00 € HT
Contact:
thomas.baron@femto-st.fr

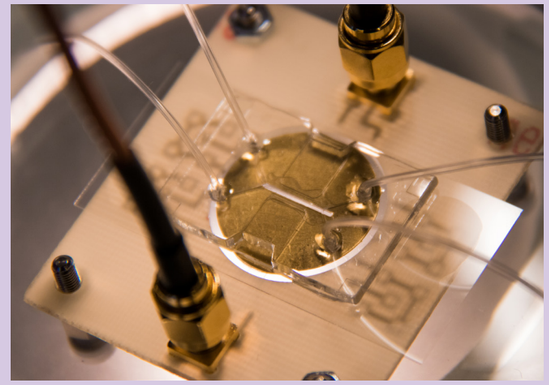


BIOPROCESS IMPROVEMENT

EU CALL: FEDER-FSE + BOURGOGNE-FRANCHE-COMTÉ ET MASSIF DU JURA 2021-2027

Thérèse leblois - local coordinator for UMLP

On October 14 2024, the BioImp project was officially launched, bringing together several major academic and industrial players in health and the engineering sciences from the Bourgogne-Franche-Comté region. The aim is to further the development of biomedicines, i.e. drugs whose active element is of biological origin. Despite the convincing scientific and technological results these drugs have shown, high production costs have limited their availability. FEMTO-ST is using its expertise in engineering science and biotechnology to develop miniaturized in-line acoustic (bio)sensors, actuators for controlling biological interactions, instrumentation for monitoring contamination, lab-on-a-chip for drug validation, and artificial intelligence processing algorithms for automatic control. These intelligent microdevices will enable non-contact sorting of biological elements, specific detection of analytes in complex environments, characterization of cell populations and cell-derived elements, quality control, and drug validation. The aim of these innovative devices is twofold: first, to monitor drug production in real time and, second, to predict a patient's eligibility for therapy by using in-vitro tests that reproduce conditions as close as possible to those of the human body.



Microfluidic circuit for cell sorting

Academic partners:
Etablissement Français du Sang (EFS) Academic partners: Université Marie et Louis Pasteur: FEMTO-ST Institute and UMR RIGHT
Industrial partners:
Cell Quest, Diaclone, MIP Pharma, RD- Biotech, FC'Innov
Funding for FEMTO-ST:
4.6 M€
Total funding:
17,8 M€
Website:
https://www.efs.sante.fr/bioimp-un-projet-denvergure-pour-optimiser-la-fabrication-des-biomedicaments
Contact:
therese.leblois@femto-st.fr

PEPR PROJECTS

A PEPR (Priority Research Program and Equipment) aims to build or strengthen French leadership in scientific fields that are or could potentially be linked to technological, economic, societal, health-related, or environmental transformations, and which are considered priorities at the national or European level.

There are two types of PEPRs:

- PEPRs aligned with national acceleration strategies, designed to further an ongoing transformations involving clearly identified products, services, uses, and stakeholders (e.g., Hydrogen, Recycling, TASE, Electronics).

- Exploratory PEPRs, aimed at supporting transformations that are just beginning to emerge or are still in their early stages (e.g., DIADEM, O2R, Ensemble).

FEMTO-ST is heavily involved in these programs. In 2024, it **coordinated 4 projects in PEPR DIADEM, Hydrogen,** and Electronics and **participated in 17 PEPR projects as a partner.**

In total, FEMTO-ST is involved in 8 different programs that address major issues such as renewable energy, ecological transition, robotics, hydrogen, quantum technologies, and micro-nanotechnologies.

ELECTRONIQUE	**Coordinator** BioElectronPhoton NanoFiLN **Partner** AC PAC, RENATECH-CNRS
DIADEM	**Coordinator** ASTERHYX
HYDROGÈNE	**Coordinator** hYperStock **Partner** PROTEC CELCER DURASYS-PAC PEMFC95 FLEXISOC HYSYSPEM DURABILITHY
RECYCLAGE	**Partner** RECYCOMP
02R	**Partner** Materials, architecture, and embodied AI and soft robotics Multi-scale and biomechanical scientific modelling and simulation
TASE	**Partner** IOTA FLEX MEDIATION DC-ARCHITECT
ENSEMBLE	**Partner** DECO
QUANTIQUE	**Partner** EpiQ

ASTERHYX

ACCELERATED STRESS TESTS FOR LOW-TEMPERATURE ELECTROLYSERS DEDICATED TO HYDROGEN PRODU(X)CTION

PEPR HYDROGENE DECARBONNEE

Daniel Hissel (Project Leader), Zhongliang Li, Elodie Pahon, Marie-Cécile Pera

Hydrogen is set to play a central role in the decarbonization of economies, with France looking to become a leader in carbon-free hydrogen production by 2030. The transition requires the electrolysis of water, whose efficiency is dependent on proton exchange membrane (PEM) electrolysers. The ASTERHYX project aims to develop PEM electrolysers that are sustainable and cost-effective. Having recognized the need to evaluate their long-term performance and reliability under simulated or emulated actual operating conditions, it focuses on accelerated stress testing (AST) protocols, seeking to augment marketability by improving the evaluation of degradation mechanisms and reliability, a process that will include a modeling phase to determine stress factors and long-term trials for protocol design that will be validated through post-mortem analysis.

Facility:
FCLAB

Project led by FEMTO-ST / Energy:
Daniel HISSEL

Partners:
FCLAB (CNRS), LEMTA (CNRS), LAPLACE (CNRS), LITEN (CEA)

Funding for FEMTO-ST:
400k€ + 89k€ for FCLAB

Total funding:
1,7M€

Contact:
daniel.hissel@femto-st.fr

PEM Water Electrolyser Test Bench

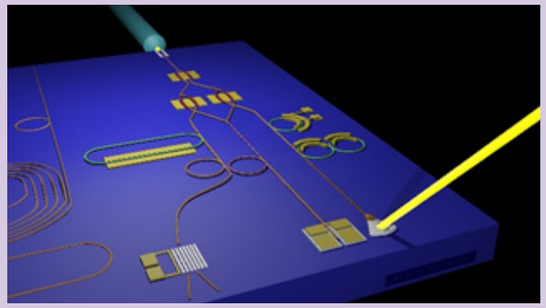
NANOFILN

PEPR ELECTRONIQUE

Mathieu Chauvet

The NanoFiLN project aims to prepare a national academic technology sector for next-generation integrated optics components that are based on the use of $LiNbO_3$ films. The nanoguides at the heart of these high-performance photonic components allow for the production of chips that can integrate multiple functions, with key applications in optoelectronics and quantum optics. There are also plans to hybridize $LiNbO_3$ components with other platforms. At FEMTO-ST, researchers are already involved in developing electro-optic components, passive and non-linear components, epitaxial $LiNbO_3$ films, new cleanroom processes, device fabrication, and optical characterization.

Coordinator: FEMTO-ST
Partners: LAAS, INPHYNI, C2N, CEA-Leti



Artist's rendering of a multifunctional integrated photonic chip based on the use of $LiNbO_3$ thin films.

Facility:
MIMENTO

Funding for FEMTO-ST:
1,4 M€

Total funding:
3M€

Website:
https://www.pepr-electronique.fr/nanofiln/

Contact:
mathieu.chauvet@femto-st.fr

PEPR PROJECTS

BEP – BIOELECTRONPHOTON

PEPR ELECTRONIQUE

Daniel Brunner

The BioElectronPhoton project aims to significantly reduce the energy consumption of electronics for computing. It draws on the workings of the brain, which connects neurons in a dense, three-dimensional and reconfigurable way. The BEP strategy is to combine ultra-reconfigurable electronics with communication-efficient photonics, allowing ultra-dense 3D connections to mimic the brain's energy-efficient architecture. These national electronic/photonic hybrid bioinspired computation systems will be complemented by memory technologies imitating synapses, which we will optimize so that developed circuits can learn as the brain does, with high recognition rates. Finally, we will produce interconnected nano-neurons capable of extremely complex calculations with few components.

Partners (Country):
Daniel Brunner, FEMTO-ST, Pilot
Damien Querlioz, C2N Paris Saclay, Pilot, coordinator
Elisa Vianello, CEA, Pilot
Jean-Michel Portal, Aix-Marseille Université, PI
Fabrice Raineri, INPHYNI

Funding for FEMTO-ST:
506 kEuro

Total funding:
3 402 kEuro

Website:
https://www.pepr-electronique.fr/projet_cible_bep/

Contact:
Daniel.brunner@femto-st.fr

HYPERSTOCK

HIGH PRESSURE HYDROGEN STORAGE, FRAME OF REFERENCE AND METHODOLOGIES FOR MATERIALS

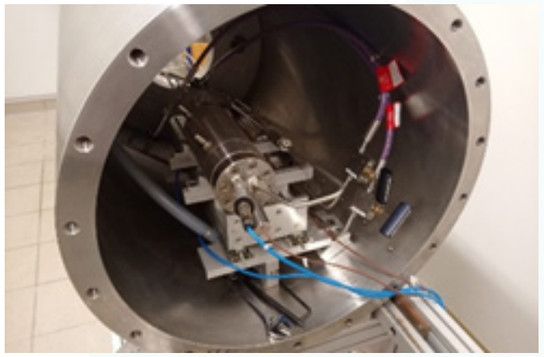
PEPR HYDROGENE

David Chapelle

The project focuses on identifying materials that can reduce the carbon impact of compressed hydrogen transport and storage through an approach that takes into account the synthesis and the recyclability of the materials used in Type 4 tanks and the processes involved in manufacturing them. We propose to set a material reference in a severe H2 environment. By studying their mechanical, physical, and chemical properties under severe conditions the project will offer a detailed way in which to determine the potential of the materials and confirm their characteristics.

Coord. UMLP-FEMTO-ST

Partners:
ISAE-ENSMA (Fr), IFPEN (Fr), INSA Lyon (Fr),
CEA (Fr), Univ. La Rochelle (Fr), USPN (Fr), MSE (Fr), INPT (Fr), UB (Fr), ENSAM Bordeaux (Fr).



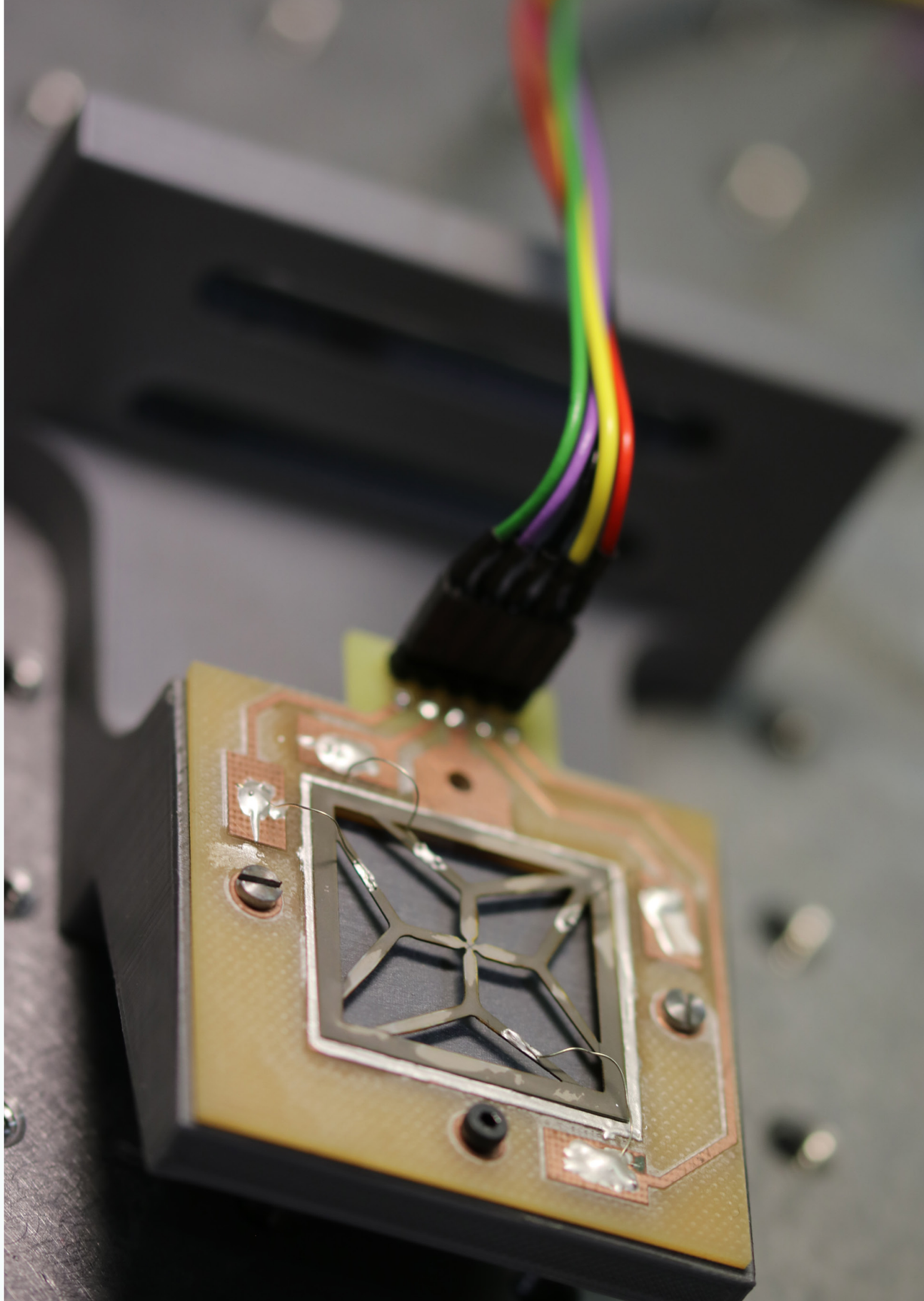
H2 high-pressure pressurization chamber to promote damage to materials used in Type 4 tanks.

Funding for FEMTO-ST:
478,5 k€

Total funding:
3,9 M€

Website:
https://www.pepr-hydrogene.fr/projets/hyperstock/

Contact:
David.chapelle@femto-st.fr



EVENTS

10TH INDUSTRIAL HISTORY DAYS: WOMEN AND INDUSTRY, 17TH-21ST CENTURIES

RECITS

Laurent Heyberger, Catherine Cuisance

Place:
Sevenans

Number of participants:
45

These Industrial History Days looked at the position and role of women workers and non-workers in industry and craft companies, in the perspective of a professional world in which women have always had more of a voice than they have had in politics in general.

The conference also helped challenge the notion of women as a-technical and, in so doing, questioned the legend of 'pioneering' women company directors, executives, and patent holders by examining historically their role in creating production techniques and know-how.

The proceedings of the conference will be published shortly.

Contact:
laurent.heyberger@utbm.fr

INTERNOISE

53RD INTERNATIONAL CONGRESS & EXPOSITION ON NOISE CONTROL ENGINEERING

APPLIED MECHANICS

Morvan Ouisse, Rafael Teloli, Emeline Sadoulet-Reboul

Place:
Nantes

Number of participants:
1800

Internoise is the world's largest annual conference on noise control engineering. The 2024 event took place in Nantes on August 25-29, with the support of the French Acoustical Society (SFA), under the presidency of Adrien Pelat (LAUM), Judicaël Picaut and Julien Cesbron (IFSTTAR).

Morvan Ouisse, from FEMTO-ST, was one of the conference's 5 program chairs, in charge of the principal theme "Vibration and Acoustical Engineering Science" that consisted of 43 sessions and 380 talks, while Rafael Teloli and Emeline Sadoulet-Reboul served as session chairs.

Website:
https://internoise2024.org/

Contact:
morvan.ouisse@femto-st.fr

6TH EDITION OF THE FRENCH PHOTONICS DAYS 2024

OPTICS

John Dudley, Maxime Jacquot, Nadège Courjal,

Hervé Maillotte, François Courvoisier, Jean-Charles Beugnot,

Luc Froehly

Place:
Besançon, Espace Grammont

Number of participants:
180

On October 15 and 16, 2024, Besançon hosted the 6th annual French Photonics Days conference on the theme of Disruptive Photonic Micro-Nanotechnologies. This event, co-organized by FEMTO-ST, Photonics France, and SupOptique Alumni, welcomed more than 180 participants from 120 different companies and institutions from France and around the world to exchange the most recent results and ideas relating to photonics research and applications. Additional discussions focused on optics education and outreach, and Pierre Chastanet, Head of Unit at the European Commission for the Microelectronics and Photonics Industry, gave a special presentation by videoconference. Leading academic participants included Remi Carminati, director of the Institut d'Optique Graduate School, and Yves Bellouard, head of the Galatea lab at EPF. Industry participants included local companies Exail, Aurea Technology, and Percipio Robotics, as well as national and European enterprises: ST Microelectronics, Safran, Thales, Saint Gobain, and LASEA. Many of those in attendance visited the FEMTO-ST research laboratories and local photonics companies.

Website:
https://urls.fr/ws_7XV
https://urls.fr/82EAUH
https://urls.fr/AqW466

Contact:
john.dudley@univ-fcomte.fr

EVENTS

8TH IFAC WORKSHOP ON LAGRANGIAN AND HAMILTONIAN METHODS FOR NONLINEAR CONTROL

AS2M

Yann Le Gorrec, Yongxin Wu, Ning Liu

Place:

Espace Grammont, Besançon

Number of participants:

77

From June 10 to 12, FEMTO-ST organized the 8th IFAC (International Federation of Automatic Control) Workshop on Lagrangian and Hamiltonian Methods for Nonlinear Control at the Diocesan Center in Besançon. The event was supported by IFAC, IEEE, ANR, the Bourgogne-Franche-Comté region, the city of Besançon, SUPMICROTECH, the University of Franche-Comté, the CNRS, and EUR EIPHI. The workshop brought together 77 experts from 24 countries and featured 63 high-level scientific presentations, including 4 in plenary session. Participants were able to exchange views on new theoretical approaches to modeling, analysis, and control, and their application to advanced engineering systems.

Website:

https://conferences.ifac-control.org/lhmnc24/

References:

8th IFAC Workshop on Lagrangian and Hamiltonian Methods for Nonlinear Control (LHMNC 2024), IFAC Newsletter No. 06, December 2024, www.ifac-control.org

Contact:

legorrec@femto-st.fr

GDR CARMA NANO AXIS DAY

MN2S

Guillaume Colas & Céline Elie-Caille

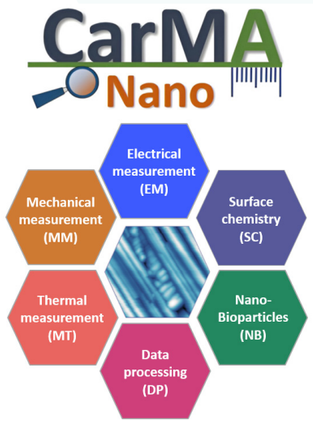
Place:

Besançon

Number of participants:

11 persons for the NanoBioParticles axis and 22 persons for the Nanomechanics axis

The CarMaNano research group's first meetings on nanomechanics and nanobioparticles were held on November 26, 2024 at the FEMTO-ST Institute in Besançon. Separate sessions on each area of research, bringing together 33 participants from academia and industry, concluded with an overall presentation on the nanomechanical characterization of nanobioparticles given by Geetika Raizada, a PhD student at FEMTO-ST Institute.



Quantification, Accuracy, Precision, Reproducibility, Repetability of nanoscale measurement

The meetings on mechanics showcased the broad range of scientific approaches to taking nanomechanical measurements (AFM, Nanoindentation, MEMs based systems, dedicated nanorobotics, etc.), identified the scientific communities to reach out to, and determined direction and objectives. The discussion on objectives for research in nanobioparticles led participants to define the various needs for nanobioparticle characterization experienced by academics and researchers, outline the expertise and skills in the fields of nanobioparticle characterization and potential technology transfers (from one type of nanobioparticle to another), and identify or take into account the needs and requirements of industrial partners.

Website:

https://gdr-carmanano.cnrs.fr/

Contacts:

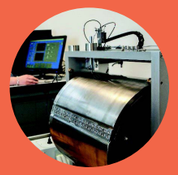
Guillaume.colas@femto-st.fr

celine.elie@femto-st.fr

FACILITIES

PRINCIPAL FACILITIES

FEMTO-ST's principal facilities are grouped into centers to make them accessible for research and development projects not only to FEMTO-ST members, but also to teachers and regional, national, and international industrial and academic partners. Each has its area of specialization. :



AMETISTE

Mechanical characterization of materials, surfaces, and structures in a wide range of dimensions and frequencies

CLIPP

(Bio) chemistry, chemical physics, nano- and micro-engineering, biostatistics, and bioinformatics

CMNR

Micro/nanocomponents, characterization, manipulation, and micro-assembly

FLUIDIX

Fluidic and thermal characterization of complex flows

FRANCHE-COMTE MESOCENTRE

Numerical simulation, high-performance computing

HYDROGEN ENERGY (FCLAB)

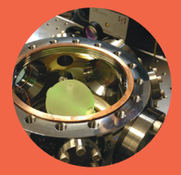
Hydrogen energy and the testing of fuel cell systems, the durability of energy sources for electric and hybrid vehicles, and for stationary applications.

MIFHYSTO

Micromanufacturing, mechanics, micromachining, powder injection molding, metal additive manufacturing, surface treatment, filled polymers, metrology, and material characterization

MIMENTO

Micro-nano-optics, micro-nano-acoustics, micro-opto-electro-mechanical systems (MOEMS), and micro-robotics. Member of the «RENATECH» network.



OSCILLATOR IMP

Oscillator instability measurements, frequency references (from RF to optics), and state-of-the-art comparative measuring instruments

SMARTLIGHT

Photonics for AI and AI for photonics facilities (photonics and optoelectronic state-of-the-art equipment)

SURFACE

Development and characterization of thin-film materials

MIMENTO

OTHER FACILITIES

FACILITIES – HIGHLIGHTS

MIMENTO

ENERGY SAVING

Alain Bresson, Jean Claude Jeannot, Toufik Nouiri,

Guillaume Jutzi, Thomas Baron

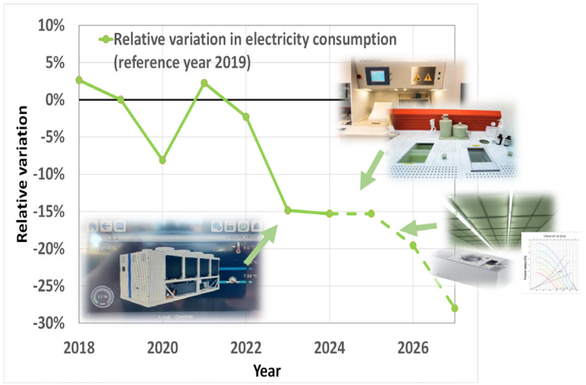
The MIMENTO platform team has long been working to reduce its energy consumption. With the first phase of that work having been completed, 2024 provided an opportunity to measure its impact. The figures in the diagram show a 15% reduction in energy consumption for 2023 and 2024 compared with 2019.

During that time, one refrigeration unit was replaced by a new generation model that is more efficient, the cooling circuits were separated, and two air compressors for compressed air along with their associated air dryers were upgraded.

With the help of funding from PEPR Electronics and FEDER Bourgogne-Franche-Comté (NEXT project, N°Synergie - BFC003001), there are plans for further energy savings, with the goal for 2025 and 2026 being a further reduction of more than 15%. The plans include:

- Replacement of one refrigeration unit and installation of a heat recovery system on both
- Installation of an air extraction network in the cleanroom to reduce extraction through fume hoods in the chemistry area
- Replacement of the FFUs.

FEMTO-ST is part of a working group (RENATECH network) that strives to reduce the environmental impact of activities linked to CNRS technology centers.



Relative variation in electricity consumption (reference year 2019)

Contact:

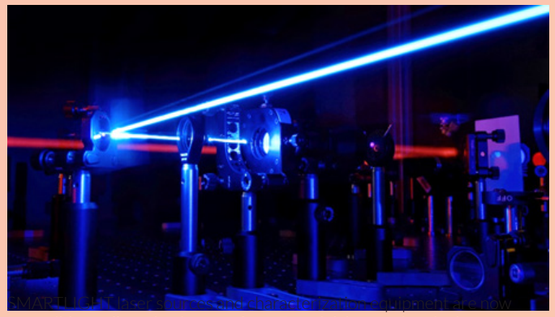
mimento@femto-st.fr

SMARTLIGHT

SMARTLIGHT IS NOW PART OF THE NATIONAL PEPR LUMA NETWORK

SMARTLIGHT is a platform in optics and photonics known for its equipment for academic research and industrial innovation in the fields of photonics and artificial intelligence. It is jointly run by FEMTO-ST Institute in Besançon and the ICB Laboratory in Dijon, and funded by EQUIPEX+. The facility houses a number of different laser sources (cw, fine-linewidth, tunable OPO, femtosecond laser sources, OPAs), equipment for characterization of photonic components and laser beams, and, notably, a 100 GHz oscilloscope with an arbitrary waveform generator, both of which are unique in French academe.

This year, SMARTLIGHT was chosen to be a member of the LUMA infrastructure hub, a national network of 12 platforms. Via LUMA, academics from French laboratories have free access to state-of-the-art photonic equipment and laser sources. That SMARTLIGHT is now part of the hub stands as recognition of the high scientific level at which it operates and of the complementarity of its equipment and expertise.



accessible to all academic users from French laboratories via the LUMA infrastructure hub (Remi Meyer)

Website:

https://www.smartlight.fr/

Contact:

remi.meyer@femto-st.fr

FACILITIES HIGHLIGHTS

HYDROGEN

NEW AREA DEDICATED TO ELECTROLYSER AND LITHIUM BATTERY TESTS

SHARPAC team

Pending completion of an Ecocampus building, UMLP has been providing space in Belfort for low-temperature electrolyser and battery testing since October 2024. More than 300m² are available for the Energy Department and the FCLAB to carry out experiments and perform a variety of testing services for industry.

The new platform is expected to be fully operational by summer 2025. Two of the four test benches dedicated to Proton exchange membrane (PEM) electrolysers are already functional as are two battery test benches for experiments on lithium-based and other battery technologies. The safety systems needed for hydrogen tests are currently on order.

Testing facility at FCLAB (photo © Simon Daval - Périples & Cie)

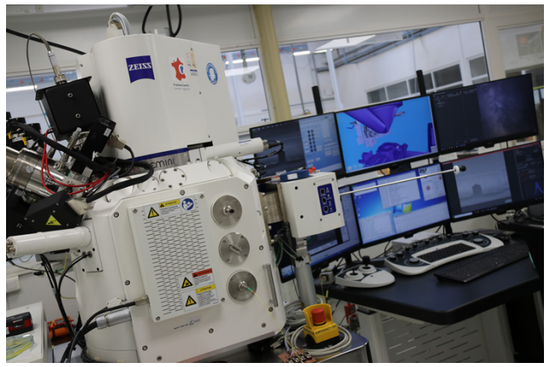
Contact:

david.bouquain@univ-fcomte.fr

CMNR

MICROROBOTIC, MICROASSEMBLY, MICRO-NANOMANIPULATION, MICROFORCE MEASUREMENTS

The Center for Micro and Nano Robotics (CMNR), operational since 2014 and a member of the ROBOTEX national network of research platforms, offers a unique environment for micro assembly automation and micro- and nano-systems characterization. In 2024, the CMNR diversified its service offerings and structured itself around 10 platforms, most of them drawn directly from research done at the FEMTO-ST Institute, dedicated to the manipulation, characterization, and assembly of micro- and nano-objects in a variety of environments (vacuum, air, liquid, and confined media). Typical applications include the characterization of plant fibers or biological cells, the assembly of optical components, and the design of robots for inspection in confined environments. CMNR is wholly committed to quality and has earned ISO 9001 certification.



Platform for manipulation and assembly in a vacuum

Website:

https://platforms.femto-st.fr/cmnr/fr

Contact:

cmnr@femto-st.fr

OSCILLATOR IMP

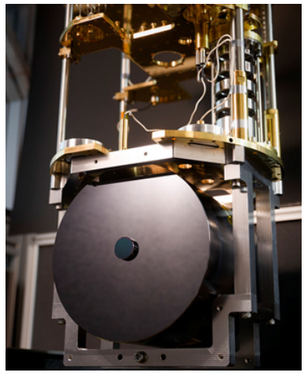
OSCILLATOR INSTABILITY MEASUREMENT PLATFORM (OSCILLATOR IMP)

Time and Frequency, OSU-THETA,

Femto Engineering

Oscillator IMP aims to be a leader in the measurement of noise, fluctuations, and the short-term stability of oscillators and related components/devices across the radio spectrum, including microwave photonics. It is supported with funds from ANR Equipex and the Bourgogne-Franche-Comté region; its services are available to agencies, research institutions, and private companies. Our measurements (phase noise, frequency stability, time interval, frequencies) run from standard calibrations, at the highest national level under NF/EN 17025 accreditation, to the most advanced characterization of innovative oscillators, components, methods, and measuring instruments. Our laboratory is associated with the National Metrological Laboratory in France (LNE) and recognized as such by the International Bureau of Weights and Measures under the name LNE-LTFB.

Oscillator IMP plays a role in the management and governance of FIRST-TF and is at the origin of the EFTS, the leading international seminar providing theoretical and laboratory training in time frequency.



Optical Fabry-Pérot cavity at sub-kelvin temperature in a 3He/4He refrigerator, in progress. The theoretical instability is below 10^{-17}

Website:

https://www.femto-engineering.fr/en/equipement/oscillator-instability-measurement-platform/

Contact:

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jacques.millo@femto-st.fr

rubiola@femto-st.fr

FACILITIES HIGHLIGHTS

MIFHYSTO

NEW EXCEPTIONAL MICRO-MACHINING EQUIPMENT ON THE MIFHYSTO PLATFORM

The MIFHySTO platform has just received the first ML-5 micro-machining machine ever delivered to France. Acquired from GF Machining Solutions, it is a laser micro-machining machine equipped with a 20W green femtosecond laser source in a 3-axis configuration. We do not intend to use it for laser texturing but rather for cutting operations (with or without controlled drafts or backdrafts), drilling, and machining high-precision cavities of just a few millimeters with micrometric precision. The green femtosecond laser source allows for precision machining on metals, ceramics, and very hard materials, as well as glass and silicon.

This equipment was acquired as part of the FEDER RIS3 SAMI collaborative project between the Université Marie et Louis Pasteur and SUPMICROTECH-ENSMM and was funded by a FEDER grant from the Bourgogne-Franche-Comté region. This equipment will notably be used for high-precision tooling by hybridizing MEMS

(MIMENTO) and micromechanical (MIFHySTO) technologies and produce high-precision and high-tech components that were until now beyond our capabilities.

Contacts SAMI Project:
samuel.queste@femto-st.fr
sebastien.thibaud@ens2m.fr

Contacts MIFHySTO:
gerard.michel@ens2m.fr
martial.personeni@femto-st.fr

SURFACE

NEW EQUIPMENT FOR TRIBOLOGICAL MEASUREMENT

The new step500 platform produced by Anton Paar is a mechanical characterization platform equipped with an optical microscope and several indenters that can measure the hardness of thin films at nanometric and micrometric scales as well as the adhesion of the coating to its substrate, using a scratch test. Very localized indentation measurements can determine the elastic properties of materials and their hardness, in particular as a function of depth (dynamic indentation measurement).

The technique is particularly useful when applied to complex coatings (multilayer, with microstructural or chemical gradients). By introducing a reference surface around the indenter (patented by Anton Paar), it is now possible to overcome difficulties related to thermal drift, local flatness of the sample, and damage to the tip; stiffness of frame can be taken into account as well. In addition, the combination of the heads and the microscope allows for local observation of the area of analysis prior to the indentation test, which makes it possible to deal with drifts caused by inhomogeneities or lateral gradients. Finally, the microscope allows us to observe the shape of the imprint or scratch and perform a qualitative analysis of mechanical behavior.

This equipment is co-funded by the MN2S Department and the Pays de Montbéliard agglomération (PMA).

Website:
https://platforms.femto-st.fr/SURFACE/fr

Contact:
pascal.briois@femto-st.fr

The Step500 platform produced by Anton Paar, available on the SURFACE platform, and equipped with an NHT3, NST3, and MCT3 indenter and an optical microscope.

REGIONAL COMPUTATION CENTER (MÉSOCENTRE)

REGIONAL FACILITY FOR REPETITIVE OR TIME-CONSUMING COMPUTATIONS

The Mésocentre is a joint service of the Université de Franche-Comté, the Université Technologique de Belfort-Montbéliard, and the École Supérieure Nationale de Mécanique et des Microtechniques. Supported by a grant from the Région de Bourgogne-Franche-Comté, it provides researchers and faculty with access to high-performance computing and AI resources, including computing nodes optimized for parallel processing across multiple cores or nodes (CPUs or GPUs), using technologies such as OpenMP or MPI.

The Mésocentre staff offers training sessions and, when possible, direct assistance with parallelization techniques. By sharing resources, the facility ensures more efficient use, and housing the machines in a single location allows for optimized cooling and reduced energy consumption.

Very soon the Mésocentre will be relocated to an upgraded facility within the regional data center based in Dijon. Named MésoBFC, it will provide researchers in the Bourgogne-Franche-Comté region with access to a more powerful computer, housed in an optimized environment.

Subset of the computing nodes installed at the Mésocentre

Website:
http://meso.univ-fcomte.fr/

Contact:
svpmeso@univ-fcomte.fr

INNOVATION

TRANSFER SUCCESS STORIES

BRA CONNECT CLINICAL TRIALS AND MATURATION

AS2M

Zeina Al Masry

BRA CONNECT (CBRA) is a connected wearable device designed for early detection of breast cancer. The BRA is equipped with thermal sensors and artificial intelligence models to detect abnormalities in breast tissue, especially cancerous ones. Through contact with the skin, the device generates a high-resolution thermal map in a matter of minutes. This is analyzed in real time by an artificial intelligence-driven algorithm that accounts for uncertainties to accurately detect and localize the anomaly.

Ongoing multicenter clinical trials at the Hôpital Nord Franche-Comté and the Institut de Cancérologie de Strasbourg have already shown promising results for 50 out of 70 patients and control subjects. The main objective of the pilot study is to assess the device's ability to detect, or fail to detect, breast abnormalities in both healthy women and women diagnosed with breast cancer.

The clinical trial is registered with ClinicalTrials.gov (Identifier: NCT05294016). A patent has been filed and a maturation program has been initiated with SATT SAYENS (Société d'Accélération du Transfert de Technologie). At the end of the maturation project, the extension of the wearable device to all types of breast morphology will be validated.

The first prototype used in clinical trials of a CBRA equipped with thermal sensors

Website:

https://ichgcp.net/fr/clinical-trials-registry/NCT05294016

Reference:

https://www.francebleu.fr/infos/sante-sciences/un-soutien-gorge-connecte-pour-depister-le-cancer-du-sein-a-l-hnfc-2431939

Contact:

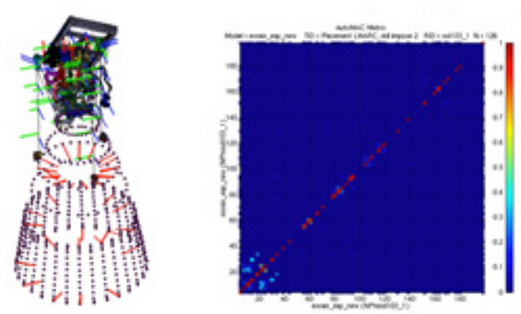
zeina.almasry@femto-st.fr

AESOP: A PLATFORM FOR EXPERIMENTAL VALIDATION OF ELASTODYNAMIC STRUCTURES

APPLIED MECHANICS

Scott Cogan, Betty Auzanneau,

AESOP (Analytical Experimental Structural Optimization Platform) is a MATLAB-based development environment dedicated to the experimental model validation of linear elastodynamic structures. It uses a multi-model and multi-analysis strategy for performing multi-query investigations including global sensitivity analysis, experimental test design, test-analysis correlation, model calibration, uncertainty quantification, and design robustness analysis. AESOP drives commercial finite element codes including MSC-NASTRAN, ANSYS, COMSOL, ABAQUS, and PERMAS.



Optimal sensor design for a modal test of the VINCI rocket engine.

Contact:

scott.cogan@univ-fcomte.fr

HELIOS : A PLATFORM FOR VIRTUAL HOMOLOGATION OF RAILWAY DYNAMICS

APPLIED MECHANICS

Scott Cogan, David Renault

HELIOS is a MATLAB-based development environment dedicated to the virtual homologation of railway vehicles that aims to ensure the comfort and safety of novel designs. A digital twin paradigm implemented for multibody simulations and testing allows the application of multi-query approaches for model validation and design decision support under uncertainty. ALSTOM estimates that HELIOS, which is owned and distributed by the CNRS, will reduce virtual homologation costs by 50% per mainline project.

I Nove You™ is Alstom's annual program designed to reward the creativity of its personnel. In 2023-2024, HELIOS won the award for best overall innovation out of 1518 submissions from 101 sites and 36 countries.

HELIOS is a dedicated decision support tool for the virtual homologation of railway vehicles to ensure the comfort and safety of novel designs.

Contact:

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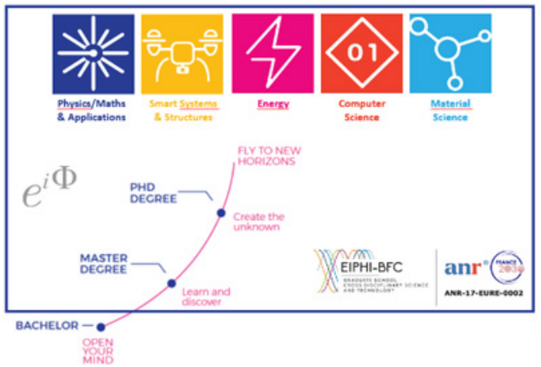
EDUCATION

EIPHI GRADUATE SCHOOL

STRUCTURING ROLE IN THE RESEARCH-TRAINING-INNOVATION TRIAD

After restructuring the higher education landscape in Bourgogne-Franche-Comté for the last six years, we can now reflect on how EIPHI has effected pedagogical transformation, strengthening the ties between professional training and research and fostering a sense of unity.

EIPHI (the Graduate School in «Engineering and Innovation through the Physical Sciences, High-Technologies, and Cross-Disciplinary Research») was founded by three CNRS research institutes (FEMTO-ST, ICB, IMB) and built upon the Labex ACTION. Other major groups performing research in the engineering sciences quickly joined (ICMUB, ImVIA, UTINAM, and LmB). EIPHI features a multidisciplinary approach, leveraging the expertise of its seven research institutes to combine training, research, technology, innovation, and societal impact study. It addresses societal challenges and seeks to achieve international influence.



The school is committed to graduate-level education in the five domains presented in the figure above, with an emphasis on instruction given in English. It reinforces the link between research and training, curriculum continuity between masters and PhD degrees, innovative pedagogy, and graduate professionalization.

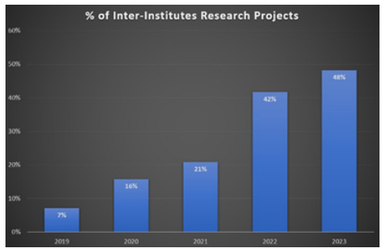
EIPHI aims to bring the academic excellence and international recognition of Bourgogne Franche-Comté to new levels by structuring the research-training-innovation triad and aligning with the region's industrial and socioeconomic strategy and recognized Masters tracks, including the Erasmus Mundus programs.

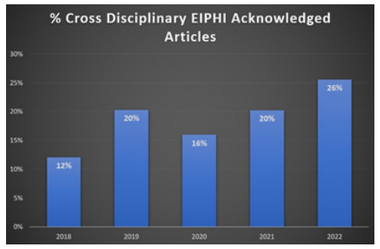
EIPHI's personnel include over 700 research and training faculty, 160 postdoctoral fellows, 395 support staff, and over 950 graduates. It represents 85% of the research and training workforce in the engineering sciences in Bourgogne-Franche-Comté.

The 7 research institutes focus on various scientific domains, among them micro- nano-systems, photonics, molecular chemistry, and imaging. EIPHI's activities are funded by PIA and supported by numerous technological platforms to address societal challenges such as safety, environment, health, and energy.

The year 2024 marked a turning point for the EIPHI project. It followed the highly laudatory review that we received at the end of 2023 from an international jury that encouraged us to continue the transformations we had undertaken and extended funding through May 2028 (see evaluation). 2024 also marked the initiation of the institutionalization of the Graduate Schools. There follows a look back at the work done these five years transforming and restructuring the education and research landscape in Bourgogne Franche-Comté (BFC).

EIPHI has funded 183 research projects, 92 PhDs, 77 postdocs, and 143 Masters internships since 2018. From 2018 to mid-2023, it produced 1,037 articles in peer-reviewed journals, with a significant increase in high-impact publications. The excellence of this research has been recognized by over 120 distinctions, including ERC grants, IUF chairs, and international prizes.





EIPHI has also fostered international collaborations, including partnerships with prestigious institutions and participation in EU projects. Support from Bpifrance, the BFC region, and SATT SAYENS has made the landscape favorable for innovation, paving the way for 70 patents and seven start-ups.

The EIPHI training and research boards serve as think tanks that focus on the interplay between research and training. Doctoral students co-sponsored by EIPHI and the Bourgogne-Franche-Comté Region are required to conduct a minimum of 30 hours of scientific, technological, and industrial culture (CSTI) work. The «Diffusion» call supports events like conferences and workshops, encouraging student involvement and networking.

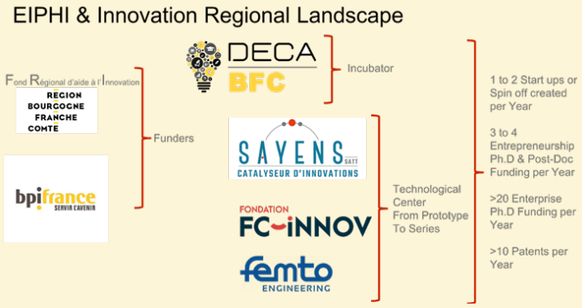
EIPHI's curriculum includes «lab projects» to immerse students in the laboratory environment. The approach is supported by funding for technology platforms and Openlabs and provides practical training on real research problems. Training in research extends to undergraduates and engineering students as well, with laboratory internships co-directed by Masters students. EIPHI is involved in organizing courses, summer schools, and seminars, open to all students.

EIPHI has also encouraged student involvement in events like Hacking Health Besançon, designed to promote interaction between the Masters and Doctoral levels. The school's multidisciplinary nature facilitates joint initiatives. PhD students contribute to

training through interdisciplinary courses in the 'French + Sciences' program (https://www.campusfrance.org/fr/le-programme-frenchsciences) that helps them enhance their supervisory and communication skills. Students receive recognition for these activities through the Open Badges system, which certifies extra-academic proficiency and achievements in Dissemination (internal seminars, conferences etc.), Science Technology & Industrial Culture (hackathons, junior enterprises, etc.), Tutoring Peers (student project management, internship tutoring, etc.) and Networking (career events, alumni associations, student chapters, etc.). At the end of their training, students are awarded a specific badge on the basis of the number of points they have earned. The Open Badges system, implemented in coordination with PIA3 NCU RITM-BFC, has issued over 450 badges to EIPHI students, complementing the formal recognition they receive and their CVs.

To initiate bonding, EIPHI hosts a welcoming event at the start of the academic year at which the training curriculum's unique approach is presented. Interdisciplinary courses, such as those focused on environmental impact, enhance collective intelligence and collaboration among students.

We aim to increase the synergy between Masters tracks and strengthen ties with the industrial world. While socio-economic actors are very much involved at the doctoral level, industry participation in Masters programs needs to be developed further. To this end, we have launched initiatives for lifelong training for technical staff and industrial partners.



THEMATIC SCHOOLS

HYDROGEN FUEL CELLS AND MOBILITY

ENERGY

Joëlle Marc, Zhongliang Li

Place:
Belfort

Number of participants:
32 students

In the fall of 2024, as part of the INTERREG Green SKHy project, Université Marie et Louis Pasteur organized a 4-day course on hydrogen fuel cells and mobility.

The session was jointly run with the School of Engineering and Architecture of Fribourg (Switzerland) and HAN University of Applied Sciences (The Netherlands). 32 students from these 3 countries took theoretical and practical courses and visited two major hydrogen production plants (McPhy and H2SYS).

Website:
https://events.femto-st.fr/GreenSKHy/en/

Contact:
joelle.marc@femto-st.fr
zhongliang.li@univ-fcomte.fr

ELECTROCHEMICAL AND HYDROGEN ENERGY STORAGE FOR MOBILITY AND MICROGRIDS

ENERGY

Abdesslem Djerdir, Daniela Chrenko

Place:
Belfort

Number of participants:
21 students, 17 speakers

In the course of a four-day program held in Belfort in 2024, speakers from academia and industry shared their knowledge and experience in electrochemical and hydrogen energy storage through seminars, courses, tutorials, and demonstrations.

The aim was to provide students with advanced training focused on applications to mobility and energy microgrids. Students, researchers, and representatives from industry shared their experience and best practices with each other through presentations and discussions, stimulating collaboration and offering students and young professionals the opportunity to expand their networks.

School website:
http://www.utbm.fr/summer-school-fclab

Contact:
Abdesslem.djerdir@utbm.fr
daniela.chrenko@utbm.fr

ADVANCED MICRO-/NANO-MANUFACTURING METHODS AND PROCESSES AND ADVANCED PHOTONICS

OPTICS/MN2S/TF/AS2M/APPLIED MECHANICS

Jean-Charles Beugnot, Aurélie Sabanovic

Place:
Neuchatel Microcity, (Switzerland)

Number of participants:
40 persons (20 FEMTO-ST; 20 EPFL)

Every June, under the aegis of Collegium SMYLE, FEMTO-ST and EPFL co-organize two summer programs: one on advanced micro-/nano-manufacturing methods and processes and the other on advanced photonics.

Ten professors from EPFL and FEMTO-ST give courses on laser micro/nano-manufacturing nonlinear optics, optical computing, nanophotonics, micromachining sensors and actuators, micro/nano-assembly, advanced photolithography, the manufacturing of nano-optics, and 3D printing for materials and meta-materials.

The summer programs are open to all FEMTO-ST and EPFL PhD students, with financial support for housing, travel, and meals from the SPIM school and Collegium SMYLE.

School website:
https://events.femto-st.fr/collegium-smyle/

Reference:
https://www.youtube.com/watch?v=k-6jqoElvs0

Contact:
smyle@femto-st.fr

THEMATIC SCHOOLS

GDR I-GAIA

OPTICS

Daniel Brunner

Place:
The Sorbonne, Paris

Number of participants:
65 students

The I-GAIA research group week brought together researchers in the fields of solid mechanics, fluids, structures and processes, electronics, photonics, and multiphysics couplings to study the applications of artificial intelligence and machine learning

for research in the engineering sciences. It provided a diverse range of presentation formats: a day of invited speakers and lectures on fundamental techniques, followed by a one-day master class on the hands-on coding of neural network techniques, and ending with another day of talks by guest speakers. This year's program was organized by Paola Cinnella from the Jean Le Rond D'Alembert Institute (the Sorbonne) with support from a steering committee that included Emmanuel Baranger (LMPS, CNRS), Clément Jailin (LMPS, CNRS), Daniel Brunner (FEMTO-ST), and Francisco (Paco) Chinesta (PIMM, ENSAM Paris).

Event website:
https://gdr-week2024.sciencesconf.org/?lang=fr

Contact:
Daniel.brunner@femto-st.fr

2024 EFTS

TIME AND FREQUENCY,

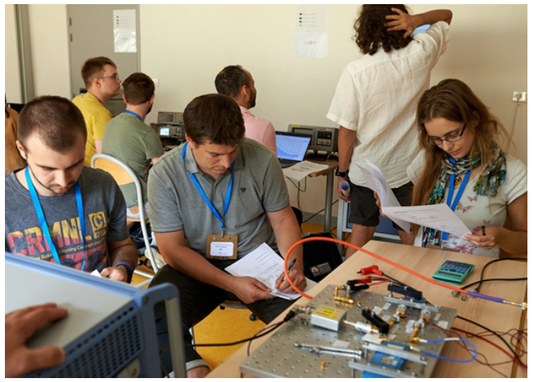
Enrico Rubiola, Clément Lacroûte

Place:
Besançon

Number of participants:
36 students

The European Frequency and Time Seminar is a theoretical and practical course on the measurement of frequency and time founded in 2013 by Enrico Rubiola in collaboration with FIRST-TF, Oscillator IMP, and a committee of researchers from major metrology labs, and hosted by Supmicrotech/ ENSMM.

The course includes 23 hours of lectures,12 hours of hands-on lab sessions in small groups, and social events, and involves the participation of 25 lecturers and staff members. The governing committee chooses high-profile researchers from metrological labs and universities while the staff and lab instructors come from FEMTO-ST, FEMTO Engineering, the Besançon Astronomical Observatory, and Supmicrotech. Local PhD students and researchers (there were 8 in 2024) have free and unlimited access to lectures (but not to labs), coffee breaks, and lunch. In the past eleven years we have worked with 370 students. The demand is growing so fast that spaces for the 2024 session were filled in weeks.



Website:
https://efts.eu

Contact:
frequency-time-seminar@femto-st.fr

CMI STUDENTS AS ARTISTS IN RESIDENCE

ENERGY

Robin Roche, Daniel Hissel, Samir Jemei

The ecodesigner Quentin Didierjean was in residence at the Energy Department of the FEMTO-ST Institute in 2024 as part of the Université Marie et Louis Pasteur program "Un Artiste / Un Labo".

During his stay, an exploratory workshop in design was organized on the theme of hydrogen for second-year students from the Master's in Engineering program "Hydrogen Energy and Energy Efficiency."

Drawing on their knowledge of the subject and their familiarity with approaches to the design process, they were able to produce fictional scenarios, images generated by artificial intelligence software, and an engraving.

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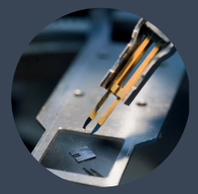
SCIENCE AND SOCIETY

FEMTO-ST INSTITUTE FOSTERS RESEARCH AND INNOVATION TO ADDRESS SOCIETAL CHALLENGES

HEALTH AND WELL-BEING

- **Therapy**
- **Diagnosis, Screening, and Biological Qualification**
- **Ethics and Acceptability**



CLEAN, SAFE & EFFICIENT ENERGY

- **Hydrogen energy**
- **Energy Harvesting**
- **Energy Efficient Systems**

ENVIRONMENT

- **Environmental sensors**
- **Geodesy**
- **Water and Air Treatment**
- **Vibration and Noise Protection**
- **Preservation of Resources**

INTELLIGENT SYSTEMS

- **Artificial Intelligence: Distributed Systems, Diagnosis and Prognosis**
- **Smart Objects and Complex Systems**
- **Ethics**

COMMUNICATION AND INFORMATION

- **Ultra-localized optics**
- **Quantum Technologies**
- **Telecommunication Systems and Materials**

INDUSTRY OF THE FUTURE

- **New Materials and Processing**
- **Sensors and Actuators**
- **Factory 4.0**

DEFENSE - SECURITY

- **Network and Software Security**
- **Intelligent Systems for Defense**

SCIENCE AND SOCIETY

In 2024, FEMTO-ST strengthened its commitment to sharing science with the general public through a series of diverse and engaging events held across its various geographical locations.

During “Pint of Science” (May 2024), our researchers stepped out of the lab to discuss their work in bars, in a friendly and relaxed atmosphere. Topics included light, health, robotics, hydrogen, and innovative materials.

The European Researchers’ Night (September 2024), held at the “Franche-Comté – Cité des Arts” in Besançon, offered an evening of spontaneous and informal exchanges between five of our scientists, four artists working on various projects, and a curious audience.

At the “Fête de la Science” (October 2024), the general public discovered our research through booths, activities, and interactive demonstrations. More than 25 FEMTO-ST members spoke of their work on microrobotics, artificial intelligence, and optics, and over 300 schoolchildren were introduced to micro- and nanotechnologies and their applications in the health sector.

The «One Class, One Researcher» program enabled students throughout the year to meet a FEMTO-ST scientist and gain insight into the life of a researcher.

During the “24h du Temps” (June 2024), our colleagues presented projects related to time, mechanics, and precision at the innovation village. Highlights included “Stardust Odyssey”, the world’s smallest stop-motion animated character, ultra-precise time measurement using an atomic clock, and the world’s tiniest house, built on the tip of an optical fiber, its construction drawing on cutting-edge robotic assembly and nanocomponent manipulation technologies.

Finally, during the regional final of the Three-Minute Thesis Competition held in March in Besançon, one of our PhD students, Raniya Kefti (DISC Department), successfully met the challenge of explaining her research in just three minutes. Raniya also won the high school students’ choice award.

REESPIRATION - SOFT ROBOTICS IN AN INTERACTIVE WORK OF ART

AS2M

Maude Guirault, Mehdi Salah, Alexis Lefevre, Sylvain Hernandez Pierre Roux, François Marionnet, Kanty Rabenorosoa

RÉESPIRATION is a work of art created by Samuel Bianchini, commissioned by Nouveaux commanditaires with support from the French Ministry of Culture and the Fondation de France. The project was carried out with the help of current and former members of the R3S Department at Pitié-Salpêtrière Hospital in Paris and other hospital staff, and the mediation work of the 3CA association.

At the heart of a parabola 1.7 meters in diameter, the shape of an abstract object undergoes change, as if it were breathing, its movements amplified by the embroidery covering it. The embroidery reacts to the light diffused by the parabola, which also produces sounds that envelop the viewer. FEMTO-ST institute played a key role in the creation of RÉESPIRATION by designing and producing the soft robot and its pneumatic actuation and control system.

Facility:

S.MART Platform

Website:

https://reespiration.org/

Contact:

rkanty@femto-st.fr

RÉESPIRATION: an art project of scientific and medical import using a soft robot.

NANO-LANDSCAPES

MN2S

Jérome Dejeu, Céline Elie-Caille

In March 2024, Adèle Tilouine and Tyler Kaufman, TakT science-artists, spent four weeks in the Nano2Bio team laboratory as artists in residence, watching researchers perform experiments in imaging extracellular vesicles and generally sharing their lives.

During their residency, they designed and produced installation artworks in close collaboration with the researchers, experimenting with different techniques, materials, and new technologies to create their shapes. Alongside the works they produced themselves, they also oversaw the work of Masters and PhD students in the lab who made two works of installation art of their own.

Website:

https://taktzeitt.wordpress.com/2024/01/02/la-residence-artistique-de-takt-au-laboratoire-femto-st-de-besancon/

References:

https://www.echosciences-bfc.fr/articles/les-nano-paysages

Contact:

takt.zeitt@gmail.com

Creating a “Vibrating Laser” and a “Golden Globe” with Nano2BIO team students.

SCIENCE GAMES

OPTICS

Pierre Ambroise Lacourt

In October 2024, the national “Fête de la Science” held on the Bouloie campus of the University of Franche-Comté featured a science game created by the Optics Department at FEMTO-ST that was conceived as a tool for mediation and educational purposes for everyone from 4th graders to PhDs. The event benefitted from the support and organizational input of the Department of Science, Arts, and Culture (SSAC) at the University.

References:

Est républicain (2024 october 13) : involvment of FEMTO-ST in the « Fête de la Science »

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Youngsters fascinated by the games

SCIENCE AND SOCIETY

TEACHING MODERN OPTICS THROUGH HISTORY

OPTICS

John Dudley, Julie Langlois, Luc Froehly, Jérôme Salvi

In 2015, we initiated a program dedicated to safeguarding our laboratory's scientific heritage by preserving and showcasing historical documents and artifacts. As part of this initiative, we began offering internships that bridge history and science, demonstrating how modern tools can shed light on the evolution of scientific knowledge.

When we first set out to document the history of optics at the Université de Franche-Comté, we did not fully anticipate the educational potential of our collection. However, it soon became evident that the analysis of historical instruments using modern optical design software was a very effective means to make learning engaging and practical, while simultaneously enriching our understanding of local scientific heritage.

Covering approximately 100 square meters, our collection of holograms and instruments represents a valuable educational asset. It offers the possibility for hands-on applications and interactive learning, and enhances visits from dignitaries, guests, and the general public with a unique educational and cultural experience. Moreover, these resources serve as a source of inspiration for students and faculty alike, encouraging the use of historical knowledge as a foundation for pioneering innovations in optics and photonics.

Website:

https://projects.femto-st.fr/patrimoine-scientifique/

References:

Université de Franche-Comté (2023). Trésors du savoir: 1423-2023, 600 ans d'histoire (s) de l'université de Franche-Comté. Tome 1 1423-1968. Presses universitaires de Franche-Comté.

Dordor, L. Froehly, L., Jacquot, M., & Dudley, J. M. (2024, April). Journey through time: Optics of Yesterday and Today through Charles Féry's Spectrophotometer. SPIE Optical Systems Design, Proc. SPIE 13019, Optical Design and Engineering IX; 130191G.

J. M. Dudley, L. Froehly, J. Salvi, P. Verschueren, M. Jacquot. Preserving Optics Heritage at the University of Franche-Comté. Optics and Photonics News Volume 36, 38-45 (2025)

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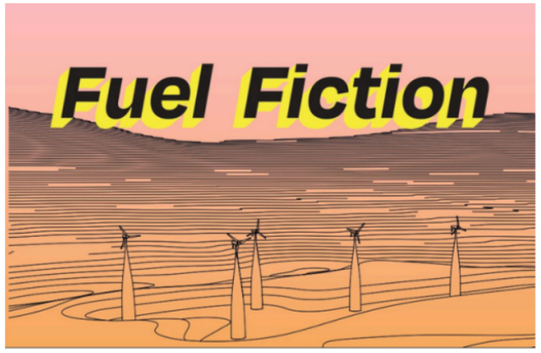
FUEL FICTION

ENERGY

Robin Roche



As part of the «ONE ARTIST | ONE LAB» program sponsored by the Université Marie et Louis Pasteur, eco-designer Quentin Didierjean was intermittently in residence with the SHARPAC research team in the Energy Department at FEMTO-ST Institute during the period stretching from October 2023 to May 2024.

His experience led to an exhibit of his works exploring the challenges of the hydrogen technologies being researched in the laboratory. In its cross-disciplinary perspective joining science and artistic creation, the exhibit questioned the role of hydrogen in shaping the narrative of a desirable and sustainable energy transition.

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SCIENCE & SCIENCE ART IN THE CASTLE

MN2S, AS2M, TIME AND FREQUENCY

Céline Elie-Caille, Jérome Dejeu, Alain Rouleau, Eugénie Vidal, Zeina Al Masry, Julien Mollard, Nicolas Brosseau Habert, Jean Yves Rauch

The idea was to get science out of the lab, to bring it closer to children, and introduce research to the general public. On October 13, 2024, from 10am to 4pm, in an exceptional setting, Villersexel castle, scientists from the FEMTO-ST Institute presented their work and did experiments for some 300 students from 10 different area schools, while science-artists helped children and others discover and experience science through art.

In the evening, the event was opened to the public at large with live music and a visual display. The day concluded with a free-wheeling discussion between researchers, science-artists, and the audience.

References:

Video realized by the DRARI : https://fb.watch/xNqe7uX_5L/

The 300 school children in attendance, in front of Villersexel castle.

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