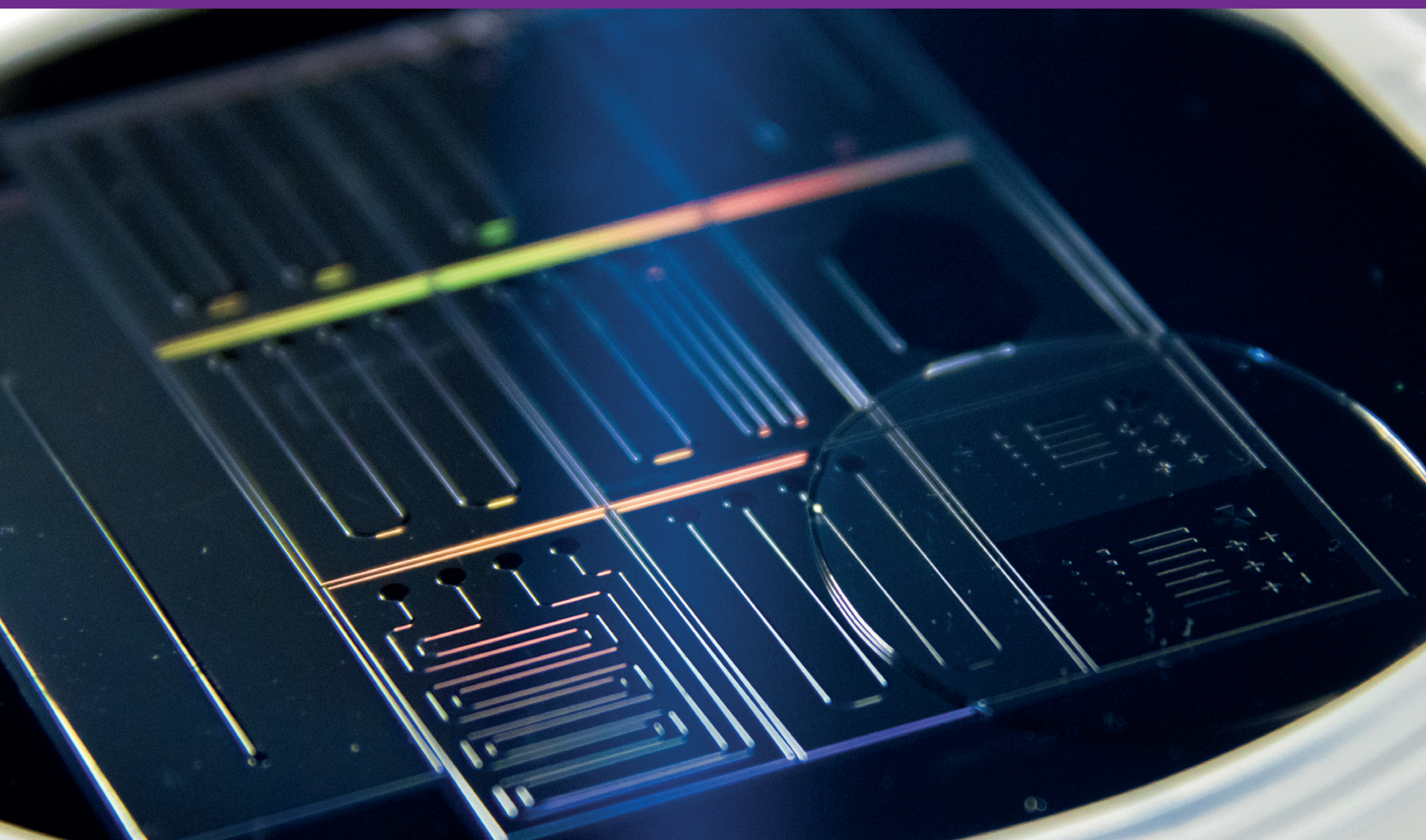


*Cultivating innovation,  
from basic research  
to industry partnership*



# FEMTO-ST INSTITUTE



## KEY FIGURES

700 staff & students  
7 scientific departments  
10 technological platforms  
400 research papers per year  
400 annual research contracts

*FEMTO-ST's scientific objective is to harness micro and nanotechnologies, develop new components and systems, optimize their performance, add new functionalities and enable them to be "intelligent".*

*FEMTO-ST's research activities have a strong societal impact, developing a Research-Training-Innovation continuum, and cultivating links between science, society and the local region.*

## ABOUT

In the Bourgogne-Franche-Comté region, FEMTO-ST conducts multi-disciplinary research in the fields of engineering physics, information and communication, with the aim of both advancing knowledge and having a socio-economic impact. Created in 2004, it is a joint research unit attached to 1 national research organization and 3 local higher education establishments, now federated around a regional university.

The French National Center for Scientific Research (CNRS)

The University of Franche-Comté (UFC)  
École Nationale Supérieure de Mécanique et des  
Microtechniques (SUPMICROTECH - ENSMM)  
Belfort-Montbéliard University of Technology (UTBM)  
FEMTO-ST's facilities are located in Besançon, Belfort,  
Montbéliard and Sevenans.

## POSITIONING

FEMTO-ST's work ranges from fundamental research to industrial applications, in sectors such as energy and transport, healthcare, telecommunications, space and defense, instrumentation and metrology, luxury goods, watchmaking and precision jewellery.

## STRENGTHS

- Internationally-recognized scientific and technological skills in line with the region's industrial traditions (microtechnologies, energy)
- Interdisciplinary research projects based on scientific excellence, addressing topics positioned at the international forefront.
- The support of state of the art technology platforms, including the MIMENTO microfabrication center, a national leader.
- A proactive policy of technology transfer (industrial partnerships, spinoffs, intelligent regional specialization, FEMTO Engineering center).
- A scientific strategy that seeks to identify application targets focused on major social and economic issues (energy transition, climate crisis, health, technological innovations).
- Active participation in training programs of excellence combining science, technology and innovation (e.g. Master's degree programs in Engineering, engineering programs, Graduate Schools).

## LARGE-SCALE PROJECTS

FEMTO-ST is involved in a number of France 2030 investment programs:

- 22 projects of excellence (Graduate schools EIPHI and InteGraTe, Labex FIRST-TF in time-frequency)
- 9 facilities of excellence in the fields of time and frequency metrology, materials, photonics, hydrogen-energy, microrobotics, micro-nanotechnology
- 1 technological research institute (IRT M2P)
- Strong involvement in priority research programs and equipment (PEPR: Electronics, Decarbonized Hydrogen, Advanced Energy Systems Technologies, Organic Robotics, Quantum Technologies, Recycling).

The institute participates in several joint research structures in France and abroad:

- International collaborations with prestigious research centers (IBM, NIST, Harvard, KIT, etc.)
- SMYLE international collegium on Smart Systems with EPFL (Switzerland)
- Joint laboratories with industry partners
- A FC LAB research support unit (Belfort), focusing on hydrogen-energy systems
- An OSU THETA service unit in the field of time and frequency metrology
- FIRST-TF Time-Frequency Research Federation
- A national hydrogen research federation FR-H2.

FEMTO-ST is behind the creation of 24 spin-offs. Stemming from the institute's know-how, they have created over 300 jobs and sales of €40 million by 2022.

## INFLUENCE AND AWARDS

- European Research Council (ERC) award winners
- CNRS Silver, Bronze and Innovation Medals
- Members of the Institut Universitaire de France
- National and international scientific and innovation awards
- Fellow nominations and international awards from prestigious learned societies (IEEE, Optica, SPIE)
- Support for international events with the UN and UNESCO (International Day of Light).

## SCIENCE AND SOCIETY

- Science outreach: Fête de la Science, Nuit des Chercheurs, Visites Insolites, Pint of Science
- Art and Science: collaborations with artists
- Events and visits to middle and high schools.

# PLATFORMS



*The technology platforms created by FEMTO-ST support the research activities carried out within the institute, and are also open to its industrial and academic partners, as well as for training purposes.*

*They are jointly financed by Europe, the French government, the Bourgogne-Franche-Comté region, other local authorities and research projects.*

## **CLEANROOM MICRO & NANOFABRICATION TECHNOLOGY CENTER: MIMENTO**

FEMTO-ST's MIMENTO technology center develops new technologies as part of research projects in micro-nano acoustics, micro-nano optics and micromechanics.

FEMTO-ST is a member of the RENATECH national research infrastructure (national network of major CNRS technology centers), and since 2004 has benefited from the RTB program dedicated to basic technological research.

It hosts 3 types of complementary and interacting activities:

- fundamental research into materials for nanotechnologies and integrated components designed to fulfil new functionalities obtained by exploiting original physical principles;
- the development of technology chains for the complex production of hybrid microdevices and microsystems;
- R&D and breakthrough industrial innovation (in particular through an industrial production line for micro-nano-components that can be manufactured in batches in collective production).

ISO 9001 certified.

## **MICRO HYBRID MANUFACTURING (MIFHYSTO)**

This platform (shared with our academics partners) is developing new technologies for mechanical microfabrication, surface functionalization and hybridization with cleanroom-type processes for the production of components with dimensions or characteristic details on the submillimeter scale.

## **TIME AND FREQUENCY METROLOGY (OSCILLATOR IMP)**

Approved as part of the future investment programs, it is dedicated to characterizing relative short-term frequency stability (from 1 ms to 1 day). This tool uses the best current frequency references covering a very broad frequency spectrum (from RF to Optics) and state-of-the-art metrological comparison instruments. It significantly improves measurement resolution, both for accredited service activities (calibration, ISO 9001 certification) and for R&D needs.

ISO 9001 certified for calibration.

## **HYDROGEN - ENERGY**

The hydrogen-energy platform features experimental facilities for testing hydrogen fuel cell systems and water electrolyzers, for both mobility and stationary applications. The platform is operated by UAR FCLAB.

## **MICRO-NANO ROBOTICS CENTER (CMNR)**

Recognized as a National Research Infrastructure (ROBOTEX 2.0) and supported by future investment programs, it offers services for the characterization, manipulation and micro-assembly of micro-nanocomponents.

## **PHOTONIC / OPTICAL TECHNOLOGIES (SMARTLIGHT)**

SMARTLIGHT (shared ICB - FEMTO-ST) aims to share cutting-edge scientific equipment between the academic scientific community and industry in the field of intelligent photonics (quantum technologies, characterization of ultra-short optical pulses, nonlinear effects and sensors in exotic optical fibers, photonic crystals and hybrid integrated optics).

## **MECHANICAL CHARACTERIZATION OF MATERIALS AND STRUCTURES (AMETISTE)**

The AMETISTE platform brings together a wide range of equipment for the mechanical characterization of materials, surfaces and structures over a wide range of dimensions and frequencies. It provides resources and services for research and industry.

ISO 9001 certified.

## **FLOW AND HEAT EXCHANGE METROLOGY (FLUIDIX)**

All FLUIDIX equipment constitutes a high-performance, dedicated technical platform for fluidic and thermal characterization of complex flows. This equipment is complemented by thermal machine characterization benches, notably for cogeneration, refrigeration production and the study of coupled thermal/electrical phenomena in sliding contacts.

## **DEVELOPMENT AND CHARACTERIZATION OF THIN FILMS (SURFACE)**

The SURFACE platform brings together a range of skills and equipment specifically dedicated to the design, development, characterization and study of the physical properties of thin-film and ultra-thin-film materials. The SURFACE platform is characterized by its ability to promote access to cutting-edge technologies for all academic and industrial partners wishing to solve complex challenges in the field of thin-film materials.

ISO 9001 certified.

## **PROTEOMICS (CLIPP)**

Awarded the IBISA label in 2016, the CLIPP platform is focused on proteome analysis in biology and clinical applications. It offers expertise in proteomics, drawing on know-how in (bio)chemistry, physical chemistry, nano- and micro-engineering, biostatistics and bioinformatics.

# SOCIETAL ISSUES



## AREAS OF INNOVATION

### ENERGY AND TRANSPORT

- Fuel cell and hydrogen systems
- Electric and hybrid powertrains
- Thermal machines, micro-cogeneration
- Energy storage
- Noise and vibration control
- Composite and hybrid materials and structures
- Software for shared mobility
- Automatic test generation for embedded systems.

### HEALTH

- Intelligent medical devices
- Medical microrobotics
- Bioinformatics and e-health
- Bio microsystems
- Clinical Proteomics
- Microtechnologies for biomedicines
- Call prediction and analysis for emergency services
- Automated analysis of medical images (CT-SCAN, MRI)
- Anonymization of medical data.

### LUXURY, WATCHMAKING & PRECISION JEWELLERY

- High-precision machining
- Hybrid microfabrication and microassembly
- Advanced materials
- Functional surfaces, surface treatments
- Intelligent mechanical components
- Service life monitoring.

### TELECOMMUNICATIONS, SPACE, DEFENSE

- Ultra-stable clocks and oscillators
- Nanophotonic components and telecoms
- Optical and optoelectronic systems for information processing
- Information security and reliability, quantum information
- Complex photonic and AI processors and computers
- Communications security and reliability.

### METROLOGY, INSTRUMENTATION

- High-resolution instruments for TF metrology
- Piezoelectric materials and transducers
- Photonic instrumentation
- Advanced laser sources
- System prognosis and diagnosis
- MEMS and MOEMS Micro-sensors and sensor networks.



## CROSS-CUTTING THEMES AND TECHNOLOGIES

### BIOM'@X'

The Biom'@x transverse axis brings together the work carried out in FEMTO-ST's 7 departments on issues related to life sciences and health. This work covers a wide range of themes, from molecular and cellular scales, to individual organs, through to the entire human body.

Some emblematic projects:

- Micro-fluidics and robotic micro-manipulation for biomedicine production and blood analysis;
- Minimally invasive robotic microsurgery of the vocal cords or brain;
- Biomechanical impact of vibrations in certain manual trades;
- Portable devices for early detection of breast cancer ;
- Chemical sensors for detecting lung cancer via breath
- AI for diagnostic assistance from medical images ;
- AI for the organization of operating theatres or the prediction of critical events for emergency services.

### ARTIFICIAL INTELLIGENCE SOFTWARE AND EQUIPMENT

- Optical neural network processor
- Prediction of complex systems, diagnosis and prognosis
- Non-conventional imaging & AI
- Sensors and sources in quantum technologies.

### MULTI-PHYSICS COMPONENTS, SYSTEMS AND FUNCTIONS ON MICRO & NANO SCALES

- Enhanced functionalities for silicon microelectronics (exotic electroactive materials -LiNbO3 -for 5G and 6G mobile telephony)
- Microfluidics on glass,
- Surface chemistry pollution sensors
- Atomic micro-clocks for ultra-precise and secure networked time distribution
- Integrated 3D OCT microscopy for biopsy-free skin cancer detection
- Integrated optical electric field sensors
- Integrated optical ionizing radiation dose sensors.

# SCIENTIFIC DEPARTMENTS



SCIENTIFIC EXCELLENCE

## AUTOMATIC CONTROL AND MICROMECHATRONIC SYSTEMS (AS2M)

Micro and nanorobotics, small-scale instrumentation and perception, deformable, flexible and dexterous robotics, optimization and control of complex multiphysical systems, systems health and data science.

- Nanorobotics, force metrology and applications for dynamic environments at micro-nano scales, Perception, liquid and non-contact micro robotics and structural optimization
- Continuously deformable robotics, parallel and dexterous robotics, models, model structure, control observation
- Neurosciences, prognostics and health management, sustainable decision and optimization.

## ENERGY

Design, characterization, control, optimization, sustainability and integration.

- Fuel cell and electrolyzer systems
- Hybrid electric systems
- Storage for power systems and hydrogen
- Electromagnetic and static converters
- Thermal machines and systems
- Building insulation
- Metrology and instrumentation in energy.

## COMPLEX SYSTEMS COMPUTING (DISC)

Modeling, development, validation and optimization of complex (distributed, intelligent) systems for the safety, security and reliability of communications and information systems, applied to the fields of health, mobility, logistics, energy management, security, programmable matter and sensor networks.

- Distributed numerical algorithms, AI and optimization
- Distributed systems, parallel scheduling, distributed AI
- Di-MEMS, scheduling and wireless networks
- Verification and validation of software and embedded systems.

## APPLIED MECHANICS (DMA)

From the heart of matter to innovative integrated technologies. Functionalize, optimize and control materials, microsystems and structures.

- Materials for the ecological transition
- Mechanics for health
- Mechano-chemistry and tribology
- Intelligent Microtechnologies
- Manufacturing Processes and Surfaces and Materials Interactions
- Structural dynamics and vibro-acoustics.

## MICRO-NANOSCIENCES AND SYSTEMS (MN2S)

Design and production of acoustic, optical and biomedical components and microsystems; development and characterization of functional materials and nanostructured surfaces.

- Instrumented microdevices for biology and biomedicine,
- Biodetection and nanocaracterization of biological objects,
- Thin films and nanomaterials for microsystems and energy,
- Nanosciences, nanophononics and optical microsystems,
- Phononics, acoustic metamaterials and microscopies.

## OPTICS

New concepts in light propagation, light-matter interaction and advanced optical functions, integrated systems in nonlinear photonics, light sources, fiber photonics, nano-photonics, ultrafast optics, quantum information, unconventional imaging, photonic AI.

- Non-linear optics
- Optoelectronics
- Nano-optics

## TIME-FREQUENCY (TF)

Ultrastable devices (oscillators and clocks) for time and frequency measurements, surface acoustic wave sensors for the environment.

- Ultra-stable frequency sources (oscillators and clocks from RF to optics)
- Acoustic wave sensors
- Time and frequency metrology
- Accredited calibration service for frequency sources
- MEMS/piezoelectric solid-state and thin-film resonators.

## RÉCITS

RECITS is a Humanities and Social Sciences (HSS) group that conducts disciplinary and interdisciplinary HSS research on technology (history, economics, sociology, philosophy, spatial/urban planning, ergonomics) and interdisciplinary research between HSS and Engineering Physical Sciences.

# INDUSTRIAL PARTNERSHIPS



INNOVATION  
FOR  
INDUSTRIAL  
PARTNERS

*FEMTO-ST's commitment and ability to develop partnerships with industry have earned it awards at the highest national level.*

## SPIN-OFFS

FEMTO-ST has spawned several spin-offs over the past 10 years. This is reflected in the regional economic fabric by the emergence of high-tech companies exploiting the innovations resulting from its research.

- AUREA TECHNOLOGY (systems for quantum technologies)
- SHARE&MOVE (software for mobility and alternative transport)
- FREC'N'SYS (part of the SOITEC group - telecommunications components)
- PERCIPIO ROBOTICS (microrobotics and micro-assembly)
- MAHYTEC (part of the HENSOLDT group - hydrogen storage solutions)
- COVALIA INTERACTIVE (now part of Maincare Solutions - software tools and systems for telemedicine)
- H2SYS (fuel cell generator sets)
- VERSO Optim (logistics optimization software)
- ANANKE (industrial waste heat recovery)
- AFULudine (ecological lubricants)
- VIBISCUS (for airflow noise reduction)
- AMAROB (minimally invasive, multi-functional miniature surgical robots)
- CLHYNN (micro fuel cells for low-power energy sources)

## SMART REGIONAL SPECIALIZATION

Participation in the Regions' Intelligent Specialization Strategy (RIS3), in conjunction with nearly 30 companies and involving over €30 million in European economic development grant.

Examples of projects supported:

- $\mu$ D2 (micro-machining of hard metals for the watchmaking industry)
- Smart-Inn (new-generation RF telecom filters)
- 3S-MEMS (hybrid MEMS sensor without power supply)
- MiMédi (Microtechnologies for the production of biotherapies)
- NextWatch (MEMS-based miniature watch motors)
- Vhyctor (reservoirs and H2 distribution network)

## FEMTO ENGINEERING

Housed within the FC'INNOV partnership foundation, FEMTO Engineering employs staff dedicated to technology transfer. Their mission is to bring FEMTO-ST's research results to technological maturity, transforming them into potential applications close to the market.

The activities of FEMTO Engineering, a member of Carnot TSN, are financed either by industry to meet their R&D needs, or by public subsidies or resources generated by industrial contracts to develop in-house innovations that can then be transferred.

## DIRECT INDUSTRIAL COLLABORATIONS

An open intellectual property framework encourages these direct interactions (> 10 patents per year, licensing, know-how sharing).

Direct collaborations take the form of short research contracts, industry-partnered PhD's, or the creation of joint laboratories to forge closer, long-term links and share scientific and technological strategies.

## THEY TRUST US

AR ELECTRONIQUE, AIRBUS, TOTAL, C&K COMPONENTS, DIAMATEC, TCONCEPT, SONAXIS, FAURECIA, GRUPO ANTOLIN, SAFRAN, ORANGE, SCHLUMBERGER, ALSTOM, SNCF, CNES, Exail...

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