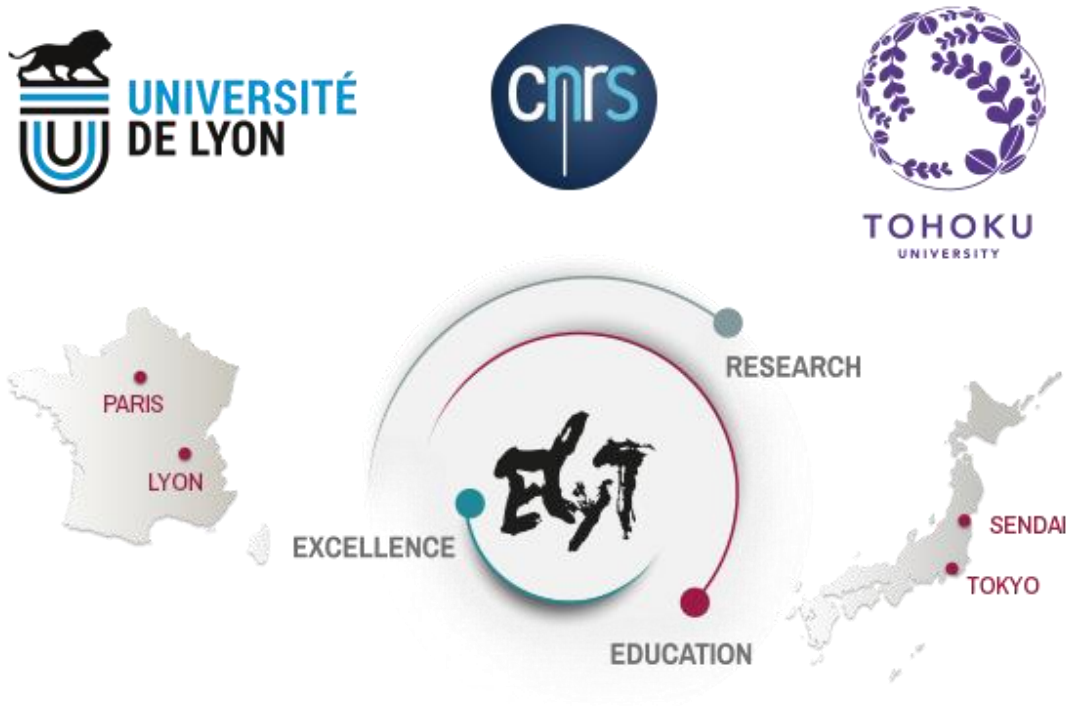


# Annual Report 2023

Authors (excl. project reports): Mickaël LALLART, Jean-Yves CAVAILLE,
Gaël SEBALD, Vincent FRIDRICI, Nicolas MARY, Tetsuya UCHIMOTO,
Yutaka SATO, Makoto OHTA, Kazuhiro OGAWA



https://www.elyt-lab.com/

# *Executive Summary*

This document exposes the actions of the ELyT Global IRN[1] during the year 2023.

2023 showed a stabilization in the activities of the IRN, after a large post-COVID renewal in 2022. International exchanges are almost back to normal and research activities with international collaborations could operate almost normally in 2023. This allowed us to organize many events, to promote the collaborations in the framework of the IRN.

26 projects were running in 2023, including 3 new ones. 2 projects stopped in 2023. 98 researchers from 32 labs (15 French, 12 Japanese, 1 joint FR/JP, 1 Chinese, 1 Indian; 1 Greek and 1 Polish) were involved in these projects, representing 156 person-months in total. These numbers are in slight increase compared to 2022, and are comparable to pre-COVID situation. New projects also permitted young people joining the IRN. On that aspect, projects involved 8 Master students, and 25 Ph.D. students among which 10 are performing a Double Degree.

The end of travel restrictions allowed us to organize face-to-face meetings. Hence, ELyT School was held in Japan in 2023 for the first time since 2018 and with a normal duration of 10 days. Different mini-workshops, symposia and events were held in 2023, including the steering committee of ELyT Global and ELyTMaX in Lyon in December 2023. After the workshop held in Lyon at the end of 2022, we decided to organize the next workshop in Sendai in 2024, to go back to the favorable dates of February / March for holding the annual workshop.

This report aims to expose the idea behind the ELyT initiative in general, and ELyT Global in particular. Then the actions performed in 2023 are reported, along with the detailed description of associated projects. Finally, some future opportunities and challenges are discussed.

[1] International Research Network

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# *The ELyT initiative*

ELyT, namely "Engineering science Lyon-Tohoku", emerged about 3 decades ago through collaborations between researchers from Tohoku University and INSA-Lyon and Ecole Centrale de Lyon. Since then, the joint scientific, socio-economical and cross-cultural interest never stopped growing between the institutions, bringing new researchers, students, staff, laboratories into the journey. This long-term fruitful collaboration nowadays resulted in a full structure, declined into 3 main activities:

- **ELyT Global IRN** (International Research Network - previously LIA i.e. International Associated Laboratory), consisting of networking and collaborative research activities, facilitating and promoting joint scientific researches and exchanges between Tohoku, Lyon, and beyond through, for instance, exchanges programs, workshops and summer/spring schools. This document reports the activity of this structure in the year 2023.
- **ELyTMaX** (Material under eXtreme conditions) **IRL** (International Research Laboratory, previously UMI i.e. International Mixt Unit), consisting of a classical independent laboratory, having premises both in Japan and in France. Although closely related to ELyT Global activities, ELyTMaX focuses on particular topics of ELyT Global. It does not manage the networking and exchange activities (but is strongly involved in practice).
- **ELyT School**, part of ELyT Global, aiming at showing students and early researchers the opportunities offered by this unique international collaboration through a summer school. This school also constitutes a premium entry door for joint Master's or Ph.D. students between the Japanese and French laboratories.

## Partner description

### Engineering of Materials and Systems in Tohoku University

Tohoku University strives to develop itself as a world's top research institution by fortifying its research and education infrastructures. Along with its notable academic achievements, the university's Materials Science is globally recognized for its top-class performance in world citation ranking. Physics and Chemistry are highly ranked fields as well. In the world university rankings such as *THES-QS World University Rankings* and *Academic Ranking of World Universities* compiled by the *Shanghai Jiao Tong University*, Tohoku University is ranked among Japan's top 5 universities and highly evaluated in quality of universities in the world. It has been even ranked 1st university in Japan in the TIMES Higher Education ranking since 2020[2].

The University was accepted by the government as one of the top 5 WPI (World Premier International) research centers in Japan. On October 1, 2007, it established an exciting and innovative research center, WPI Advanced Institute for Materials Research (AIMR), which aims at promoting the development of new materials for interdisciplinary research. By concentrating on the development of new research frontiers, Tohoku University intends to reinforce its research areas' strength, focusing on engineering and science, which become the keys for improving the quality of human life and contributing to society. In 2020, Tohoku University was ranked 97th concerning the impact ranking measuring one institution's impact on the local and global environment according to societal challenges decided by OCDE.

In 2014, Tohoku University's "Global Vision" led to its selection as part of MEXT's Top Global University program. Tohoku University is actively pursuing partner universities for its International Joint Graduate Programs. They aim to enter the world's Top Ten in four fields while challenging three new academic disciplines.

[2] https://www.tohoku.ac.jp/en/news/university_news/number_one_in_the_rankings_number_one_in_our_hearts.html

## Engineering of Materials and Systems in Lyon

Research in engineering sciences is a long tradition in the Lyon area, with many research labs and institutions in this field, including Engineering Schools. They belong now to Université de Lyon (UdL), which brings together Claude Bernard University Lyon 1, ECL (and its internal school ENISE), INSA Lyon, ENS Lyon, and 15 other institutions in Lyon and Saint Etienne on various joint projects. For more than 10 years now, 5 academic institutions among Université de Lyon, namely, the Claude Bernard University (UCBL), the Ecole Normale Supérieure de Lyon (ENS), the Ecole Nationale d'Ingénieur de Saint-Etienne (ENISE), Ecole Centrale de Lyon (ECL) and Institut National des Sciences Appliqueés de Lyon (INSA Lyon), focused all together with a large part of their human and research resources on a project called "Engineering@Lyon" (I@L, in French).

This global project covered three aspects: (i) academic research level, (ii) academic-industry transfer (within the frame of Carnot Institute mainly based on UCBL, ECL, and INSA resources)[3] , and (iii) dedicated experimental platforms (such as "Material, Mechanical and Tribological measurements"[4], "High-Tech equipment for microscopy"[5], "Micro-Nanotechnology process and characterization," etc.). The label of *Laboratory of Excellence* (LabEx) was attributed to two consortiums of research units working, on the one hand on physics, mechanics, and chemistry, and on the other hand on the surface and interface engineering. These LabEx are called *Institute for Multiscale Science and Technology* (IMUST) and *Science and Engineering of surfaces and interfaces* (MANUTECH SISE), respectively.

It is noteworthy that most of the teams involved in this network belong to CNRS as joint laboratories (UMR, for "Unités Mixtes de Recherche"). Strong relationships link together several teams of the institutions mentioned above. They are at the origin of the multidisciplinary approach of collaboration with Tohoku University, described below.

## A long history of collaboration

Starting in the 1990's, very close collaborations between two Lyon/France institutions (Ecole Centrale de Lyon and INSA Lyon) and Tohoku University in Japan have been developed. Originally, "Tribology" and "Smart materials" have been the themes for joint research and sustainable cooperation. Research in Engineering, Tribology, Materials Science and Mechanics is identified in Lyon as top-level in France and internationally. In Japan, Tohoku University is as well internationally recognized for its expertise in Flow Dynamics (Institute of Fluid Science), Material Science (Institute for Materials Research), and Mechanical Engineering (Graduate School of Engineering). Several types of collaboration have been jointly conducted, such as bilateral seminars ("Smart Materials and Systems"), Inter research Center Cooperative program (supported by CNRS and JSPS), Core-to-Core programs[6], and joint forums in France and Japan. Both French institutions have signed an agreement for a double degree with Tohoku University. Bi-directional exchanges of students and researchers are implemented in both ways.

2007 was a particular year as the three institutions have respectively celebrated their 150$^{th}$ (ECL), 100$^{th}$ (Tohoku University), and 50$^{th}$ (INSA) anniversary. To commemorate this auspicious occasion, two Japan-France Joint Forums, "*Lyon-Tohoku, teaming for the future*" were organized in February in Lyon and Tokyo-Sendai December. Both in education and research, remarkable achievements had been

[3] Directed at that time by A. Combescure (INSA) and J.L. Loubet (ECL). It is noteworthy that a second Carnot Institute, devoted to biochemistry (LISA) is headed by Prof. M. Lagarde, French leader of the Theme "Bioscience and Engineering", see below.

[4] J.Y. Cavaillé (INSA) and P. Kapsa (ECL)

[5] T. Epicier (INSA), C. Geantet (Institut de Recherche sur le Catalyse et l'Environnement, IRCELyon, UCB), J.M. Martin (ECL), and B. Reynard (ENS).

[6] e.g., "*Establishment of International Research Consortium for Advanced Biomedical Engineering in Interface Flow Dynamics for Blood Flows, Blood Vessels and Biomaterials*" (2008-2009).

accomplished. These forums' success, highlighting more potential fields of cooperation and common values such as “international, excellence” obviously emphasized the growth of exchanges and the increasing determination to foster further joint researches. Therefore, it has been decided, following the frame of the international and research strategy of the respective institutions, to establish an international joint laboratory in agreement with the CNRS (LIA) “Laboratoire International Associé” / “International Associated Laboratory”.

## The ELyT Lab LIA

This joint international lab, called **ELyT Lab**, created by CNRS, has officially started in January 2009. Thanks to the successful activities of ELyT Lab, it was reapproved by CNRS in 2012. This lab was co-supervised by Prof. Jean-Yves Cavaillé (MATEIS, INSA Lyon) and Dr. Philippe Kapsa (LTDS, ECL) on the French side and by Prof. Toshiyuki Takagi (IFS, Tohoku University) on the Japanese side. If about 50% of the collaborations were then already running, about 50% of them have started recently. This lab led to incredible achievements in the Materials Science and Engineering field with a large number of co-published papers, a dozen of double degree PhD, and the organization of annual workshops.

Such scientific achievements were reached thanks to the support of several organisms in France and Japan, which are acknowledged here. From the French side, we have to mention, besides the CNRS, INSA Lyon, and ECL, the Région Rhône-Alpes (now Auvergne-Rhône-Alpes), which provided substantial funds for travel expenses and workshop organization. Université de Lyon (UdL) also supported ELyT School, allowing many Master Students and Ph.D. students to participate.

At the first Tsunami Mitigation Workshop (September 2012), Prof. Michel Lussault from Université de Lyon met the President of Tohoku University, Prof. Satomi, to reinforce relationships. Since that time, several meetings were organized with Prof. Satomi, Prof. Ueki, and Prof. Ito (Executive Vice Presidents of Tohoku University). In September 2013, an agreement was signed between UdL and TU.

In 2015, a JSPS Core-to-Core Program “*International Research Core on Smart Layered Materials and Structures for Energy Saving*” was initiated. This project was placed in the evolving context of our long-term joint research on “intelligent materials and structures” between Tohoku University and Université de Lyon and aims at developing a novel form of intelligent structures through the fusion between functional multi-materials and sensing technologies. Mostly, it focused on interactions between fluids and intelligent structures to create energy-saving effects and developed its academic infrastructure. Beyond the France-Japan collaborations, an international research team consisting of Fraunhofer Institute for Non-Destructive Testing and Nanjing University of Aeronautics and Astronautics was organized with Tohoku University and Universities in Lyon and Grenoble, France. It accelerated the development of smart layered materials and structures for energy saving.

## The ELyTMaX UMI/IRL[7]

Some researchers involved in bilateral collaborations within the frame of ELyT Lab were willing to deepen the collaborations and start new research activities. Therefore, the creation of a UMI[8] was proposed. The creation agreement of this new UMI, ELyTMaX, was signed in October 2015, with an official start in Sendai in April 2016, allowing French researchers to experience long-term stays in Sendai, and launch new research activities. In 2018, ELyTMaX also opened offices and lab space in Lyon, to welcome Japanese researchers to this mirror site. Simultaneously, the Institute of Fluid Science of Tohoku University launched its Lyon Center (http://www.ifs.tohoku.ac.jp/LyC/eng/index.html).

The research activities of the UMI ELyTMaX – now an IRL (International Research Laboratory) – are devoted to the study of materials and structures submitted to extreme conditions, such as pressure,

[7] https://www.elyt-lab.com/en/content/elytmax-umi-3757

[8] UMI means "International Joint Unit". The main difference is that UMI is managed exactly like all other CNRS - University joint laboratories, while LIA are not independent of their "parent" laboratories. Hence, UMIs are self-standing laboratories.

temperature, irradiation, electric/magnetic fields, energy, etc. It includes biosystems as well as artificial materials and structures. Special attention is given to the topic "Boundary Surface and Interface; Comprehension, Design, and Application".

### The IFS LyC[9]

The Tohoku IFS Lyon Center (LyC) aims to welcome Japanese professors from the University of Tohoku, as well as their master students in the fields covered by ELyT Global. It is located in the ELyTMaX premises in Lyon.

The Lyon Center was established in Université de Lyon in April 2018 by Tohoku University's Institute of Fluid Science. At this center, fluid science researchers from the IFS and other Japanese institutions conduct collaborative research projects with materials science researchers mainly from Université de Lyon. Through these collaborative research activities, we will also educate young researchers and students.

The IFS is pioneering a new type of problem-solving academic program, a combination of different academic fields with fluid science as its base, and is addressing social problems related to energy, next-generation transport systems and medical engineering. To encourage further progress and developments we established its base at Université de Lyon, a center for Europe's materials science research and academia-industry cooperation. From here collaborative research utilizing the strengths of each party will be operated, promoting world-leading human resources development.

In 2022, LyC was selected as part of the ¥10 trillion government fund project and has been renewed for 6 years as a commitment of the strong collaboration background and associated actions.

### Cross-appointed professor & associate professor positions

In 2019, an initiative of Tohoku University in agreement with INSA Lyon was launched and consisted in employing on a part-time basis ("cross-appointment") four researchers from INSA (3 assistant/associate professors and one emeritus professor), with support at several levels (administrative, life and scientific). Following the success of this scheme, these positions have been renewed for the second time in 2021, with possibilities of extending the number of involved researchers in the program.

### The ELyT Global LIA/IRN [10]

After 8 years of collaborations, the LIA ELyT Lab had to come to an end in December 2016, but participants were firmly willing to continue their collaborations. To keep the network (and associated successful actions such as ELyT workshop or ELyT School) active, a new LIA proposal, ELyT Global, was submitted and granted by CNRS in 2017. ELyT Global proposes a new management architecture for the research collaborations by tackling societal issues such as transportation, energy, and biomedical applications, hence addressing a much broader scope than ELyTMaX, while developing and promoting research networks for successful collaborations. ELyT Global has permitted to put forward new thematics while involving young researchers in this collaboration. Efforts have also been made to have more implications for industrial partners with some success. For example, we can cite an industrial/academic collaboration with Nippon Steel or with Michelin.

Moreover, we have also been deeply involved in structuring the institutional collaboration between the two administrative regions. For example, during spring 2019, a large delegation of Lyon's city led by G. COLLOMB came to Sendai and met the Miyagi prefecture representatives and some companies interested in launching activities in France. This visit has been organized partly by the members of the IRN. The other point about this IRN was to broaden the collaboration at the University of Lyon level.

[9] Institute of Fluid Science Lyon Center

[10] https://www.elyt-lab.com/en/content/elyt-global

ELyT took a large part in the definition of the program STARMAJ (exchange of Master students) and structuration of Lyon-Japan actions, permitting the mobility of master students between Tohoku and Lyon.
ELyT Global IRN was again recognized by CNRS and the instutitions in 2022, for another 5-year period. In 2023, ELyT Global IRN received financial support from Région Auvergne-Rhône-Alpes for the next 3 years.

## ELyT Global and structure

### Objectives and organization

The scientific organization of ELyT Global relies on the three main fields of **transportation**, **energy,** or **engineering for health**, nevertheless being open to new topics depending on the proposed collaborative projects. Moreover, it is clear that to be further internationally recognized, the IRN should apply for international research proposals. Therefore, ELyT Global adopted a core-shell organization (Figure 1). It has already been successful in the last years as **an International ANR-JST Project (PYRAMID), 2 ANR projects (ECPOR and FIESTA) and a KAKENHI project have been obtained from the French and the Japanese governments**. The core partners of ELyT Global are Université de Lyon and Tohoku University because of their historical relationship and numerous common projects. However, around this core, a club of other industrial or academic partners is introduced. Some of them are already identified as KTH, Saarland University for instance. They are working on areas close to the themes addressed by ELyT Global. Since they bring their specificities and expertise, the subjects addressed by ELyT Global benefit from a better and broader understanding. Moreover, gathering such a network of preferential partners is expected to be very efficient for answering international calls for projects (European ones for instance).
ELyT Global addresses the broad subject of **Engineering of Materials and Systems**. It means that the projects included within the IRN can cover all the aspects of materials engineering, from synthesis to structural characterization and functional behavior evaluation, including experiments and numerical modeling. The projects also deal with the materials' interaction with their environment (Systems) through the study, the optimization, and the interfaces' simulation.
The IRN objectives are to strengthen the underway actions with financial supports. Simultaneously, it encourages and facilitates the creation of new ones (with a consortium including ELyT members and other partners that may eventually join the network, or through young talents promotion). Fundamental aspects but also applications and links with industrial partners are encouraged. It is one of the critical points of the network. Within a few years, we can observe that many contacts have been taken with industrial partners interested in research collaboration among the network. It has led to joint PhDs such as with Michelin or Denso. A collaboration with Nippon Steel had also emerged. An engineer from this company (Masato Taira) is now preparing for his PhD in MATEIS lab at INSA Lyon.

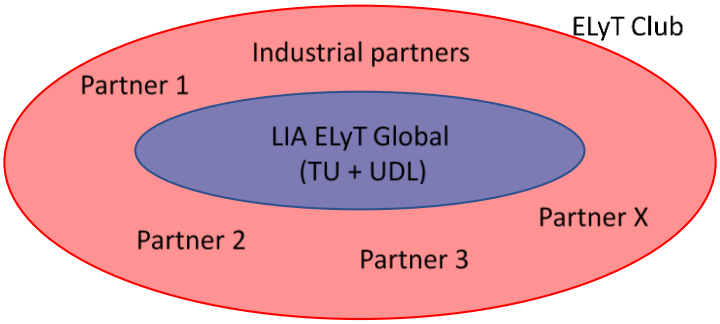



*Figure 1: Scheme of the concept of ELyT Global and ELyT Club.*

*Research aspect - the ELyT Global chart*

Both Tohoku University and Université de Lyon are renowned for their contributions to engineering sciences, "ELyT" standing indeed for "Engineering sciences Lyon-Tohoku". In the first years of the collaboration, five topics were put forward:

- Biosciences & engineering,
- Durability, reliability in energy and transportation,
- Nano & micro-scale materials and devices,
- Flow dynamics, heat transfers, and microfluidics,
- Tribology.

The goal of ELyT Global is not only to allow high-quality research but also to improve transfers towards the industry and answer current societal stakes. As depicted in Figure 2, scientific developments may lead to a better understanding of phenomena, but not necessary to develop new technologies. For the latter point, several fields of research need to be considered jointly. Likewise, technological development can be done empirically sometimes without accurately understanding the fundamental phenomena at stake. Therefore, for a technology to become mature, with the possibility of evolving towards better efficiency and reliability and spreading to other applications, some fundamental researches are still necessary.

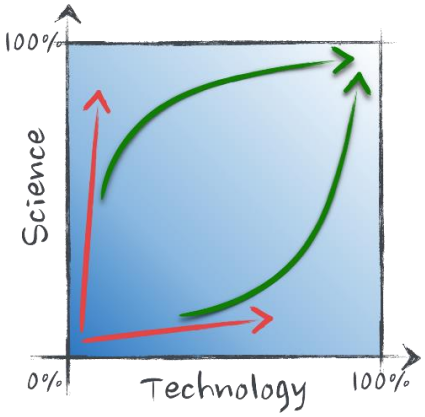



*Figure 2: Schematic illustrating the paths towards mature technologies, based on the combination of science and technology. ELyT Global aims at following the green arrows, using science to improve technology.*

It is why ELyT Global is organized not only by scientific fields, but also by application fields, to help scientific understanding along with technological development. Considering challenges for our modern society nowadays, together with people involved in ELyT Global, 3 application field, called "themes", were defined:

- **Transportation** – From car and rail industry to aeronautics;
- **Energy** – From traditional energy sources towards renewable ones;
- **Engineering for Health** – From materials for biomedical application to biological interactions.

On the other hand, the scientific fields where significant signs of progress are expected from collaborations within ELyT Global have been gathered into 3 "scientific topics":

- **Materials and structure design** – From synthesis to characterization;
- **Surfaces and interfaces** – Mechanical, chemical, and physical interactions;
- **Simulation and modeling** – From the atoms to the system.

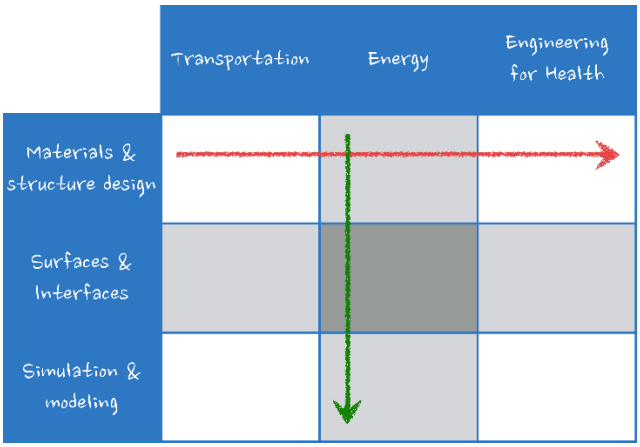



*Figure 3: The 3 main themes (columns) and the three main topics (rows) of ELyT Global. Projects will belong either to a theme for application-oriented ones, or to a topic for science-oriented ones.*

Each of the 3 main themes needs support from the 3 main scientific topics, and likewise, scientific achievements in the 3 main topics might be applied for all 3 main themes. It allows science-oriented projects (horizontal red arrow on Figure 3) and application-oriented projects (vertical green arrow on Figure 3).

## The three main themes

### Transportation

In all industrialized societies, transportation represents a strategic issue for economic development. The need to transport persons or goods is also increasing enormously with human and resource development, impacting the environment. Many transportation systems have been developed for one or two centuries, and for some of them, the progress has been very rapid. Space or aeronautics industries, automotive and railways industries, are strategic issues for a nation and competitions are severe in developing the best systems.

The challenges that we consider are related to various aspects:

- Respect the natural resources by using energy-saving systems,
- Respect the quality of life with environment-friendly systems,
- Improve the safety and reliability of transportation,
- Provide more comfortable systems,
- Develop performant and durable systems.

As a consequence, the scientific and technological objectives that the society have to tackle are:

- a decrease in the weight of mechanical systems, to reduce the energy spent to move the systems themselves while preserving (or even improving) their safety and reliability;
- an increase of performances and lifetime associated to:
  - a control of friction for all tribological parts – decrease of friction for sliding contacts, especially under boundary and hydrodynamic lubrication regime, or increase of friction for force transfer systems, like clutches, brakes, or tires,
  - an increase of wear, corrosion and oxidation resistance to reduce maintenance costs and wasting of materials, for increasingly severe operating conditions required by the improvement of performances;
- a decrease of vibrations and noise, for improved comfort;
- a decrease of pollutants emission, from the manufacturing to the operation of the systems;
- a decrease in air and fluid resistance around transportation system such as airplane, ship, train, automotive car and so on;

- the development of new technologies to support the increasing use of electric power in transportation.

We have to study the structures, materials (conventional and new materials, structural materials, surface treatments, coatings, composites…), and lubricants. Mechanics of materials is then an essential field of research, together with tribology and manufacturing processes.

In the network of ELyT Global, many of the related topics are considered; the following sub-themes can be defined:

- **Materials and structures design**. It is essential to understand and optimize the behavior of systems from the macro to the microscale,
- **Surfaces and interfaces** are essential for the behavior of materials and systems as particularly in the field of tribology and lubricants,
- **Simulation and modeling** will undoubtedly help for progress in these fields.

### Energy

Our modern societies face a critical challenge: the energy demand is continuously increasing to sustain worldwide development, while it is now generally accepted that $CO_2$ emissions must be drastically decreased to fight changes of the earth's climate. Whatever the energy source – fossil, nuclear or renewable –, and whatever the level (microwatt to gigawatt), similar issues must be addressed:

- Improving the safety, reliability, and economy for energy production,
- Improving the efficiency of energy production systems,
- Developing solutions for energy storage and energy vectors.

The safety and reliability of energy production systems are indeed critical. It may seem quite apparent in nuclear power, where the risk of accidents must be minimized. Simultaneously, the operating life of existing plants requires more extensions than ever for economic reasons. But despite the comparatively reduced danger of an accident on a renewable energy plant, we should keep in mind that the reliability is directly related to maintenance costs: replacing a ball bearing on a windmill is not an easy task and requires heavy-duty operations. Understanding the materials degradation mechanisms, predicting the lifetime of systems, and the health monitoring of the structures are therefore vital challenges.

Improving the efficiency of energy production systems is usually related to an increase in the severity of operating conditions, like higher temperatures for fossil fuel power generation, harsher environments for next-generation nuclear plants (e.g., liquid Na or Pb environments instead of pressurized water), or higher mechanical stresses in the case of renewable energies. It requires the improvement of existing materials and/or the development of new ones and considering layered materials to preserve structural properties while promoting surface protection.

Finally, the challenge of energy storage and transport must also be considered. The mismatch between energy production and energy consumption requires the development of efficient storage solutions based on mechanics (e.g., pumped-stored hydroelectricity) or on chemistry (e.g., electricity in batteries or hydrogen production for fuel cells). On the other hand, a large amount of energy is used for transportation, where fossil fuels are extensively used. New energy vectors must be thus considered as electricity in batteries or as hydrogen. Again, advanced materials must sustain harsh electrochemical conditions or face hydrogen embrittlement and stress corrosion cracking.

While these challenges are clear for large-production plants at first, it has to be noted that they also apply to low-energy systems. Indeed, the latter devices are deployed in large numbers (e.g., Internet of Things). The cumulative energy therefore reaches similar levels than large production systems (for instance, information and communication technologies consume roughly the same energy as the airline industry), hence raising very similar issues.

All these technological challenges related to energy rely on the multiscale and multilevel design of materials and structures, including health monitoring systems, on the optimization of interactions at surfaces and interfaces, and the use of simulation and modeling, especially for lifetime prediction.

### Engineering for health

Challenges of engineering for health are maintaining health (involving anti-aging) and curing patients less invasively. Recent research activities focus only on a single discipline, which means developments are performed with a single viewpoint. However, health needs a multi-disciplinary approach (Figure 4), because health devices must follow strict regulations. Not only nano-bio material, but also macro-biomaterial is necessary for the success of health engineering. Multidisciplinary community and harmonization are strongly recommended under the governmental regulations.

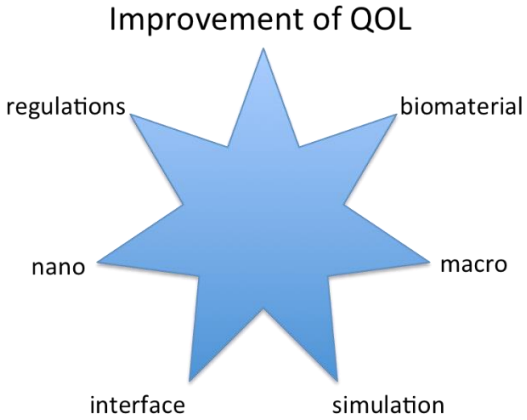



*Figure 4: Schematic of the different challenges to address for improving quality of life (QOL).*

Therefore, the next breakthroughs are considered necessary:

1. **Biomaterial:** Nano- and Macro- materials to overcome the limitations of current devices are challenged;
2. **Interfaces:** The interactions between the human body and biomaterial (medical devices) need to be clarified;
3. **Simulations:** To achieve optimized treatments, simulation techniques need to be improved, considering the variety of interactions (biological, physical, chemical, mechanical) and the multi-scale nature, from nano- to macro-scale, of these interactions.
4. **Regulations:** Medical devices (MD) have to follow ever stronger regulations to ensure patients' safety and comfort. For example, Europe adopted regulations focused on MD's safety and performances (EU 2017/745), and authorities will pay greater attention to the articular prosthesis or dental implants' characteristics and their constitutive materials.

In this respect, a better knowledge of the interactions between cells or tissues and materials is challenging. ELyT Global can significantly help to address several issues related to this domain.

## The three main scientific topics

### Materials and structure design

Materials' design is a new trend in materials science. We include the term “structure” because many of the situations tackled will deal with microstructures or systems that can be regarded as structures, such as micro-devices for local energy harvesting or self-health monitoring. The problem can be foreseen from both an experimental and a modeling point of view:

- Modeling can first be used to predict the best microstructure or structure to obtain a targeted property or a set of targeted properties. For example, this is already used by some of the partners of ELyT Global for predicting the best structure of porous materials through shape

optimization. It can be further developed in the field of bulk multiphase materials (metallic alloys, co-polymers, ceramics and their composites). This shape optimization, applied to the microstructure, can be implemented at different relevant scales, using the most appropriate modeling methods (from ab initio, up to FE).

- One of the big advantages of our group of partners is that corresponding optimized microstructures can be experimentally produced. Different fabrication methods, including additive manufacturing and/or thermomechanical treatments, could produce the targeted microstructures.

This transversal topic is declined in the three different application fields. We give in this paragraph a few examples. There is a need for materials and structure design for energy applications. Microstructures could be optimized to obtain better creep or corrosion resistance, for instance, in severely loaded samples. In transportation, shape optimization of porous structures and their fabrication by additive manufacturing is an already existing challenge. Several challenges can be considered in health applications, like improvement of metals' fatigue life through appropriate thermomechanical processing or optimization of the morphology of pores for better cell ingrowth.

### Surface and interfaces

Depending on the scientific community, the surface and interface thicknesses are defined from 1-10 nanometers (adventitious/adsorbed layers), to 10-100 nm (oxides layers etc…) or even thicker layers like in the case of plastic deformation (100-500 µm). Since only relatively few atoms are involved in the surface compared to the bulk, specific techniques are dedicated to study their morphology, topography, physicochemical composition, or structure. W. Pauli used to say that “God made solids, but surfaces were the work of the devil”. Tailoring surfaces to the right application is thus a current scientific challenge.

The study of an interface is even more complicated when considering the transition between two different phases of matter. Adding the fact that surfaces and interfaces are not always static but could be under motion makes it even more challenging for their studies.

Surface and interface properties play a vital role in many application fields such as catalysis, corrosion science, tribology, heat and fluid transfer etc. Below are some challenges that ELyT Global contributes addressing:

- **Tribology:**
  - ***Fundamental phenomena controlling friction & wear:*** depending on system nature and contact conditions, different phenomena can be involved, like adhesion or abrasion, controlled not only by the mechanical properties and the chemistry of interfacial materials but also by the heterogeneities of the sliding surfaces. In situ experimental techniques (environmental XPS, SEM tribometer…) and numerical simulations techniques (Molecular Dynamics, QC Molecular Dynamics…), which can be gathered thanks to ELyT Global, are helpful to deepen our understanding.
  - ***Tailoring surfaces for lubricant application:*** texturing is a promising way of tailoring surfaces to the right application, as it can impact hydrodynamic and elastohydrodynamic effects. It can provide lubricant’s reservoir, have some cooling effect, or could trap wear particles.
  - ***Biotribology:*** The study of the friction behavior of soft materials, like hydrogels, which have complex visco-elastic behavior under motion, is of great interest and has many applications for soft tissues, for instance, to mimic real tissue behavior for the practice of surgeons. Another interesting subject is to take the benefit of frictional heating for cell treatment.
- **Fundamental of corrosion science:** For instance, tribocorrosion or H embrittlement of steels, since they play a leading role in materials lifetime, they require more fundamental understanding.

- **Investigating surface reactivity under mechanical stress, or mechanical behavior under various environments:** in many fields, such as biology, stress corrosion cracking, tribology, and tribochemistry or mechanochemical polishing, the origin of mechanochemical phenomena, *i.e.*, how chemical reaction and mechanical stress affect each other, remains a fundamental question.
- **Heat and fluid transfer:**
  - ***Modelling of liquid bridges:*** Dynamic resistance of liquid bridge movement changes depending on the contact angle, including the difference between static and kinetic ones. Since the liquid-gas interface is significantly contributing to the whole system, the amount of kinetic momentum transfer cannot be estimated from macroscopic analyses, and the development of proper models is thus paramount.
  - ***Surface tailoring for fluid dynamics application:***
    - Reduction of fluid resistance can be expected by making appropriate surface, like "shark skin".
    - Wettability control: it is possible to control transfer resistance by controlling the contact angle of liquid. For example, proton transferability in polymers changes drastically depending on surface wettability, affecting fuel cells' performance.
  - ***Fundamental of heat transfer at interface:*** the control of thermal conductivity is possible by reducing interfacial thermal resistance, which opens many applications to various functional materials. Especially, nanoscale surface texturing has been reported to provide a drastic reduction of thermal resistance.

### Simulation and modeling

To ensure sustainability, new technologies are under development to provide new materials and structures, new surfaces and interfaces for Transportation, Energy and Engineering for health applications. The main challenges to consider are:

- the understanding of the physical phenomena that limit the lifetime and the performances of the existing solutions,
- the design and prediction of new solutions' performances: which synthesis process for which matter structures to control the final properties?

The physical phenomena of interest may find their origin at the system size and down to the atomic scale. Moreover, the matter properties not only depend on the microstructure but also the atomic organization. Thus, combined with the latest experimental characterization tools, modeling, and simulations are of great help to study the matter from the atomic- to the system-scale.

Université de Lyon and Tohoku University have access to local hardware facilities required for High-Performance Computation. They both use the same kind of software to deal with Fluid Mechanics and Solid Mechanics simulations (Abaqus, Fluent) but also Molecular Dynamics (LAMMPS, GROMACS) and Quantum Chemistry (DMol3, and also Colors, which is developed at TU). It allows tackling with multiscale and multi-physical approaches, which are both mandatory to study 'materials and structures design' and 'Surfaces and Interfaces', whatever the field of application (Transportation, Energy or Engineering for Health).

As an example, simulations are used to study the heat and mass transfer at the nanoscale in nanostructures and interfaces with applications for:

- new generation of fuel cells and batteries,
- steel, ceramic and polymer ageing under several environments: irradiation, corrosion…
- friction and wear reduction…

Also, Fluid Mechanics and Solid Mechanics simulations at the system size using discretization techniques are carried out to ensure that the whole system is reliable (large deformation simulations, energy dissipation…) and to evaluate its lifetime (fatigue simulation). Considering the importance of

simulations, ELyT Global seeks to promote projects in which the collaboration between the research teams includes the simulation to increase the research's added value.

### Outputs

To summarize, the research collaborations of ELyT Global contribute to various societal challenges, which are considered paramount in our two countries. They can be gathered under the following non-exhaustive list:

- Systems'efficiency:
  - Reduction of $CO_2$ emissions and environmental impact,
  - Reduction of energy consumption: from airplane to internal medical devices,
  - Optimization of processes.
- Safety & reliability:
  - Protecting the populations,
  - Increasing lifetime of devices to minimize maintenance impact,
  - Improving lifetime prediction and monitoring.
- Resources management:
  - Improving the use of natural resources,
  - Life cycle of materials and systems,
  - A better design for an easier recycling.
- Quality of life:
  - Provide more comfort to the people,
  - Less invasive and more biocompatible materials,
  - Protecting the environment.

### ELyT workshops

The success of ELyT Global is based on exchanges and active joint researches. To support this, a workshop is organized each year, alternatively in France and Japan. These 3 or 4 days allow researchers to present the new results obtained in the IRN framework, and it is a good opportunity to have scientific discussions and prospect new projects. Partners of the ELyT Club are also invited to these workshops as well as others academic and industrial potential partners. It is worthy to notice that about 80 - 100 participants attend these meeting among them at least 40 - 50 come from abroad.

### *Education aspect – training through international research*

### ELyT School[11]

#### Overview

ELyT School is a summer school program: it is the principal instrument for students' training in the framework of long-lasting collaborations between Sendai and Lyon.

It is organized every year (alternating between France and Japan), and was created in 2009 in the framework of ELyT Lab. Between 30 and 40 students (mainly from Tohoku University, INSA Lyon and ECL) participate to ELyT School every year. Since 2013, students from other institutions (partners of Tohoku University, INSA Lyon and/or ECL) can also participate. Since 2014, each student attending ELyT School is awarded 2 ECTS credits (or equivalent).

One of the main goals is to present ELyT Global network and the partner institutions to students from the other country – mainly Master students, to encourage the creation of jointly-supervised PhD research projects (in a similar approach than "Ph.D. track" programs), and undergraduate students to promote Master double-degree programs. It has already proven its efficiency: since ELyT School was created, almost all the students who went for a double degree (either master or PhD level) between Tohoku University and INSA Lyon or ECL participated in, at least, one edition of ELyT School.

[11] https://www.elyt-lab.com/en/content/elyt-school

### Objectives

The objectives of ELyT School, for the training of engineering students, are:

- scientific training in the theme of ELyT School;
- multicultural experience (incl. knowledge about a foreign country and its culture);
- active learning with project work in a multicultural group;
- promotion of ELyT Global (incl. research theme in partner labs) and organizing institutions.

Concerning the scientific training, since the earthquake and tsunami in Tohoku in March 2011, the theme of ELyT School was "Energy, Environment and Safety". From 2016, the theme of ELyT School is "Materials, Energy, Environment and Safety".

### Program

Usually, the ELyT School lasts about 10 days. It includes scientific activities, for about 40 to 50 hours, and cultural, social, and sightseeing activities, for about 20 to 30 hours.

The program includes scientific activities related to its theme with:

- academic lectures (scientific presentations) given by Japanese and French professors,
- project research work in small groups on this subject with oral presentations,
- an industry tour – *e.g.*, a hydroelectric power plant, a dam and a lock (from Compagnie Nationale du Rhône CNR) in France; a natural gas power plant and a production site of photovoltaics energy in Japan,
- student presentations,
- campus and labs tours to increase awareness of research that might be of mutual interest.

Concerning project research work, the students are divided into 3 subgroups on one of the following themes:

- renewable energy,
- nuclear waste,
- safety and energy production,
- new energies for transportation to improve the environment.

They spent time together for brainstorming, exchange of ideas, information search, and synthesis. For each subgroup, a 20 min presentation in front of all the students and a jury of professors conclude this project work. The award of 2 ECTS depends on the quality of this project presentation and attendance to all other activities.

The cultural, social, and sightseeing activities consist of introducing French or Japanese culture, French or Japanese language lessons, photo contest, tea ceremony, picnic, trip to Chamonix or Hiraizumi…

Students actively participate in ELyT School, during the project work and cultural, social and sightseeing activities. On top of that, some events are organized by local students and some students, who participate in 2 successive ELyT Schools can help in the organization of their second ELyT School.

Amongst the many positive results of the previous editions of the ELyT School, we should emphasize:

- The excellent quality of the student presentations on their project work;
- The high level of the scientific presentations from the lecturers;
- The quality of the cultural, social and sightseeing activities;
- The fruitful exchanges between students from different countries and cultures.

## Exchange Master and PhD students

Since 2009 and the launch of ELyT Lab, many students were involved through extended stays in Lyon or Sendai research laboratories. Such research stays fall within the frame of joint research projects within ELyT Global and thus depend on project activities. These stays can have three forms:

- Research stay in a lab (from few weeks to one year) at the master or Ph.D. level
- Double Degree Master
- Double Degree PhD

Concerning Double Degree Master, about 5 to 10 students are involved each year, but only one came from Tohoku University to Lyon since the beginning of the program. It may be because most of the lessons are given in French, while Master programs in Japan include a large part of training through research inside the labs. To address this issue, attracting Japanese Master students through abroad internships in international collaboration is promoted by the IRN.

### ELyT Global: a pool of well-trained students for industry

The current activities of ELyT School, as well as the students' exchange, from simple research visit to double degree master or Ph.D. is strongly supported by ELyT Global. Although the primary goal of an IRN is not education but research, the students' exchanges are a very efficient way to promote collaborative research between our distant countries. In such exchanges, the student learns new skills and discovers different ways of thinking, while the collaborating laboratories can identify students with high potential and have some workforce to help their common research topics. ELyT School is thus a very efficient way to attract high-level students. It is even more real when considering that the Japanese Master's curriculum is strongly research-oriented, with most of the time spent in laboratories. Moreover, an additional benefit of training students through the collaborative research projects is to attract industrial companies' attention towards ELyT Global. Indeed, such well-trained students opened to different cultures, and with high-level scientific skills, should be of high interest for such companies' recruitment. In the long run, we hope to increase their interest in ELyT Global, and eventually for joining ELyT Club. Also, as future deciders in the industrial world, students may contribute to the industrial partnership development within ELyT Global following such training.

## *Management and administration*

### Team

Management team is presented in Table 1. Some actions, representing a significant amount of work (*e.g.* ELyT School), have their dedicated person-in-charge.

| | INSA | ECL | Tohoku University |
|---|---|---|---|
| **Head** | Prof. LALLART Mickaël<br>mickael.lallart@insa-lyon.fr | Dr. FRIDRICI Vincent<br>vincent.fridrici@ec-lyon.fr | Prof. UCHIMOTO Tetsuya<br>uchimoto@ifs.tohoku.ac.jp<br>Dr. SATO Yutaka<br>ytksato@material.tohoku.ac.jp |
| **Liaison Office** | Dr. JOLY POTTUZ Lucile<br>lucile.joly-pottuz@insa-lyon.fr | | Prof. UCHIMOTO Tetsuya<br>uchimoto@ifs.tohoku.ac.jp |
| **Financial aspects** | Ms DORIEUX Evelyne<br>evelyne.dorieux@insa-lyon.fr | Ms COURSAGE Elodie<br>elodie.coursage@ec-lyon.fr | Prof. UCHIMOTO Tetsuya |
| **ELyT School** | Dr. FAVE Alain<br>alain.fave@insa-lyon.fr<br>Dr. JOLY POTTUZ Lucile | Dr. BESSET Sébastien<br>sebastien.besset@ec-lyon.fr | Prof. UCHIMOTO Tetsuya |
| **Annual workshop** | Prof. LALLART Mickaël<br>Ms DORIEUX Evelyne | Dr. FRIDRICI Vincent<br>Ms SABIN Allyriane<br>allyriane.sabin@ec-lyon.fr | Prof. UCHIMOTO Tetsuya |

*Table 1. ELyT Global management team.*

### Steering committee

The steering committee defines the IRN's internal regulations. It formulates recommendations about budget and orientations, makes sure that the strategy which has been defined by the scientific committee is implemented, and controls the project management. In addition to the directors, members are:

- The Director of the CNRS Institute of Information and Engineering Sciences, or her representative,
- The dean of research of Ecole Centrale de Lyon or his representative,
- The dean of research of INSA-Lyon or her representative,
- Two representatives of Tohoku University.

It meets 3 times during the IRN renewing period: first year, half period and last year.

### Scientific committee

To help in defining the scientific strategy of ELyT Global, and to provide feedback on the annual scientific reports, a scientific committee with an internal representative of each theme and scientific topics as well as dedicated actions (*e.g.* ELyT School) in addition to IRN directors meet each year to discuss and define the orientations of the IRN.

### Involved laboratories

Laboratories involved in the ELyT Global actions are listed in Table 2.

| ***French side*** | |
|---|---|
| *Laboratory* | *Institutions* |
| Center for Thermal Science of Lyon (CETHIL) | INSA Lyon / UCBL CNRS |
| Lyon Institute of Nanotechnology (INL) | ECL / INSA Lyon / UCB CNRS |
| Contacts and Structural Mechanics Laboratory (LaMCoS) | INSA Lyon / CNRS |
| Laboratory of Electrical Engineering and Ferroelectricity (LGEF) | INSA Lyon |
| Laboratory of Vibration and Acoustics (LVA) | INSA Lyon |
| Laboratory of Fluid Mechanics and Acoustics (LMFA) | ECL / INSA Lyon / UCBL / CNRS |
| Laboratory of Tribology and Systems Dynamics (LTDS) | ECL / ENISE / CNRS |
| Materials, Engineering & Science (MATEIS) | INSA Lyon / CNRS |
| Institute of Light and Matter (ILM) | UCBL / CNRS |
| Materials under Extreme Conditions (ELyTMaX) | TU / CNRS / INSA / ECL / UCBL |
| Laboratory of Earth Sciences (LST) | UCBL / ENS / CNRS |
| Research Center for Acquisition and Image Processing for Health (CREATIS) | INSA / CNRS / INSERM UCBL |
| Cardiovascular, Metabolism, Diabetologia and Nutrition (CARMEN) | INSA / INSERM / UCBL |
| Materials and Processes Science and Engineering Laboratory (SIMaP) | Grenoble INP / CNRS |
| Laboratory of Geophysical and Industrial Flows (LEGI) | Grenoble INP / UJF / CNRS |
| ***Japanese side*** | |
| *Laboratory* | *Institutions* |
| Graduate School of Engineering (GSE) | Tohoku University |
| Institute of Fluid Science (IFS) | Tohoku University |
| Institute for Materials Research (IMR) | Tohoku University |
| Graduate School of Science (GSS) | Tohoku University |
| Graduate School of Medicine (GSM) | Tohoku University |
| Graduate School of Biomedical Engineering (GSBE) | Tohoku University |
| New Industry Creation Hatchery Center (NICHe) | Tohoku University |
| International Research Institute of Disaster Science (IRIDeS) | Tohoku University |
| Center for Information Technology in Education (CITE) | Tohoku University |
| Frontier Research Institute for Interdisciplinary Sciences (FRIS) | Tohoku University |
| Enriching Society through Materials Science (WPI-AIMR) | Tohoku University |
| Graduate School of Environmental Studies (GSES) | Tohoku University |
| Institute of Multidisciplinary Research for advanced Materials (IMRAM) | Tohoku University |
| Institute of Molecular Biomembrane and Glycobiology | Tohoku Pharmaceutical University |
| Department of Control and Information Systems Engineering | National Institute of Technology, Tsuruoka College |

*Table 2. laboratories involved in ELyT Global activities.*

# *2023 activities*

## Forewords

2023 can be considered as a **stabilization year**, with almost back-to-normal situation compared to pre-COVID years. The **significant release of the travel conditions** (that restarted in 2022) allowed researchers and students exchanges, and effective international collaboration in projects.

The **significant positive dynamic** that arose in the network in 2022 was kept and enlarged in 2023. This shows the **resilience of the network** and led to stabilization or slight increase of the majority of the indicators. Hence, the number of **involved researchers slightly increased to 98** (+2 compared to 2022). The number of projects also slightly increased from 25 in 2022 to **26 in 2023.** We have a turn-over of about 10% (2 projects stopped and 3 new projects started). The number of labs involved in ELyT Global increased from 27 in 2022 to **32 in 2023**. After the **metamorphosis** shown in ELyT Global in 2022, we are then in a phase of stabilization, where projects are developing and collaboration is strengthening.

The freedom to travel allowed us to organize many events and celebrations face-to-face (like the restart of **ELyT School** in a normal format, or **mini workshops**) along with other **numerous activities** as detailed below.

## ELyT workshop

No edition of conventional ELyT workshop was held in calendar year 2023, as the previous edition was held in November 2022. ELyT workshop 2024 happens in March 2024 in Japan and we want to go back to the annual rhythm of workshop, in February or March, alternatively in France and in Japan, and keep this rhythm for the future. Nevertheless, we had workshops both in university years 2022/2023 and 2023/2024 and in Japanese fiscal years 2022 and 2023.

## Scientific workshops

### ELyT mini workshop

On December 13$^{th}$ and 14$^{th}$, 2023, a **mini-workshop focusing on ELyT themes** gathered 30 participants from ECL, INSA and TU. The workshop provided an opportunity to share common projects and build new ones, through 15 presentations as well as lab tours. This mini workshop was the occasion of fruitful discussion around some of the ELyT themes, such as combustion, medical imaging, battery or fuel cell, energy and energy conversion, ammonia application… Pictures taken during the mini workshop are shown on Figure 5. Figure 6 presents the program of the mini workshop.

*Figure 5: Pictures taken during the mini workshop.*

Mini Workshop

Tohoku University – Ecole Centrale Lyon – INSA Lyon

December 13th-14th

December 13th (afternoon)

Location : École Centrale Lyon, building W1, room 106

| | | |
|---|---|---|
| **2 :00 PM – 2 :20 PM** | **Welcome (Vincent Fridrici)** | |
| 2 :20 PM – 2 :40 PM | T. Tokumasu | Large scale molecular simulations for transport phenomena in next generation energy systems |
| 2 :40 PM – 3 :00 PM | T. Uchimoto | TBD |
| 3 :00 PM – 3 :20 PM | D. Nelias | A numerical analysis on how friction at the tire / pavement interface may damage roads |
| 3 :20 PM – 3 :40 PM | K. Ogawa | Evaluation of Degradation of Thermal Barrier Coatings in Reducing Environment |
| 3 :40 PM – 4 :00 PM | J. Raviol | PROGNOSIS OF INTRACRANIAL ANEURYSMS BREAKING RISK - Numerical demonstration and in vivo application of an intracranial aneurysm mechanical characterisation device. |
| 4 :00 PM – 4 :30 PM | Coffee break | |
| 4 :30 PM – 5 :30 PM | V. Fridrici | Labs tour at ECL |

December 14th (morning)

Location : INSA Lyon, Bibliothèque Marie Curie, amphithéâtre

| | | |
|---|---|---|
| **8 :45 AM – 9 :00 PM** | **Welcome (Nicolas Mary, Mickael Lallart)** | |
| 9 :00 AM – 9 :20 AM | K. Funamoto | Microfluidic platform to observe cellular behaviors under simultaneous exposure to flow and hypoxia |
| 9 :20 AM – 10 :00 AM | H.J. Ling | Intraventricular vector flow imaging using physics-informed deep learning |
| 10 :00 AM – 10 :20 AM | M. Hasegawa | Computational Fluid Dynamics of Air for Respiratory Diseases |
| 10 :20 AM – 10 :40 AM | Coffee break | |
| 10 :40 AM – 11 :00 AM | K. Yanagisawa | Development of a pipeline for blood flow high-speed analysis using deep learning techniques |
| 11 :00 AM – 11 :30 AM | A. Karan | NH2* chemiluminescence in premixed-ammonia air flames |
| 11 :30 AM – 12 :00 AM | P. Xavier | Investigation of flame-wall interactions in aircraft combustion chambers |
| 12 :00 AM – 12 :20 AM | T. Adachi | Electrification of aircraft environmental control system |

*Figure 6: Program of the mini workshop.*

## Events organized by Tohoku Forum for Creativity (TFC)

In 2023, TFC managed 2 "Future Society Design" programs involving researchers from the ELyT Global network:

- Sustainable Structural Integrity for Energy Infrastructure [12], with lectures and symposia organized in Sendai;
- Establishment of Lightning Resistant Metal Coating Technology on CFRP Assisted by Kinetic, Physical and Chemical Energies[13], with a research forum organized in hybrid mode.

[12] https://www.tfc.tohoku.ac.jp/future-society-design-program/program/5005.html

[13] https://www.tfc.tohoku.ac.jp/future-society-design-program/program/5001.html

## Tohoku-Lyon Symposium: Bridging Nano and Macro Mechanics

A seminar entitled "Tohoku-Lyon Symposium: Bridging Nano and Macro Mechanics" was organized on September 22nd, 2023 at Tohoku University, Sendai, Japan by Prof Mizukami, NICHe, co-hosted by CREST-JST and ELyTMaX. Gathering 25 participants, the discussions were focused on the mechanics of soft matter, ice as well as understanding of friction and development of new materials for circular economy. This symposium is related to the activities of the ELyT Global project FRIISE, within the framework of the JST-CREST program. Speakers and participants were from Japan and France: Tohoku University, Keio University, The University of Tokyo, INSA Lyon and Ecole Centrale de Lyon. The program is provided on Figure 7. A next edition will be held in 2024 in Lyon.


*Figure 7: Program of the "Tohoku-Lyon Symposium: Bridging Nano and Macro Mechanics".*

## Steering committee

On December 15th, 2023, ELyTMaX and ELyT Global steering committee took place in Lyon, with the participation of institution representatives and external experts. This event also marked the inauguration of the new premises of ELyTMaX@Lyon, where Professor Ueki, Executive Vice President for General Affairs, Financial Affairs and International Relations of Tohoku University, and Mr. Consul Kuratomi signed the guestbook of the Liaison Office of Tohoku University in Lyon (Figure 8).

*Figure 8: Signature of the guestbook of the Liaison Office of Tohoku University in Lyon*

*Figure 9: Foreign Minister's Commendation award for Professor Cavaillé*

## Awards and recognition

Still on December 15th, 2023, Professor Jean-Yves Cavaillé was awarded the Japanese Foreign Minister's Commendation (Figure 9). The award ceremony was organized by the Consul of Japan in Lyon, Mr. Kuratomi. This high distinction is awarded by the Japanese government to individuals who have made outstanding achievements in the field of international relations, and who have played a major role in promoting friendship between Japan and other countries. Through this certificate of honor, Japan wishes to acknowledge and salute the achievements initiated and developed by Jean-Yves Cavaillé over the last twenty years, to strengthen scientific and technological cooperation between Japan and France.

On February 21st, 2023, Chrystelle Bernard and Lucas Ollivier-Lamarque have each been awarded Jean Capelle / Gaston Berger medals. This distinction recognizes the scientific implication and recognition of researchers. Chrystelle Bernard received the medal due to her outstanding work on numerical simulation of Cold Spray, which led to the Hyogo-Kansai Caterpillar STEM Award (special prize of the committee). Lucas Ollivier-Lamarque received the prize of the best presentation of the 18th ICFD, for his work on « Methodology to detect water uptake in Polymer Materials Using Non-Contact capacitor sensor». Both of them were involved for many years in research projects in the framework of ELyT Global. In addition to ELyT researchers, Marie-Pierre Favre (former vice-president for International Affairs at INSA de Lyon) received the medal as well for her outstanding contribution to the ELyT initiative. She also recently got the internationalization award from Tohoku University.

## ELyT School

The fourteenth edition of the Summer School "ELyT School" took place **from August 31th to September 8th, 2023 in Sendai** (Miyagi Prefecture, Japan), on the campus of Tohoku University. Due to COVID, the last Japanese edition dated from 2018 and it was with great enthusiasm that teachers and students met again around the themes of engineering and energy. **40 students** participated in this edition: 20 from Lyon, and 20 from Tohoku University. For students from Tohoku University, many **undergraduate students** participated (together with few master students) in order to promote the collaboration earlier and to try to attract them for DD master or for students exchanges during their master studies. It was the first edition of ELyT School after COVID with the regular length (10 days) because the 2022 edition in Lyon was shortened to a few days, in parallel to the 2022 edition of ELyT workshop.

In addition to the **group work carried out by the students** on subjects linked to the synchrotron, 3D printing or even machine learning, cultural activities made it possible to **build relationships** between young Japanese and French people: visit to a temple, introduction to the tea ceremony, photo competition... This 2023 edition was **a great success** for all!

Pictures taken during ELyT School 2023 are presented in Figure 10. The detailed timetable of the ELyT School is provided in Table 3.

*Figure 10: Pictures taken during ELyT School 2023 in Sendai.*

| | August 31 | September 1 | September 2 | September 3 | September 4 | September 5 | September 6 | September 7 | September 8 | September 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thursday | Friday | Saturday | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| 8:30 - 9:00 | | | | | | | | | | |
| 9:00 - 9:30 | | Opening ceremony | Chusonji temple tour | Free time | Lecture:Joly-Pottuz L | Lecture: Uchimoto T | Lecture: Yashiro W | Lecture: Anzai H | Lecture: Fave A | Free discussion |
| 9:30 - 10:00 | | | | | | | | | | |
| 10:00 - 10:30 | | Student presentation | | | | Lecture: Mary N | | | | |
| 10:30 - 11:00 | | | | | Student presentation | | Student project | Student project | Student project | |
| 11:00 - 11:30 | | | | | | Lecture: Feuillard G | | | | |
| 11:30 - 12:00 | Arriving | | | | | | | | | |
| 12:00 - 12:30 | | Lunch@Kawauchi | | | Lunch@Aobayama | Lunch@Katahira | Lunch@Aobayama | Lunch@Aobayama | Lunch@Aobayama | Leaving |
| 12:30 - 13:00 | | | | | | | | | | |
| 13:00 - 13:30 | | Student project | | | Student project | Student project | Student project | Lab tour@Aobayama | Project presentation | |
| 13:30 - 14:00 | | | | | | | | | | |
| 14:00 - 14:30 | | Lecture: Fukai Y | | | Nano Terasu visiting | Lab tour@Katahira | Tea ceremony | | | |
| 14:30 - 15:00 | | | | | | | | | | |
| 15:00 - 15:30 | | | | | | | | | | |
| 15:30 - 16:00 | | Lecture: Kurita H | | | | | | | | |
| 16:00 - 16:30 | Welcome reception | | | | | | | | SP award | |
| 16:30 - 17:00 | | | | | | | | | | |
| 17:00 - 17:30 | | | | | | | | | | |
| 17:30 - 18:00 | | | | | | | | | | |
| 18:00 - 18:30 | | | | | | | | | Farewell party | |
| 18:30 - 19:00 | | | | | | | | | | |
| 19:00 - 19:30 | | | | | | | | | | |
| 19:30 - 20:00 | | | | | | | | | | |

*Table 3. ELyT School schedule.*

## Ab Initio and Molecular Dynamics School 2023

In February 2020, the first Molecular Dynamics school was organized in Sendai within the ELyT Global framework. A second edition of this school was organized in March 2022 in Lyon in a hybrid format, still within the ELyT Global Framework, but enlarged to a new partner: Aristotle University of Thessaloniki (AUTH), Greece. The topic of the school was then enriched since Molecular Dynamics but also Ab Initio simulations were parts of the program.

The third edition of this school was held from **March 10$^{th}$ to March 18$^{th}$, 2023** at AUTH in Greece. In this school, the fundamentals and applications of Ab Initio calculations by Quantum Espresso and Molecular Dynamics simulations by Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS) were studied. 7 teachers (2 from Japan, 4 from France and 1 from Greece) and 26 students (5 from Japan, 2 from France and 19 from Greece) attended this school.

The goals of this school are:

- To give students the **principles and basis** of AI and MD simulations,
- To teach them **how to use softwares** for AI and MD simulations (LAMMPS, Quantum Espresso),
- To work on a **simulation project** (students make a group and solve each subject by using AI and MD).

Through this school, students studied not only the technique of AI and MD but also the interconnection with foreign students (see Figure 11).

*Figure 11: Pictures taken during Ab Initio and Molecular Dynamics School 2023 in Greece: left: lecture by teacher; right: group discussion for practical training.*

## Tohoku IFS LyC and IFS LyC projects

Tohoku Institute of Fluid Science Lyon Center[14] aims at providing a **hub to link Japanese and French/European engineering activities on materials and fluid sciences**, with premises located at INSA and ECL. The Center targets collaborations involving both **academic and industrial** partners. One particular action (among others) managed by the LyC and substantially contributing to the ELyT initiative consist in **Collaborative Research Projects** (CRP[15]), with a call entirely **dedicated to the LyC**. Hence, **14 projects** have been granted in 2023. Out of them **11** were involving researchers from the ELyT Global IRN and contributing to the network activities.

## Collaborative scientific activities in the framework of ELyT Global

### 2023 projects

With the release of sanitary condition since mid-2022, ELyT Global projects have undergone a profound metamorphosis in 2022, with almost half of the pre-2022 projects that stopped, but with more new projects that started. 2023 saw a stabilization of the projects list, with **2 projects that stopped and 3 new projects**, leading to a total of **26 projects** (one more compared to 2022).

Researcher and student-researcher mobility (excluding DD Ph.D. students and person in delegation) is comparable to 2022, with more than **600 days cumulatively**, including **3 long stays** of more than 1

[14] http://www.ifs.tohoku.ac.jp/LyC/eng/index.html
[15] https://www.ifs.tohoku.ac.jp/eng/collabo/kobo.html

month and **1 very long stay** greater than 6 months (Table 4). This is remarkable as the activities at the end of 2022 led to a white year for the ELyT workshop, which next edition is in March 2024.

| **FR→JP** | | **JP→FR** | |
|---|---|---|---|
| **2023** | **Total declared (running projects only)[16]** | **2023** | **Total declared (running projects only)[16]** |
| 428 days (incl. 1 very long stay > 6 months and 1 long stay > 1 month)[17] | 1324 days (incl. 3 long stays > 1 month and 4 very long stays > 6 months)[17] | 249 days (incl. 4 long stays > 1 month)[17] | 1601 days (incl. 15 long stays > 1 month)[17] |

*Table 4. 2023 visits and total declared in project forms (excluding Double Diploma students and researchers in delegation).*

For 2023, **10 DD Ph.D. students** are actively involved in the IRN, confirming the excellent dynamics initiated in 2021 (11 in 2022). This positive trend confirmation is also confirmed considering **the whole Ph.D. student pool** (single and double degree), going from **15 in 2021 to 24 in 2022 and 25 in 2023** (Table 5). Again, this demonstrates the liveliness of the network **to attract a new generation of early stage researchers**. Such an increase is **even more pronounced for M.Sc. students, with 8 actively involved in 2023** (5 in 2022). Apart from the release of sanitary restrictions, this intensification is also permitted by dedicated funding and programs within the network.

| **Ph.D. students** | | **M.Sc. students** | |
|---|---|---|---|
| **2023** | **Total (running projects only)[16]** | **2023** | **Total declared (running projects only)[16]** |
| 25 (incl. 10 Double Degree students) | 32 (incl. 13 Double Degree students) | 8 | 22 |

*Table 5. Students involved in the projects.*

Figure 12 exposes the **cumulative number of DD Ph.D. students involved in ELyT** since the settlement of the DD agreement between INSA and TU and between ECL and TU. Although 2023 does not show a particular increase (which should be addressed in 2024), a significant increase of the dynamic can be observed since 2021, notably explained by the **diversification of funding** (institutions, ANR, CNRS, JSPS…). Among the 32 students involved, **10 are ongoing, 20 graduated** (occupying diverse positions, but mostly in academia) **and 2 resigned**. This demonstrates the success of the program, which besides significantly strengthens the collaborations between permanent researchers.

[16] "Total declared" refers to the whole project duration for those still running in 2021. Former projects are not taken into account, so that global numbers for all ELyT projects since the beginning of the initiative is much higher.
[17] Excluding DD Ph.D students and researchers in delegation.

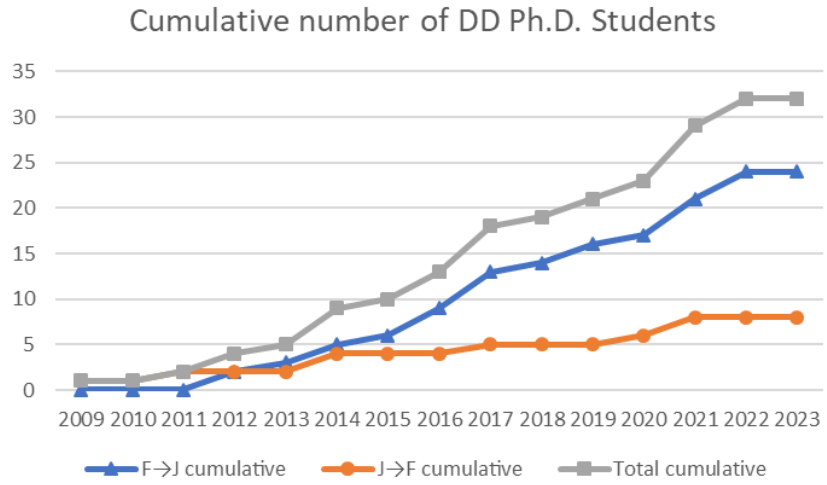



*Figure 12: DD Ph.D. students.*

In terms of scientific communication (Table 6), 2023 experienced a significant increase compared to 2022 (**23 articles**, 77% increase), going even further than 2021. The number of **conference** communications also remarkably increased, from 41 in 2022 to **52 in 2023**. Such a very positive dynamic is notably explained by the developments done in the framework of projects that started in 2022.

| **Journal papers** | | **Conferences** | |
|---|---|---|---|
| **2023** | **Total declared (running projects only)[16]** | **2023** | **Total declared (running projects only)[16]** |
| 23 | 62 | 52 | 127 |

*Table 6. Scientific communications (+2 patents).*

The **positioning** of the IRN projects is still **well spread across the scientific thematic and applicative themes** (Figure 13), denoting the relevance of such an organization. It can be noted that for the applicative themes in particular, some projects place themselves in a **transdisciplinary fashion**, especially at the interface between transportation and energy. For the scientific topics, the projects are **well distributed within the subjects**, highlighting the relevancy of such organization. Finally, the general overview (Figure 13.c) shows a **quite homogeneous distribution**, while in previous year the prevalence of the "Energy" theme existed.

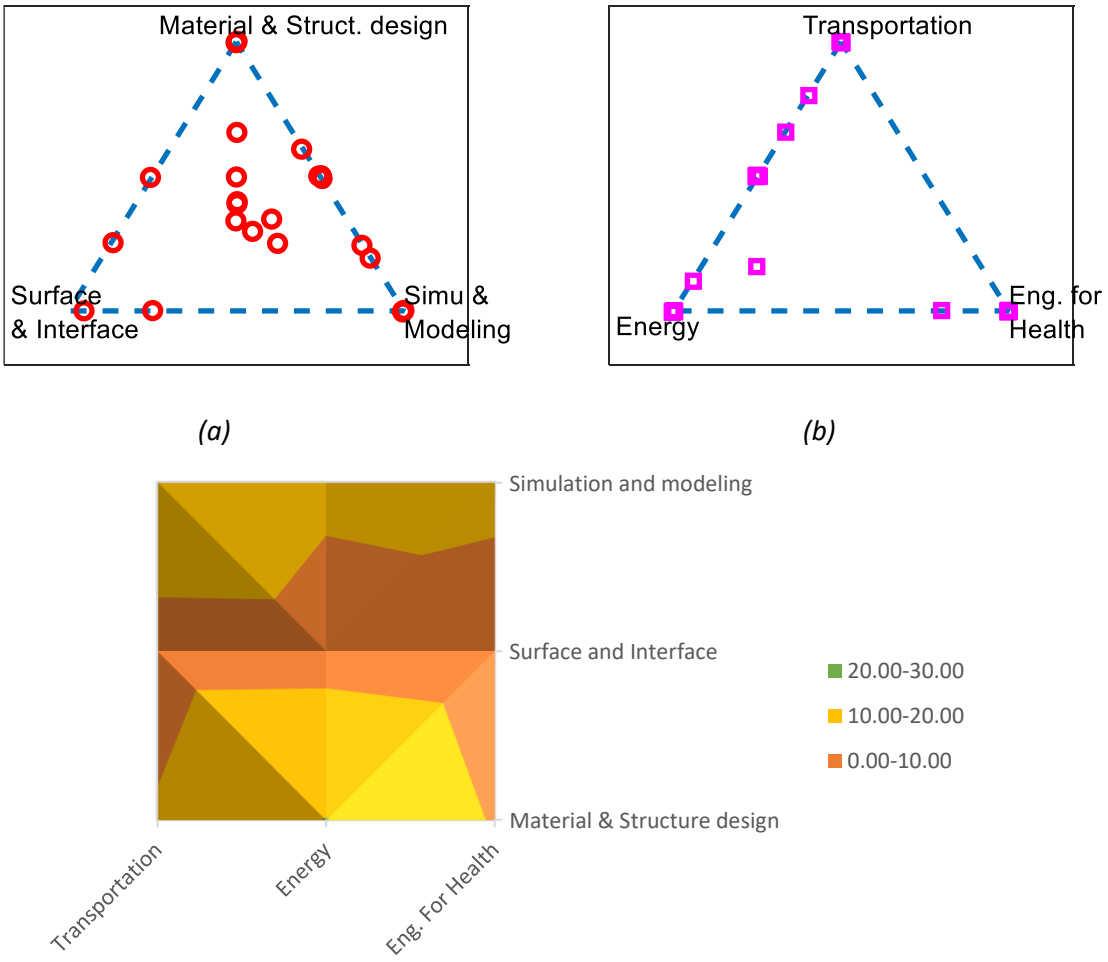



*Figure 13: Repartition of projects (percentages): (a) by scientific topics; (b) by themes and (c) general overview.*

| | 2022 | 2023 |
|---|---|---|
| **Average number of participants** | 4.84 | 4.73 |
| **Task force** | 6.4 person-months | 6 person-months |
| **Average FR→JP stays** | 17 days (2022) / 48 days (total declared) | 16 days (2023) / 51 days (total declared) |
| **Average JP→FR stays** | 7.8 days (2022) / 57 days (total declared) | 9.6 days (2023) / 62 days (total declared) |
| **Average international journal paper** | 0.52 (2022) / 2.2 (total declared) | 0.9 (2023) / 2.1 (total declared) |
| **Average international conference** | 1.64 (2022) / 4.52 (total declared) | 2 (2023) / 4.2 (total declared) |
| **Average annual budget**[18] | 19.1 k€ | 34.2 k€ |

*Table 7. Average projects data.*

Table 7 exposes the average **data for the projects**, along with a comparison with last year's data. The values are **rather stable** (with a very slight decrease for some of them yet), with however a **significant increase for journal's papers** (almost doubled), explained by the fact that many projects started in 2022. Also, it can be noted that the **average budget** (among 15 projects that declared an associated

[18] 15 projects declared budget. Hence, the average has been calculated on this number.

budget) also significantly **increased by 80**%, almost going back to the values of 2021, indicating the fulfilment of the IRN's role to be a unique place for starting collaborations that further grow into bigger projects. The total declared budget is **513 k€**. The **JP→FR stays also significantly increased**, possibly in relation to the numerous events at the end of 2023 in Lyon.

In 2022, 27 laboratories (including 13 from France and 10 for Japan) participated in the projects. For 2023, this number experienced a significant increase again, with **32 laboratories involved in the IRN** (**15 from France**[19]**, 12 from Japan**[20]**, 1 joint France/Japan**, 1 in China, 1 in Greece 1 in India, and 1 in Poland - Table 8). **Cross-collaborations and interactions**, exposed in Table 9, confirm the **significant positive development** that started in 2022, with numerous projects involving **several laboratories from each country**, yielding the development of a **dense and strong network**. The total number of participating researchers reached in 2023 **98 persons**, quite stable compared to 2022 (96 persons) after a significant increase last year (71 in 2021 and 77 in 2020).

| France | | Japan | |
|---|---|---|---|
| **Lab.** | **Projects / Researchers** | **Lab.** | **Projects / Researchers** |
| MATEIS INSA-Lyon | 7/15 | IFS Tohoku | 12/14 |
| LTDS ECL | 5/14 | GSE Tohoku | 8/14 |
| LGEF INSA-Lyon | 6/8 | IMR Tohoku | 4/5 |
| CREATIS INSA-Lyon | 2/3 | NICHe Tohoku | 3/5 |
| ILM UCBLyon1 | 4/3 | FRIS Tohoku | 2/2 |
| LaMCoS INSA-Lyon | 1/2 | GSBE Tohoku | 2/2 |
| LMFA ECL | 2/2 | µSIC Tohoku | 1/1 |
| LMFA INSA-Lyon | 1/2 | AIMR Tohoku | 1/1 |
| Cancer Research Centre of Lyon | 1/1 | IFS Lyon Center Tohoku | 1/1 |
| CEA Paris Saclay, Paris | 1/1 | Kyushu University, Fukuoka | 1/1 |
| CETHIL INSA-Lyon | 1/1 | Osaka University, Osaka | 1/1 |
| IMP INSA-Lyon | 1/1 | Smarttech-lab Tohoku | 1/1 |
| IPSB-Faculty of Pharmacy UCBLyon1 | 2/1 | | |
| LIRIS ENISE | 1/1 | | |
| LMS Polytechnique, Paris | 1/1 | | |

| Joint FR/JP | |
|---|---|
| **Lab.** | **Projects / Researchers** |
| ELyTMaX CNRS/Université de Lyon/Tohoku University | 15/20 |

| Other | |
|---|---|
| **Lab.** | **Projects / Researchers** |
| Southwest Jiaotong University (China) | 1/1 |
| Aristotle University of Thessaloniki (Greece) | 1/1 |
| IIT Dhanbad (India) | 1/1 |
| University of Wroclaw (Poland) | 1/1 |

*Table 8. Participating laboratories in 2023 projects.*

[19] 13 from Lyon
[20] 10 from Tohoku

| Interactions FR-JP | | | Japan | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *IFS Tohoku* | *GSE Tohoku* | *FRIS Tohoku* | *GSBE Tohoku* | *IMR Tohoku* | *AIMR Tohoku* | *IFS Lyon Center Tohoku* | *NICHe Tohoku* | *µSIC Tohoku* | *Kyushu University, Fukuoka* | *Osaka University, Osaka* | *Smarttech-lab Tohoku* |
| | | | (19) | (11) | (4) | (4) | (4) | (3) | (3) | (3) | (1) | (1) | (1) | (1) |
| France | *MATEIS INSA-Lyon* | (16) | 3 | 5 | 2 | | 2 | 1 | 1 | 1 | 1 | | | |
| | *LGEF INSA-Lyon* | (9) | 3 | 1 | 1 | | | 1 | 1 | 2 | | | | |
| | *ILM UCBLyon1* | (6) | 2 | 1 | | 1 | 1 | | | | | | 1 | |
| | *LTDS ECL* | (5) | 1 | 1 | | 1 | 1 | | | | | 1 | | |
| | *IPSB-Faculty of Pharmacy UCBLyon1* | (3) | 1 | 1 | | 1 | | | | | | | | |
| | *LMFA ECL* | (3) | 2 | 1 | | | | | | | | | | |
| | *CREATIS INSA-Lyon* | (2) | 2 | | | | | | | | | | | |
| | *Cancer Research Centre of Lyon* | (1) | | | | 1 | | | | | | | | |
| | *CEA Paris Saclay, Paris* | (1) | 1 | | | | | | | | | | | |
| | *CETHIL INSA-Lyon* | (1) | 1 | | | | | | | | | | | |
| | *IMP INSA-Lyon* | (4) | 1 | | 1 | | | 1 | 1 | | | | | |
| | *LaMCoS INSA-Lyon* | (1) | | 1 | | | | | | | | | | |
| | *LIRIS ENISE* | (1) | 1 | | | | | | | | | | | |
| | *LMFA INSA-Lyon* | (1) | 1 | | | | | | | | | | | |
| | *LMS Polytechnique, Paris* | (1) | | | | | | | | | | | | 1 |

*Table 9. FR-JP lab interactions (without ELyTMaX, the lab being both JP and FR).*

## Pluri-annual project follow-up

Figure 14 exposes the **total number of declared projects each year** since 2020. It can be seen that, after the decrease in 2021 due to the pandemic situation, a **renewal of the IRN occurred in 2022**, while **2023 confirmed the positive dynamic observed** over the last three years, along with a **securing** of the new projects launched in 2022.

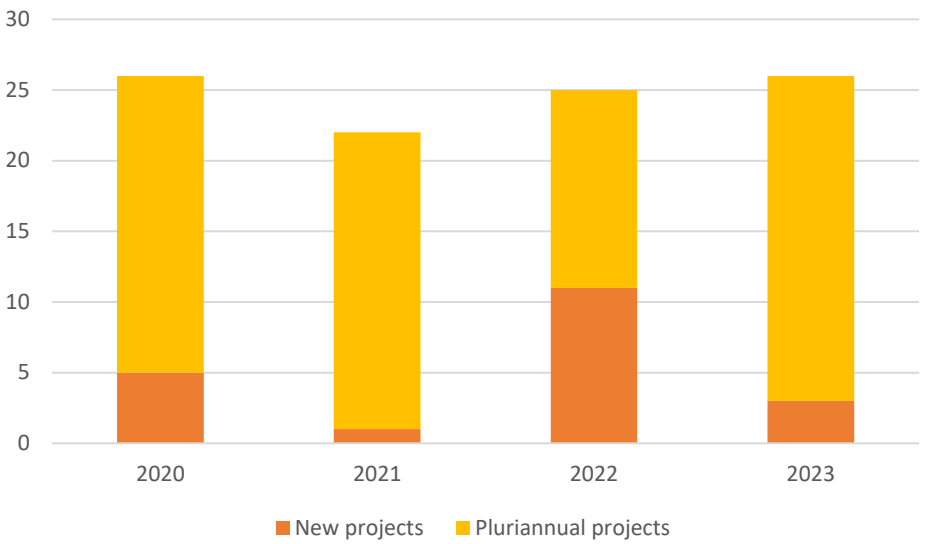



*Figure 14: Number of projects since 2020.*

Following **recommendation from institutions** and taking note of the **significant number of new projects in 2022**, a **pluri-annual individual project follow-up** has been established since 2022, taking data from 2020. The criteria retained for this follow-up encompass the **implication of researchers, exchanges, education through research and valorization**. Each criterion is then **normalized** by its maximum value over the years. The graphical representation is done according to a **radar chart**, allowing **through the area the assessment of the project life** through the years. An example of such an implementation (taken from 2022) is shown in Figure 15. In this case, I can be seen that the project follows a positive dynamic since 2019.

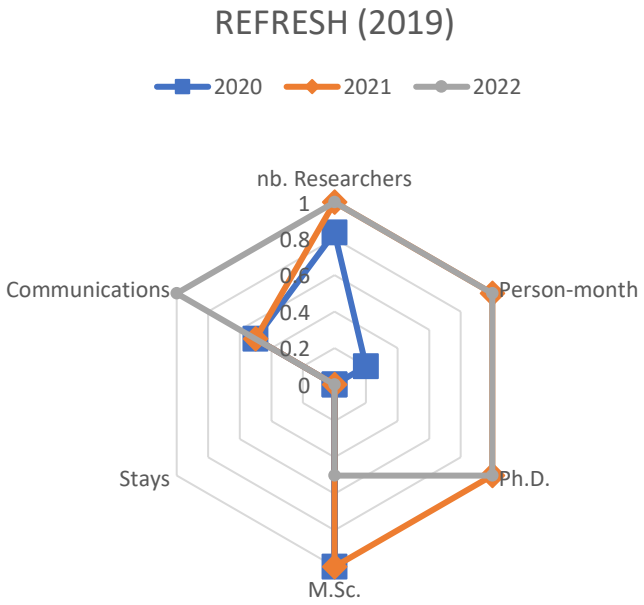



*Figure 15: Example of pluri-annual project (REFRESH) follow-up chart (example from 2022).*

Such a follow-up allows a **global view of the IRN liveliness** according to the chosen Key Performance Indicators, as demonstrated in Figure 16. It can be seen that the **number projects with positively evolving indicators is for each criterion greater than decreasing one**. Notable KPIs lie in **stays and communications** (especially for the latter), which is explained by the large number of new projects in 2022, which shows a positive dynamic and confirm the **consolidation of the newly launched collaborations**.

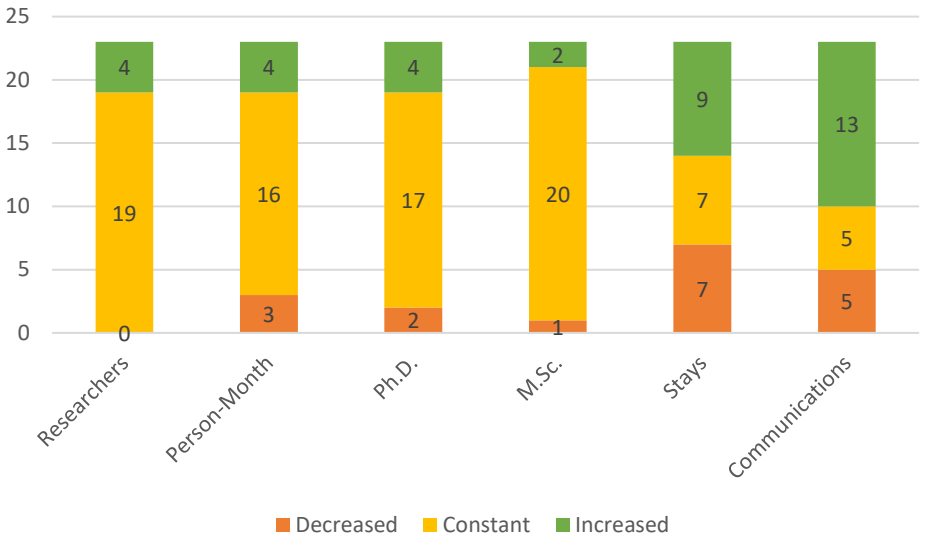



*Figure 16: Global evolution of projects: number of projects with decreased, stable or increased KPI (excluding new projects).*

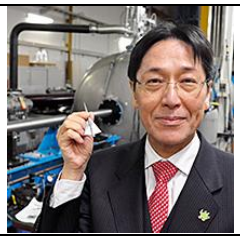
## List of active 2023 projects and project reports

| Acronym | Name |
|---|---|
| AATIGSA | *Atmospheric Aircraft Turbulence Investigated by Global Stability Analysis* |
| BENTO | *Nonlinear and dynamic micromagnetic Behavior modeling and characterization for Non-Destructive Testing techniques optimization* |
| BLESS-US* | *Boundary Layer Evaluation of Streaming Structure induced by Ultra-Sound* |
| BOSMA | *Blood flOw Simulation for Medical Applications* |
| CarboEDiffSim | *Simulation of Carbon electro diffusion in Iron with phase change* |
| DECCOBABA | *DEvelopment and Characterization of New CO BAsed alloys for Biomedical Applications* |
| EM Tracking* | *Electromagnetic tracking of catheter using Giant-magneto resistance* |
| EPOPEE | *Elaboration of POrous Powders by liquid mEtal dEalloying* |
| ESANSHSJN | *Clarification of Flow Structures related to jet Noise Generation using Mode Analysis and High-precision Jet Flow Simulation* |
| FIESTA | *Ferroelectric-ferroelectric transitions Induced by External STress for Applications in sensing and energy harvesting* |
| FRIISE | *Multi-scale elucidation of friction mechanisms in ice-rubber interfaces* |
| MAGELLAN* | *Magnetorheological Elastomers: finite strain visco-elasto-plastic behavior under general loading conditions* |
| MARECO | *MAgneto-Rheological elastomers for Energy COnversion* |
| MATSURI | *MAgneToStrictive coUpling for eneRgy harvestIng* |
| MicroCell | *Microsystems for Cell Engineering* |
| MIMECHAS | *Microstructure and Mechanics of Aluminum - Steel welds* |
| MOREOVER | *MOdelling of the long-term coRrosion bEhaviOr from detailed analysis of excaVated anciEnt cultural aRtifact* |
| MuORoD | *Multi-Objective Robust Design* |
| PIARR | *Prognosis of intracranial aneurysm rupture risk* |
| PolymColdSprayCoat | *Resilient Polymeric Cold Spray Coating* |
| PREDOXCAN | *Investigation of a predictive therapeutic response under controlled oxygen condition in spheroids and cancer patient-derived organoids* |
| REFRESH | *REFRigEration based on Solid-state cooling: Heat transfer mechanisms* |
| ScinGlass | *Scintillator Glasses* |
| T2 TRIBOCHEM | *Syperlubricity of a ta-C/Si3N4 contact in presence of castor oil* |
| TEmPuRA | *Theory for Electrostriction of PolymeRic Actuator* |
| TFS | *Touch feeling and Surface* |

*Table 10. Active projects (*: new projects).*

# Atmospheric Aircraft Turbulence Investigated by Global Stability Analysis

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Ryoichi Yoshimura[a]** | **Aiko Yakeno[a]** | **Benoit Pier[b]** | **Shigeru Obayashi[a]** |

[a] *Institute of Fluid Science, Tohoku Univ. Japan*

[b] *Laboratoire de mécanique des fluides et d'acoustique (LMFA), Ecole Centrale de Lyon, France*

**Contact:** ryouichi.yoshimura.s2@dc.tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2022 **Current researchers** (permanent/non-permanent): 4 persons/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | 80% | 20% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

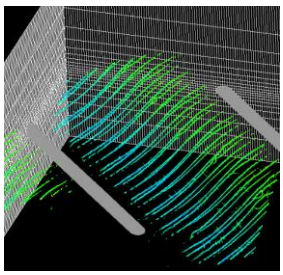
- JSPS 2020-2024 Fund for the Promotion of Joint International Research (Fostering Joint International Research (A))

Estimated annual budget: 14 k€

### Highlights & Outstanding achievements *(3-5 bullet points)*

- Computational Fluid Dynamics (CFD) was used to investigate the formation process of clear-air turbulence.
- CFD simulated Kelvin-Helmholtz (KH) instability waves in real atmospheric wind profiles.
- We estimated the sensitivity of KH waves to the frequency-band of wind perturbation and understood the process by which KH waves break down and become dangerous to aircraft, i.e., turbulence onset.
- The wind perturbation grows in the high strain region between two KH eddies, and its growth rate depends on the wavenumber of the perturbation structure.

### Illustration *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Atmospheric Turbulence in one of the causes of airborne accidents. Especially, CAT (clear air turbulence) is more dangerous than other kinds of turbulence because it is not visible. CAT is often caused by KH (Kelvin-Helmholtz) instability in the atmospheric wind shear. Several meteorological organizations forecast CAT based on indices such as wind shear magnitude and Richardson number. However, these indices only evaluate the onset of the KH instability, not the secondary instability that destroys the KH instability waves to generate turbulent eddies dangerous to airplanes. Therefore, a CAT forecast based on the indices have uncertainties in location and strength of CAT. Investigation on the property of the secondary instability of KH instability in the atmosphere will give us knowledge to improve the current CAT forecasting methods using the indices.

**Key scientific question** (2 lines max; Calibri 11)

Growing processes of the secondary instability structures in the atmosphere
Relation between the growth rate of the structures and shapes of the initial wind perturbation

**Research method** (8 lines max; Calibri 11)

Before the analysis we ran a weather forecasting model to reproduce a realistic atmospheric wind profiles with a strong wind shear. A CFD was performed to generate the baseflow for the analysis, in which KH instability waves were induced in the input atmospheric wind profiles. We perturbed the baseflow KH waves with several wind structures to investigate the secondary instability structures growing on the KH waves. The KH waves were perturbed at the time when their amplitudes saturated. Vortex-shape perturbation and wavenumber-controlled perturbation were utilized in the analysis.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- R. Yoshimura (3rd year, Institute of Fluid Science, Tohoku University)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- B. Pier (12 to 16, Dec 2022, 5 days)

*JP to FR (date, duration):*

- R. Yoshimura (16 to 18, Nov.. 2022, 3 days)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | R. Yoshimura, A. Yakeno and S. Obayashi | Global Sensitivity Explaining Atmospheric Shear Layer Transition | 75th Annual Meeting of the Division of Fluid Dynamics, APS | Nov.20-22, 2022 | Indianapolis | USA | |
| 2 | R. Yoshimura, A. Yakeno, J. Ito, S. Obayashi | Direct Global Stability of Atmospheric Shear Flow That Causes Aircraft Turbulence | 12th International Symposium on Turbulence and Shear Flow Phenomena, TSFP 2022 | Jul. 19-22, 2022 | Virtual | Virtual | |
| 3 | R. Yoshimura, A. Yakeno, B. Pier and S. Obayashi | Sensitivity analysis to investigate the secondary structure from atmospheric shear flow | ELyT Workshop 2022 | Nov. 16-18, 2022 | Lyon | France | |

# BENTO

Nonlinear and dynamic micromagnetic Behavior modeling and characterization for Non-Destructive Testing techniques optimization

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Tetsuya UCHIMOTO[a]** | **Benjamin DUCHARNE[b,c]** | **Gael SEBALD[c]** | **Sho TAKEDA[a]** |

[a]Institute of Fluid Science, Tohoku University, Sendai, Japan.
[b]Laboratoire de Génie Electrique et Ferroélectricité – INSA de Lyon, Villeurbanne, France.
[c]ELyTMaX UMI 3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan.

**Contact:** tetsuya.uchimoto.c7@tohoku.ac.jp, benjamin.ducharne@insa-lyon.fr, gael.sebald@insa-lyon.fr, sho.takeda.b6@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2016 **Current researchers** (permanent/non-permanent): 6 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 25% | 25% | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | 25% | 25% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☒ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
OCEA i-demo project (400 k€ for our labs)
SAFRAN collaboration (100 k€ since 2021)
CETIM collaboration (50 k€ since 2021)

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- B. Gupta received the best Ph.D. award of 2019 by INSA under the category "Transports: Structures, infrastructures et mobilité".
- Simulation tools have been developed.
- More than 100 k€ in Industrial collaborations.
- More than 17 scientific papers have been published and more than 30 conference participations.

**Illustration** *(5x5 cm² max)*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

In the framework of Non-Destructive Testing of metallic parts used in the field of electrical power plants or in transportation, a fine modeling of tested materials is developed, including particular frequency dependencies of the signals and ferromagnetic behavior. The collaboration focuses on the modeling and testing of innovative electromagnetic Non-Destructive Testing (NDT) techniques, based on micromagnetic properties of tested materials. Both the modelling of the materials itself (including magnetic major and minor hysteresis loops and their frequency dependence), as well as the modelling of the NDT techniques (such as Barkhausen noise and Magnetic Incremental Permeability) are investigated in order to go further in the sensitivity of the techniques and their ability to differentiate different kind of defects or structural material degradations, in addition to also finding a co-relation between mechanical and magnetic properties of the materials.

**Key scientific question** (2 lines max; Calibri 11)

Identification of structural defects or degradation through electromagnetic signatures.

**Research method** (8 lines max; Calibri 11)

The magnetic state of a ferromagnetic material is sensitive to multiple parameters including the temperature, the mechanical state, the microstructural content… Under stable conditions, magnetism can be used as an indirect way to identify and characterize one of these parameters. Electromagnetic non-destructive testing is the concept of using an electromagnetic signature to anticipate a level of integrity. Electromagnetic methods exist already but the simulation tools and methods based on the magnetization mechanisms we developed allow to improve their performances by a deeper understanding and interpretation of the resulting signals.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Bhaawan Gupta (2016-2019)
- Shurui Zhang (2020-2023) double degree (INSA/TU)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

B. Ducharne, Jan 2019, 10 Days
B. Ducharne, Jul 2019, 10 Days
B. Ducharne, Mar 2019, 10 Days
B. Ducharne, Oct 2018, 10 Days
B. Ducharne, Jan 2018, 10 Days

*JP to FR (date, duration):*

S. Zhang, 2022-2023, 12 months
T. Uchimoto, 2019, 61 Days total
A. Kita, Sep 2019, 2 months
S. Zhang, Sep 2019, 3 months
T. Matsumoto, May 2018, 3 months
T. Uchimoto, Jul 2019, 2 weeks
T. Uchimoto, Nov 2019, 1 week

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | B. Ducharne, Y.A. Tene Deffo, S. Zhang, G. Sebald, M. Lallart, T. Uchimoto, C. Gallais, O. Ghibaudo | Carburization depth evaluation from magnetic nondestructive testing | NDT & E International | 137 | 102864 | 2023 | https://doi.org/10.1016/j.ndteint.2023.102864 |
| 2 | P. Fagan, S. Zhang, G. Sebald, T. Uchimoto, B. Ducharne | Barkhausen noise hysteresis cycle: theoretical and experimental understanding | Journal of magnetism and magnetic materials | 578 | 170810 | 2023 | https://doi.org/10.1016/j.jmmm.2022.170810 |
| 3 | B. Ducharne, Y.A. Tene Deffo, G. Sebald, T. Uchimoto, C. Gallais, O. Ghibaudo | Low-frequency incremental permeability for the evaluation of deep carburization treatments: theoretical understanding | Journal of magnetism and magnetic materials | 586 | 171236 | 2023 | https://doi.org/10.1016/j.jmmm.2022.171236 |
| 4 | S. Zhang, B. Ducharne, G. Sebald, S. Takeda, T. Uchimoto | Magnetic indicators for evaluating plastic strains in electrical steel: Toward non-destructive assessment of the magnetic losses | NDT & E International | 134 | 102780 | 2022 | https://doi.org/10.1016/j.ndteint.2022.102780 |
| 5 | B. Ducharne S. Zhang, G. Sebald, S. Takeda, T. Uchimoto | Fractional derivatives for the core losses prediction: State of the art and beyond | Journal of magnetism and magnetic materials | 563 | 169961 | 2022 | https://doi.org/10.1016/j.jmmm.2022.169961 |
| 6 | S. Zhang, B. Ducharne, S. Takeda, G. Sebald, T. Uchimoto | Low-frequency behavior of laminated electric steel sheet: investigation of ferromagnetic hysteresis loop and incremental permeability | Journal of magnetism and magnetic materials | 538 | 168278 | 2021 | https://doi.org/10.1016/j.jmmm.2021.168278 |
| 7 | S. Zhang, B. Ducharne, S. Takeda, G. Sebald, T. Uchimoto | Identification of the ferromagnetic hysteresis simulation parameters using classic non-destructive testing equipment | Journal of magnetism and magnetic materials | 531 | 167971 | 2021 | https://doi.org/10.1016/j.jmmm.2021.167971 |

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|---|---|---|---|---|---|---|---|
| 8 | B. Gupta, B. Ducharne, T. Uchimoto, G. Sebald, T. Miyazaki, T. Takagi | Comparison of electromagnetic inspection methods for creep-degraded high chromium ferritic steels | NDT & E International | 118 | 102399 | 2020 | https://doi.org/10.1016/j.ndteint.2020.102399 |
| 9 | S. Zhang, B. Ducharne, T. Uchimoto, A. Kita, Y.A. Tene Deffo | Simulation tool for Eddy Current Magnetic Signature (EC-MS) non-destructive method | Journal of magnetism and magnetic materials | 513 | 167221 | 2020 | https://doi.org/10.1016/j.jmmm.2020.167221 |
| 10 | B. Gupta, B. Ducharne, T. Uchimoto, G. Sebald, T. Miyazaki, T. Takagi | Non-destructive testing on creep degraded 12% Cr-Mo-WV ferritic test samples using Barkhausen noise | Journal of magnetism and magnetic materials | 498 | 166102 | 2020 | https://doi.org/10.1016/j.jmmm.2019.166102 |
| 11 | B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto, T. Miyazaki, T. Takagi | Physical interpretation of the microsctructure for aged 12 Cr-Mo-VW steel creep test samples based on simulation of magnetic incremental permeability | Journal of magnetism and magnetic materials | 486 | 165250 | 2019 | https://doi.org/10.1016/j.jmmm.2019.165250 |
| 12 | B. Gupta, T. Uchimoto, B. Ducharne, G. Sebald, T Miyazaki, T. Takagi | Magnetic incremental permeability non-destructive evaluation of 12 Cr-Mo-VW steep creep test samples with varied ageing levels and thermal treatments | NDT & E International | 104 | 42-50 | 2019 | https://doi.org/10.1016/j.ndteint.2019.03.006 |
| 13 | T. Matsumoto, T. Uchimoto, T. Takagi, G. Dobmann, B. Ducharne, S. Oozono, H. Yuya | Investigation of electromagnetic nondestructive evaluation of residual strain in low carbon steels using the eddy current magnetic signature (EC-MS) | Journal of magnetism and magnetic materials | 479 | 212-221 | 2019 | https://doi.org/10.1016/j.jmmm.2019.01.103 |
| 14 | T. Matsumoto, B. Ducharne, T. Uchimoto | Numerical model of the Eddy current magnetic signature (EC-MS) non-destructive micro-magnetic technique | AIP advances | 9 | 035045 | 2019 | https://doi.org/10.1063/1.5079995 |
| 15 | B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto | A space discretized ferromagnetic model for non-destructive eddy current evaluation | IEEE Transactions on magnetics | 54 | 1-4 | 2018 | https://doi.org/10/1109/TMAG.2017.2773517 |
| 16 | B. Zhang, B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto | Dynamic magnetic scalar hysteresis lump model, based on Jiles-Atherton quasi-static hysteresis model | IEEE Transactions on magnetics | 54 | 6200204 | 2017 | https://doi.org/10/1109/TMAG.2018.2773517 |

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|---|---|---|---|---|---|---|---|
| | | extended with dynamic fractional derivatives | | | | | |
| 17 | B. Zhang, B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto | Preisach's model extended with dynamic fractional derivative contribution | IEEE Transactions on magnetics | 54 | 6100204 | 2017 | https://doi.org/10/1109/TMAG.2018.2759421 |

# BLESS-US

*Boundary Layer Evaluation of Streaming Structure induced by Ultra-Sound*

## MAIN PARTICIPANTS


|  |  |  |
|---|---|---|
| **Valéry BOTTON**[a] | **Sophie MIRALLES**[a] | **Atsuki KOMIYA**[b, c] |

[a] *INSA-Lyon, LMFA, UMR CNRS 5509, 69621, Villeurbanne, France*
[b] *Institute of Fluid Science, Tohoku University, 980-8577, Sendai, Japan*
[c] *ELyTMaX IRL3757, CNRS, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon, Tohoku University, Sendai, Japan*

**Contact:** valery.botton@insa-lyon.fr, sophie.miralles@insa-lyon.fr, komiya@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2023 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 50% | |
| **Surfaces and interfaces** | 12.5 % | | 12.5 % |
| **Simulation and modeling** | 12.5% | | 12.5 % |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project

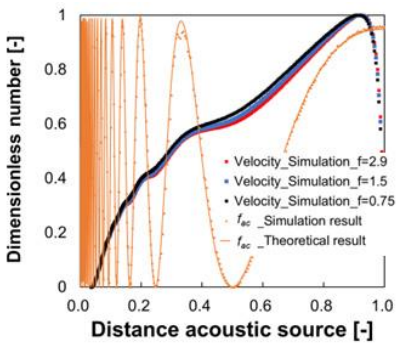
- Collaborative Research Project of the Institute of Fluid Science, Tohoku University, 2023
- JSPS Grant in Aid for Scientific Research Kiban B 21H01257 2021-2023

Estimated annual budget: 26 k€ + 4 M¥

### Highlights & Outstanding achievements

- We have developed a precise measurement system of micro-scale protein mass transfer phenomenon.
- A local mass transfer control system was proposed by using tiny ultrasound- induced flow.
- A numerical simulation of ultrasound-induced flow was performed.
- An oral presentation has been selected as the special issues of the Applied Thermal Engineering.

### Illustration



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Natural convection is used for large cooling systems due to its property of enhancing heat transfer at larger scale without any external input power. However, when compared to forced convection, the amount of heat transfer is significantly weak. Therefore, it is important to investigate methods to enhance the heat transfer by natural convection. This study focuses on the active method, thinning the thermal boundary layer (TBL) between high and low temperature regions. This method might be easy to install and control of the TBL. Previous studies have proposed a method using impinging jet and vibrating ribbons providing mechanical perturbation. In this study, a new method was proposed using ultrasound induced flow. It has the advantage that installation and flow control are easier than in previous impinging jet method. The aim of this study is to evaluate the performance of natural convection heat transfer by utilizing ultrasound induced flow.

**Key scientific question** (2 lines max; Calibri 11)

How to control the TBL and concentration boundary layer using ultrasound induced flow?
What is the key factor for enhancing the heat and mass transfer by controlling the layers?

**Research method** (8 lines max; Calibri 11)

In this collaborative research, we have been developing an experimental equipment for the precise visualization of thermal and concentration boundary layers. By applying and installing a tiny ultrasound generator to transient diffusion field, we intentionally control the thickness of thermal/concentration boundary layer locally and enhance the heat and mass transfer phenomena. Numerical simulations are also parallelly performed and we evaluate the possibility of local control of boundary layers formation. The key technology is how we can measure the temperature/concentration field in micro-scale precisely. To achieve this point, we are applying a specially designed optical interferometer.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Ruiyao Zhu (2023-2025, Tohoku University – INSA Lyon, DD student)

*Master/Bachelor students (years):*

- Taisei Takagi (2023-2024), Tohoku University

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- V. Botton (September 2023, 11 days)

*JP to FR (date, duration):*

- R. Zhu (March 2024, 1 year)
- A. Komiya (May 2023, 7 days)
- A. Komiya (January 2024, 5 days)
- A. Komiya (March 2024, 5 days)

# COMMUNICATIONS AND VALORIZATION

**Conferences** *(gray color for previous years)*

| | **Authors** | **Title** | **Conference** | **Date** | **City** | **Country** | **DOI** *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Valéry Botton, Nouhayla El Ghani, Sophie Miralles, Danel Henry, Hamda Ben Hadid, Benoit Ter-Ovanessian and Sabrina Marcellin | Flows driven by ultrasounds in liquids in a wall mass transfer enhancement perspective. | The 33rd International Symposium on Transport Phenomena | 24-27 Sep., 2023 | Kumamoto | Japan | |
| 2 | Ruiyao Zhu, Juan Felipe Torres, Shuichi Moriya, Yuki Kanda and Atsuki Komiya | *Experimental evaluation of pore pattern on protein hindered diffusion in macro porous membranes* | The 33rd International Symposium on Transport Phenomena | 24-27 Sep., 2023 | Kumamoto | Japan | |

# BOSMA

*Blood flOw Simulation for Medical Applications*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Carole FRINDEL[a]** | **Makoto OHTA[b]** | **Guillaume LAVOUE[c]** | **Hitomi ANZAI[d]** |

[a] *CREATIS, INSA Lyon, Lyon Center IFS, Tohoku University*
[b] *ElyTMax, IFS, Tohoku University*
[c] *LIRIS, ENISE Saint-Etienne*
[d] *IFS, Tohoku University*

**Contact:** carole.frindel@insa-lyon.fr, makoto.ohta@tohoku.ac.jp, guillaume.lavoue@enise.fr, anzai@biofluid.ifs.tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2019 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | 100 % |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

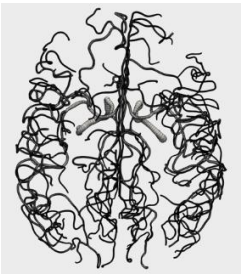
- Pack Ambition International from Région Auvergne-Rhône-Alpes, 2019-2022, SIMAVC
- INSA funding for PHD of Méghane Decroocq in the framework of ELyTMax
- Collaborative research project J22Ly15, IFS, Tohoku University since Oct. 2022

Estimated annual budget:10 K€

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- We have developed a structured meshing methodology for large vascular networks
- We will soon provide a database of 60 high quality meshes of the whole cerebral arterial network, ready for CFD analysis
- Granted project from Région Auvergne-Rhône-Alpes, 2019-2022, SIMAVC

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Cerebrovascular disease includes all disorders in which an area of the brain is temporarily or permanently affected by lack of blood flow. Understanding the inner workings of the cardiovascular system has been central to many studies involving clinical, interventional or computational approaches. Although the collected in-vivo measurements can be highly accurate, such interventional techniques are sometimes expensive and suffer from limitations that are not easy to address, e.g., difficulties of placing probes in cerebral arteries. These limitations motivate the use of non-invasive measurement techniques such as bio-medical imaging (Doppler ultrasound or Magnetic Resonance Imaging). However, critical variables such as the pressure cannot be directly measured by a non-invasive technique. Recent advances in clinical measurement and computational modeling techniques introduce new capabilities for monitoring the human cardiovascular dynamics.

**Key scientific question** (2 lines max; Calibri 11)

Make fluid dynamics simulation as realistic as possible
Analyze information provided by medical imaging to improve the accuracy of the simulations
Create fully virtual databases available for machine learning approaches

**Research method** (8 lines max; Calibri 11)

The objectives of BOSMA encompass medical imaging, mesh geometry, fluid dynamics and machine learning. The idea of BOSMA is to simulate medical images with a high degree of physiological realism in the context of stroke and vascular malformations, in order to create datasets large enough to allow machine learning approaches to be effective. To do this, we develop high quality meshes of the whole cerebral arterial network (ready for CFD analysis) and image simulators enabling the generation of synthetic and annotated ground truth images and associated simulated acquired images.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Yutaro KOHATA (2021-2024, Directors: OHTA, ANZAI and FRINDEL)
- Méghane DECROOCQ (2019-2022, Directors: FRINDEL, LAVOUE and OHTA)

*Master/Bachelor students (years):*

- Keito YANAGISAWA (2023-present, Directors: OHTA, ANZAI and FRINDEL)
- Yutaro KOHATA (2019-2019, Directors: OHTA, ANZAI and FRINDEL)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- Méghane DECROOCQ (April 2022-April 2023, 1 year)
- Méghane DECROOCQ (January-December 2021, 1 year) ->delayed due to COVID19
- Méghane DECROOCQ (November 2019, 1 month)
- Méghane DECROOCQ (Oct.2018-March 2019, 6 months)

*JP to FR (date, duration):*

- Keito YANAGISAWA (December 2023-February 2024, 2 months)
- Yutaro KOHATA (June 2022-June 2023, 1 year)
- Yutaro KOHATA (Sept-Oct. 2019, 2 months)

# COMMUNICATIONS AND VALORIZATION

**Papers** *(gray color for previous years)*

| | **Authors** | **Title** | **Journal** | **Year** | **DOI** *(if applicable)* |
|---|---|---|---|---|---|
| 1 | M. Decroocq , C. Frindel, P. Rougé, M. Ohta, G. Lavoue | Modeling and hexahedral meshing of cerebral arterial networks from centerlines. | Medical Image Analysis 89: 102912. | 2023 | https://doi.org/10.1016/j.media.2023.102912 |

**Conferences** *(gray color for previous years)*

| | **Authors** | **Title** | **Conference** | **Date** | **City** | **Country** | **DOI** *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Y. Kohata, M. Decroocq, S. Rit, C. Frindel, M. Ohta, H. Anzai | Virtual angiography for evaluation of velocity estimation method | 19th International Conference of Flow Dynamics | 9-11 November 2022 | Sendai | Japan | |
| 2 | M. Decroocq , C. Frindel, M. Ohta, G. Lavoue | A Software to Visualize, Edit, Model and Mesh Vascular Networks | 44th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2022 | 11-15 July 2022 | Glasgow | UK | |
| 3 | M. Decroocq , C. Frindel, M. Ohta, G. Lavoue | Hexahedral meshing of arterial networks with aneurism for computational fluid dynamics | 9th World Congress of Biomechanics | 10-14 July 2022 | Taipei | Taiwan | |
| | H. Anzai, M. Ohta, S. Mugikura, N. Mori, N. Juchler, S. Hirsch, C. Frindel and M. Oshima | Modelling the anatomical variability of vascular systems | 7th International Conference on Computational and Mathematical Biomedical Engineering | 27-29 June 2022 | Milano | Italy | |
| 4 | N. Debs, M. Decroocq, T.-H. Cho, C. Frindel | Patient-Specific Hemodynamic Simulation for Stroke Lesion Prediction | 17th International Conference of Flow Dynamics | 28-30 Oct. 2020 | Sendai | Japan | |
| 5 | M. Decroocq , C. Frindel, M. Ohta, G. Lavoue | Meshing Arterial Networks from Manually Extracted Centerlines | 17th International Conference of Flow Dynamics | 28-30 Oct. 2020 | Sendai | Japan | |
| 6 | M. Decroocq , C. Frindel, M. Ohta, G. Lavoue | Structured meshing of large vascular networks for computational fluid dynamics | Virtual Physiological Human | 24-28 Aug. 2020 | Paris | France | |

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|---|---|---|---|---|---|---|---|
| 7 | Y. Kohata, H. Anzai, M. Ohta, M. Decroocq, C. Frindel, S. RIT | A study on Optical Flow Method for Hemodynamics Estimation | 2nd International Symposium on Computational Biofluid | 16 Dec. 2020 | Johor | Malaysia | |

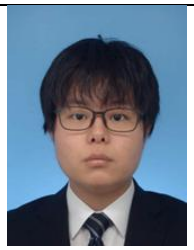
**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | K. Yanagisawa, C. Frindel, D. Garcia, M. Ohta, H. Anzai | ELyT Workshop 2024 | Oral presentation | 11-13 March, 2024 |
| 2 | Y. Kohata, H. Anzai, M. Decroocq, S. Rit, C. Frindel, M. Ohta | ELyT Workshop 2022 | Oral presentation | 16-18 November, 2022 |
| 3 | Y. Kohata, H. Anzai, M. Decroocq, S. Rit, C. Frindel, M. Ohta | ELyT Workshop 2021 | Oral presentation | 21-25 June, 2021 |
| 4 | M. Decroocq, E. Maury, G. Lavoué, C. Frindel, M. Ohta | ELyT Workshop 2021 | Oral presentation | 21-25 June, 2021 |
| 5 | M. Decroocq, C. Frindel, M. Ohta, G. Lavoue | ELyT Workshop 2020 | Oral presentation | 17-19 Feb., 2020 |
| 6 | Y. Kohata, H. Anzai, M. Ohta, M. Decroocq, C. Frindel, S. Rit | ELyT Workshop 2020 | Poster presentation | 17-19 Feb., 2020 |
| 7 | M. Decroocq, C. Frindel, M. Ohta, G. Lavoue | ELyT Workshop 2019 | Oral presentation | 9-12 March, 2019 |
| 8 | M. Decroocq, C. Frindel | ELyT Seminar | Oral presentation | 6 June, 2018 |

# CarboEDiffSim

*Simulation of Carbon electro diffusion in Iron with phase change*

## MAIN PARTICIPANTS


|  |  |  |  |  |
|---|---|---|---|---|
| P. Chantrenne [a] | T. Tokumasu [b] | C. Adessi [c] | J. Kioseoglou [d] | R. Onozuka [b, e] |

[a] *MATEIS, INSA-Lyon, France*
[b] *Institute of Fluid Science, Tohoku University, Japan*
[c] *Institut Lumière Matière, University Claude Bernard Lyon 1,France*
[d] *COSSPHY, Theoretical and Computational Solid State Physics, Aristotle University of Thessaloniki, Greece*
[e] *Graduate School of Engineers, Tohoku University, Japan*

**Contact:** tokumasu@ifs.tohoku.ac.jp, patrice.chantrenne@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2017 **Current researchers** (permanent/non-permanent): 5 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 50% | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | 50% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

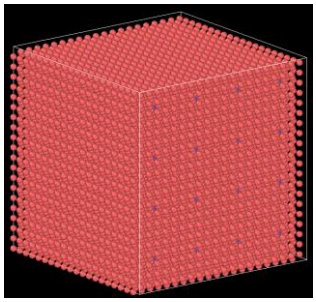
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: None

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- We constructed a new interatomic potential based on ABO potential to prevent the carbon condensation.
- The energy barrier obtained by our potential was consistent whit that by DFT calculations, although that obtained from diffusion coefficient is smaller. The reason why this contradiction occurs will be analyzed by analyzing the diffusion path of carbon in Fe.
- Ab initio and Molecular Dynamics school was held in March 2024 in IFS, Tohoku University

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Iron is used in a wide range of fields such as aerospace and automobiles, but it needs to be strengthened before it is used in these fields. There are many ways to strengthen it, such as work hardening, solid solution strengthening, and grain boundary strengthening. The diffusion of carbon atoms in iron is related to solid solution strengthening. Since the interstitial diffusion of carbon atoms affects the reaction rate of phase transformation of steel, the properties of iron are affected by the carbon inside the iron. Until now, the main driving force for carbon diffusion was considered to be transfer by heat, but in recent years, in the Spark Plasma Sintering method, carbon diffusion by an electric field has attracted a great deal of attention. However, although the study of carbon diffusion in iron by thermal diffusion has been widely conducted, the study of carbon diffusion under electric current has not been sufficiently conducted.

**Key scientific question** (2 lines max; Calibri 11)

Analyzing the diffusion phenomena of carbon in an electric field.
Analyzing phase transition of iron under inclusion of carbon.

**Research method** (8 lines max; Calibri 11)

In this study, we focused on iron in the cubic lattice such as body-centered or face-centered, and performed a simulation using the molecular dynamics method to clarify the effect of the electric field on carbon diffusion inside iron. In this simulation the structural characteristics of iron are understood from the lattice constants of each temperature, and the transport characteristics of carbon at each temperature are obtained from mean square displacement. Moreover, the phase transition of iron including carbon are analyzed in detail and relation of the diffusion coefficient of carbon and each phase is obtained.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- None

*Master/Bachelor students (years):*

- Ryuta Onozuka (2022-2023, IFS)
- Kairi Kita (2020-2021, IFS)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

*Patrice Chantrenne (2024.2.29 – 2024.3.13)*
*Christophe Adessi (2024.2.29 – 2024.3.13)*
*Konstantinos Termentzidis (2024.2.29 – 2024.3.13)*
*Patrice Chantrenne (Feb 2020, 7 days)*

*JP to FR (date, duration):*

*Takashi Tokumasu(2023.6.20 – 2022.6.23)*
*Ryuta Onozuka(2023.6.20 – 2023.6.23)*
*Takashi Tokumasu(2023.12.13 – 2023.12.15)*
*Takashi Tokumasu(2022.6.7 – 2022.6.10)*
*Takashi Tokumasu(2022.11.2 – 2022.11.4)*
*Ryuta Onozuka(2022.11.2 – 2022.11.18)*
Takashi Tokumasu (*Jun.-Jul. 2020, 2 months)*
*Naoya Uene (Jun.-Jul. 2020, 2 months)*
*Kyohei Ishikawa(Oct.-Nov. 2020, 2months)*
*Koki Nakajima(Oct.-Nov. 2020, 2months)*

# COMMUNICATIONS AND VALORIZATION

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Ryuta Onozuka, Christophe Adessi, Joseph Kioseoglou, Patrice Chantrenne, Takashi Tokumasu | CarboEDiffSim : Carbon Diffusion in Iron assisted by an Electric Field: models and experiments | ELyT workshop 2023 | 11-13 March 2024 | Sendai(Miyagi) /Kaminoyama(Yamagata) | Japan | |
| 2 | Ryuta Onozuka, Takuya Mabuchi, Patrice Chantrenne, Takashi Tokumasu | CarboEDiffSim :Molecular Theory Analysis of Carbon Diffusion in Iron which is Happened Phase Transformation under Electric Field | ELyT workshop 2022 | 16-18 November 2022 | hybrid | France | |
| 3 | Kairi Kita, Takuya Mabuchi, Sofia Molina-Montoya, Christophe Adessi, Patrice Chantrenne, Takashi Tokumasu | Multiscale Simulation of Carbon Electromigration in Iron | ICFD2021 | 27-29 October 2021 | online | Japan | |
| 4 | K. Kita, T. Mabuchi, P. Chantrenne, T. Tokumasu | Molecular Dynamics Study of carbon diffusion inside iron under an electric field | The 34th Symposium on Computational Fluid Dynamics | 21-23 Dec., 2020 | Okinawa | Japan | https://dx.doi.org/sd.3432/0522-4530/de3c1f |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | T. Tokumasu, P. Chantrenne, J. Kioseoglou | MD School @ Lyon | Teachers and students | 4-11 March 2022 |
| 2 | Takashi Tokumasu, Patrice Chantrenne, Kairi Kita | MD School @ IFS | Teachers and students | 27th Sept. 2020 |

# DECCOBABA

*DEvelopment and Characterization of New CO BAsed alloys for Biomedical Applications*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Kenta YAMANAKA[a]** | **Damien FABREGUE[b]** | **Eric MAIRE[b]** | **Akihiko CHIBA[c]** |

[a] *Institute for Materials Research, Tohoku University, Sendai, Miyagi, Japan*
[b] *MATEIS, INSA Lyon, Villeurbanne, France*
[c] *New Industry Creation Hatchery Center, Tohoku University, Sendai, Miyagi, Japan*

**Contact:** kenta.yamanaka.c5@tohoku.ac.jp, damien.fabregue@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2019 **Current researchers** (permanent/non-permanent): 6 person-month/year

| **Positioning** | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 20 % | 80 % |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | |

**Other:**

Include partner from ☒ Outside ELyT ☒ Industry

Main funding source(s)
☒ Public project(s) ☒ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project

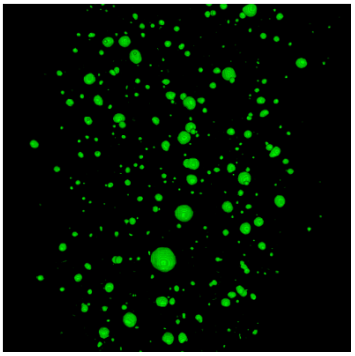
- JSPS, 2018-2022, Construction of electron beam 3D printing metallic materials

- Estimated annual budget:

### Highlights & Outstanding achievements

- We quantified gas pores in Co-Cr-Mo alloy powders and their 3D-printed materials using X-ray computed tomography.
- The dependence of porosity on carbon concentration was precisely determined.
- The reduction of gas pores during electron beam powder bed fusion was attributed to solidification behavior.
- The findings suggested a potential alloy design approach to mitigate gas pores in 3D-printed materials for critical applications.
- A publication has been accepted in Additive Manufacturing, IF=11

### Illustration



# PROJECT DESCRIPTION

**Background**

3D printing technologies, which fabricate materials/components via high-energy laser or electron beam irradiation to consolidate metal powders, have been growing rapidly in both academic and industrial realms. However, several critical issues remain unexplored. Eliminating gas pores, which originate from raw powders and trigger cracking in their 3D printed parts upon loading, is one such issue crucial for applications in the biomedical and aerospace industries. Therefore, hot isostatic pressing has been employed to reduce the volume of gas pores, although the associated microstructural evolution is not always beneficial to mechanical properties. Moreover, unlike other printing defects such as lack-of-fusion and keyhole defects, gas pores are generally difficult to eliminate via optimization of process parameters. Therefore, a novel strategy is highly anticipated. Furthermore, the behavior of gas pores in the melt pool during 3D printing has been less studied.

**Key scientific question**

Reducing gas pores from 3D-printed materials for critical applications.
Demonstrating an alloy design to mitigate gas pores.

**Research method**

The DECCOBABA project aims to develop new Co-based alloys. In this study, Co-Cr-Mo alloy powders with varying carbon concentrations were prepared by gas atomization and consolidated via 3D printing based on electron beam powder bed fusion. The alloys were designed not only for biomedical implants but also for broader industrial applications in harsh tribocorrosive environments. X-ray computed tomography experiments were performed at INSA Lyon, and the volume fractions and sizes of gas pores were determined from the 3D reconstructions. The solidification microstructures were characterized at Tohoku University to correlate the variation of porosity with the solidification mechanisms.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

*Master/Bachelor students (years):*

- A. Numata : October 2019 – March 2020 (4 months)
- S. Aota (2019, Tohoku University)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- D. Fabrègue, January 2023-February 2023 (10 days)

*JP to FR (date, duration):*

- A. Numata : October 2019 – March 2020 (4 months)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | S. Aota, K. Yamanaka, M. Mori, Nobuyuki Sasaki, J. Adrien, E. Maire, D. Fabrègue, A. Chiba | Solidification behavior and porosity in electron-beam powder bed fusion of Co–Cr–Mo alloys: Effect of carbon concentrations | Additive Manufacturing | 59 | 103134 | 2022 | https://dx.doi.org/10.1016/j.addma.2022.103134 |
| 2 | K. S. N. Sesha, K. Yamanaka, M. Mori, Y. Onuki, S. Sato, D. Fabrègue, A. Chiba | Demonstrating a duplex TRIP/TWIP titanium alloy via the introduction of metastable retained β-phase | Materials Research Letters | 10(11) | 754-761 | 2022 | https://doi.org/10.1080/21663831.2022.2096419 |
| 3 | Kenta Yamanaka, Manami Mori, Kazuo Yoshida, Sandra Balvay, Daniel Hartmann, Damien Fabrègue, Akihiko Chiba | Preparation of high-strength Co− Cr− Mo alloy rods via hot-caliber rolling | Materialia | 12 | 100729 | 2020 | https://doi.org/10.1016/j.mtla.2020.100729 |
| | | | | | | | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | K. Yamanaka, S. Aota, M. Mori, J. Adrien, E. Maire, D. Fabrègue, A. Chiba | Reducing gas pores in electron beam powder bed fusion via controlling solidification mechanism | Thermec 2023 | 4 Jul., 2023 | Wien | Austria | |
| 2 | K. Yamanaka, S. Aota, M. Mori, J. Adrien, E. Maire, D. Fabrègue, A. Chiba | Alloy design approach for reducing powder-originated gas pores in electron beam powder bed fusion | International Conference on Electron Beam Additive Manufacturing (EBAM 2023) | 23 Mar., 2023 | Erlangen | Germany | |

# EM Tracking of Catheter

*Electromagnetic tracking of catheter using Giant-magneto resistance*

## MAIN PARTICIPANTS


| Louis PAQUET[1] | Makoto OHTA[2] | Benjamin DUCHARNE[3] | Kevin TSE VEE KOON[1] | Aurélie SOLIGNAC[4] |
|---|---|---|---|---|

[1] *CREATIS, Lyon, France*
[2] *IFS, Tohoku University, Sendai, Japan*
[3] *ELyTMaX, Sendai, Japan*
[4] *CEA, Paris-Saclay, France*

**Contact:** louis.paquet@creatis.insa-lyon.fr, Benjamin.ducharne@insa-lyon.fr, makoto.ohta.e2@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2023, **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | 25 % |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | 75 % |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project

- Estimated annual budget:

| **Highlights & Outstanding achievements** | **Illustration** |
|---|---|
| • Giant-Magneto resistors of adequate size (>=300µm²) have been manufactured and characterized.<br>• The feasibility of the method has been demonstrated in 1D. | |

# PROJECT DESCRIPTION

**Background**

Catheterization is a widely use minimally invasive surgery to perform diagnostic and treatment on the vascular network of a patient. To localize the catheter, once inserted into the arteria, x-ray fluoroscopy imaging is used. The method has proven efficient but really on ionizing ray and the injunction of contrast agent into the patient arteria. It also shows a projection of the vascular network, hence presenting a 2D view of a 3D object. To work on some of the limitations, it is proposed to install a magnetic sensor into the tip a catheter. By generating a known magnetic field around the patient, the goal is to find the position of the catheter by measuring the field value. The full position and the orientation $(x, y, z, \alpha, \beta, \gamma)$ of the sensor, hence the catheter could give more information than what can be obtained via fluoroscopy. It does not require contrast agent or x-ray and could thus reduced the dosage of both.

**Key scientific question**

Using Giant-Magnetoresistance, integrated into a catheter to measure a magnetic field.
Generating a time-varying magnetic field capable of transmitting positional information on sensor.

**Research method**

An experimental setup will be installed to test the feasibility of the method. The GMR sensors are prepared and manufactured at the CEA, SPEC-LNO laboratory in Paris, Saclay. The catheters used will firstly be on-shelf catheter, available at IFS laboratory. The rest of the equipment needed is either home-made for the magnetic field generation or readily available. The mounted setup should enable a 1D, 2D and if possible 3D localization a catheter in a determined volume using a beforehand carefully generated magnetic field. The spatial resolution and time resolution are the two keys parameters of such tracking system and should be determined via the experimental setup. The experimental results will be confirmed with simulation.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Louis PAQUET (2023-present, CREATIS – INSA-Lyon)

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- L. PAQUET (November 2023 – November 2023)

*JP to FR (date, duration):*

# EPOPEE

*Elaboration of POrous Powders by liquid mEtal dEalloying*

## MAIN PARTICIPANTS


|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| **Louis LESAGE** [a,b,d] | **Pierre-Antoine GESLIN** [a] | **Nicolas MARY** [a,d] | **Hidemi KATO** [c,d] | **Takeshi WADA** [c] | **Christophe LE BOURLOT** [a] | **Eric MAIRE** [a] |

[a] Univ. Lyon, INSA Lyon, CNRS, MatéIS, UMR5510, 69621 Villeurbanne, France
[b] Graduate School of Engineering, Tohoku University, Sendai, Japan
[c] Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[d] ELyTMaX IRL3757, CNRS, Univ Lyon, INSA Lyon, Centrale Lyon, UCB Lyon 1, Tohoku University, Sendai, Japan

**Contact:** pierre-antoine.geslin@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2021 **Current researchers** (permanent/non-permanent): 2 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | 50 | | |
| **Surfaces and interfaces** | | 50 | |
| **Simulation and modeling** | | | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

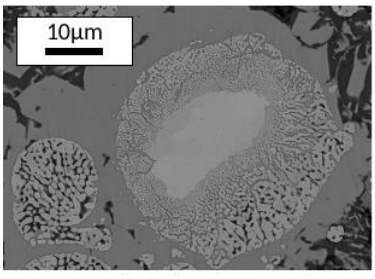
- none

Estimated annual budget: none

### Highlights & Outstanding achievements *(3-5 bullet points)*

- Porous Fe powders were successfully elaborated via the liquid metal dealloying process
- Our model for dealloying of NiCu alloys reached semi-quantitative agreement with experiments

### Illustration *(5x5 cm² max)*




*Partially dealloyed Invar powder – SEM-BSE cross-section*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Introduced by Wada et al. In 2011[1], liquid metal dealloying (LMD) is a novel technique for elaborating porous metals and metallic foams. LMD can be applied to a wide range of metals and consequently overcomes the weak point of electrochemical dealloying which cannot be used with noble metals. The resulting porous metals present a high specific surface and pores opened to the surface of the material which can make it a good catalyst.

This project aims at applying LMD to powders. Their small dimensions are expected to ease the control of the kinetics and the morphology of dealloyed structures. Dealloyed powders would present interesting properties not only for catalysis but also as ingredients for additive manufacturing or coating techniques. This work will be completed by the development of a predictive numerical model for dealloying kinetics and morphologies.

1. Wada T, Yubuta K, Inoue A, Kato H. Dealloying by metallic melt. Materials Letters. 2011 Apr 15;65(7):1076–8.

**Key scientific question** (2 lines max; Calibri 11)

Understanding of liquid metal dealloying kinetics and resulting morphology.
Applications for porous powders elaborated via liquid metal dealloying.

**Research method** (8 lines max; Calibri 11)

This project « EPOPEE » comes after the «DeProMiNa » project which was led by Morgane Mokhtari's PhD work, supervised by Hidemi KATO, Eric MAIRE and Christophe LE BOURLOT. It lies on the synergy between the knowledge of Professor Kato's team at IMR (Tohoku University) about elaborating materials by LMD and the skills in characterization of MATEIS laboratory members (INSA Lyon, CNRS).
This three-part work (elaboration-characterization-simulation) will focus on the dealloying of FeCrNi powders.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

Louis LESAGE (CNRS international Grant) 2021/11 - 2024/10

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

Louis LESAGE: *2022/07 – 2023/01* and *2023/10 - 2024/10* (tentative)

Pierre-Antoine GESLIN: *2022/04 - 2022/10 and 2022/12/20 - 2023/01/31*

*JP to FR (date, duration):*

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | L. Lesage, T. Suga, T. Wada, H. Kato, C. Le Bourlot, E. Maire, N. Mary, P.-A. Geslin | A diffusion model for liquid metal dealloying. Application to NiCu precursors dealloyed in liquid Ag. | Submitted to Acta Materialia in 2024/01 | | | | |
| 2 | L. Lesage, C. Le Bourlot, E. Maire, T. Wada, H. Kato, W. Ludwig, N. Mary, P.-A. Geslin | Exploring equilibrium conditions in liquid metal dealloying of powders by synchrotron in situ X-ray diffraction. | In preparation | | | | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato | Elaboration of porous metallic powders by liquid metal dealloying | Euromat 2023 | 2023/09/07 | Frankfurt | Germany | |
| 2 | L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato | Thermodynamics of liquid metal dealloying: powders and bulk samples | 4th International Symposium on Nanoporous Materials by Alloy Corrosion | 2023/04/24 | Nohfelden | Germany | |
| 3 | L. Lesage, T. Wada, H. Kato, N. Mary, P.-A. Geslin | Thermodynamic modeling of liquid metal dealloying | ELyT Workshop 2022 | 2022/11/16 | Lyon | France | |
| 4 | L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato | Elaboration of micro-porous powders by liquid metal dealloying (Poster session) | VISUAL JW and DEJI2MA | 2022/10/25 | Osaka | Japan | |
| 5 | L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato | Processing of micro-porous metallic powders by liquid metal dealloying (Oral presentation) | JIM Annual Autumn meeting 2022 | 2022/09/23 | Fukuoka | Japan | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot | ESRF experiment (synchrotron) | Monitoring of liquid metal dealloying kinetics and phase transformations via *in situ* XRD and X-ray tomography | 2023/04/18-21 |

# Clarification of Flow Structures related to jet Noise Generation using Mode Analysis and High-precision Jet Flow Simulation

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Shota Morita**[a,b] | **Aiko Yakeno**[a] | **Christophe Bogey**[c] | **Shigeru Obayashi** [a] |
| [a] *Institute of Fluid Science, Sendai, Japan*<br>[b] *Department of Aerospace Engineering, Sendai, Japan* | | [c] *Ecole Centrale de Lyon(ECL) , Lyon, France* | |

**Contact:** shota.morita.t7@dc.tohoku.ac.jp, aiko.yakeno@tohoku.ac.jp, christophe.bogey@ec-lyon.fr, s.obayashi@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2021 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | | | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | 100 % | | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

- IFS, 2021-2022, Extraction and sensitivity analysis of noise sources of high-speed subsonic jet noise

Estimated annual budget:

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- We have developed the new sensitvity analysis to clarify the relationship between acoustic waves and jet flow instability
- By using the sensitivty analysis, we have found that the feedback loop phenomena seen in supersonic and collisional jets also occur in subsonic free jets.
- Based on above archivements, two conferences have been attended, one journal has been accepted, and two jounrals have been submitted

**Illustration** *(5x5 cm² max)*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Jet noise is caused by unsteady and complex turbulent vortices, which is also called a vortex sound. Recent advances in computing have enabled us to obtain highly accurate data on aeroacoustic. However, it is difficult to understand the huge and complex turbulence data without the appropriate analysis methods.

In this project, we aim to investigate the mechanisms responsible for high-speed subsonic jet noise, which is the main cause of a commercial aircraft jet engine, based on Computational Fluid Dynamics (CFD) and data science approach.

These studies are expected to provide a clear guideline for the future noise reduction design of a jet engine.

**Key scientific question** (2 lines max; Calibri 11)

Clarification of a subsonic jet noise mechanism

Setting a clear guideline for the future noise reduction design of a jet engine

**Research method** (8 lines max; Calibri 11)

The objectives of this project encompass Aeroacoustics, Fluid Dynamics and Data Science. In order to clarify the jet noise mechanism, the first is to perform large-scale numerical simulations of aerodynamic noise using jet flow simulations that are accurate enough to resolve the acoustic waves. The second is to try to extract the structures related to the noise generation from the numerical simulation data carried out by Dr. Bogey using data-driven methods such as mode decomposition.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Shota Morita (2021-present, Department of Aerospace Engineering, Tohoku University)

*Master/Bachelor students (years):*

- No

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- None

*JP to FR (date, duration):*

- Shota Morita *(June, 2022, 3days, November, 2022, 5 days)*

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | Flow Sensitivity Analysis for the Feedback Loop Phenomenon of Subsonic Jet Noise Generation | Progress in Turbulence X | | | 2024 | (Accepted) |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | Clarification of flow structures related to jet noise generation using mode analysis and high-precision jet flow simulation | The Twentyth International Conference on Flow Dynamics (ICFD2023) | November 6-8, 2023 | Sendai, Miyagi | Japan | |
| 2 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | Flow Sensitivity Analysis for the Feedback loop phenomenon of subsonic jet noise generation | Interdisciplinary Turbulence Initiative(iTi) 2023 | July 24$^{th}$-26$^{th}$, 2023 | Bertinoro, Bologna | Italy | |
| 3 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | Flow Structure Extraction Related to the Noise Generation in A Subsonic Free Jet by Using Mode Decomposition Methods | ElyT workshop 2022 | 16-18 Nov., 2022 | Lyon | France | |
| 4 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | *Flow Structure Analysis Related to the Acoustic Wave Generation in Subsonic Free Jet Using Dynamic Mode Decomposition* | WCCM-APCOM 2022(15th World Congress on Computation Mechanics & 8th Asian Pacific Congress on Computation Mechanics) | 31 Jul.-5 Aug., 2022 | Yokohama (Online) | Japan | |
| 5 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | *Modal Approach for Extracting Flow Structure Related to the Subsonic Jet Noise Generation* | ICFD2022(Nineteenth International Conference on Flow Dynamics) | 9-11 Nov.,2022 | Sendai | Japan | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | *Flow Structure Analysis Related to the Acoustic Wave Generation in Subsonic Free Jet using the Mode Decomposition Method* | JSASS northern Branch 2022 (Japanese name:日本航空宇宙学会北部支部 2023 年講演会ならびに第 4 回再使用型宇宙輸送系シンポジウム) | 17-19 Mar. 2022 | Sendai (Online) | Japan | |
| 7 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | *Mode Decomposition Method for Extracting Characteristic Structures Related to the Subsonic Jet Noise Generation* | Eighteenth International Conference on Flow Dynamics(ICFD2021) | 27-30 Apr. 2021 | Sendai (Online) | Japan | |
| 8 | S.Morita, A. Yakeno, C. Bogey and S. Obayashi | *Modal approach for extracting flow structure related to the subsonic jet noise generation* | ELyT workshop 2021 | 25 Jun. 2021 | Sendai (Online) | Japan | |

**Patents** *(gray color for previous years)*

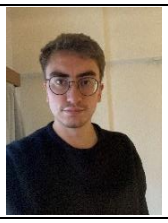
**Others** *(gray color for previous years)*

Project report 2023

# FIESTA

*Ferroelectric-ferroelectric transitions Induced by External STress for Applications in sensing and energy harvesting.*

## MAIN PARTICIPANTS




| Gaspard Taxil[1,2,3] | Mickaël Lallart[2,*] | Gaël Sebald[1] | Benjamin Ducharne[1] | Tung Thanh Nguyen[1,3] | Hiroki Kuwano[3] |
|---|---|---|---|---|---|

[1] *ELyTMaX IRL3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan*
[2] *Univ. Lyon, INSA-Lyon, LGEF EA682, F-69621, France*
[3] *New Industry Creation Hatchery Center (NICHe), Tohoku University, 6-6-10 Aramaki-Aoba, Aoba-ku Sendai, Miyagi 980-8579, Japan*

**Other contributors:** Elie Lefeuvre, Ausrine Bartasyte, Merieme Ouhabaz, Jhordan Chavez, Takahito Ono

**Contact:** [*] *mickael.lallart@insa-lyon.fr*


## OVERVIEW *(keep within this page)*

**Starting year:** 2021 **Current researchers** (permanent/non-permanent): 15 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 60 % | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | 40 % | |

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☑Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☑ No

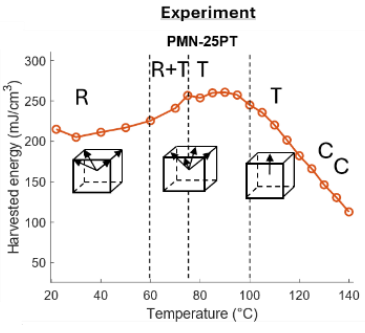
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- ANR-FIESTA project, 2021-2024

Estimated annual budget: 70 000 euros

### Highlights & Outstanding achievements *(3-5 bullet points)*

- Investigation and characterization of different ferroelectric materials under high excitation levels for energy harvesting.
- Theoretical investigation of optimal phase transition in different oriented ferroelectric single crystal for pyroelectric and piezoelectric energy harvesting
- Identification of the best polarization mechanisms and phase transitions in PZN-8PT and PMN-25PT single crystals.
- Development of a smart tile with associated electrical interface to reach high excitation levels previously investigated on different materials. Energy output ~100 time beyond the state of the art.

### Illustration *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Recently, ferroelectric materials are foreseen as potential materials for numerous energy harvesting applications. People's activities and industrial applications are considered as the sources for electromechanical energy harvesting using ferroelectric materials. Yet, the true potential in terms of maximum energy that could be converted is still an open issue. Such a questioning is even more under-documented considering non-resonant conditions, that although covering a wide range of applications. While nonlinearities in materials are usually considered as a drawback in applications, it is however possible to take them into advantage to address the maximal energy that can be converted. This research therefore aims at evaluating this maximum energy, notably by taking advantage of phase transitions induced by stress, electric field and/or temperature.

**Key scientific question** (2 lines max; Calibri 11)

What is the possible maximum energy that can be converted in mechanical energy harvesting? (Material, thermodynamic conditions, mechanical structure and electrical interface investigation)

**Research method** (8 lines max; Calibri 11)

Energy conversion abilities of different ferroelectric materials using thermodynamic cycles under high excitations levels have been characterized. Landau-Devonshire phenomenological approach, confirmed by experimental characterization at different temperatures, allowed identifying ideal polarization mechanisms and optimal phase transitions under high stress and electrical field. A real device which supports high values of stress and electric field was developed based on these finding, along with realistic (passive) electrical interface (Bennet doubler), yielding ultra high energy output of 320 mJ per cycle, which is nearly two orders of magnitude above the state-of-the art.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Gaspard Taxil (2021-2024, DD INSA-Lyon/Tohoku)

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- G. Taxil (May 2022, 18 months)
- M. Lallart (Nov. 2023, 7 days)
- M. Lallart (Nov. 2022, 7 days)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | G. Taxil, G. Sebald, T. T. Nguyen et al. | Stress and electric field induced phase transitions for ultra high energy conversion in ferroelectrics | Acta Materialia | 261 | 119367 | 2023 | https://doi.org/10.1016/j.actamat.2023.119367 |
| 2 | G. Sebald, N. T. Tung, G. Taxil et al. | Piezoelectric small scale generator: towards near-Joule output energy generation | Smart Mater. Struct. | 32(8) | 085009 | 2023 | https://doi.org/10.1088/1361-665X/acdf31 |
| 3 | N. Tung Thanh, G. Taxil, & G. Sebald & al | Ultimate electromechanical energy conversion performance and energy storage capacity of ferroelectric materials under high excitation levels. | Applied Energy | 326 | 119984 | 2022 | 10.1016/j.apenergy.2022.119984 |
| 4 | G. Taxil, M. Lallart & G. Sebald & al | Modeling of Olsen cycle for pyroelectric energy harvesting and assessment of abnormal electrocaloric effect in ferroelectric single crystals. | Journal of Applied Physics | 132 | 144101 | 2022 | 10.1063/5.0107429 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | G. Taxil, G. Sebald, B. Ducharne et al. | Characterization and Implementation of Piezoelectric Energy Harvesting under Ultra-high Levels | IWPMA 2023 | Oct. 31st-Nov. 3rd 2023 | Jeju | Korea | |
| 2 | G. Taxil, M. Lallart, G. Sebald et al. *(invited)* | Exploiting Stress-Induced Phase Transitions in Ferroelectric Materials for Energy Conversion Magnification | IWPMA 2023 | Oct. 31st-Nov. 3rd 2023 | Jeju | Korea | |
| 3 | G. Taxil, G. Sebald, B. Ducharne et al. | Phase transition in ferroelectric single crystals for ultra high energy harvesting | JNRSE 2023 | June 12-13, 2023 | Paris | France | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | G. Sebald, N. T. Tung, G. Taxil et al. *(invited)* | Piezoelectric generator: ultimate energy density and near Joule output example | JNRSE2023 | June 12-13, 2023 | Paris | France | |
| 5 | G. Sebald, N. T. Tung, G. Taxil et al. | Piezoelectric energy harvesting from a direct force application: an experimental proof of concept for ultra-high output energy | ISAF-ISIF-PFM 2023 | July 23-27, 2023 | Cleveland | USA | |
| 6 | G. Taxil, M. Lallart, G. Sebald et al. | Ferroelectric Materials and Their Phase Transitions for Energy Harvesting | ISAF-ISIF-PFM 2023 | July 23-27, 2023 | Cleveland | USA | |
| 7 | N. Tung Thanh, G. Taxil, & G.Sebald & al | Simple and Accurate Estimation of Electromechanical Energy Conversion Performance of Ferroelectric and Paraelectric Phase Ferroelectric Materials | ISAF 2022 | 27-1 June-July 2022 | Tours | France | |
| 8 | G. Taxil, M. Lallart & G. Sebald & al | Phase transition in ferroelectric materials for pyroelectric energy harvesting | IWPMA 2022 | 24-26 October 2022 | Online | Online | |
| 9 | G. Taxil, M. Lallart & G. Sebald & al | Modeling of Olsen cycle for pyroelectric energy harvesting and assessment of abnormal electrocaloric effect in ferroelectric single crystals. | ELyT Workshop | 16-18 November 2022 | Lyon | France | |
| 10 | G. Taxil, M. Lallart, G.Sebald & al | Modeling ferroelectric phase transitions for energy harvesting | ELyTWorkshop | 21-25 July., 2021 | Online | Online | |

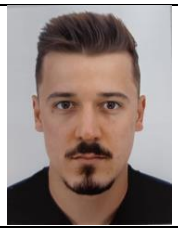
**Others** *(gray color for previous years)*

| | **People** | **Event** | **Description** | **Date** |
|---|---|---|---|---|
| | G. Sebald | Katahira Masturi | Presentation of the smart tile to young students in the framework of scientific mediation event | 07/10/2023 |

# FRIISE

*Multi-scale elucidation of friction mechanisms in ice-rubber interfaces*

## MAIN PARTICIPANTS


|  |  |  |
|---|---|---|
| **Anderson DALAVALE KAISER PINTO[a]** | **Denis MAZUYER[b]** | **Juliette CAYER-BARRIOZ[c]** |

[a] *PhD Student, LTDS, Ecole Centrale de Lyon, Lyon, France*
[b] *Professor ECL, Ecole Centrale de Lyon, Lyon, France*
[c] *CNRS Director of Research LTDS, Lyon, France*

**Contact:** anderson.dalavale-kaiser-pinto@ec-lyon.fr, juliette.cayer-barrioz@ec-lyon.fr, denis.mazuyer@ec-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2020 **Current researchers** (permanent/non-permanent): 2 / 1

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | |
| **Surfaces and interfaces** | 95% | | |
| **Simulation and modeling** | 5% | | |

**Other:**

Include partner from ☒ Outside ELyT ☒ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

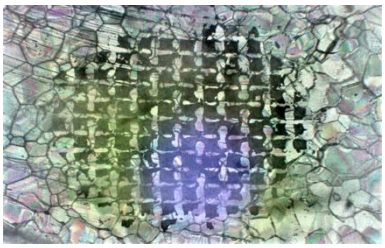
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- ANR-CREST project, 2021-2025, FRIISE

Estimated annual budget: 125 k€/year (French side)

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Visualization of the real contact area between smooth or rough rubber and ice using a transparent ice layer, combined with friction measurements under controlled kinematics, in order to accurately estimate the interfacial shear stress during sliding.
- Visualization of the water formation at the end of the sliding experiment, likely correlated with heat generation at the contact interface, thereby providing valuable insights into the thermodynamic dynamics governing the interaction.
- Development of a new cooling chamber to extend temperature during experiments, to very low values, down to -28 °C.

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Driving on icy roads presents significant safety hazards due to reduced tire grip, while minimizing energy loss from tire friction is crucial, necessitating intricate adjustments to tire materials, typically composed of viscoelastic materials. As we aim for sustainable technology and a safer society, there is a growing interest in understanding the interactions between rubber and ice. Various mechanisms influence the frictional behavior of ice and rubber, including ice melting (Oksanen et al., 1981) and premelting (Kasuya et al., Langmuir 2019), as well as the adhesion at the ice-rubber interface (Schallamach, 1968) and the viscoelasticity of rubber (Tabor, 1955). Moreover, these mechanisms are known to be affected by both temperature and shear velocity (Hemette et al., 2019). The dynamic nature of these properties and their interplay contribute to the complex frictional characteristics observed at ice-rubber interfaces.

*This project is in collaboration with Tohoku University and Tokyo University.*

**Key scientific question** (2 lines max; Calibri 11)

Multiscale characterization of the ice-rubber interfaces.

Elucidate and propose predictive model of ice-rubber friction, and material designing.

**Research method** (8 lines max; Calibri 11)

The objective of the FRIISE project for the French side is to elucidate the phenomenon of ice-rubber friction using an experimental approach coupling in situ contact area visualization and force measurements under controlled contact kinematics, such as rolling, sliding and rolling/sliding. Rubber materials provided by Michelin can be either smooth or rough in order to analyze the topography influence on friction. An additional focus is made to identify the potential formation of ice water at the rubber/ice interface during sliding.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- DALAVALE KAISER PINTO Anderson (2022-present, ECL, Lyon, FRANCE)

*Master/Bachelor students (years):*

..

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- 22nd of September 2023, 1 day

*JP to FR (date, duration):*

..

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | S. Hemette, J. Cayer-Barrioz, D. Mazuyer | Thermal effects versus viscoelasticity in ice-rubber friction mechanisms | Tribology International | 162 | 107129 | 2021 | https://doi.org/10.1016/j.triboint.2021.107129 |
| 2 | Florian Lecadre, Motohiro Kasuya, Sylvain Hemette, Aya Harano, Yuji Kannoc and Kazue Kurihara | Ice premelting layer of ice–rubber friction studied using resonance shear measurement | Royal Society of Chemistry | | | 2020 | DOI: 10.1039/d0sm00478b |
| 3 | S. Hemette, J. Cayer-Barrioz, D. Mazuyer | Friction setup and real-time insights of the contact under controlled cold environment: The KO⁻ RI tribometer for rubber-ice contact application | Review of Scientific Instruments | 89 | 123903 | 2018 | https://doi.org/10.1063/1.5048844 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | A. Dalavale Kaiser Pinto, J. Cayer-Barrioz, D. Mazuyer | Multi-scale Analysis of Ice-Rubber Sliding Interface | ITC Fukuoka 2023 | 19 - 30 September., 2023 | Fukuoka | Japan | |
| 2 | S. Hemette, D. Mazuyer, J. Cayer-Barrioz (invited) | Ice-rubber Friction Mechanisms | ACS Fall 2019 | 25-29 August, 2019 | San Diego | USA | |

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|
| 1 | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| | | | | |

Project report 2023

# MAGELLAN

*Magnetorheological Elastomers: finite strain visco-elasto-plastic behavior under general loading conditions*

## MAIN PARTICIPANTS


|  |  |  |
|---|---|---|
| **Masami NAKANO [a,b]** | **Konstantinos DANAS[b,c]** | **Gaël SEBALD[c]** |

[a] *Smarttech-lab, Tohoku University, Sendai, Japan*
[b] *LMS, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau, France*
[c] *ELyTMaX IRL3757, CNRS, Univ Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan*

**Contact:** mnakano@smarttech-lab.com, konstantinos.danas@polytechnique.edu, gael.sebald@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2023 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 50% | | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | 50% | | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

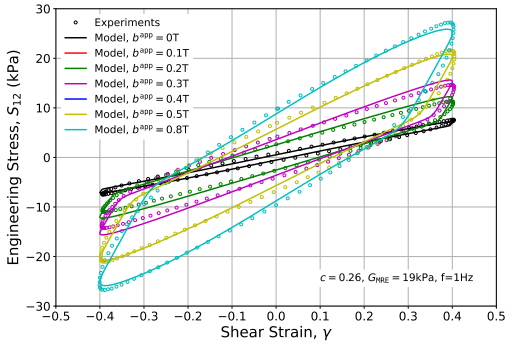
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: 5 k€

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- First explicit finite strain, nonlinear viscoelastic model allowing to recover experiments at finite strains and magnetic fields
- Experimental setup is unique in providing fairly "uniform" magnetic fields in the tested sample
- The simplicity of the model allows its full implementation in general purpose commercial FE packages (e.g. ABAQUS)

**Illustration**[21] *(5x5 cm² max)*




[21] *After G. Sebald, M. Nakano, M. Lallart, T. Tian, G. Diguet, J.-Y. Cavaille, , Science and Technology of Advanced Materials 18(1) (2017) 766-778*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Magnetorheological elastomers (MREs) comprise magnetic particles embedded in an otherwise non-magnetic polymer matrix. Under the application of a magnetic field, the particles interact strongly with each other changing substantially the mechanical response of the material. In particular, it is experimentally shown that the magnetic fields affect significantly the elastic modulus, viscoelasticity/viscoplasticity and more generally the nonlinear mechanical response of the MRE. One may observe a ten- to twenty-fold increase of the apparent viscosity of the MRE and a reduction of the viscoplastic exponent at moderately applied magnetic fields. This transforms the response of the MRE from that of an elastomer to that of a highly viscous/plastic solid. As a result, one may consider MREs as potential candidates for dynamically controlled dissipation driven applications such as active braking systems, active sealing, impact problems, as well as robotic devices.

**Key scientific question** (2 lines max; Calibri 11)

What and how can we design the visco-elasto-plastic behavior of MREs under large strain amplitudes and magnetic fields?

**Research method** (8 lines max; Calibri 11)

We propose a class of homogenization-guided models that are able to model the finite strain viscoelastic response of soft MREs under the application of shear cyclic loads at different mechanical frequencies and strain rates. Extensive experimental campaigns are conducted on soft MREs under various operating conditions. The experiments involve relaxation tests under combined magnetic and mechanical loads as well as shear testing at various frequencies. The models meet the experiments via straightforward calibration thus allowing a comprehensive design framework using optimization codes, finite element full field simulations and device design and realization.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration): September 2023 – August 2024 (K. Danas)*

*JP to FR (date, duration):*

# MARECO

*MAgneto-Rheological elastomers for Energy COnversion*

## MAIN PARTICIPANTS


|  |  |  |  |  |
|---|---|---|---|---|
| **Gaël SEBALD[a]** | **Masami NAKANO [a,b]** | **Mickael LALLART[c]** | **Gildas DIGUET[a]** | **Jean-Yves CAVAILLE[a]** |

*[a] ELyTMaX IRL3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University , 980-8577, Sendai, Japan*
*[b] New Industry Creation Hatchery Center, Tohoku University, Sendai, Japan*
*[c] Univ. Lyon, INSA-Lyon, LGEF EA682, F69621 Villeurbanne, France*

**Contact:** gael.sebald@insa-lyon.fr, masami.nakano.b2@tohoku.ac.jp, mickael.lallart@insa-lyon.fr, gildas.diguet.d4@tohoku.ac.jp, jean-yves.cavaille@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2015 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 50% | 50% | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | |
| **Other:** | | | |

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

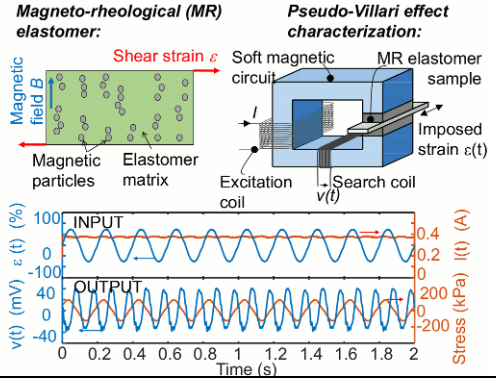
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: 10 k€

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- The magneto-mechanical energy conversion in polymer composites with magnetic particles was elucidated
- Routes of improvement were proposed, considering that the polymer matrix plays no role in the energy conversion, opening the way of ultra-soft elastomer matrix

**Illustration**[22] *(5x5 cm² max)*




[22] *After G. Sebald, M. Nakano, M. Lallart, T. Tian, G. Diguet, J.-Y. Cavaille, , Science and Technology of Advanced Materials 18(1) (2017) 766-778*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

In the framework of **energy harvesting from vibrations**, resonant systems exhibit the highest energy conversion potential. Considering the typical frequency range encountered in transportation or energy industries (100Hz and below), it is necessary to explore alternatives to piezoelectric or electromagnetic systems. In this frame, it is investigated the **potential of soft elastomers** composites including magnetic particles. In this framework, the use of soft polymers offers the advantages of being low-cost and mechanically very soft compared to their piezoelectric counterparts.

A Magneto-Rheological Elastomer (MRE) exhibits a **magneto-mechanical coupling**, i.e. a dependence of the mechanical modulus on the magnetic field and a dependence of the magnetic permeability on the mechanical strain. However, the latter effect has been barely considered within the scientific community. MRE can therefore be utilized for energy conversion, such as vibrational energy converted into magnetic one, and through induction in coils, into electrical one.

**Key scientific question** (2 lines max; Calibri 11)

What are the physical mechanisms driving the magneto-mechanical energy conversion in MRE? What energy density conversion can be reached?

**Research method** (8 lines max; Calibri 11)

Within this project, we aim at evaluating and enhancing the capability of MRE for energy harvesting by working on three complementary aspects:

- Elaboration and optimization of the material,
- Modeling and characterization,
- Application to the design of an energy harvesting demonstrator.

In 2021 and 2022, the work focused mostly on a new class of smart material using elastomer foam.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- Mickael LALLART, visit at TU, Nov. 2022 (5 days)
- Mickael LALLART, JSPS invited researcher at TU, Sept 2019 -June 2020 (10 months)
- Mickael LALLART, visit at TU, March 2019 (10 days)
- Mickaël LALLART, visit at TU, October 2017 (1 week)

*JP to FR (date, duration):*

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | Gildas Diguet, Gaël Sebald, Masami Nakano, Mickaël Lallart , Jean-Yves Cavaillé | Magnetic behavior of Magneto-Rheological Foam under Uniaxial Compression Strain | *Smart Materials and Structures* | 31 | 025018 | 2022 | doi: 10.1088/1361-665X/ac3fc8 |
| 2 | Gildas Diguet, Gael Sebald, Masami Nakano, Mickael Lallart, Jean-Yves Cavaille | Analysis of magnetorheological elastomers for energy harvesting systems | *International Journal of Applied Electromagnetics and Mechanics* | 46 (1-4) | pp.439-446 | 2020 | doi: 10.3233/JAE-209350 |
| 3 | G. Diguet, G. Sebald, M. Nakano, M. Lallart, J-Y Cavaillé | Optimization of the magneto-rheological elastomers for energy harvesting applications | *Smart Materials and Structures* | 29(7) | 075017 | 2020 | doi: 10.1088/1361-665X/ab8837 |
| 4 | G. Diguet, G. Sebald, M. Nakano, M. Lallart, J.-Y. Cavaillé | Magnetic particle chains embedded in elastic polymer matrix under pure transverse shear and energy conversion | *Journal of Magnetism and Magnetic Materials* | 481 | 39-49 | 2019 | doi:10.1016/j.jmmm.2019.02.078 |
| 5 | G. Sebald, M. Nakano, M. Lallart, T. Tian, G. Diguet, J.-Y. Cavaille | Energy conversion in magneto-rheological elastomers | *Science and Technology of Advanced Materials* | 18(1) | 766-778 | 2017 | doi: 10.1080/14686996.2017.1377590 |
| 6 | M. Lallart, G. Sebald, G. Diguet, J.-Y. Cavaille, M. Nakano | Anisotropic magnetorheological elastomers for mechanical to electrical energy conversion | *Journal of Applied Physics* | 122 | 103902 | 2017 | doi: 10.1063/1.4998999 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Gildas Diguet, Gael Sebald, Masami Nakano, Mickael Lallart, Jean Yves Cavaille | MagnetoRheological Foams for Energy Harvesting | Eighteenth International Conference on Flow Dynamics (ICFD 2020) | October 27 - 29, 2021 | (online) Sendai | Japan | |
| 2 | G. Diguet, G. Sebald, M. Nakano, M. Lallart, J. Y. Cavaille | Experimental and Theoretical Investigation on the Influence of the Volume Fraction of the Particles on MR and Villari Effect | Sixteenth International Conference on Flow Dynamics (ICFD2019) | November 6 – 8, 2019 | Sendai | Japan | |
| 3 | G. Diguet, G. Sebald, M. Nakano, M. Lallart, J.Y. Cavaille, T. Takagi | Magneto Rheological Elastomers for Energy Harvesting Systems | The 19th International Symposium on Applied Electromagnetics and Mechanics (ISEM2019) | September 15-18, 2019 | Nanjing | China | |
| 4 | G. Sebald, M. Nakano, M. Lallart, G. Diguet, J.-Y. Cavaille | Polymer composites for magneto-mechanical energy conversion: experimental comparison of several magneto-rheological elastomers | Fifteenth International Conference on Flow Dynamics (ICFD2018) | November 7-9, 2018 | Sendai | Japan | |
| 5 | G. Diguet, J.-Y. Cavaille, G. Sebald, M. Nakano. M. Lallart | Effect of the Magnetic Saturation on the Magnetic Induction Variation in MRE Under Pure Strain | Fifteenth International Conference on Flow Dynamics (ICFD2018) | November 7-9, 2018 | Sendai | Japan | pp.560-561 |
| 6 | G. Diguet, G. Sebald, M. Nakano, M. Lallart, J.-Y. Cavaillé | Saturation of MR Elastomers impact in a pure sheared-based energy harvesting device | The 5th Int'l Conference on Advanced Composite Materials (ACM 2018) | July 14-16, 2018 | Kunming | China | |
| 7 | G. Diguet, G. Sebald, M. Nakano, M. Lallart | MR Elastomers for Energy Harvesting System | INTERMAG 2018 | April 23-26, 2018 | Singapore | Singapore | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | M. Lallart, G. Sebald, G. Diguet, J.-Y. Cavaille, M. Nakano | Modeling of Anisotropic MagnetoRheological Elastomers for Mechanical to Electrical Energy Conversion | Fourteenth International Conference on Flow Dynamics | November 1-3, 2017 | Sendai | Japan | |
| 9 | G. Sebald, M. Nakano, M. Lallart, T. Tian, G. Diguet, J.-Y. Cavaille | Experimental Testing of Pseudo-Villari Effect in Magnetorheological Elastomers | Fourteenth International Conference on Flow Dynamics | November 1-3, 2017 | Sendai | Japan | |
| 10 | G. Sebald, M. Nakano, M. Lallart, J.-Y. Cavaille, G. Diguet | Pseudo-Villari Effect in Magneto-Rheological Elastomers | 18th International Symposium on Applied Electromagnetics and Mechanics | September 3-6, 2017 | Chamonix | France | |

**Patents** *(gray color for previous years)*

| | **Inventors** | **Title** | **PCT #** | **Year** |
|---|---|---|---|---|
| | | | | |
| | | | | |

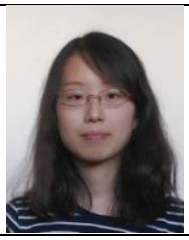
**Others** *(gray color for previous years)*

| | **People** | **Event** | **Description** | **Date** |
|---|---|---|---|---|
| | | | | |
| | | | | |

# MATSURI

*MAgneToStrictive coUpling for eneRgy harvestIng*

## MAIN PARTICIPANTS


|  |  |  |  |  |
|---|---|---|---|---|
| **Mickaël LALLART[a]** | **Kanjuro MAKIHARA[b]** | **Gaël SEBALD[c]** | **Benjamin DUCHARNE[a,c]** | **Yuanyuan LIU[a,b,c]** |

[a] *Univ. Lyon, INSA-Lyon, LGEF EA 682, F-69621, France*
[b] *Space Structure Lab, Department of aerospace engineering, Tohoku University, Japan*
[c] *ELyTMaX UMI 3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan*

**Contact:** mickael.lallart@insa-lyon.fr, kanjuro.makihara.e3@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2020 **Current researchers** (permanent/non-permanent): 15 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 10 % | 30 % | |
| **Surfaces and interfaces** | | 20 % | |
| **Simulation and modeling** | | 40 % | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

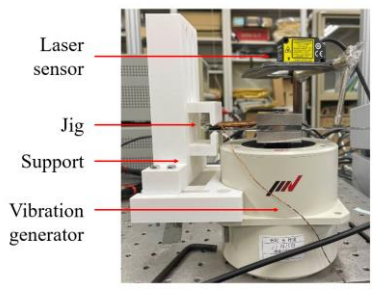
- MESRI, 2020-2023, Magnetostrictive materials and systems for energy harvesting

Estimated annual budget: 30 k€

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Global approach analysis (material, mechanical and electrical)
- Involvement of a double degree Ph.D. student (in progress)
- Forecasted demonstrator development.
- Characterisation of Metglas 2605 SA1
- Development of mechanical structure

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Ambient energy sources can be an attractive and reliable way to replace batteries (that are limited by their self-discharge) in autonomous sensors. More particularly, vibrations are a widely spread energy source, with numerous electromechanical conversion effect possibilities. In this project, magnetostrictive elements, as an extension to electromagnetic devices, are under investigation. Such materials present the advantage of high admissible stress and boosted conversion capabilities compared to the electromagnetic approach. Still, intrinsic mechanisms of the physical operations of such materials have received little attention, and their realistic application in energy conversion devices, both in the structural and electrical aspects, is an open question. Last progress in the project enabled the characterization of materials, along with unveiling a specific optimal magnetic frequency, along with the design of ultralow voltage rectifier.

**Key scientific question** (2 lines max; Calibri 11)

What are the mechanisms behind magnetostriction?
How to efficiently interface (at mechanical and electrical aspects) magnetostrictive elements?

**Research method** (8 lines max; Calibri 11)

The objectives of the project are fourfold. It aims at developing innovative scientific routes into each of the considered domains: (1) material & modeling: The tensile and compressive characterization of the material is done with a dedicated setup with two actuators and an anhysteretic biphasic model is developed for the prediction of energy density. (2) structure: a structure was developed with a vibration generator and the harvested energy due to the pure magnetostrictive effect is investigated, and (3) electrical interface, ultimately providing (4) a unified and global approach in terms of system development.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Yuanyuan LIU (2020-present, DD INSA-TU)

*Master/Bachelor students (years):*

-

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- Mickaël LALLART (November 2023, 5 days)
- Mickaël LALLART (November 2022, 5 days)
- Yuanyuan LIU (May 2022 - Present)

*JP to FR (date, duration):*

- Yuanyuan LIU (November 2022, 10 days)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Y. Liu, L. Daniel, G. Sebald, M. Lallart, K. Makihara and B. Ducharne | Energy harvesting using magnetostrictive materials: Effects of material anisotropy and stress multiaxiality | Sensors and Actuators A: Phys. | 366 | 115017 | 2024 | https://doi.org/10.1016/j.sna.2024.115017 |
| 2 | Y. Liu, M. Lallart, B. Ducharne, K. Makihara and G. Sebald | Analysis of energy conversion capability among various magnetostrictive materials for energy harvesting | Smart Mater. Struct. | 32 | 125004 | 2023 | https://doi.org/10.1088/1361-665X/ad0392 |
| 3 | Y. Liu, B. Ducharne, G. Sebald, K. Makihara and M. Lallart | Investigation of energy harvesting capabilities of Metglas 2605SA1 | Applied Sciences | 13(6) | 3477 | 2023 | https://doi.org/10.3390/app13063477 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | B. Ducharne, Y. Liu, L. Daniel, G. Sebald, M. Lallart and K. Makihara | Energy Harvesting Using Magnetostrictive Materials: Effects of Material Anisotropy and Stress Multiaxiality | IWPMA 2023 | Oct. 31st-Nov. 3rd 2023 | Jeju | Korea | |
| 2 | Y. Liu, L. Daniel, B. Ducharne, G. Sebald, M. Lallart and K. Makihara | Anisotropic magnetostriction for low-frequency energy harvesting applications | INTERMAG 2023 | May 15th-19th 2023 | Sendai | Japan | |
| 3 | Y. Liu, B. Ducharne, G. Sebald, K. Makihara and M. Lallart | Analysis of energy conversion potentials of magnetostrictive materials for energy harvesting with a special focus on Metglas | IWPMA 2022 | Nov. 24-26 | Online | | |
| 4 | Yuanyuan LIU, Benjamin DUCHARNE, Gaël SEBALD, Kanjuro MAKIHARA, Mickaël LALLART | Analysis of energy conversion potentials of Metglas 2605SA1 for energy harvesting applications by measuring Ericsson cycle | Elyt workshop 2022 | Nov 16-18 | Lyon | France | |
| 5 | Yuanyuan LIU, Benjamin DUCHARNE, Gaël SEBALD, Kanjuro MAKIHARA, Mickaël LALLART | Magnetic characterization of Metglas under tensile stress for energy harvesting applications | Elyt workshop 2021 | June 21-25 | Online | | |

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | | | | |

# MicroCell

*Microsystems for Cell Engineering*

## MAIN PARTICIPANTS


**Jean-Paul RIEU** [a]

**Kenichi FUNAMOTO** [b]

[a] *Institut Lumière Matière, Université Claude Bernard Lyon 1, Villeurbanne, France*
[b] *Institute of Fluid Science, Tohoku University, Sendai, Japan*

**Contact:** jean-paul.rieu@univ-lyon1.fr


## OVERVIEW

**Starting year:** 2017 **Current researchers** (permanent/non-permanent): 12 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | | | 40 % |
| **Surfaces and interfaces** | | | 30 % |
| **Simulation and modeling** | | | 30 % |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

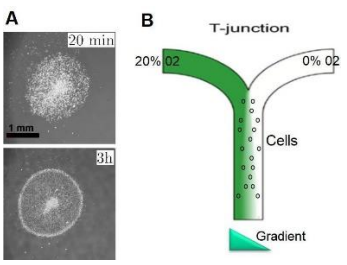
- IFS LyC project 2019-2023
- ANR SHAPE-Med Lyon1 2023-25 ORGANOX
- CNRS, Invited researcher positions for K. Funamoto (2 months in 2019, 1 month in 2023)

Estimated annual budget: 30 k€

### Highlights & Outstanding achievements *(3-5 bullet points)*

- We developed a microfluidic device to control heterogeneous oxygen concentration in a microenvironment.
- We have shown that *Dictyostelium* (Dicty) cells enhances their cell migration under a low oxygen concentration (aerokinesis) and migrate toward an oxygen-rich regions under the 0-2% $O_2$ only (aerotaxis) and that ROS or mitochondria are not involved in aerotaxis.
- We have shown that *Acanthamoeba castellani*, an asocial amoeba, respond to $O_2$ gradients in 0-2% $O_2$ range as well.
- Two research papers were published in (1) Frontiers in Cell and Developmental Biology, and (2) Scientific Reports in 2023.
- An ANR funded SHAPE-Med (Lyon) project led by N. Aznar (CRCL) was obtained in 2023.

### Illustration *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

It is well known that eukaryotic cells sense oxygen tension and change their behaviors accordingly either by regulating gene expression. It is less known that they can also move to regions of favorable oxygen level (aerotaxis). Using a self-generated hypoxic assay, we showed at iLM that the social amoeba Dictyostelium (Dicty) displays a spectacular aerotactic behavior. When a cell colony is covered by a coverglass, cells quickly consume the available $O_2$ and move toward the oxygen-rich area, forming a dense expending ring moving at a constant speed. Although this self-generated hypoxic assay is very simple, to get further insight in the $O_2$ sensing mechanisms, we need to develop microfluidic devices for controlling oxygen tension in a microenvironment and to investigate the cell responses to various types of $O_2$ gradient as functions of gradient steepness and absolute $O_2$ level.

**Key scientific question** (2 lines max; Calibri 11)

The detection and sensing mechanisms $O_2$ which leads to a directed migration of Dicty cells are still an enigma.

**Research method** (8 lines max; Calibri 11)

We have fabricated a very efficient microfluidic device enabling to control the $O_2$ concentration in the range of 0.3-20% $O_2$ within 15 min with two gas channels positioned just above the media channels where cells were cultured. An $O_2$-sensing polymer films was also developed and utilized to monitor the oxygen condition inside the device. Cells (*Dictyostelium* and *Acanthamoeba*) seeded in the media channels were observed while generating various $O_2$ gradients or uniform $O_2$ conditions by supplying gas mixtures into the two gas channels. The sequential microscopic images were then analyzed to evaluate their migratory behaviors. In addition, mathematical models based on cellular Potts model were constructed to interpret the mechanisms of the aerotaxis of the cells.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- S. HIROSE (2020-2023, Tohoku University)
- J. HESNARD (Sept. 2021-present, Université Claude Bernard Lyon 1)
- N. GHAZI (Oct. 2021-present, Université Claude Bernard Lyon 1)

*Master/Bachelor students (years):*

- S. HIROSE (2019-2020, Tohoku University)
- J. HESNARD (2020-2021, Université Claude Bernard Lyon 1)
- N. GHAZI (2020-2021, Université Claude Bernard Lyon 1)
- S. YANAGITA (2022-24), Tohoku University
- N. KAWAHARA (2023-25), Tohoku University

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- N. GHAZI (Nov 2023, 1 week)
- J.-P. RIEU (Oct-Nov 2022,20 days)
- J.-P. RIEU (Dec 2019,5 days)
- J.-P. RIEU (June 2019,5 days)
- J.-P. RIEU (Nov 2018, 5 days)

*JP to FR (date, duration):*

- K. FUNAMOTO (Dec 2023, 4 days)
- K. FUNAMOTO (June-July 2023, 1 month)
- S. HIROSE (Jan 2022-June 2022, 5 months)

- K. FUNAMOTO (Nov 2022, 4 days)
- S. HIROSE (Dec 2021, 1 month)
- K. FUNAMOTO (Feb 2020, 4 days)
- K. FUNAMOTO (Sept 2019, 2 months)
- S. HIROSE (Sept 2019, 2.5 months)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | S. Hirose, J. Hesnard, N. Ghazi, D. Roussel, Y. Voituron, O. Cochet-Escartin, J.-P. Rieu, C. Anjard and K. Funamoto | The aerotaxis of *Dictyostelium discoideum* is independent of mitochondria, nitric oxide and oxidative stress | Frontiers in Cell and Developmental Biology | 11 | 1134011 | 2023 | 10.3389/fcell.2023.1134011 |
| 2 | N. Takahashi, D. Yoshino, R. Sugahara, S. Hirose, K. Sone, J.-P. Rieu, K. Funamoto | Microfluidic platform for the reproduction of hypoxic vascular microenvironments | Scientific Reports | 13 | 5428 | 2023 | 10.1038/s41598-023-32334-9 |
| 3 | S. Hirose, J.-P. Rieu, C. Anjard, O. Cochet-Escartin, K. Funamoto | The Oxygen Gradient in Hypoxic Conditions Enhances and Guides Dictyostelium discoideum Migration | Processes | 10 | 318 | 2022 | https://doi.org/10.3390/pr10020318 |
| 4 | O. Cochet-Escartin, M. Demircigil, S. Hirose, B. Allais, P. Gonzalo, I. Mikaelian, K. Funamoto, C. Anjard, V. Calvez, J.-P. Rieu | *Hypoxia triggers collective aerotactic migration in Dictyostelium discoideum* | eLife | 10 | e64731 | 2021 | doi: 10.7554/eLife.64731 |
| 5 | A. Shirai, Y. Sugiyama, J.-P. Rieu | Differentiation of neutrophil-like HL-60 cells strongly impacts their rolling on surfaces with various adhesive properties under a pressing force | Technology and Health Care | 26(1) | 93-108 | 2018 | doi: 10.3233/THC-171052 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | N. Ghazi, M. Demircigil, S. Hirose, A. Chauviat, V. Calvez, K. Funamoto, C. Anjard, J.-P. Rieu | Hypoxia Triggers Collective Aerotactic Spreading of Eukaryotic Cells (Oral) | ICFD 2023 | Nov. 2023 | Sendai | Japan | |
| 2 | N. Ghazi, M. Demircigil, S. Hirose, A. Chauviat, V. Calvez, K. Funamoto, C. Anjard, J.-P. Rieu | Hypoxia Triggers Collective Aerotactic Spreading of Eukaryotic Cells (Poster). | GDR AQV 2023 | May 2023 | Oléron | France | |
| 3 | N. Ghazi, A. Chauviat, S. Fabre, O. Cochet-Escartin, M. Demircigil, S. Hirose, V. Calvez, K. Funamoto, C. Anjard, J.-P. Rieu | Hypoxia triggers collective aerotactic spreading of eukaryotic cells | LyonSE&N & ELyT Global workshop 2022 | 18 Nov 2022 | Lyon | France | |
| 4 | N. Ghazi, A. Chauviat, S. Fabre, O. Cochet-Escartin, M. Demircigil, S. Hirose, V. Calvez, K. Funamoto, C. Anjard, J.-P. Rieu | Hypoxia triggers collective aerotactic spreading of eukaryotic cells | SFP (Société Française de Physique) | 22-26 Aug 2022 | Lyon | France | |
| 5 | S. Hirose, J.-P. Rieu, K. Funamoto | Migration characteristics of *Dictyostelium discoideum* depending on oxygen environment | The 11th Asian-Pacific Conference on Biomechanics (AP Biomech 2021) | 4 Dec 2021 | On-line | Japan | |
| 6 | S. Hirose, J.-P. Rieu, C. Anjard, O. Cochet-Escartin, H. Kikuchi, K. Funamoto | Aerotaxis and aerokinesis of *Dictyostelium discoideum* under hypoxic microenvironments | The 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2021) | 1 Nov 2021 | On-line | Mexico | |
| 7 | S. Hirose, J.-P. Rieu, C. Anjard, O. Cochet-Escartin, K. Funamoto | Oxygen gradient under severe hypoxia changes *Dictyostelium* migration directionality | The 18th International Conference on Flow Dynamics (ICFD2021) | 29 Oct 2021 | On-line | Japan | |
| 8 | O. Cochet-Escartin, M. Demircigil, S. Hirose, V. Calvez, K. Funamoto, C. Anjard, J.-P. Rieu | Modelling self-organization by oxygen with reaction-diffusion models | The 21st International Symposium on | 28 Oct 2021 | On-line | Japan | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Advanced Fluid Information (AFI-2021) | | | | |
| 9 | S. Hirose, J.-P. Rieu, K. Funamoto | Evaluation of motility enhancement of *Dictyostelium discoideum* by hypoxic exposure | The 33rd Bioengineering Conference Annual Meeting of Bioengineering Division, JSME (in Japanese) | 25 Jun 2021 | On-line | Japan | |
| 10 | S. Hirose, O. Cochet-Escartin, C. Anjard, J.-P. Rieu, K. Funamoto | Reduced oxygen availability triggers aerotaxis and aerokinesis of *Dictyostelium* | LyonSE&N & ELyT Global workshop 2021 | 21 Jun 2021 | On-line | Japan France | |
| 11 | S. Hirose, J.-P. Rieu, K. Funamoto | *Motility analysis of Dictyostelium discoideum under oxygen gradient by microfluidic device* | The 31th JSME Conference on Frontiers in Bioengineering (in Japanese) | 12-13 Dec 2020 | On-line | Japan | |
| 12 | S. Hirose, J.-P. Rieu, K. Funamoto | *Evaluation of Dictyostelium migration under oxygen concentration gradient* | The 17th International Conference on Flow Dynamics (ICFD2020) | 30 Oct 2020 | On-line | Japan | |
| 13 | O. Cochet-Escartin, S. Hirose, K. Funamoto, C. Anjard, J.-P. Rieu | *Hypoxia triggers collective aerotactic migration in Dictyostelium discoideum* | The 20th International Symposium on Advanced Fluid Information (AFI2020) | 28 Oct 2020 | On-line | Japan | |
| 14 | K. Funamoto, J.-P. Rieu | *Microfluidic Tools to Study Aerotaxis in Eukaryotic Cells* | Elyt Workshop | 17-19 Feb 2020 | Vogüé | France | |
| 15 | O. Cochet-Escartin, M. Demircigil, S. Hirose, K. Funamoto, C. Anjard, V. Calvez, J.-P. Rieu | *Hypoxia triggers collective aerotactic migration in Dictyostelium discoideum* | CNRS MITI, AAP Modélisation du Vivant | 13 Feb 2020 | Paris | France | |

# MIMECHAS

*Microstructure and Mechanics of Aluminum - Steel welds*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Kiyoaki SUZUKI[a]** | **Benjamin LEFLON[b,c,d]** | **Sylvain DANCETTE[b,c]** | **Yutaka SATO[a]** |
|  |  |  |  |
| **Shun TOKITA[a]** | **Thibaut CHAISE[d]** | **Christophe LE BOURLOT[c]** | **Nicolas MARY[c]** |

*[a] Department of Materials Processing, Tohoku University, Sendai 980-8579, Japan*
*[b] ELyTMaX IRL3757, CNRS, Univ Lyon, INSA Lyon, Centrale Lyon, Tohoku University, Sendai 980-8577, Japan*
*[c] Univ Lyon, INSA Lyon, CNRS UMR5510, Laboratoire MATEIS, F-69621, Villeurbanne Cedex, France*
*[d] Univ Lyon, INSA Lyon, CNRS UMR5259, LaMCoS, F-69621 Villeurbanne Cedex, France*

**Contact:** sylvain.dancette@insa-lyon.fr, ytksato@material.tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2022 **Current researchers** (non-permanent): 24 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 34 % | | |
| **Surfaces and interfaces** | 33 % | | |
| **Simulation and modeling** | 33 % | | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial X Own resources

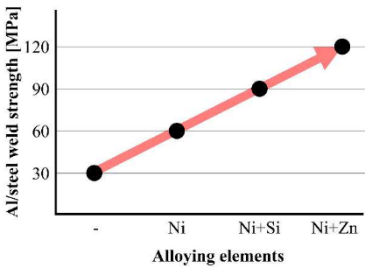
IFS CRP/LyC project? ☐ Yes X No

For main projects: *(up to 3, past projects in gray)*
- NA

Estimated annual budget:

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Al-steel TIG welds with improved strength are produced by careful alloying element addition in the weld pool.
- A calibrated finite element model of the process gives access to the full-field temperature history in the weld.
- 2D and 3D image correlation setups are developed to monitor the mechanical behavior of the welds *in situ* under tensile shear loading.



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Joining aluminum to steel has been a long-running scientific and technological problem for many applications, starting with those in the transportation industry. It would unlock new designs of optimized vehicle structures combining strength, lightweight and energy absorption ability. Troubles arise from the brittle intermetallic compound (IMC) layer appearing at the Fe-Al interface during the welding process. Its low fracture toughness causes premature brittle fracture of the weld joint when subjected to load.

**Key scientific question** (2 lines max; Calibri 11)

How do composition and thermal history at the faying surface control the formation and microstructure of the IMC? How does it impact the fracture behavior of the welds?

**Research method** (8 lines max; Calibri 11)

Welds are produced by TIG welding with a low carbon steel sheet and an aluminum alloy of controlled chemical composition. Thermal cycle measurement during welding is being developed and compared to finite element simulation of the process. The influence of alloy composition and process parameters on the weld and IMC microstructure is analyzed.

The fracture properties of the welds are measured, including *in situ* monitoring of the tests in 2D and in 3D by X-ray tomography. Then they are discussed with respect to the weld microstructure and finite element simulation of damage during the tests.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Kiyoaki SUZUKI (2022-present, JSD Tohoku-INSA Lyon)
- Benjamin LEFLON (2022-present, DD Tohoku-INSA Lyon)

*Master/Bachelor students (years):*

- NA

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- B. Leflon (Oct. 2023 – today, 1 year)
- S. Dancette (Sept. 2022 - today, 1 year)

*JP to FR (date, duration):*

- K. Suzuki (June-July 2022, 2 months)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Suzuki, K. T.; Omura, S.; Tokita, S.; Sato, Y. S.; Tatsumi, Y. | Drastic Improvement in Dissimilar Aluminum-to-Steel Joint Strength by Combining Positive Roles of Silicon and Nickel Additions | Materials & Design | 225 | | 2023 | https://doi.org/10.1016/j.matdes.2022.111444 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Suzuki, K. T.; Dancette, S.; Tokita, S.; Sato, Y. S. | Interfacial Microstructure of Dissimilar Weld of Aluminum to Steel Containing Alloying Elements and Its Effect on Mechanical Properties | 6th Symposium on International Joint Graduate Program in Materials Science and Spintronics | December 2023 | Sendai | Japan | |
| 2 | Leflon, B.; Dancette, S.; Chaise, T.; Le Bourlot, C.; Mary, N.; Aoyama, Y.; Suzuki, K. T.; Sato, Y. S. | Coupled Numerical-Experimental Approach to Access Interfacial Temperature during Aluminum-Steel Dissimilar Arc Welding | PRICM11 - The 11th Pacific Rim International Conference on Advanced Materials and Processing | November 2023 | Jeju | Korea | |
| 3 | Suzuki, K. T.; Sato, Y. S.; Tokita, S.; Adrien, J.; Dancette, S. | FEM Estimation of Interfacial Strength of Dissimilar Al/Fe Arc Weld through Fracture Analysis by X-Ray Tomography | PRICM11 - The 11th Pacific Rim International Conference on Advanced Materials and Processing | November 2023 | Jeju | Korea | |
| 4 | Suzuki, K. T.; Omura, S.; Tokita, S.; Sato, Y. S.; Dancette, S. | Interfacial Microstructure of Dissimilar Weld of Steel to Aluminum Containing Intermediate Metals and Its Effect on Mechanical Properties | 76th IIW Annual Assembly and Intl. Conf. on Welding and Joining (IIW 2023) | July 2023 | Singapore | Singapore | |
| 5 | K.T Suzuki, S. Dancette, J. Adrien, Y.S. Sato | Fracture behavior of Al-Fe welds | ELyT Worshop 2022 | Nov. 16, 2022 | Lyon | France | |

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| | | | | |
| | | | | |

Project report 2023

# MOREOVER

***MO**delling of the long-term co**R**rosion b**E**havi**O**r from detailed analysis of excaV**a**ted anci**E**nt cultural a**R**tifact*

## MAIN PARTICIPANTS


| Yutaka WATANABE[a,c] | Bernard NORMAND[b] | Zhixin DONG[b,c] | Benoît TER-OVANESSIAN[b] |
|---|---|---|---|
| Hiroshi ABE[a] | Nicolas MARY[b,c] | | |

[a] *Tohoku University, GSE, Department of QSE, Sendai, Japan*
[b] *Université de Lyon, INSA-LYON, MATEIS UMR CNRS 5510, Bât L. de Vinci, 21 Avenue Jean Capelle, 69621 Villeurbanne cedex, France*
[c] *ELyTMaX UMI3757, CNRS, Tohoku university, Université de Lyon, Sendai Japan*

**Contact:** yutaka.watanabe.d3@tohoku.ac.jp ,hiroshi.abe.c3@tohoku.ac.jp , bernard.normand@insa-lyon.fr, nicolas.mary@insa-lyon.fr , benoit.ter-ovanessian@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2022 **Current researchers** (permanent/non-permanent): 2/1 person-month

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | | | |
| **Surfaces and interfaces** | | 75% | |
| **Simulation and modeling** | | 25% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

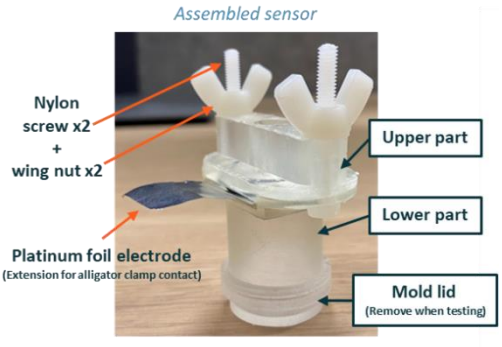
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Project started in Nov.2022
- Proof of concept of the non-invasive EIS sensor
- Validation of the sensor on controlled surface.

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

The purpose of a geological repository is to protect man and the environment from the impact of radioactive waste by confining radioactivity up to several hundred thousand years . Most repository systems are based on the use of several natural and/or artificial barriers to prevent the transport of radionuclides to the biosphere. Whatever the solution selected, long-term corrosion under very specific environmental conditions may occur on the overpack material (copper or non-alloyed steel). As corrosion tests can generally take place over short periods in the time scale of a repository, mechanistically based modelling of the corrosion products nature, formation and growth rates based are required to predict the long term behavior. Data acquisition are first needed in order to perform estimations of service life-times. Archaeological artefacts are then useful by providing such a database and a detailed investigation of them is appropriated to validate the model.

**Key scientific question** (2 lines max; Calibri 11)

Develop a sensor to identify and quantify the corrosion product layer of buried materials.
Predict the corrosion rate of buried material

**Research method** (8 lines max; Calibri 11)

A first step is to develop a non-invasive and non-destructive analysis method using a sensor to quantify the features of corrosion product grown on buried materials (archaeological analogues, or overpack). Based on the indirect electrolysis method, a sensor with solid state contacts will be developed. Different corrosion products whose thickness, nature and morphology are controlled, will be formed at the laboratory to test and calibrate this sensor. Regarding these results, the accuracy and the limits will be discussed. In a second step, the sensor will be used on archeological artifacts. Then, the determination of the corrosion rate will have to be carried out in order to model and predict later the oxidation life of the storage materials.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Zhixin Dong (2022- …, DD INSA-LYON/ TOHOKU)

*Master/Bachelor students (years):*

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- N. Mary (Assoc. Prof.), stay at Tohoku and ElytMax, November 2023 (1 week)

*JP to FR (date, duration):*

- H. Abe (Assoc. Prof.), stay at MATEIS (INSA-Lyon), November 2022 (1 week)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

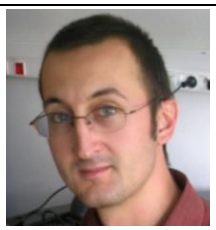
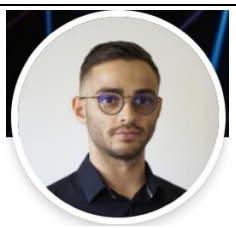
**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |

# MuORoD

*Multi-Objective Robust Design*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Koji SHIMOYAMA[a]** | **Sébastien BESSET[b]** | **Frédéric GILLOT[b]** | **Achille JACQUEMOND[b]** |

[a] *Department of Mechanical Engineering, Kyushu University, Japan*
[b] *LTDS UMR CNRS 5513, DySCo Team, ECL, Lyon, France*

**Contact:** shimoyama@tohoku.ac.jp, frederic.gillot@ec-lyon.fr, sebastien.besset@ec-lyon.fr, achille.jacquemond@ec-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2012 **Current researchers** (permanent/non-permanent): (3/2) person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 20% | | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | 80% | | |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

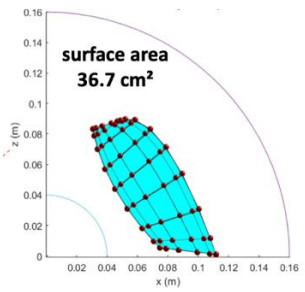
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- 3 MNRT funds for Ph.D.
- Rhône Alpes AAP grant awarded (2021 – 2024, 30keuros)
- JSPS Summer Grant 2022 for Achille
- JSPS Short Term Post Doc, 1year, 05/2023 for Achille

Estimated annual budget: From institutions 35keuros

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- We have proposed an innovating optimization scheme based on the IGA formulation
- Optimization criteria is original and contact handling in such situation has been treated
- Four journal papers have been accepted recently, three under review currently
- Ph.D. Student Pradeep has defended his Ph.D. for the Double Diploma in July 2021
- Achille received the JSPS Summer grant for summer 2022 / JSPS Short Term Post Doc in April 2023 for 1 year

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

In this project we focus on the robust shape optimization aiming at decreasing the squeal noise of a classical brake system. In the first steps a FEM of the pad and the disk have been modelized. Then stability diagrams have been generated to understand how geometrical parameters influence stability behavior of the structure. Next step will be to describe the pad as an iso-geometric element (IGA) in contact with the disk. Such formulation will enable fast and accurate shape optimization loop based on EGO approach, i.e. meta-heuristics optimizer on a meta-model surface response of the physical model. To address the complex nature of the studied functions, surrogate-based strategies are employed. Furthermore, in industrial systems, uncertainties are inevitable and can lead to non-robust optimal solutions and system malfunction. Thus, uncertainties need to be taken into account in a robust optimization loop.

**Key scientific question** (2 lines max; Calibri 11)

Numerical optimization scheme for non-gradient criteria.
Uncertainties quantification handle by the optimization loop.

**Research method** (8 lines max; Calibri 11)

Shape optimization with iso-geometric models is a hot topic nowadays, as it will enable significant improvement in computing time cost and result accuracy. One the other hand nearly no results have been obtained on robust shape optimization of brake systems as such systems are very complex to simulate when considering non-linear behavior such as squeal noise. Black box optimization approaches have been successfully developed recently to address complex problems, such as robust optimization, where at least the first and second moment order of the cost function are to be considered. We aim at enabling practical systems such as brakes to benefit from such approach. particles.

**Research students involved** *(gray color for previous years)*

*Post-doc (years, institution):*

- *Renata Troian (2013-2014, ANR JCJC S.Besset)*

*Ph.D. candidates (years, institution):*

- Thanasak Wanglomklang (2023-2025, MNRT)
- Achille Jacquemond (2021-2024, MNRT)
- Pradeep Mohanasundaram (2016-2021, MNRT)

*Master/Bachelor students (years):*

- Kazuki Ozawa (2018-2019, IFS Tohoku University)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- F. Gillot (Sept. 2023 – Aug. 2024, 1 year)
- A. Jacquemond (April 2023 – May 2024, 1 year)
- A. Jacquemond (June 2022 – August 2022, 3 months)
- P. Mohannasundaram (Jan. 2021 – March. 2021, 3 months)
- S. Besset (July 2019, 1 week)
- P. Mohannasundaram (Sept. 2018 – Aug. 2019, 1 year)
- F. Gillot (Sept. 2019-Aug. 2020, 1 year)
- F. Gillot (May 2015, 1 month)

*JP to FR (date, duration):*

- K. Ozawa (Dec. 2018 – Feb. 2019, 3 months)
- K. Shimoyama (Feb. 2016, 1 month)
- K. Shimoyama (Oct – Dec 2013, 3 months)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Mohanasundaram, P., Gillot, F., Besset, S., Shimoyama, K. | "Modelling friction-induced dynamic instability dedicated for Isogeometric formulation" | Shock and Vibration | 2023 | 8669237 | 2023 | https://doi.org/10.1155/2023/8669237 |
| 2 | Mohanasundaram, P., Gillot, F., Besset, S., Shimoyama, K. | "Multi-references acquisition strategy for shape optimization of disc-pad-like mechanical systems." | Struct Multidisc Optim | 64, | 1863–1885 | 2021 | https://doi.org/10.1007/s00158-021-02947-7 |
| 3 | Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset | "Shape optimization of a disc-pad system under squeal noise criteria." | SN Applied Sciences | 2(4) | 1-15 | 2020 | |
| 4 | Troian, Renata, Koji Shimoyama, Frédéric Gillot, and Sébastien Besset | "Methodology for the design of the geometry of a cavity and its absorption coefficients as random design variables under vibroacoustic criteria." | Journal of Computational Acoustics | 24(02) | 1650006 | 2016 | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Wanglomklang, T., Gillot, F., Besset, S. | An Intersection Interaction Hybrid Method for Energy Flow at Mid-High Frequency for Complex Cavities Acoustic | ECCOMAS 2024 | 2024 | Lisbon | Portugal | https://eccomas2024.org/ |
| 2 | Jacquemond, A., Besset, S., Shimoyama, K., Gillot, F. | Automotive disc-brake squeal noise modeling for shape optimization under uncertainties | INTERNOISE 2023 | 2023 | Chiba | Japan | https://2023.internoise.org/, ISBN 978-4-905648-68-0 |
| 3 | Jacquemond, A., Gillot, F., Besset, S., Shimoyama, K | "Robustness Criteria Analysis for an Isogeometric-based Robust Shape Optimization Scheme of a | WCCM-APCOM 2022 | 2022 | Yokohama | Japan | https://www.wccm2022.org/dl/index/program_book.pdf |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Disc-pad System under Dynamical Criteria" | | | | | |
| 4 | Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset | Iga based shape optimization under mechanical stability criteria | 14th WCCM 2020 | 2020 | Paris | France | |
| 5 | Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset | Effect of IGA formulation on the simulation of friction instabilities of disc-pad systems | 7th International congress on Isogeometric Analysis - IGA 2019 | 18th-20th September 2019 | Munich | Germany | |
| 6 | Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset | Sensitivity of shape parameters of brake systems under squeal noise criteria | 6th International congress on Engineering Optimization – EngOpt 2018 | 17th-19th September 2018 | Lisbon | Portugal | |
| 7 | Frederic Gillot, Renata Troian, Koji Shimoyama, Sebastien Besset | Robust shape optimization under vibroacoustic criteria and uncertain parameters | 11th World Congress on Structural and Multidisciplinary Optimization | 7th - 12th, June 2015 | Sydney | Australia | |

# Prognosis of intracranial aneurysm rupture risk

*Development of an in vivo aneurysm mechanical characterisation device*

## MAIN PARTICIPANTS


|  |  |  |  |  |
|---|---|---|---|---|
| **Guillaume PLET[a]** | **Jolan RAVIOL[a]** | **Hélène MAGOARIEC[a]** | **Cyril PAILLER-MATTEI[a,b]** | **Makoto OHTA[c,d]** |

[a] *Laboratoire de Tribologie et Dynamique des Systèmes, UMR CNRS 5513, École Centrale de Lyon, France*
[b] *University of Lyon, University Claude Bernard Lyon 1, IPSB-Faculty of Pharmacy, France*
[c] *Institute of Fluid Science, Tohoku University, Sendai, Miyagi, Japan*
[d] *ELyTMaX UMI 3757, CNRS – Université de Lyon – Tohoku University, International Joint Unit, Tohoku University, Sendai, Miyagi, Japan*

**Contact:** cyril.pailler-mattei@ec-lyon.fr, Helene.magoariec@ec-lyon.fr, makoto.ohta@tohoku.ac.jp


## OVERVIEW

**Starting year:** 2022 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | 50 % |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | 50 % |

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

**Highlights & Outstanding achievements**

- *In vitro* experimental study of an intracranial aneurysm mechanical characterisation device: successfully performed on phantom arteries.
- Development of a patient specific PVA-H phantom artery for further *in vitro* device testing.
- Development of a Fluid-Structure Interaction numerical model based on the patient specific phantom artery for the device testing in patient specific boundary conditions.

**Illustration**

## PROJECT DESCRIPTION

**Background**

This project is part of the treatment of a public health pathology: strokes due to intracranial aneurysm rupture. This is currently a major problem: it is estimated that between 2 and 5% of the population has a cerebral aneurysm without necessarily being aware of it, and the annual risk of aneurysm rupture varies between 1 and 4% in the carrier population. The location and identification of the aneurysm occurs mostly late in its rupture, which leads, in a large proportion of cases, to the death of the patient, sometimes even before his or her arrival at the hospital. In cases where the aneurysm is located incidentally during medical examinations, there is no consensus on the question of treatment. Indeed, although it is an anatomical anomaly resulting from a structural and residual deformation of the wall of a cerebral artery, the practitioner has no quantitative criteria taking into account the mechanics of the arterial wall to predict rupture. The choice of intervention or non-intervention is based on qualitative criteria such as morphology, location of the pathology, and epidemiological criteria such as hypertension or alcohol consumption. There is currently no way to determine in situ the biomechanical properties of the aneurysm wall, which would be particularly important data in assessing the risk of rupture.

**Key scientific question**

Development of a device enabling to quantify the *in situ* mechanical properties of unruptured intracranial aneurysms.

**Research method**

The proof of concept and the prototyping of such a device is currently done through two linked doctoral works: an experimental development of the device, which passes by a first stage of experiments on phantom artery obtained by additive manufacturing before passing on small animal, and its numerical counterpart with the modelling of the device and the exploitation of the data to obtain biomechanical images. A scientific lock of this project is to obtain an artificial artery with biofidelic mechanical properties. The goal of this collaboration is to take advantage of the hydrogel technology developed by Prof. Ohta to have an inhomogeneous elastic behavior on the aneurysm.

**Research students involved**

*Ph.D. candidates (years, institution):*

- Riko Hasegawa (2023-present, TU)
- Guillaume Plet (2020-present, ECL)
- Jolan Raviol (2021-present, ECL)

**Visits and stays**

*FR to JP (date, duration):*

- Guillaume Plet (29/10/2022-14/11/2022)
- Jolan Raviol (29/10/2022-14/11/2022)

*JP to FR (date, duration):*

- Masahiro Hasegawa(13/12/2023-15/12/2023)
- Makoto Ohta (13/12/2023-15/12/2023) (16/11/2022-18/11/2022) (09/06/2022)
- Riko Hasegawa (16/11/2022-18/11/2022)
- Hanif Saifurrahman (16/11/2022-18/11/2022)
- Kotaro Daibo (16/11/2022-18/11/2022)
- Ryuhei Yamaguchi (16/11/2022-18/11/2022)
- Kazuyoshi Jin (16/11/2022-18/11/2022) (09/06/2022)
- Yutaro Kohata (16/11/2022-18/11/2022)
- Yukiko Kojima (09/06/2022)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | J Raviol , G Plet , R Hasegawa, K Yu, H Kosukegawa, M Ohta, H Magoariec, C Pailler-Mattei | Towards the mechanical characterisation of unruptured intracranial aneurysms: Numerical modelling of interactions between a deformation device and the aneurysm wall | Journal of the Mechanical Behavior of Biomedical Materials | 153 | | 2024 | https://doi.org/10.1016/j.jmbbm.2024.106469 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | J. Raviol, G. Plet, M. Ohta, H. Magoariec, C. Pailler-Mattei | Patient specific numerical study of an intracranial aneurysm mechanical characterisation device | ESB | 9-12 Jul. 2023 | Maastricht | Netherland | |
| 2 | J. Raviol, G. Plet, H. Magoariec, C. Pailler-Mattei | Numerical modelling of a polymeric aneurysm in support for dimensioning a mechanical characterization device | ESB | 26-29 Jun. 2022 | Porto | Portugal | |
| 3 | G. Plet, J. Raviol, H. Magoariec, C. Pailler-Mattei | Design of an *in vivo* biomechanical characterization device for unruptured intracranial aneurysms: calibration study on phantom arteries | ESB | 26-29 Jun. 2022 | Porto | Portugal | |

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|
| 1 | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | Masahiro Hasegawa | Mini ELyT Workshop | Computational Fluid Dynamics of Air for Respiratory Diseases | 13/12/2023-15/12/2023 |
| 2 | J.Raviol, G. Plet, M. Ohta, H.Magoariec, C.Pailler-Mattei | ElytWorkshop | Design of a polymeric cerebral aneurysm based on numerical modelling for the development of an aneurysm mechanical characterization device | 16-18 Nov. 2022 |
| 3 | G. Plet, J.Raviol, M. Ohta, H.Magoariec, C.Pailler-Mattei | ElytWorkshop | Calibration of an in vivo biomechanical characterisation device for unruptured cerebral aneurysms: first results on polymeric phantom arteries | 16-18 Nov. 2022 |
| 4 | Hanif Saifurrahman | ELyT Workshop | Observation of endothelial cell response to various stenting deployment in an in vitro flow system | 16/11/2022-18/11/2022 |
| 5 | Kotaro Daibo | ELyT Workshop | Effect of difference wall stiffness between single-segment models and two-segments models on velocity map | 16/11/2022-18/11/2022 |
| 6 | Ryuhei Yamaguchi | ELyT Workshop | Effect of wall elasticity on flow instability and wall shear stress of a full-scale, patient-specific phantom in middle cerebral artery | 16/11/2022-18/11/2022 |
| 7 | Yutaro Kohata | ELyT Workshop | Blood flow simulations in cerebrovascular models from BraVa database | 16/11/2022-18/11/2022 |
| 8 | Yukiko Kojima | MiniWorkshop | The Effect of Stent Angle on Flow and Endothelialization Process in a Parallel Chamber | 09/06/2022 |
| 9 | Kazuyoshi Jin | MiniWorkshop | Development of Virtual Database of Brain Vascular with Individual Differences for Brain Vascular Sickness | 09/06/2022 |
| 10 | G. Plet, J.Raviol, H.Magoariec, C.Pailler-Mattei | ElytWorkshop | Towards the *in situ* mechanical characterization of intracranial aneurysms: first steps of experimental and numerical designs | 21-25 Jun. 2021 |

# PolymColdSprayCoat

*Resilient Polymeric Cold Spray Coating*

## MAIN PARTICIPANTS








| Kazuhiro Ogawa[a,b] | Chrystelle Bernard[a,b,c] | Olivier Lame[d] | Jean-Yves Cavaillé[b] | Kesavan Ravi[e] | Hidemasa Takana[f] | Gildas Diguet[g] |
|---|---|---|---|---|---|---|

[a] *Tohoku University, GSE, FRRI, Sendai, Japan*
[b] *ELyTMaX IRL3757 -CNRS-TU-UdL, Sendai Japon*
[c] *Tohoku University, FRIS, Sendai, Japan*
[d] *INSA Lyon – CNRS, MATEIS, Villeurbanne, France*
[e] *Indian Institute of Technology Dhanbad, Indian*
[f] *IFS, Tohoku University, Sendai, Japan*
[g] *µSIC, Tohoku University, Sendai, Japan*

**Contact:** kogawa@rift.mech.tohoku.ac.jp, ch.bernard@tohoku.ac.jp, olivier.lame@insa-lyon.fr, jean-yves.cavaille@insa-lyon.fr, kesavanravi@iitism.ac.in, takana@tohoku.ac.jp, gildas.diguet.d4@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2014 **Current researchers** (permanent/non-permanent): 3/1

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | 15% | 15% | |
| **Surfaces and interfaces** | 15% | 15% | |
| **Simulation and modeling** | 20% | 20% | |

**Other:**

Include partner from ☐ Outside ELyT ☒ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

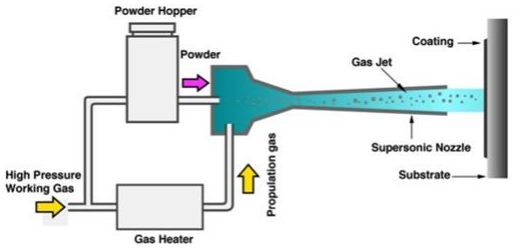
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- CRP-IFS, 2023-2024, J23Ly12
- Kakenhi, 2023-2026, JSPS—Wakate 23K13214
- TI-FRIS, 2021-2026

Estimated budget: 1,5 M¥/year

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Understanding and improving the formation of polymer coating on metallic substrates by Cold Spray
- Modelling the flow dynamics inside the nozzle and the particles' thermal gradient
- In total:
- 15 publications in peer-review journals, 1 patent, 6 awards

**Illustration**



# PROJECT DESCRIPTION

Polymer coatings have a strong variety of applications like surface protection from corrosion, protection from cavitation erosion or mechanical impacts, electronic applications, packaging, and biocompatible membrane etc. The applications of coatings have greatly increased, largely driven by the competitive need to reduce costs, weight and volume. The high molecular weight of UHMWPE provides exceptional mechanical properties. In particular, it has an excellent wear resistance. It also has an excellent resistance to impacts. It has a large elongation at break (typically several hundred percent) and, as a result, a great ability to absorb energy before fracture. Cold-Spray technique is being observed as a technique to coat UHMWPE onto different materials, i.e., to perform particles sintering by projecting them at ultrahigh speed. The challenge consists in (i) improving adhesion between the coated polymer layer (1st layer) and the substrate and the subsequent layers of polymers to limit particle rebounds and (ii) in finding the conditions leading to a near bulk density compaction.

**Key scientific question** (2 lines max; Calibri 11)

What are the mechanisms involved in polymer coating by cold spray?
How is it possible to optimize the process to obtain such coatings using numerical simulation?

**Research method** (8 lines max; Calibri 11)

This project is based on both (i) experimental approaches and (ii) modeling & simulation. Two scales are targeted, molecular scale for adhesion analysis and mesoscopic scale for understanding the polymer behavior under ultra-high deformation and temperature rate.
Encouraging results have been already obtained for UHMWPE coatings as well as preliminary molecular simulations on adhesion. UHMWPE cold spray simulations are ongoing.
Other polymer materials, such as fluoropolymer and polyimide coatings have been investigated by low-pressure cold spray where successful coatings have been obtained.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Mathieu Salse (2022, MATEIS)
- Kesavan Ravi (2015-2018, Double PhD degree between TU and MATEIS)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

| | | |
|---|---|---|
| • JY Cavaillé | Stay at ELyTMaX, Oct-Nov 2023 | 2 weeks |
| • JY Cavaillé | Stay at ELyTMaX, Oct-Nov 2022 | 2 weeks |
| • JY Cavaillé | Stay at ELyTMaX, Feb-March 2019 | 2 weeks |
| • JY Cavaillé | Stay at ELyTMaX, Apr-2019 | 1 week |
| • JY Cavaillé | Stay at ELyTMaX, June-July 2019 | 2 weeks |
| • JY Cavaillé | Stay at ELyTMaX, Oct-Nov 2019 | 2 weeks |
| • JY Cavaillé | Stay at ELyTMaX, Decembre-2019 | 1 week |
| • K. Ravi | Stay at GSE & ELyTMaX (TU), January – February 2018 | 2 months |
| • K. Ravi | Stay at GSE & ELyTMaX (TU), May – October 2017 | 6 months |
| • K. Ravi | Stay at GSE & ELyTMaX (TU), May – October 2016 | 6 months |

*JP to FR (date, duration):*

| | | |
|---|---|---|
| • C. Bernard | Stay at INSA Lyon, November-December 2023 | 1 month |
| • C. Bernard | Stay at INSA Lyon, January 2023 | 1 month |
| • C. Bernard | Stay at INSA Lyon, October 2022 | 1 month |
| • C. Bernard | Stay at INSA Lyon, September 2019 | 1 week |
| • C. Bernard | Stay at Grenoble Univ., Sept; – Oct. 2018 | 2 months |

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 12 | W. Lock Sulen, C. Bernard, S. Onodera, J. Ishizaki, N. Mary, Y. Ichikawa, K. Ogawa | Improvement of deposition efficiency and adhesion by laser surface texturing for cold sprayed fluoropolymer coating | Surface and Coating Technology | 478 | 130489 | 2024 | doi.org/10.1016/j.surfcoat.2024.130489 |
| 11 | C.A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé | Thermal gradient of polymeric particles during cold spray process | Computational Particle Mechanics | 10 | 1697-1716 | 2023 | doi.org/10.1007/s40571-023-00583-0 |
| 10 | C.A. Bernard, H. Takana, O. Lame, K. Ogawa, J.-Y. Cavaillé | *Influence of the nozzle inner geometry on the particle history during cold spray process* | *Journal of Thermal Spray Technology*, | 31 | 1776 | 2022 | doi.org/10.1007/s11666-022-01407-y |
| 9 | CA Bernard, O Lame, T Deplancke, JY Cavaillé, K Ogawa | From rheological to original three-dimensional mechanical modelling of semi-crystalline polymers: application to a wide strain rate range and large deformation of Ultra-High Molecular Weight semi-crystalline polymers | Mechanics of Materials | 151 | 103640 | 2020 | doi.org/10.1016/j.mechmat.2020.103640 |
| 8 | CA Bernard, H Takana, G Diguet, K Ravi, O Lame, K Ogawa, JY Cavaillé | Thermal gradient of in-flight polymer particles during cold spraying | Journal of Materials Processing Technology | 286 | 116805 | 2020 | doi.org/10.1016/j.jmatprotec.2020.116805 |
| 7 | W Lock Sulen, K Ravi, C Bernard, Y Ichikawa, K Ogawa | Deposition Mechanism Analysis of Cold-Sprayed Fluoropolymer Coatings and Its Wettability Evaluation | Journal of Thermal Spray Technology | 29 | 1643-1659 | 2020 | doi.org/10.1007/s11666-020-01059-w |
| 6 | W Lock Sulen, K Ravi, C. Bernard, N Mary, Y. Ichikawa, K Ogawa | Effects of nano-ceramic particle addition for cold sprayed fluoropolymer coatings | Key Engineering Materials | 813 | 141-146 | 2019 | doi.org/10.4028/www.scientific.net/KEM.813.141 |
| 5 | K Ravi, W Lock Sulen, C Bernard, Y Ichikawa, K Ogawa | Fabrication of micro-/nano-structured super-hydrophobic fluorinated polymer coatings by cold-spray | Surface and Coatings Technology | 373 | 17-24 | 2019 | doi.org/10.1016/j.surfcoat.2019.05.078 |

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|---|---|---|---|---|---|---|---|
| 4 | K Ravi, T Deplancke, O Lame, K Ogawa, JY Cavaillé, F Dalmas | Influence of nanoceramic interlayer on polymer consolidation during cold-spray coating formation | Journal of Materials Processing Technology | 273 | 116254 | 2019 | doi.org/10.1016/j.jmatprotec.2019.116254 |
| 3 | K Ravi, T Deplancke, K Ogawa, JY Cavaillé, O Lame | Understanding deposition mechanism in cold sprayed ultra high molecular weight polyethylene coatings on metals by isolated particle deposition method | Additive Manufacturing | 21 | 191-200 | 2018 | doi.org/10.1016/j.addma.2018.02.022 |
| 2 | K Ravi, Y Ichikawa, K Ogawa, T Deplancke, O Lame, JY Cavaille | Mechanistic Study and Characterization of Cold-Sprayed Ultra-High Molecular Weight Polyethylene-Nano-ceramic Composite Coating | Journal of Thermal Spray Technology | 25 | 160-169 | 2016 | doi.org/10.1007/s11666-015-0332-1 |
| 1 | K Ravi, Y Ichikawa, T Deplancke, K Ogawa, O Lame, JY Cavaille | Development of ultra-high molecular weight polyethylene (UHMWPE) coating by cold spray technique | Journal of Thermal Spray Technology | 24 | 1015-1025 | 2015 | doi.org/10.1007/s11666-015-0276-5 |

**Conferences** *(gray color for previous years)*

| | **Authors** | **Title** | **Conference** | **Date** | **City** | **Country** | **DOI** *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 11 | C. A. Bernard, H. Takana, O. Lame, K. Ogawa | Which mechanisms govern polymer deposition by cold spray process? | ICFD2023 | November 2023 | Sendai | Japan | |
| 10 | C. A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé | Temperature distribution of polymer particles during the cold spray process | ITSC2023 | May 2023 | Québec | Canada | |
| 9 | C. A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé | Evaluation of the thermal gradient of in-flight polymer particles during cold spray process | ELyT Worshop 2022 | November 2022 | Lyon | France | |
| 8 | C.A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé | Evolution of the polymer particle thermal history during cold spray process | ICFD2022 | November 2022 | Sendai | Japan | |
| 7 | C.A. Bernard, H. Takana, G. Diguet, O. Lame, J.-Y. Cavaillé, K. Ogawa | In-flight thermal gradient of polymer particles during cold-spray process | ICFD2021 | Oct. 27-29, 2021 | Sendai | Japan | |
| 6 | Y. Kaneko, W. Lock Sulen, C. Bernard, H. Saito, Y. Ichikawa, K. Ogawa | Progressive improvement in deposition efficiency for cold sprayer fluoropolymer coatings | ELyT Workshop 2021 | June 21-24, 2021 | online | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | C. A. Bernard, H. Takana, O. Lame, K. Ogawa, J.-Y. Cavaillé | Nozzle design for polymer coating by cold spray process | ELyT Workshop 2021 | June 21-24, 2021 | online | | |
| 4 | W. Lock Sulen, H. Saito, C.A. Bernard, Y. Ichikawa, K. Ogawa | Extremely high deposition efficiency of robust and super-hydrophobic fluoropolymer coating on a metallic intermediate layer by low-pressure cold spray | International Thermal Spray Conference 2021 | May 24-28, 2021 | online | | |
| 3 | W Lock Sulen, H Saito, C Bernard, S Onodera, J Ishizaki, N Mary, Y Ichikawa, K Ogawa | Improvement of Deposition Efficiency and Adhesion by Laser Surface Texturing for Cold Sprayed Fluoropolymer Coating | 10th Asian Thermal Spray Conference | Nov. 1st-3rd, 2020 | Ningbo | China | |
| 2 | CA Bernard, H Takana, O Lame, K Ogawa, JY Cavaillé | Computational simulation on particle-laden flow during polymer cold-spray process | ICFD2020 | Oct. 28-30, 2020 | Sendai | Japan | |
| 1 | CA Bernard, H. Takana, G Diguet, K Ravi, O Lame, K Ogawa, JY Cavaillé | Polymer coating by cold-spray: a review | ElyT Workshop 2020 | Feb. 17-19, 2020 | Vogüé | France | |

**Patents** *(gray color for previous years)*

| | **Inventors** | **Title** | **PCT #** | **Year** |
|---|---|---|---|---|
| | Cavaille Jean-Yves [Fr]; Lame Olivier [Fr]; Deplancke Tiana [Fr]; Ogawa Kazuhiro [Jp]; Kesavan Ravi [Jp] | Powder for Cold Spray, Method for Manufacturing Macromolecular Coating Film, and Macromolecular Coating Film, | International Patent: WO2015185546 (A1) | 2015 |

**Others** *(gray color for previous years)*

| | **People** | **Event** | **Description** | **Date** |
|---|---|---|---|---|
| 8 | K. Ogawa, Y. Ichikawa, H. Saito, O. Lame | International workshop on metal deposition on CFRP | Organization of international event | Jan. 2023 |
| 7 | CA Bernard | 19th International Conference on Flow Dynamics | Best Presentation Award for Young Researcher | Nov. 2022 |
| 6 | K. Ogawa, Y. Ichikawa, H. Saito, O. Lame | Webinar on metal deposition on CFRP | Organization of international event | Sept 2022 |
| 5 | CA Bernard | The 2nd Caterpillar STEM Award | Special Recognition Award | Feb.2020 |
| 4 | CA Bernard | 16th International Conference on Flow Dynamics | Best Presentation Award for Young Researcher | Nov. 2019 |
| 3 | K Ravi | Japan Thermal Spray Society (JTSS) 2015 | Award for young Engineer | May 2015 |
| 2 | K Ravi | 6th Asian Thermal Spray Conference (ATSC) 2014 | Best Poster Award | Nov.2014 |
| 1 | K Ravi, W Lock Sulen, S Gao, Y Ichikawa, K Ogawa | The 15th "Challenge Cup" International Students Technology Innovation Carnival | Grand Prize | Nov.2017 |

# PREDOXCAN

*Investigation of a predictive therapeutic response under controlled oxygen condition in spheroids and cancer patient-derived organoids.*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Satoshi ARATAKE[a]** | **Jean-Paul RIEU[b]** | **Nicolas AZNAR[c]** | **Kenichi FUNAMOTO[a]** |
| *[a] Tohoku University, Sendai, Japan*<br>*[c] Cancer Research Centre of Lyon, France* | | *[b] Université Claude Bernard Lyon 1, France* | |

**Contact:** Nicolas.AZNAR@lyon.unicancer.fr , funamoto@tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2021 **Current researchers** (permanent/non-permanent): 4 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | | 25% |
| **Surfaces and interfaces** | | | 25 % |
| **Simulation and modeling** | | | 50 % |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

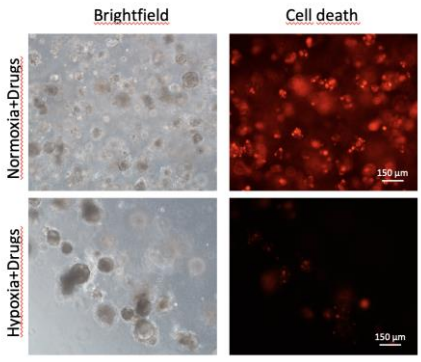
- IFS LyC project 2022-2023
- ShapeMed 2023-2025
- IFS LyC project 2020-2022

Estimated annual budget: 20 000€

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Optimization of CRC patient-derived organoid (PDO) cultures from fresh tumors.
- Hypoxic condition confers resistance of PDO to conventional therapies.
- We designed an innovative 3D cell culture system combined with oxygen gradient.

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Although some cancers are effectively treated through the standard strategy of surgery, radiation and/or chemotherapy, some patients have a recurrence of their cancer. Despite decades of research, we are still unable to predict which cancers will be efficiently treated and which are likely to spread, thus there is an urgent need to find new or better treatment alternatives for colorectal cancers (CRC). Cancer stem cells (CSC) located within the tumor constitute a key medical issue. Due to their high plasticity, this particular cancer cell population is extremely resistant to conventional therapy and responsible for the recurrence of the disease in patients. Therefore, identify novel mechanisms regulating cancer cell plasticity and targeting those CSCs is a prerequisite to open novel therapeutic avenues. The main goal of this project is to study how oxygen (O2) concentration influence CSC plasticity and their response to anti-cancer therapies.

**Key scientific question** (2 lines max; Calibri 11)

Understand how $O_2$ could impact cancer cell plasticity (CSCs properties)
Improve efficacy of conventional chemotherapy.

**Research method** (8 lines max; Calibri 11)

Cells cultivated in 2D conditions don't develop CSC cell phenotype. However, it has been described that cultivating cell in spheroids favors CSC. Therefore, in order to determine the impact of $O_2$ levels on CSC we generated 3D spheroids from HCT116 and HT29 colorectal cancer cell lines using the hanging drop method or an alternative method using ultra low attachment plates. Spheroids were then cultivated in normoxia (21% $O_2$) versus hypoxia (1% $O_2$) to assess the impact of $O_2$ tension on tumor growth and CSC markers expression. Last but not least, spheroids cultivate in similar conditions were treated with 5FU and oxaliplatin to measure CSC resistance to conventional therapies.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Satoshi ARATAKE (2022-present, Sendai)

*Master/Bachelor students (years):*

- Zhouxing SU (2022, Lyon)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- Nicolas AZNAR (CRCN CNRS, November 2023, 20 days)
- Jean-Paul Rieu (UCBL, November 2022, 10 days)
- Nicolas AZNAR (CRCN CNRS, November 2022, 20 days)
- Zhouxing SU (Master student, April-June 2022, 3 months)

*JP to FR (date, duration):*

- Kenichi Funamoto (Assistant professor, Decembre 2023, 4 days)
- Kenichi Funamoto (Assistant professor, June 2023, 10 days)
- Kenichi Funamoto (Assistant professor, November 2022, 3 days)
- Satoshi ARATAKE (PhD student, May-Nov. 2022, 6 months)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Nicolas Aznar | Predictive Therapeutic Response Optimization in Colorectal Cancer Patient-Derived Organoids under Controlled Oxygen | ICFD | Novembre 2023 | Sendai | Japan | |
| 2 | Satoshi Aratake, Zhouxing Su, Jean-Paul Rieu, Nicolas Aznar, Kenichi Funamoto | Cancer cell migration under oxygen concentration gradients | LyonSE&N & ELyT Global workshop 2022 | 18 Nov 2022 | Lyon | France | |

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |

Project report 2023

# REFRESH

*REFRigEration based on Solid-state cooling: Heat transfer mechanisms*

## MAIN PARTICIPANTS


|  |  |  |  |  |  |
|---|---|---|---|---|---|
| **Gaël SEBALD[a]** | **Giulia LOMBARDI[a,b]** | **Atsuki KOMIYA[a,b]** | **Jacques JAY[c]** | **Gildas COATIVY[d]** | **Laurent LEBRUN[d]** |

[a] *ELyTMaX IRL3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon, Tohoku University 980-8577, Sendai, Japan*
[b] *Institute of Fluid Science, Tohoku University, 980-8577, Sendai, Japan*
[c] *Univ. Lyon, CNRS, INSA-Lyon, CETHIL, UMR5008, F-69621, Villeurbanne, France*
[d] *Univ. Lyon, INSA-Lyon, LGEF, EA682, F-69621, Villeurbanne, France*

**Contact:** gael.sebald@insa-lyon.fr, giulia.lombardi.a1@tohoku.ac.jp, komiya@tohoku.ac.jp, jacques.jay@insa-lyon.fr, gildas.coativy@insa-lyon.fr, laurent.lebrun@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2019 **Current researchers** (permanent/non-permanent): 15 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 50% | |
| **Surfaces and interfaces** | | 25% | |
| **Simulation and modeling** | | 25% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

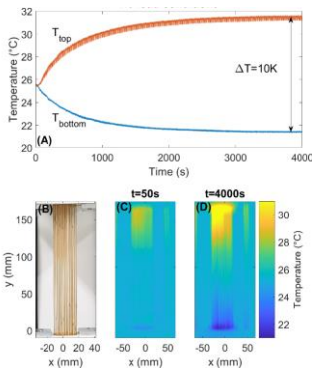
- ANR ECPOR (ANR-17-CE05-0016) 2017-2022
- JSPS Grant in Aid for Scientific Research Kiban C 19K04230 2019-2022

Estimated annual budget: 20k€

### Highlights & Outstanding achievements *(3-5 bullet points)*

- We have developed a first functional experimental proof of concept of cooling system based on elastocaloric natural rubber
- Radio pitch of France culture on the experimental proof of concept
- A publication received distinction of "Editor's Pick" in 2020, and was the subject of a "SciLight" (scientific highlight) by the American Institute of Physics.
- Way Szu Xuen (M1 student, Tohoku University) received the "Excellent Presentation Award" at the 21st Student Presentation of the Heat Transfer Society of Japan (Tohoku branch) held on 8 May 2021

### Illustration *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

In the framework of alternative refrigeration technologies, caloric materials exhibit entropy variations as the result of the application of an external quantity that could be an electric /magnetic field or a mechanical stress. Among them we study here the potential of natural rubber and the feasibility of its integration into preliminary proof of concept.

When driven cyclically, such a material exhibits time oscillations of temperature, and the conversion of it into a spa tial gradient requires a system. Regenerative systems are among the most promising solutions. It consists of moving a fluid cyclically along the caloric material, synchronously to its temperature variations. The heat transfer mechanisms and the optimization routes remain open questions. In addition it is investigated single stage systems where the heat released / absorbed by the active material is moved to heat or cold heat exchangers.

**Key scientific question** (2 lines max; Calibri 11)

How to convert time variations of temperature into spatial gradients in a regenerative system?
What are the key properties of the caloric materials?

**Research method** (8 lines max; Calibri 11)

Within REFRESH project, we develop experimental proofs of concept, along with adequate modeling. Although Finite Element Modelling and Computational Fluid Dynamics may bring accurate simulation for complex geometries, but costly in terms of calculations and time, it is preferred from the beginning to start from simplified approach and keep analytical solutions as much as possible, in an attempt to elucidate refrigeration mechanisms. It highlights also the key properties of caloric materials.

On the other hand the development of experimental proofs of concept helps (i) verifying the models assumptions, (ii) proving the refrigeration capability of the system.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Marianne Sion (2021-2024, CNRS, INSA Lyon – Tohoku University)

*Master/Bachelor students (years):*

- Ishii Shun (2023-2026), Tohoku University
- Way Szu Xuen (2020-2023, Tohoku University)
- Lilian Maury (2021, INSA Lyon, 5 month internship)
- Alban Duval (2020, INSA Lyon, 5 months internship)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- January 2024 – September 2024 (Marianne Sion)
- June 2022 – June 2023 (Marianne Sion)
- Dec. 2021: Giulia Lombardi starts a JSPS postdoctoral fellowship for research in Japan (24 month)

*JP to FR (date, duration):*

-

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 3 | Marianne Sion, Jacques Jay, Gildas Coativy, Atsuki Komiya, Gaël Sebald | Natural rubber based elastocaloric solid-state refrigeration device: Design and performances of a single stage system | Journal of Physics: Energy | 6 | 025003 | 2024 | 10.1088/2515-7655/ad20f4 |
| 2 | G. Sebald, G. Lombardi, G. Coativy, J. Jay, L. Lebrun, A. Komiya | High-performance polymer-based regenerative elastocaloric heat pump | Applied Thermal Engineering | 223 | 120016 | 2023 | 10.1016/j.applthermaleng.2023.120016 |
| 1 | G. Sebald, A. Komiya, J. Jay, G. Coativy, L. Lebrun | Regenerative cooling using elastocaloric rubber: analytical model and experiments | Journal of Applied Physics | 127 | 094903 | 2020 | 10.1063/1.5132361 |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 11 | Marianne Sion*, Gaël Sebald, Gildas Coativy, Jacques Jay, Atsuki Komiya | Elastocaloric refrigeration system: development of a proof of concept for solid-solid refrigeration system | 26th International Congress on Refrigeration | August 21-25, 2023. | Paris | France | |
| 10 | Marianne Sion*, Gael Sebald, Jacques Jay, Atsuki Komiya, Giulia Lombardi, Jean-Marc Chenal, Laurent Chazeau, Bertrand Garnier Gildas Coativy, Laurent Lebrun | Elastocaloric elastomer material and device as an alternative route for refrigeration | 26th International Congress on Refrigeration | August 21-25, 2023. | Paris | France | 10.18462/iir.icr.2023.0774 |
| 9 | Marianne Sion, Gaël Sebald, Gildas Coativy, Jacques Jay*, Giulia Lombardi, Atsuky Komiya | Solid refrigeration by elastocaloric effect of natural rubber, prove of concept development | 31ème Congrès Français de Thermique | May 30th – June 2nd, 2023 | Reims | France | |
| 8 | Gael Sebald*, Giulia Lombardi, Gildas Coativy, Jacques Jay, Laurent Lebrun, Atsuki Komiya | Experimental regenerative elastocaloric heat pump using natural rubber | 2023 MRS Spring Meeting & Exhibit | April 10 - April 26, 2023 | San Francisco | USA | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | Giulia Lombardi*, Gael Sebald, Gildas Coativy, Jacques Jay, and Atsuki Komiya | Characterization of Natural Rubber Tubes for Elastocaloric Cooling Applications | 2023 MRS Spring Meeting & Exhibit | April 10 - April 26, 2023 | San Francisco | USA | |
| 6 | G. Lombardi, G. Sebald, G. Coativy, J. Jay, A. Komiya | Development of elastocaloric proof-of-concept heat pumps using natural rubber | 60th National Heat Transfer Symposium | 24-27 May 2023 | Fukuoka | Japan | |
| 5 | Giulia Lombardi*, Gael Sebald, Atsuki Komiya, Sze Xuen Way, Gildas Coativy, Jacques Jay | Heat Exchange in Caloric Regenerators: from CFD Preliminary Analysis to Cooling Applications | Nineteenth International Conference on Flow Dynamics (ICFD2022) | November 9-11, 2022 | Sendai | Japan | |
| 4 | Gael Sebald*, Giulia Lombardi, Atsuki Komiya, Gildas Coativy, Jacques Jay, Laurent Lebrun | Elastocaloric rubber based system for new refrigeration solutions | Nineteenth International Conference on Flow Dynamics (ICFD2022) | November 9-11, 2022 | Sendai | Japan | |
| 3 | G. Sebald*, A. Komiya, J-M. Chenal, L. Chazeau, F. Dalmas, M. Vigouroux, F. Rousset, M. Boutaous, J. Jay, B. Garnier, M. Rammal, A. O. El Moctar, H. Haissoune, G. Coativy, L. Seveyrat, K. Yuse, L. Lebrun | Main key points for developing environmental friendly solid state cooling system based on the elastocaloric effect in rubber | 2020 European Materials Research Society (E-MRS) Fall Meeting | September 16th – 19th, 2019 | Warsaw | Poland | |
| 2 | Gael Sebald*, Alban Duval, Giulia Lombardi, Jacques Jay, Atsuki Komiya, Laurent Lebrun | Modelling of regenerative cooling using elastocaloric elastomers | 2020 (shifted to 2021) Eurotherm Seminar #115 CALORIC HEATING AND COOLING | July 13th – 15th, 2021 | online | | |
| 1 | Sze Xuen Way*, Yuki Kanda, Gael Sebald, Atsuki Komiya | Evaluation of the cooling performance and heat losses of elastocaloric cooling device | 第 21 回日本伝熱学会東北支部学生発表会 (2021-5) (Student Presentation of the Heat Transfer Society of Japan) | 8 May 2021 | online | | |

**Patents** *(gray color for previous years)*

| | **Inventors** | **Title** | **PCT #** | **Year** |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| | Gael Sebald, Atsuki Komiya | | 22160602.3 | 2022 |
| | | | | |

**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | Gael Sebald | Radio pitch on France Culture | Mar. 2023: Radio pitch on the elastocaloric cooling results<br>In 2023, broad audience journal articles mentioning our work: (Liberation; L'Usine Nouvelle; Reporterre; The Telegraph…) | March 2023 |
| | | | | |

Project report 2023

# SCINTILLATOR GLASSES

*New VUV scintillator glasses for fast neutron detection*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Nobuhiko SARUKURA**[a] | **Akira YOSHIKAWA**[b] | **Georges BOULON**[c] | **Malgorzata GUZIK**[d] |

[a] *Institute of Laser Engineering (ILE), Osaka University, Japan*
[b] *Institute for Materials Research (IMR), Tohoku University, Sendai, Japan*
[c] *Institut Lumière Matière (iLM), UMR 5306 UCBLyon1- CNRS, Villeurbanne, France*
[d] *Luminescent Materials Group, Faculty of Chemistry, University of Wroclaw, Poland*

**Contacts:** sarukura-n@ile.osaka-u.ac.jp; georges.boulon@univ-lyon1.fr;


## OVERVIEW *(keep within this page)*

**Starting year:** 2019 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | | 100% | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | | |

**Other:**

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)

☒ Public project(s) ☐ Industrial ☒ Own resources from IMR Tohoku, ILE Osaka, iLM Lyon, Univ Wroclaw

IFS CRP/LyC project? ☐ Yes ☒ No

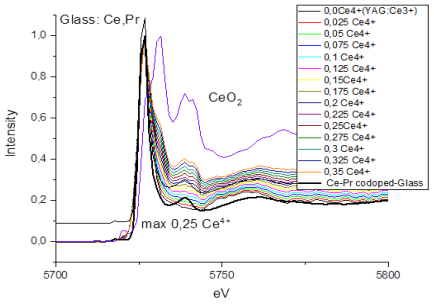
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- The realisation of this project has been oriented to cerium-doped glasses emitting an electric-dipole allowed inter-configurational 4fn-15d → 4fn transition characterized by a fast emission decay of few ns.
- Ce3+ and Ce4+ centers are confirmed by both optical absorption (UV charge transfer band) and X-ray absorption spectroscopy (XANES) along Ce L-edge energies at ESRF-Grenoble.
- Unexpected 25%Ce4+ is detected due to oxydation process during the fabrication of glasses. Its main role is to accelerate the scintillation mechanism.

**Illustration** *(5x5 cm² max)*




*XANES spectroscopy of $Ce^{3+}$ and $Ce^{4+}$ co-doped fluoro-oxide (APLF) $20Al(PO_3)_3 - 80LiF$ glass.*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Glass scintillators have the advantage of having larger sizes, being more flexible and mass-produced compared to crystals for fast scintillator applications. There are doped by $Ce^{3+}$, $Nd^{3+}$, $Pr^{3+}$, $Er^{3+}$ rare earth luminescent ions to take advantage of the electric-dipole allowed inter-configurational $4f^{n-1}5d \rightarrow 4f^{n}$ transitions which have fast emission decays of few tens nanosecondes. Although absorption and emission properties in the VUV region are always difficult to measure due to the spectral limit of many devices, most of the host materials are not suitable for detecting 270 keV fast neutrons because they lack of Li or have insufficient $^{6}Li$ content making them less sensitive to the neutrons. So, APLF glasses contain $^{6}Li$ density of 31.6 mmol/$cm^3$, the maximum amount in the conventional $^{6}Li$ glass scintillator which has a high cross section fit for scattered neutron detection discriminated from X-ray signals and primary neutrons and developed in ILE(Osaka).

**Key scientific question** (2 lines max; Calibri 11)

Making rare earth ions-doped APLF glasses to be ranked as advanced potential scintillator materials in time-of-flight detectors for high-counting-rate fast neutron detection of few ns.

**Research method** (8 lines max; Calibri 11)

The objectives of SCINTILLATOR GLASSES for fast neutron detection encompass glass science, optical properties and especially spectroscopic properties of 4f←→5d parity-allowed transitions with short decay of $Ce^{3+}$, $Pr^{3+}$, $Nd^{3+}$, and $Er^{3+}$ trivalent rare earth dopants. Due to experimental reasons in UV range, the retained luminescent cations are $Ce^{3+}$ and $Pr^{3+}$. Especially in the 2023 report we have deeply analyzed $Ce^{3+}$-doped APLF glasses in which the presence of unexpected $Ce^{4+}$ ions is pointed out and understood as an accelerator of the scintillating mechanism. $Ce^{4+}$ ions have been reported by an UV charge transfer absorption band and, above all, confirmed by X-ray absorption spectroscopy along the commonly accessed Ce L-edge energies (5723.4 to 6548.8 eV) at ESRF-Grenoble.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Keito Shinohara (2021-2023, ILE Osaka) - Ph.D. defense took place on December 20th, 2023 at ILE, Osaka

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

- G. Boulon (iLM-Lyon)-IMR Sendai March 8-17, 2024
- G. Boulon (iLM lyon)-IMR Sendai October 26-November 7, 2022, 2 weeks)
- G. Boulon (iLM lyon)-IMR Sendai October 24-November 11, 2021, 2 weeks)

*JP to FR (date, duration):*

- 9th Symposium ISOM, Tarragona, Spain, 26-30 June 2023, Chairs: Xavier Mateos, Francesc Díaz, Akira Yoshikawa. Has allowed the meeting of several French, Polish and Japanese researchers of the cooperation. A special Issue will be published in Optical Materials X.
- Keito Shinohara (ILE Osaka)-iLM Lyon Sept10-21 2022, 11 days
- Melvin Empizo (ILE Osaka)-iLM Lyon Sept10-21 2022, 11 days
- Akira Yoshikawa (IMR sendai)-iLM Lyon July 27-28, 2022, 2 days
- Melvin Empizo (ILE Osaka)-iLM Lyon February 27-March 17, 2020, 3 weeks
- Melvin Empizo (ILE Osaka)-iLM Lyon December 2-17, 2019, 2 weeks
- Nobuhiko SARUKURA (ILE Osaka)-iLM Lyon June 5-6, 2019, 2 days
- Melvin Empizo (ILE Osaka)-iLM Lyon June 5-6, 2019, 2 days
- Melvin Empizo (ILE Osaka)-iLM Lyon September 19, 2018, 1 day

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Keito Shinohara, Melvin John F. Empizo, Angelo P. Rillera, Mayrene A. Uy, Marilou Cadatal-Raduban, Kohei Yamanoi, Toshihiko Shimizu, Masashi Yoshimura, Nobuhiko Sarukura, Takahiro Murata, Hitoshi Abe, Akira Yoshikawa, Georges Boulon, Christophe Dujardin | Influence of the 4f5d-1S0 energy gap on the decay times of $Pr^{3+}$-doped fluoride scintillating glasses | Optical Materials X | submitted | 31th December 2023 | 2023 | |
| 2 | Keito Shinohara, Melvin John F. Empizo, Marilou Cadatal-Raduban, Kohei Yamanoi, Toshihiko Shimizu, Masashi Yoshimura, Nobuhiko Sarukura, Takahiro Murata, Mayrene A. Uy, Hitoshi Abe, Akira Yoshikawa, Georges Boulon, Christophe Dujardin | Radiation resistance of praseodymium-doped aluminum lithium fluorophosphate scintillator glasses for laser fusion experiments | Japanese Journal of Applied Physics | 62 | 010613 | 2023 | https://doi.org/10.35848/1347-4065/aca0d4 |
| 3 | Melvin John F. Empizo, Yuki Minami, Kohei Yamanoi, Toshihiko Shimizu, Masashi Yoshimura, Nobuhiko Sarukura, Takahiro Murata, Akihiro Yamaji, Akira Yoshikawa, Malgorzata Guzik, Yannick Guyot, Georges Boulon, Marilou Cadatal-Raduban | Investigations on the electric-dipole allowed $4f^25d \rightarrow 4f^3$ broadband emission of $Nd^{3+}$-doped $20Al(PO_3)_3$-80LiF glass for potential VUV scintillator application | Journal of Alloys and Compounds | 856 | 158096 | 2021 | https://doi.org/10.1016/j.jallcom.2020.158096 |
| 4 | Yuki Minami, Jacque Lynn, Gabayno, Verdad Canila Agulto, Youwei Lai, Melvin John F. Empizo, Toshihiko Shimizu, Kohei Yamanoi, Nobuhiko, Sarukura, Akira Yoshikawa, Takahiro Murata, Malgorzata Guzik, Yannick Guyot, Georges Boulon, John A. Harrison, Marilou Cadatal-Raduban | Spectroscopic investigation of praseodymium and cerium co-doped 20Al(PO3)3-80LiF glass for potential scintillator applications | Journal of Non-Crystalline Solids | 521 | 119495 | 2019 | https://doi.org/10.1016/j.jnoncrysol.2019.119495 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | Géraldine Dantelle, Georges Boulon, Yannick Guyot, Denis Testemale, Malgorzata Guzik, Shunsuke Kurosawa, Kei Kamada, Akira Yoshikawa | Research of efficient fast scintillators. Evidence and XANES characterization of Ce4+ in Ce3+, Mg2+-co-doped Gd3Al2Ga3O12 garnet crystals | Physica Status Solidi B | 257, n°8, | 1900510 (7 pages) | (2019) | 10.1002/pssb.201900510 |
| 6 | Melvin John F. Empizo, Marilou Cadatal-Raduban, Takahiro Murata, Yuki Minami, Keisuke Kawano, Kohei Yamanoi, Toshihiko Shimizu, Nobuhiko Sarukura, Malgorzata Guzik, Yannick Guyot, Georges Boulon | Spectroscopic properties of $Pr^{3+}$-doped 20Al(PO3)3-80LiF glasses as potential scintillators for neutron detection | Journal of luminescence | 193 | 13-21 | 2018 | https://doi.org/10.1016/j.jlumin.2017.06.029 |

**Conferences** *(gray color for previous years)*

| | **Authors** | **Title** | **Conference** | **Date** | **City** | **Country** | **DOI** *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1-12 | Georges Boulon, Christophe Dujardin, Kheirreddine Lebbou, Malgorzata Guzik, Akira Yoshikawa, Akihiro Yamaji, Yuui Yokota, Shunsuke Kurosawa, Kei Kamada, Nobuhiko Sarukura, Melvin Empizo, Keito Shinohara, | International Symposium on Optical Materials<br>Each mentioned researchers have presented a talk. | 9th Symposium ISOM, Organized every 3 years by the cooperation iLM (Lyon) and IMR (Sendai) since 1997. | 26-30 June., 2023 | Tarragona | Spain | Chairs: Xavier Mateos, Francesc Díaz, Akira Yoshikawa |
| 13 | Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, | $Nd^{3+}$-doped 20Al$(PO_3)_3$-80LiF glass : a promising VUV scintillator material for high-counting-rate | ELyT Workshop 2022 | 16-18 Nov., 2022 | Villeurbanne | France | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Nobuhiko, Yoshikawa &al | fast neutron detection | | | | | |
| 14 | Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, Sarukura, Akira Akira Yoshikawa, | The choice of 5d□4f UV emission of $Ce^{3+}$/$Pr^{3+}$-doped 20Al$(PO_3)_3$-80LiF glasses as fast scintillators for neutron detection | The XVII International Feofilov Symposium on Spectroscopy of Crystals Doped with rare Earth and transition Metal ions | 23-28 Sept 2018 | Ural Federal University Ekaterinburg | Russia | |
| 15 | Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, Nobuhiko Sarukura, Akira Yoshikawa, &al | $Pr^{3+}$-doped 20Al$(PO_3)_3$-80LiF glass as potential scintillator for neutron detection | The Phosphor Safari and The Sixth International Workshop on Advanced Spectroscopy and Optical Materials ( PS- IWASOM'17 ) | 9-14 July 2017 | Gdansk University | Poland | |

# T2 TRIBOCHEM

*Syperlubricity of a ta-C/$Si_3N_4$ contact in presence of castor oil*

## MAIN PARTICIPANTS


|  |  |  |  |
|---|---|---|---|
| **Maria Isabel DE BARROS BOUCHET** | **Jean Michel MARTIN** | **Yang WANG** | **Momoji KUBO** |

**Maria Isabel De Barros Bouchet** LTDS Ecole Centrale de Lyon 69134, Ecully, **France**.
**Jean Michel Martin** LTDS Ecole Centrale de Lyon 69134, Ecully, **France**.
**Yang Wang** Research Institute of Frontier Science, Southwest Jiaotong University, 610031, Chengdu, **China**
**Momoji Kubo** IMR Tohoku University2-1-1 Katahira, Aoba-ku Sendai 980-8577, **Japan**

**Contact:** maria-isabel.de-barros@ec-lyon.fr, momoji@imr.tohoku.ac.jp


## OVERVIEW *(keep within this page)*

**Starting year:** 2014 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | **Transportation** | **Energy** | **Eng. for Health** |
|---|---|---|---|
| **Materials and structure design** | 25 % | 25% | |
| **Surfaces and interfaces** | 25 % | | |
| **Simulation and modeling** | 25 % | | |

**Other:** Energy saving

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

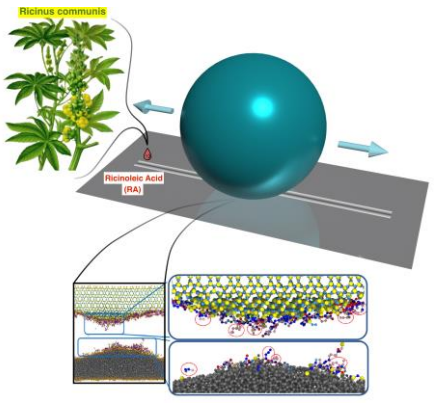
IFS CRP/LyC project? ☐ Yes ☒ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

### Highlights & Outstanding achievements

- We have demonstrated a new superlubricious system operating with a green lubricant, hydrogen-free DLC/Si3N4 contact lubricated by castor oil.
- Superlow friction is related to the in situ formation of graphitic/graphenic species but also to the presence of OH- and –(CH2–CH2)n–oligomers on the surface.
- Through tailoring initial sp2-hybridized carbon content at the ta-C surface, friction can be governed.
- A publication has been accepted in the Journal “Friction“ (IF=5.4).



# PROJECT DESCRIPTION

**Background**

To meet the surging needs in energy efficiency and eco-friendly lubricants, a novel superlubricious technology using an unsaturated fatty acid and ceramic materials is proposed. By using amorphous carbon coatings with a selected fraction of $sp^2$ and $sp^3$-hybridized carbon in presence of a commercially available silicon nitride bulk ceramic, castor oil provides superlubricity although the liquid oil film in the contact is at the nanometer scale. Local tribochemical reactions between contacting asperities are essential to maintain superlubricity at low speeds. High local pressure and shear activate chemical degradation of castor oil generating graphitic/graphenic-like species on top of asperities, thus helping both the chemical polishing of surface and its chemical passivation by H- and/or OH- species. For the first time, formation of alkane and alkene surface oligomers have been evidenced to play a major role in the friction reduction in the superlow regime.

**Key scientific question**

Developing new superlubricious lubricated systems for energy saving
Developing green superlubricants derived from vegetable oils

**Research method**

Computer simulation unveils that formation of chemical degradation products of castor oil on friction surfaces are favored by the quantity of $sp^2$-hybridized carbon atoms in the amorphous carbon structure. Moreover, short alkene chains are found to terminate the tribofilm on $Si_3N_4$ Hence, tuning $sp^2$-carbon content in hydrogen-free amorphous carbon, in particular, on the top layers of the coating, provides an alternative way to control superlubricity achieved with unsaturated fatty acids.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Yun LONG (PhD student at LTDS, 2017-2019)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

*JP to FR (date, duration):*

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Yun LONG, Yang WANG, Volker WEIHNACHT, Stefan MAKOWSKI, Momoji KUBO, Jean Michel MARTIN, Maria-Isabel DE BARROS BOUCHET | Mechanism of superlubricity of a DLC/Si3N4 contact in the presence of castor oil and other green lubricants | Friction | 10(10) | 1693–1706 | 2022 | *https://doi.org/10.1007/s40544-022-0601-1* |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|

**Patents** *(gray color for previous years)*

| | Inventors | Title | PCT # | Year |
|---|---|---|---|---|

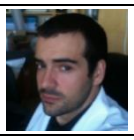
**Others** *(gray color for previous years)*

| | People | Event | Description | Date |
|---|---|---|---|---|
| 1 | Maria-Isabel DE BARROS BOUCHET | ELyT workshop 2022 | | November 16th - 18th, 2022 - Lyon, France |

# TEmPuRA

*Theory for Electrostriction of PolymeRic Actuator*

## MAIN PARTICIPANTS


| | | | | | |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| G. COATIVY[a] | H. TAKANA[b,d] | G. DIGUET[c] | V. PERRIN[a] | L. SEVEYRAT[a] | F. DALMAS[e] |
|  |  |  |  |  | |
| S. LIVI[f] | Y. GUO[g] | J. COURBON[e] | G. SEBALD[h] | JY CAVAILLE[h] | |

[a] *LGEF, EA 682,INSA Lyon, Univ. Lyon*
[b] *IFS, Tohoku University*
[c] *AIMR, Tohoku University*
[d] *IFS Lyon Center, Tohoku Univ. & LGEF, INSA Lyon*
[e] *MATEIS, UMR 5510, CNRS INSA Lyon, Univ. Lyon*
[f] *IMP, UMR 5223, INSA Lyon, Univ. Lyon*
[g] *FRIS, Tohoku University, Aoba-ku, Sendai, 980-0845, Miyagi, Japan*
[h] *ELyTMaX, IRL 3757, CNRS - Univ. Lyon - Tohoku Univ.*

**Contact:** takana@tohoku.ac.jp, gildas.coativy@insa-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2014 **Current researchers** (permanent/non-permanent): 3 person-month/year

**Positioning** *(Multiple selection allowed – total 100%)*

| | Transport ation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | | 50% | |
| **Surfaces and interfaces** | | | |
| **Simulation and modeling** | | 50% | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

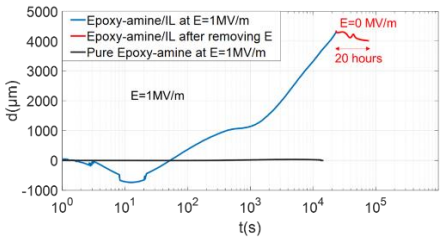
- BQR INSA 2023-2024

Estimated annual budget: 10k€

## Highlights & Outstanding achievements *(3-5 bullet points)*

- The simulation of the electro-actuation of dielectric elastomers doped with ions was improved using Fortran and COMSOL®.
- Epoxy-amine materials doped with controlled amount of ionic liquid (IL) have been synthesized.
- The addition of 0.1 wt.% of IL is sufficient to induce bending under a constant electric field of 0.1 MV/m.
- After removal of the applied electric field, a remanent displacement is observed. This has been shown to be caused by the presence of an organized layer of ionic liquid near the electrode long after the electric field has been removed.

## Illustration *(5x5 cm² max)*




*Bending of epoxy-amine doped with Ionic liquid under constant electric field and after removing the applied electric field*

# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

Conversion of energy is a hot topic in robotics and microfluidics especially in term of electromechanical coupling for actuators and energy harvesting (which includes sensors, useable for non-destructive techniques). Among the different electroactive polymers which can be used for these applications, the dielectric elastomers can be actuated under high electric field. It is well known that the presence of ionic impurities can have an impact of their electro-mechanical response under high electric field (i.e. above 1MV/m). More precisely, it can be responsible for the bending of the sample under constant electric field. However very few studies are focused on the impact of a small controlled quantity of ions on the electroactuation of polymers under high electric field. We therefore decided to study this subject.

**Key scientific question** (2 lines max; Calibri 11)

What physical mechanisms are responsible for the temporal deformation of soft polymers under electric field in the presence of small quantities of ions? How to model them?

**Research method** (8 lines max; Calibri 11)

So far, we have studied the electromechanical behavior of polyurethanes under an electric field in compression and more recently in flexion in a controlled environment (temperature and humidity). In parallel, a numerical simulation was carried out at the meso-scale in order to capture the short- and long-term time dependence of bending and current density. Modeling based on the electric carrier drift-diffusion equation is developed, and simulations using Fortran and COMSOL® are carried out: the calculated current density and curvature satisfactorily reproduce our experimental data of PU, for fields ranging from [$2.10^6$ - $10^7$ V/m] with the same set of parameters.

We are now developing and characterizing model epoxy-amine networks doped with controlled amounts of ionic liquids with a weight fraction varying between 0.1 and 10%wt to study the impact of electric charge carriers on the electroactuation of elastomers. Our materials are studied electrically (dielectric and bending spectroscopy under constant electric field), mechanically (mechanical spectroscopy) and structurally (EDX, DRX, AFM) in order to obtain data to feed our numerical simulation and to explain one of our striking results which is that when samples are subjected to an electric field, a remanent displacement is observed long after the electric field is removed. At the same time, we are starting work on the design of electroactive flexible fibres based on thermoplastic elastomers for actuation applications.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

*Master/Bachelor students (years):*

- *Djasma Djoumoi (M2 stay at IMP/LGEF/MATeIS/Elytmax December 2024)*
- *Axel Blain (M2 stay at IMP/LGEF/MATeIS/Elytmax) March-September 2023*
- Zhouyang He (M2 student of INSA, Mat. Sc. and Eng.)
- N. Boucida (M2 stay at IFS/ELyTMaX), April-September 2016

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

| | | |
|---|---|---|
| JY Cavaillé | Mar. 2024 | 2 weeks |
| G. Coativy | Nov. 2023 | 2 weeks |
| J. Courbon | Nov. 2023 | 2 weeks |
| JY Cavaillé | Nov. 2023 | 2 weeks |
| JY Cavaillé | June 2023 | 2 weeks |
| J. Courbon | Feb-Aug-2023 | 6 months |
| JY Cavaillé | November 2022 | 2 weeks |

| | | |
|---|---|---|
| K. Yuse | Nov-2019 | 1 week |
| JY Cavaillé | Oct-Nov 2019 | 2 weeks |
| K. Yuse | June-July 2019 | 1 week |
| JY Cavaillé | June-July 2019 | 2 weeks |
| JY Cavaillé | Apr-2019 | 1 week |
| JY Cavaillé | Feb-March 2019 | 2 weeks |

*JP to FR (date, duration):*

| | | |
|---|---|---|
| H. Takana | Jan. 2024 | 1 week |
| H. Takana | Sept. 2023 | 2 weeks |
| H. Takana | March 2023 | 2 weeks |
| H. Takana | September 2022 | 2 weeks |

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | G Coativy, K Yuse, G Diguet, V Perrin, L Seveyrat, F Dalmas, S Livi, J Courbon, H Takana and J Y Cavaillé, | Role of charge carriers in long-term kinetics of polyurethane electroactuation | Smart Materials and Structures | 31 | 125019 | 2022 | 10.1088/1361-665X/aca12e |
| 2 | Gildas Diguet, JY Cavaille, Gael Sebald, Toshiyuki Takagi, Hiroshi Yabu, Ai Suzuki, and Ryuji Miura | Physical behavior of electrostrictive polymers. Part 1: Polarization forces | Computational Materials Science | 190 | 110294 | 2021 | 10.1016/j.commatsci.2021.110294 |
| 3 | M.H. Jomaa, L. Roiban, D. Dhungana, J. Xiao, J.-Y. Cavaillé, L. Seveyrat, L. Lebrun, G. Diguet, K. Masenelli-Varlot | Quantitative Analysis of grafted CNT dispersion and of their stiffening of polyurethane (PU) | Composites Science and Technology | 171 | 103-110 | 2019 | 10.1016/j.compscitech.2018.12.012 |
| 4 | M.H. Jomaa, L. Seveyrat, L. Perrin, L. Lebrun, K. Masenelli-Varlot, G. Diguet, J.-Y. Cavaillé, | Difference between electrostriction kinetics, and mechanical response of segmented polyurethane-based EAP | Smart Materials and Structures | 26 | 035049 | 2017 | 10.1088/1361-665X/aa5c4b |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | J. Courbon, J.-Y. Cavaillé, G. Coativy, G. Diguet | Numerical Study on Electrical Drift and Diffusion of Ions in Polymer Strips | 20th ICFD OS7: Smart Fluids & Soft Matters and Their Advanced Applications | November 2023 | Sendai | Japan | |

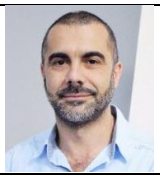
| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 2 | Axel Blain, Gildas Coativy, Florent Dalmas, Sébastien Livi, Gabriel Perli, Véronique Perrin, Laurence Seveyrat, Gildas Diguet, Joël Courbon, Hidemasa Takana, Jean-Yves Cavaillé | Study of the Electroactuation of Doped Epoxy-amine Elastomers with Ionic Liquids under High Electric Fields | 20th ICFD OS7: Smart Fluids & Soft Matters and Their Advanced Applications | November 2023 | Sendai | Japan | |
| 3 | Jean-Yves Cavaille, Gildas Coativy, Kaori Yuse, Gildas Diguet, Véronique Perrin, Laurence Seveyrat, Florent Dalmas, Sébastien Livi, Chrystelle Bernard, Joël Courbon, Hidemasa Takana | Are Charge Carriers Responsible for the Electroactivity of Polyurethane? | 19th ICFD OS7: Smart Fluids & Soft Matters and Their Advanced Applications | November 2022 | Sendai | Japan | |
| 4 | Gildas Coativy, Kaori Yuse, Gildas Diguet, Véronique Perrin, Laurence Seveyrat, Florent Dalmas, Sébastien Livi, Chrystelle Bernard, Joël Courbon, Hidemasa Takana, Jean-Yves Cavaille | Role of Charge Carriers in the Bending of Dielectric Elastomers (TEmPuRA project) | 19th ICFD OS23: IFS Lyon Center Collaborative Research Forum | November 2022 | Sendai (on line) | Japan | |
| 5 | G. Coativy, K. Yuse, G. Diguet, V. Perrin, L. Seveyrat, F. Dalmas, S. Livi, J. Courbon, H. Takana, JY Cavaillé | Cinétique de fléchissement du polyuréthane sous champ électrique | Matériaux 2022 | November 2022 | Lille | France | |
| 6 | G. Coativy, K. Yuse, G. Diguet, L. Seveyrat, V. Perrin, F. Dalmas, S. Livi, J. Courbon, H. Takana, JY Cavaillé | Electroactive polymers as actuators: why do they deform? | 18th ICFD | 2021 Oct. 29 | On line | Japan | |
| 7 | Ai Suzuki, Masayuki Miyano, Ryuji Miura, Gildas Diguet, Jean-Yves Cavaille, Gael Sebald | Estimation of Multiple Coefficients to Express Longitudinal and Transverse Electrostriction in the PTMO Crystal | 17th ICFD | 2020 Oct. 18-30 | On line | Japan | |
| 8 | K. Yuse, G. Coativy, G. Diguet, V. Perrin, L. Seveyrat, S. Livi, J.-Y. Cavaillé | Role of Charge Carrier Transport on the Understanding of Polyurethane Actuation | 17th ICFD | 2020 Oct. 18-30 | On line | Japan | |

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 9 | Ai Suzuki, Masayuki Miyano, Ryuji Miura, Gildas Diguet Gildas, JY Cavaille, Sebald Gael | Quantum chemical calculation study for the polarization evaluation of the semi-crystalline poly tetramethylene oxide elastomer | Meeting of The Institute of Electrical Engineers of Japan | 2019 Dec. 16 | Tokyo | Japan | IEJJ Digital Library, [A] Basic / Materials / Common Division Dielectric / Insulation Materials Study Group 2019-12-16, Paper No. DEI19109 |
| 10 | Kaori Yuse, Gildas Diguet, JY Cavaille | Electrical Conductivity Versus Electrostriction in Di-Block Polyurethane: New Insights | 16th ICFD | 2019 Nov. 6-8 | Sendai | Japan | |
| 11 | Ai Suzuki , Masayuki Miyano , Ryuji Miura Jean Yves Cavaille , Gildas Diguet , Gael Sebald | Polarization and Elasticity Characterization in Crystal and Amorphous States of Polytetramethylene Oxide Elastomer | 16th ICFD | 2019 Nov. 6-8 | Sendai | Japan | |
| 12 | Gildas Diguet & Kaori Yuse | Seminar on Electrostriction | Morita's Lab | 2019 July 8 | Todai, Tokyo | Japan | |
| 13 | A. Suzuki, M. Miyano, R. Miura | Theoretical estimation of dielectrics constant of electroactive polymers | 15th ICFD | 2018 Nov 7-9 | Sendai | Japan | |
| 14 | A. Suzuki, R. Miura, N. Hatakeyama, J.-Y. Cavaille, G. Diguet, G. Sebald | Multiscale Modeling of Electromechanical Coupling in Electroactive Polymers | 14th ICFD | 2017 Nov. 1-3 | Sendai | Japan | |
| 15 | Nazim Boucida, Jean-Yves Cavaillé, Jean-Marc Chenal, Gildas Diguet, Gael Sebald | Nano-structured polymer based materials for energy conversion and actuation, | ISMANAM | 2016 July 3-8 | Nara | Japan | Invited lecture |

# Touch feeling and Surface

*Elucidation of individual differences in tactile perception*

## MAIN PARTICIPANTS


|  |  |  |  |  |
|---|---|---|---|---|
| **Mami TANAKA[c]** | **Takeshi OKUYAMA[d]** | **Hassan ZAHOUANI[a]** | **Roberto VARGIOLU[a]** | **Cyril PAILLER-MATTEI[a,b]** |

[a] *Laboratoire de Tribologie et Dynamique des Systèmes, UMR CNRS 5513, École Centrale de Lyon, France*
[b] *University of Lyon, University Claude Bernard Lyon 1, IPSB-Faculty of Pharmacy, France*
[c] *Graduate School of Biomedical Engineering, Tohoku University*
[d] *Graduate School of Engineering, Tohoku University*

**Contact:** takeshi.okuyama.e7@tohoku.ac.jp , cyril.pailler-mattei@ec-lyon.fr


## OVERVIEW *(keep within this page)*

**Starting year:** 2023 **Current researchers** (permanent/non-permanent): 3 person-month/year

| **Positioning** *(Multiple selection allowed – total 100%)* | Transportation | Energy | Eng. for Health |
|---|---|---|---|
| **Materials and structure design** | | | 25 % |
| **Surfaces and interfaces** | | | 75 % |
| **Simulation and modeling** | | | |

**Other:**

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☐ Public project(s) ☐ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

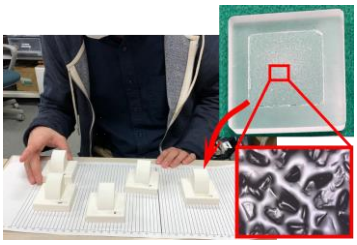
- International Society for Advanced Drawing Breakthrough project, 2021-2023, COMCOM
- ANR-JST project, 2016-2019, COMICA
- PHC, 2014-2016, Sakura

Estimated annual budget:

**Highlights & Outstanding achievements** *(3-5 bullet points)*

- Measuring the frictional properties of several silicone samples with roughness, and fingertip by equipment in ECL (2023)
- Preparation of samples with various surface textures and hardness (2022-)
- Construction of measurement system for fingertip characteristics by Optical Coherence Tomography (2022-)
- Measurement of the surface properties by Bio-tribometer (2019)
- Co-authored paper: Journal of Advanced Science, Vol.32, 32302, (2020)

**Illustration** *(5x5 cm² max)*



# PROJECT DESCRIPTION

**Background** (10 lines max; Calibri 11)

The sense of touch is a sensation that is perceived by mechanical stimulation such as friction and vibration applied to the skin and plays an important role in the perception and manipulation of the external environment and objects. Since it is important not only in daily life but also in various professional activities, the development of technology that realizes the presentation of tactile information in virtual reality and the design of tactile information in the real environment are demanded. For presentation and design of tactile information, it is necessary to elucidate the perceptual mechanism. Elucidation of the mechanism requires detailed analysis of mechanical stimuli, evaluation of human characteristics, and analysis of psychophysical quantities.
In addition, there are various individual differences in tactile perception such as changes in human characteristics due to aging, and it is necessary to analyze the mechanism in consideration of them.

**Key scientific question** (2 lines max; Calibri 11)

Investigating the relationship among tactile perception, surface properties, and human characteristics

**Research method** (8 lines max; Calibri 11)

This study aims to elucidate the factors that affect the relationship between object characteristics and sensation. In this project, we will measure the perceptual characteristics of tactile sensation, skin characteristics, psychophysical quantities, and tactile movement during tactile perception, and analyze their relationships by considering individual differences. Focusing on the illusion of hardness due to surface texture, we will prepare samples, measure their characteristics, conduct psychophysical experiments, and measure the fingertip characteristics of subjects.

**Research students involved** *(gray color for previous years)*

*Ph.D. candidates (years, institution):*

- Mahki TAKANARI (2024-present, Tohoku university)
- Syota KAWAMINAMI (2023-present, Tohoku University)

*Master/Bachelor students (years):*

- Mahki TAKANARI (2023, Tohoku university)

**Visits and stays** *(gray color for previous years)*

*FR to JP (date, duration):*

-

*JP to FR (date, duration):*

- Shota KAWAMINAMI (Sept 2023, 1 week)
- Mahki TAKANARI (Sept 2023, 1 week)

# COMMUNICATIONS AND VALORIZATION

**Journal publications** *(gray color for previous years)*

| | Authors | Title | Journal | Vol. | pp. / ID | Year | DOI |
|---|---|---|---|---|---|---|---|
| 1 | Semin KANG, Takeshi OKUYAMA, Mami TANAKA, Ramousse FLORIAN, Coralie THIEULIN, Hassan ZAHOUANI, Cyril PAILLER-MATTEI | Study on tactile illusion of stiffness feeling by surface roughness | Journal of Advanced Science | 32 | 32302 | 2020 | 10.2978/jsas.32302 |
| | | | | | | | |

**Conferences** *(gray color for previous years)*

| | Authors | Title | Conference | Date | City | Country | DOI *(if applicable)* |
|---|---|---|---|---|---|---|---|
| 1 | Mahki TAKANARI, Takeshi Okuyama, Cyril PAILLER-MATTEI, Mami Tanaka | Study on the relationship between the skin properties of the finger pad and vibration perception | ICPE 2024 | 24/10/2024 - 26/10/2024 | Sendai | Japan | (Abstract Accepted) |
| 2 | Semin KANG, Takeshi OKUYAMA, Coralie THIEULIN, Hassan ZAHOUANI, Cyril PAILLER-MATTEI, Mami TANAKA | Investigation of the effect of surface roughness on human stiffness feeling | ITC Sendai 2019 | 17/9/2019 - 21/9/2019 | Sendai | Japan | |

# *Outlook*

Following years of particular situation due to the sanitary conditions, and after the **metamorphosis and renewal** of the ELyT Global IRN in 2022, **2023 is a year of stabilization**, with development of research activities mostly within already projects and a turn-over of 10% for the stop of projects and start of new ones. With the almost back-to-normal situation for travels, the number of stays and events have been **as important as pre-Covid period**. This therefore demonstrates the remarkable **liveliness of the network**, and the **strong will and relevance of collaborations**. For sure, this extraordinary dynamic has been significantly helped by the **strong resilience** of the network during the pandemic period.

Almost **all the indicators** (numbers of researchers and labs, publications, involved students and early stage researchers…) have been **increasing**. Considering the number of projects as well as the recommendation of the steering committee, project management has also evolved, with the consolidation of a new indicator for **pluri-annual project follow-up**.


ELyT Global (“**E**ngineering sciences **Ly**on-**T**ohoku”) is an International Research Network (IRN) aiming at promoting and supporting collaborating research between Lyon and Tohoku. The purpose of the IRN is to provide a framework to top-level collaborations between French and Japanese researchers on three main scientific topics (“Materials and structure design”, “Surface and interfaces” and “Simulation and modeling”) associated to three socio-economical themes (“Transportation”, “Energy”, “Engineering for health”). ELyT Global also proposes training through research to students and researchers, through summer school and thematic spring schools.

This document exposes main actions that have been achieved in the framework of the IRN for year 2023. This is decomposed into a general presentation of the IRN and the ecosystem it belongs to (ELyT initiative), networking and promotion activities (workshops, schools, students and researcher exchanges…) as well as scientific research projects performed in the framework of the IRN, which regroups 26 projects involving 32 laboratories and 98 researchers.


*https://www.elyt-lab.com/*