Annual Report 2024

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Executive Summary

This document exposes the actions of the ELyT Global IRN[1] during the year 2024.

2024 confirmed the stabilization in the activities of the IRN, as activities fully resumed under normal operating conditions, after a large post-COVID renewal in 2022. International exchanges are now fully back to normal and research activities with international collaborations could operate normally in 2024. This allowed us to organize many events, to promote the collaborations in the framework of the IRN. Stabilization concerned the projects, the teams involved, the exchanges, the scientific production of the projects…

Structured around the long-standing partnership between CNRS, INSA Lyon, Centrale Lyon, and Tohoku University, ELyT Global continued in 2024 to promote excellence-driven, interdisciplinary research at the interface of engineering sciences and advanced technologies. 24 projects were running in 2024, including 5 new ones (7 projects stopped in 2024). 96 researchers from 27 labs (14 French, 10 Japanese, 1 joint FR/JP, 1 Greek) and a research center from an international company based in Sweden were involved in these projects, representing 127 person-months in total. These numbers are comparable to pre-COVID situation. New projects also permitted young people joining the IRN (including DD PhD students). On that aspect, projects involved 11 Master students (+3 compared to 2023, following our wish to increase the involvement of Master students in order to increase later the number of DD PhD), and 24 Ph.D. students among which 7 are performing a Double Degree.

The return to normal situation for travel allowed us to organize face-to-face meetings. Hence, ELyT School was held in France in September 2024 with a normal duration of 10 days for the first time since 2019, once again providing undergraduate and graduate students with valuable opportunities for advanced training, networking, and direct interaction with senior scientists from the ELyT community. ELyT workshop was organized in March 2024 (to go back to the favorable dates of February / March for holding the annual workshop), in Japan for the first time since 2019.

Beyond scientific production, 2024 also reinforced ELyT Global's role as a structuring framework for sustainable France–Japan collaboration.

This report aims to expose the idea behind the ELyT initiative in general, and ELyT Global in particular. Then, the actions performed in 2024 are reported, along with the detailed description of associated projects. Finally, some future opportunities and challenges are discussed.

[1] International Research Network

Table of contents

Table of Contents

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 150th (ECL), 100th (Tohoku University), and 50th (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.

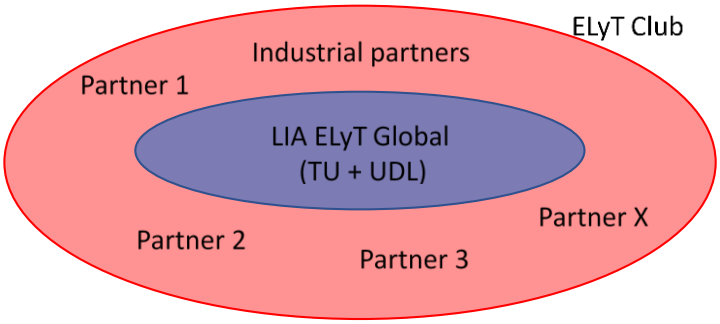


Figure 1: Scheme of the concept of ELyT Global and ELyT Club.

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.

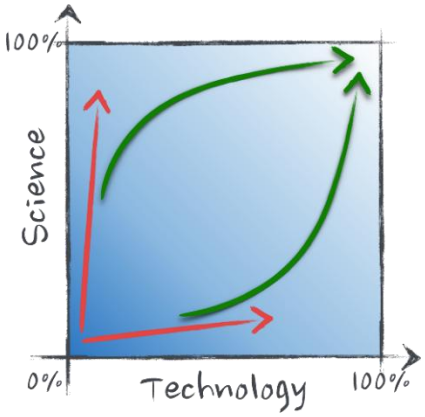


Figure 2: Schematic illustrating the paths towards mature technologies, based on the combination of science and technology. ELyT Global aims at following the green arrows, using science to improve technology.

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.

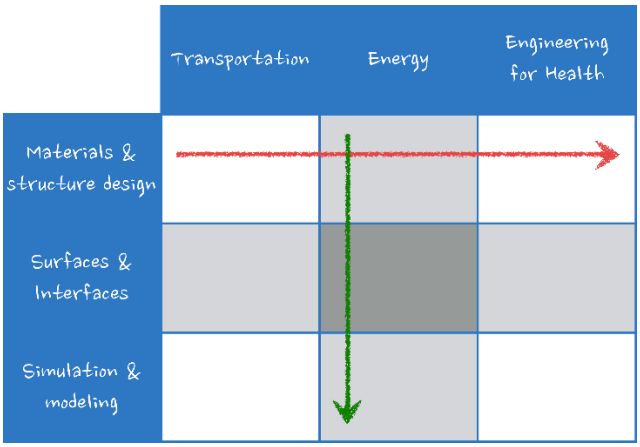


Figure 3: The 3 main themes (columns) and the three main topics (rows) of ELyT Global. Projects will belong either to a theme for application-oriented ones, or to a topic for science-oriented ones.

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.

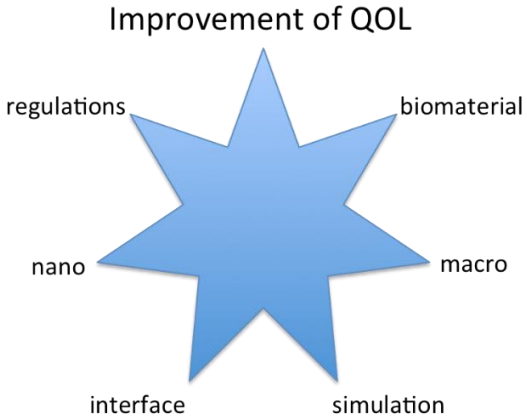


Figure 4: Schematic of the different challenges to address for improving quality of life (QOL).

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

2024 activities

Forewords

The year **2024** can be regarded as the **first full return to normal operations** after the disruptions caused by the COVID-19 pandemic. For the first time since 2019, ELyT Global was able to organize all its **events under standard conditions**. In particular, **ELyT workshop** was successfully held in March 2024 in Japan, restoring an essential platform for scientific exchange, collaborative discussions, and the reinforcement of bilateral research activities between partner institutions. In addition, **ELyT School** took place in September 2024 in France. These events marked an important milestone in re-establishing the **regular rhythm of ELyT Global's core academic activities** and contributed significantly to strengthening the visibility, cohesion, and dynamism of the network. Moreover, other **meetings** were held along with other **numerous activities** as detailed in the next section.

The **significant positive dynamic** that arose in the network in 2022/2023 was kept in 2024. This shows the **resilience of the network** and led to stabilization of the majority of the indicators. Hence, the number of **involved researchers was 98** (as in 2022 and -2 compared to 2023). The number of **projects** was **24 in 2024** (25 in 2022 and 26 in 2023), with a reasonable turn-over (7 projects stopped and 5 new projects started). The number of labs involved in ELyT Global was back to 27 (as in 2022 and -5 compared to 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.

ELyT workshop 2024

The 2024 edition of the ELyT workshop was held in a face-to-face format at Tohoku University in Sendai and Tsukioka Hotel in Kaminoyama, from March 11th to 13th (Figure 5).

The workshop gathered 79 participants (34 from France and 45 from Japan), with 43 presentations including 6 invited talks (Pierre Calmon - CEA, Yoshikazu Ohara - Tohoku University, Olivier Devos - Université de Bordeaux, Manuel Collet - Carnot Institute, Kazuhiko Endo - Tohoku University, Hiroshi Jinnai - Tohoku University). Researchers presented the results of collaborative research works between the University of Lyon and Tohoku University and made lively discussions leading to future collaborations. The detailed program is presented on Figure 6.

On March 11th, the "International Workshop on Structural Integrity Challenges of Energy Infrastructure" by Sustainable Structural Integrity for Energy Infrastructure Program of Tohoku Forum for Creativity was co-organized.

Figure 5: ELyT workshop 2024: Sendai and Kaminoyama sessions.

Program of ELyT Workshop 2024

Monday, March 11th

TFC session **Chair: Tetsuya Uchimoto (Tohoku University)**			
Time	***Title***	***Presenter(s)***	***Project***
09:20-09:30	Opening remarks EVP M. Kotani (Tohoku University) EVP D. Fabregue (INSA Lyon)		
09:30-10:30	**INVITED 1** : From NDE to SHM, recent trends and challenges for numerically assisted inspections	Pierre Calmon (CEA)	
10:30-10:40	Break		
10:40-11:40	**INVITED 2** : Recent progress on ultrasonic phased array imaging for accurate measurement of Cracks	Yoshikazu Ohara (Tohoku University)	
11:40-13:10	Lunch Break		
TFC session **Chair: Nicolas Mary (INSA Lyon)**			
Time	***Title***	***Presenter(s)***	***Project***
13:10-14:10	**INVITED 3** : In situ acoustic measurement of electrochemically controlled localized corrosion	Olivier Devos (Université de Bordeaux)	
14:10-15:00	**INVITED 4** : The Carnot Institute: a booster for developing collaborative industrial research programs	Manuel Collet (Carnot Institute)	
15:00-15:40	**INVITED 5** : Atomic Layer Processing in Nanoscale Semiconductor Devices	Kazuhiko Endo (Tohoku University)	
15:40-16:00	Break		

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

Session 1 **Chair: Jean-Yves Cavaille (ELyTMaX, Tohoku University)**			
Time	***Title***	***Presenter(s)***	***Project***
16:00-16:40	**INVITED 6** : Morphological studies of polymeric hierarchical structures by electron microscopy	Hiroshi Jinnai (Tohoku University)	
16:40-16:55	Atomic structure of bulk metallic glasses and supercooled liquids studied by transmission electron microscopy, scanning tunneling microscopy, synchrotron-radiation X-ray diffraction and ab-initio molecular dynamics simulation	D. V. Louzguine (Tohoku University)	
16:55-17:10	Magnetostrictive switching control for vibration energy harvesting	An LI (Tohoku University)	
17:10-17:25	Effect of Electron Irradiation on Impact Properties of Carbon Fiber Reinforced Heat Resistant PPS Resin Composites	Ayane IBII (Tokai University)	
17:25-17:40	Reduced-order Modeling for Flexible Multibody Systems in Hamiltonian formulation using Component Mode Synthesis Method	Shuonan DONG (Tohoku University)	
17:40-17:55	Various Insights about Heat Transfer at Solid-Liquid Interfaces and beyond via Molecular Dynamics	Donatas SURBLYS (Tohoku University)	

・18:30-20:30 Networking event in Pizzeria LAVAROCK at Trust Tower

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

Tuesday, March 12th

・07:50 Gathering up in front of IFS Building 1, Leaving for Kaminoyama by chartered bus

Session 2 **Chair: Vincent Fridrici (ECL)**			
Time	***Title***	***Presenter(s)***	***Project***
10:00-10:15	NDT based on the magnetization mechanisms: last progress in the frame of BENTO	Benjamin Ducharne (ELyT MaX)	BENTO
10:15-10:30	Elaboration of micro-porous powders by liquid metal dealloying	Louis Lesage (INSA Lyon, Tohoku University)	EPOPEE
10:30-10:45	J-F Collaboration for Developing Composite Materials Effects of EBI to Polymers & Its Composites CF/Polymers Adhesive Force Increased by EB-irradiation	Yoshitake Nishi (Tokai University)	
10:45-11:00	Energy Conversion Magnification Through Stress-Induced Phase Transitions in Ferroelectrics	Mickaël LALLART (INSA Lyon)	FIESTA
11:00-11:15	Toward understanding of bending behavior of electro-responsive polymer	H. TAKANA (Tohoku University) J-Y. CAVAILLE (ELyTMaX / Tohoku University)	TEmPuRA
11:15-11:30	Fe-Al welding - Experiments and simulations	Sylvain Dancette (ELyTMaX)	MIMECHAS
11:30-11:45	Design of an EIS-based sensor for non-invasive in-field corrosion monitoring	Z. Dong (ELyTMaX) H. Abe (Tohoku University) B. Ter-Ovanessian (INSA Lyon)	MOREOVER

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

11:45-12:00	Energy-saving identification of structures using piezoelectric transducer operated under semi-active control	Yushin HARA (Tohoku University)	
12:00-13:30	Lunch		

Session 3 **Chair: Gael Sebald (ELyTMAX)**			
Time	***Title***	***Presenter(s)***	***Project***
13:30-13:45	Robust shape optimization of a disc-brake system under dynamical criterion	Frédéric Gillot (ELyTMaX)	MuORoD
13:45-14:00	Molecular Theory Analysis of Carbon Diffusion in Iron which is Happened Phase Transformation under Electric Field	P. Chantrenne (INSA Lyon) T. Tokumasu (Tohoku University) C. Adessi (University Claude Bernard Lyon1) J. Kioseoglu (Aristotle University of Thessaloniki)	CarboEDiffSim
14:00-14:15	Evaluation of the Hydrogen Solution Effect on the Elastic and Fatigue Properties of Steel and the Enhancement of Hydrogen Solution through Electron Beam Irradiation	Helmut Takahiro UCHIDA (Tokai University)	
14:15-14:30	Research of efficient fast scintillator: Cerium-doped inorganic glasses	Georges BOULON (Université Claude Bernard Lyon 1)	SCINTILLATOR GLASSES
14:30-14:45	Electromagnetic Tracking of a catheter using Giant Magneto-resistors	Louis PAQUET (ELyTMaX)	
14:45-15:00	Viscoelastic response of magnetorheological elastomers: experiments and modeling	Kostas Danas (CNRS / ELyTMaX)	

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

15:00-15:15	Metallization of carbon fiber-reinforced thermoplastic polymers for lightning strike protection using low-pressure cold spray	H. Saito W. Kai T. Funaki Y. Ichikawa K. Ogawa (Tohoku University)	
15:15-15:30	The development of multimaterial and multimodal fibers for biosignal recording	Etienne Le Bourdonnec (Tohoku University)	
15:30-15:45	Thermal management beyond Fourier using nanomaterials	Konstantinos Termentzidis (INSA Lyon)	
15:45-16:00	Break		

Session 4 **Chair: Makoto Ohta (Tohoku University)**			
Time	***Title***	***Presenter(s)***	***Project***
16:00-16:15	Recent progress in laser-based diagnostics to study near-wall combustion in aircraft gas turbine engines	Pradip XAVIER (INSA Rouen Normandie)	
16:15-16:30	Fiber-based soft actuators via the thermal drawing	Yuto Akimoto (Tohoku University)	
16:30-16:45	Serendipity in materials science: how a simple doping leads to novel and outstanding properties in simple dielectric HfO2 !	Bertrand Vilquin (ECL)	
16:45-17:00	Structural evaluation of acoustic streaming jet for application to natural convective heat transfer enhancement	Taisei Takagi (Tohoku Univeristy)	
17:00-17:15	Surface treatment by electromagnetic pulse peening to introduce compressive residual stresses in metals and alloys	Daniel NELIAS (INSA Lyon)	

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

17:15-17:30	The effect of asymmetricity in stenosis on blood flow	K. Yanagisawa (Tohoku University) C. Frindel D. Garcia (INSA Lyon) H. Anzai M. Ohta (Tohoku University)	Engineering for Health Simulation & Modeling
17:30-17:45	Modeling electron and phonon transport at Metal/semiconductor interfaces using DFT	Christophe A. Adessi (University Claude Bernard Lyon1)	
17:45-18:00	Monte Carlo Studies on Geometrically Confined Skyrmions in Nanodots	Hiroshi Koibuchi (National Institute of Technology, Ibaraki College)	
18:00-18:15	Tribological behavior of Inconel 718 alloy obtained by additive manufacturing (Laser Metal Deposition process)	Vincent Fridrici (ECL)	
18:15-18:30	PROGRAMMABLE METACOMPOSITE FOR CONTROLLING NOISE AND VIBRATION	Manuel Collet Emanuel De Bono Kevin Billon (ECL) Morvan Ouisse (FEMTO-ST)	
18:30-18:45	Nondestructive Evaluation of Nitridation Layer in Austenitic Stainless Steel by Eddy Current Testing	L. OLLIVIER-LAMARQUE T. UCHIMOTO (Tohoku University) K. MIZUSHINO Y. MATSUNAGA T. FUJIMORI (IHI Corp. Japan)	
18:45	End of session		

- 19:00-21:00 Networking Dinner
- 21:00-22:00 Group sessions, Free discussions

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

Wednesday, March 13th

- 07:00 Breakfast

Session 5 **Chair : Hitomi Anzai (Tohoku University)**			
Time	***Title***	***Presenter(s)***	***Project***
09:00-09:15	Making cool with elastocaloric polymers: progress of the ELyT Global REFRESH project	Gael Sebald (ELyTMaX) Atsuki Komiya (Tohoku University)	REFRESH
09:15-09:30	Fiber dense media in superinsulation, understanding ageing mechanisms, coupled thermal and tomography results	Genevieve FORAY (INSA Lyon)	
09:30-09:45	Collaboration for cerebral aneurysm	M. Ohta (Tohoku University) G. Plet J. Raviol H. Magoariec C. Pailler-Mattei (ECL) R. Hasegawa S. Sasaki (Tohoku University) H. Kosukegawa K. Yu (Blue Practice Co., Ltd. / Tohoku University)	Biomechanics – Cerebral aneurysms
09:45-10:00	Design of elastocaloric refrigeration systems: development of a single stage proof of concept for near-room temperature cooling temperature cooling	Marianne SION (ELyTMaX)	

ELyT Workshop 2024 March 11-13, 2024, Sendai & Kaminoyama, Japan

10:00-10:15	Benefits of the Gleeble machine at MATEIS laboratory	Florian Mercier (INSA Lyon)	
10:15-10:30	Evaluation of Hydrogen Embrittlement on Austenitic Stainless Steels by Acoustic Emission Testing	S. TAKEDA R. MATSUMOTO T. UCHIMOTO (Tohoku University) H. ENOKI T. IIJIMA (AIST)	
10:30-10:45	Bioengineering of vascularized 3D tissues developed in vitro	Z. Delmas D. Alcaide T. Duenki J. Cacheux Y. Ikeuchi Y. T. Matsunaga B. Kim V. Salles (LIMMS, IIS, The University of Tokyo)	
10:45-11:00	Microelectric Fiber Sensors for Multiplexed Neurochemical Sensing via Electrografting and Click Chemistry	Tomoki Saizaki (Tohoku University)	
11:00-11:15	Ultrasonic testing of the tungsten-copper bonded interface in the divertor of a nuclear fusion reactor	Mohamad Faridafshin (Tohoku University)	
11:15-11:30	Study on heat transfer characteristics in cooling system by elastocaloric effect	Shun Ishii (Tohoku University)	
11:30-	Announcement of Next schedule for ELyT workshop and ELyT school		
	Concluding remarks		

Figure 6: ELyT Workshop 2024 program.

France – Japan workshop on Nanomechanics, Multiscale Mechanics and Tribology

The goal of this workshop was to gather Japanese and French researchers for presentations and discussion during 3 days in a casual atmosphere on the campus of Ecole Centrale de Lyon, to bridge the scale gaps in contact mechanics and tribology. It also aimed at promoting and helping researchers to foster future joint collaborative projects.

Japan Science and Technology Agency (JST) and the French National Research Agency (ANR, Agence Nationale de la Recherche) concluded a Framework Agreement in December 2017, to fund joint research projects conducted by Japanese and French partners within the framework of the JST-CREST program. For instance, a successful example of these joint research projects, the project FRIISE, focuses on the multiscale elucidation of friction mechanisms in ice rubber interfaces, in collaboration with Tohoku University, Keio University and LTDS from Ecole Centrale de Lyon, based on the multiscale analysis of the sliding ice rubber interface, coupling experiments and numerical simulations.

Then, 36 Japanese and French researchers were brought together at the Ecole Centrale de Lyon (Figure 7) to attend the workshop organized between France and Japan on Nanomechanics, Multiscale Mechanics and Tribology from November 13th to 15th, 2024. Academics from the ELyT community (Centrale Lyon, CNRS, INSA de Lyon, Tohoku University) and beyond (UTC, Keio University, the University of Tokyo, Kyoto University, Yokohama National University and JST), as well as industrials (from Japan and France: Bridgestone, Michelin), met to present and discuss their research results. Young researchers also participated in a dedicated session.

This event was jointly organized by CREST-JST and ANR through the FRIISE project, in collaboration with IRN ELyT Global.

More details are available here: https://www.elyt-lab.com/en/content/france-japan-crest-workshop-nanomechanics-multiscale-mechanics-and-tribology

And the program can be found here: https://www.elyt-lab.com/sites/elyt-lab.com/files/france-japan_workshop_tentative_program_1108.pdf

Figure 7: Group picture taken during CREST-JST / ANR workshop in 2024 in Lyon.

ELyT School 2024

The fifteenth edition of the Summer School "ELyT School" took place **from September 1st to September 10th, 2024 in Lyon** (France), on the campuses of INSA de Lyon and Centrale Lyon. **38 students** participated in this edition: 18 from Lyon, and 20 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) held in France, because the 2022 edition in Lyon was shortened to a few days, in parallel to the 2022 edition of ELyT workshop. Group picture taken during ELyT School 2024 is presented in Figure 8, together with ELyT School logo in Figure 9. The detailed timetable of the ELyT School is provided in Table 3.

Figure 8: Group picture taken during ELyT School 2024 in Lyon.

Figure 9: Logo of ELyT School 2024 in Lyon with sponsors.

8 **invited lecturers** gave presentations on thematic related to ELyT Global: 2 from Tohoku University, 4 from INSA de Lyon and 2 from Centrale Lyon. **Lab tours** were organized at INSA de Lyon and Centrale Lyon. **Group works were carried out by the students** (7 groups of 5 or 6 students) on subjects linked to ELyT scientific themes: evaluation of ELyT School carbon footprint assessment, ammonia combustion, wind power (key points of mechanical design), photovoltaics, energy efficiency of complex structures, engineering design using AI and building design to prevent earthquakes damages. In addition to these group projects, cultural activities made it possible to **build relationships** between

young Japanese and French people: guided visit of Confluence district, excursion to Beaujolais, wine and cheese dinner, student BBQ, French lessons, photo contest...

This 2024 edition was **a great success** for all!

Date Location	01/09 Sunday INSA-Lyon	02/09 Monday INSA-Lyon	03/09 Tuesday INSA-Lyon	04/09 Wednesday INSA-Lyon	05/09 Thursday ECL	06/09 Friday ECL	07/09 Saturday	08/09 Sunday	09/09 Monday INSA-Lyon	10/09 Tuesday INSA-Lyon
					08:15-09:00 Move to ECL (TCL)	08:15-09:00 Move to ECL (TCL)				
		9:00-9:45 Orientation by Professors Besset, Fave JSPS by Pr Takagi Amphi INL	09:00-10:10 Academic Lecture 1 Oana IOVA "Smart cities"	9h30 - 11h30 Guided Visit of Confluence District (to be confrimed)	09:15-10:25 Academic Lecture 3 Amphi 3 Pietro Salizzoni "Fluid Mechanics and the mysteries of climate change'	09:15-10:25 Academic Lecture 4 Amphi 3 Vincent Fridrici	Free Time	Outgoing excursion Beaujolais	09:00-10:10 Academic Lecture 6 Laurent Chazeau "polymer basics: from macromolecules to properties"	09:00-10:10 Academic Lecture 8 Damien Fabregue Amphi Charpy
		10:00-11:45 Interculturality by Norio Mihara / Adrien Padirac Amphi Chappe	10:20-12:00 Student Pres. 1 Amphi		10:35-12:00 Student Pres. 2 SkyLab - co-design	10:35-12:00 Student Pres. 3 SkyLab - codesign			10:15-12:00 Student Project 4 Rooms 501-123, Goodyear, Charpy, Poincaré	10:15-12:00 Student Project 6 Rooms Enrico Fermi, Goodyear, Charpy, Poincaré
		12:00-13:00 Lunch	12:00-13:00 Lunch	12:00-13:00 Lunch	12:00-13:00 Lunch	12:00-13:00 Lunch			12:00-13:00 Lunch	12:00-13:00 Lunch
		13:00-15:00 ELyT activities by M Lallart Interculturality by Norio Mihara / Adrien Padirac Amphi INL	13:10-14:20 Academic Lecture 2 Pr Hayakawa "recent progress of ammonia combustion study toward carbon neutrality" Amphi	13:10-15:00 Laboratory Tour at INSA INL, MATEIS, CETHIL, LAMCOS ???	13:10-16:00 Laboratory Tour at ECL LTDS, INL, LMFA	13:10-14:20 Academic lecture 5 Amphi 1 - Kurita : Design of Sustainable Energy and Materials			13:10-14:20 Academic Lecture 7 Alain Fave Photovoltaics and Energy transition	13:15-15:15 Student Project Presentations Amphi BMC
			14:30-15:20 Student Project 1 with tutors Rooms			14:30-17:30 Student Project 3 SkyLab - codesign			14:30-17:30 Student Project 5 Rooms 501-123, Goodyear, Charpy, Poincaré	
		15-17h French Lesson 1, Humanités	15:30-17:30 French Lesson 2, Humanités	15:00-17:00 French Lesson 3, Humanités + Halles P. Bocuse	16:15-17:30 Student Project 2 SkyLab - codesign					15:30-17:30 Wrap-up & Award Ceremony Amphi BMC
	19h Lunch Ninkasi	Wine and cheese dinner (Club Oenologie INSA) - at Espace Lyon Japon	Dinner INSA	Dinner INSA	18:30-20:30 Student BBQ at ECL	18:00-20:00 Cocktail at INSA			Dinner INSA	19:00-21:00 Fairwell Dinner Brasserie Georges

Table 3. ELyT School schedule.

Ab Initio and Molecular Dynamics School 2024

In February 2020, the first Molecular Dynamics (MD) 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 (AI) simulations were parts of the program. The third edition of this school was held in March 2023 at AUTH in Greece.

In 2024, the fourth edition of the AI & MD School was held from Thursday, February 29th, to Thursday, March 7th, in Sendai, just before the 2024 ELyT workshop (allowing some researchers and students to participate to both the School and Workshop). It took place at Large Lecture Hall, 5th floor of 2nd building of Institute of Fluid Science, as well as an online hybrid. This project is positioned as part of the activities of ELyT Global, and seven lecturers were invited from Institute of Fluid Science – Tohoku University (2) in Japan, INSA Lyon (2) in France and the University of Thessaloniki (3) in Greece to give lectures and practical training on molecular dynamics methods and quantum chemical calculations. Seven Japanese students (Figure 10), three French students, and sixteen Greek students participated in this school. (All foreign students participated online.)

The participants learned the basics of molecular dynamics and quantum chemical calculations (Ab Initio) and how to use common softwares, like LAMMPS, OVITO and Quantum Espresso. Specifically, they first received a lecture on the basic theory, and then split into groups to carry out practical exercises on several tasks. Through this school, students studied not only the technique of AI and MD but also the interconnection with foreign students and teachers.

Figure 10: Picture taken during Ab Initio and Molecular Dynamics School 2024 in Sendai.

Tohoku IFS LyC and IFS LyC projects

Tohoku Institute of Fluid Science Lyon Center[12] 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[13]), with a call entirely **dedicated to the LyC**.

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

Hence, **13 projects** have been granted in 2024. All of them were involving researchers from the ELyT Global IRN and contributing to the network activities.

Visit of Mr. Consul OGATA and Ms. Consul SAKATA

On November 29th 2024, we had the honor to welcome Mr. Consul Osamu OGATA, director of the consular office in Lyon, and Ms. Osamu Consul SAKATA, in charge of relations with the economic sector and higher education. Mr. and Ms. Consuls were invited for a lunch in INSA Lyon Director house, which was followed by the visit of ELyTMaX premise and the signature of the guest book (Figure 11). The exchanges highlighted the very high quality of the collaboration between Tohoku and Lyon, and notably in the framework of ELyT.

Figure 11: Mr. Consul OGATA and Ms. Consul SAKATA signing the ELyT guest book.

Collaborative scientific activities in the framework of ELyT Global

2024 projects

2024 confirmed the excellent dynamic observed in 2023, with a **stabilization of the collaborations** at a very high level. Hence, 2024 features **24 projects, including 5 new**. Although compared to 2023 the total project sum decreased by 2, this value remains very high, with the **securing of the projects launched after the pandemic crisis** (Figure 12), corresponding to a significant renewal of the ELyT collaborations.

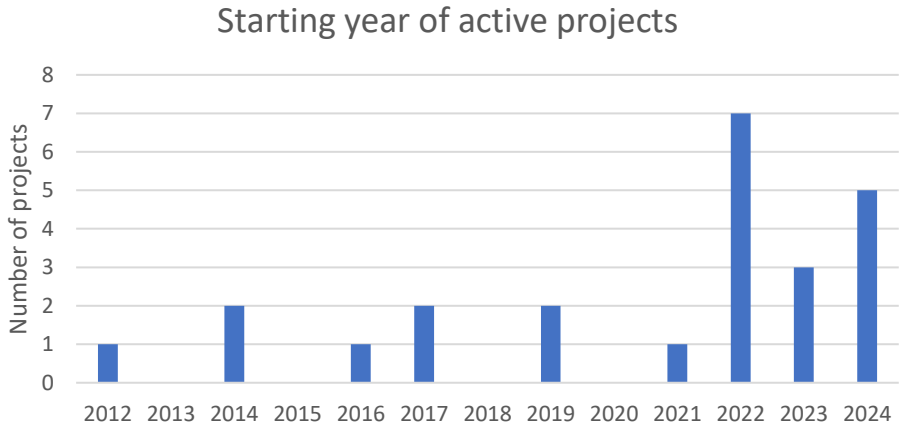


Figure 12: Starting date of 2024 running projects.

Researcher and student-researcher mobility (excluding DD Ph.D. students and person in delegation) reaches a total of approximately **500 days cumulatively** (Table 4), including 4 long stays of more than one month. While this value is slightly less than 2023 (-25%), this could be seen as a stabilization after the significant bouncing effect following the release of the sanitary conditions.

FR→JP		**JP→FR**	
2024	**Total declared (running projects only)[14]**	**2024**	**Total declared (running projects only)[14]**
235 days (incl. 1 long stay > 1 month)[15]	1011 days (incl. 5 long stays > 1 month and 3 very long stays > 6 months)[15]	264 days (incl. 3 long stays > 1 month)[15]	1459 days (incl. 14 long stays > 1 month)[15]

Table 4. 2024 visits and total declared in project forms (excluding Double Diploma students and researchers in delegation).

For 2024, **7 DD Ph.D. students** are actively involved in the IRN, which, while decreasing (-3 compared to 2023) partly explained by a withdrawal of a student from a Ph.D. grant, still confirm their importance in the success of many of the collaborations. The total number of Ph.D. students (single and double degrees) is keeping very high (24), and similar to 2023 after a significant positive dynamic since 2021 (Table 5). Again, this demonstrates the liveliness of the network **to attract a new generation of early-stage researchers**. This observation is even clearer for **M.Sc. students, with 11 actively involved in 2024** (8 in 2023). 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**	
2024	**Total (running projects only)[14]**	**2023**	**Total declared (running projects only)[14]**
24 (incl. 7 Double Degree students)	30 (incl. 11 Double Degree students)	11	27

Table 5. Students involved in the projects.

Figure 13 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. 2024 saw once again a new student, after the jump observed in 2020-2022 explained by the **diversification of funding** (institutions, ANR, CNRS, JSPS…). Among the 33 students involved, **9 are ongoing in 2024, 21 graduated** (occupying diverse positions, but mostly in academia) **and 3 resigned**. This demonstrates the success of the program, which besides significantly strengthens the collaborations between permanent researchers.

[14] "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.

[15] Excluding DD Ph.D students and researchers in delegation.

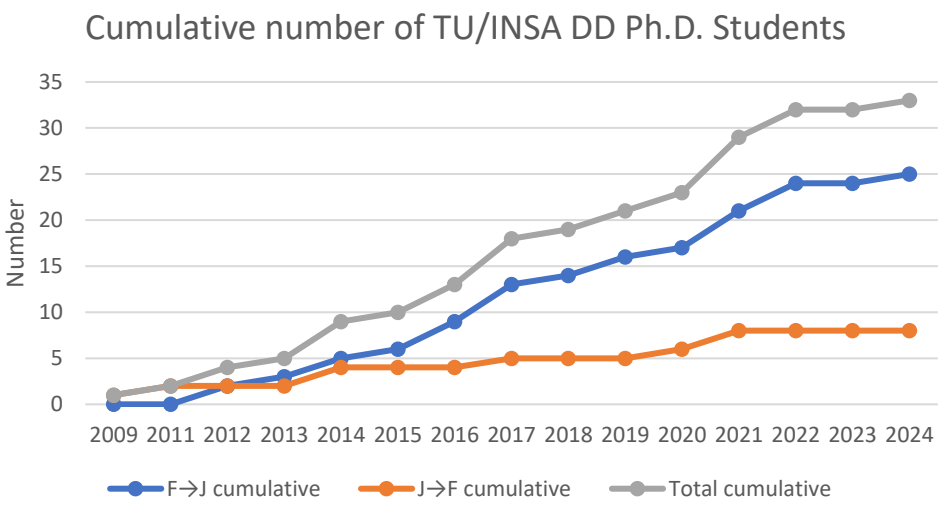


Figure 13: DD Ph.D. students.

Regarding scientific journal articles and conference communications (Table 6), a decrease compared to 2023 can be observed (in 2023, projects published articles 23 articles and 52 conferences), which is explained by the exceptionally high value of publications in 2023, following new projects that joined ELyT Global in 2022. Yet, the level of publication is high in 2024 (**15 journal articles** and **39 conference communications**), and comparable to previous years (except 2023).

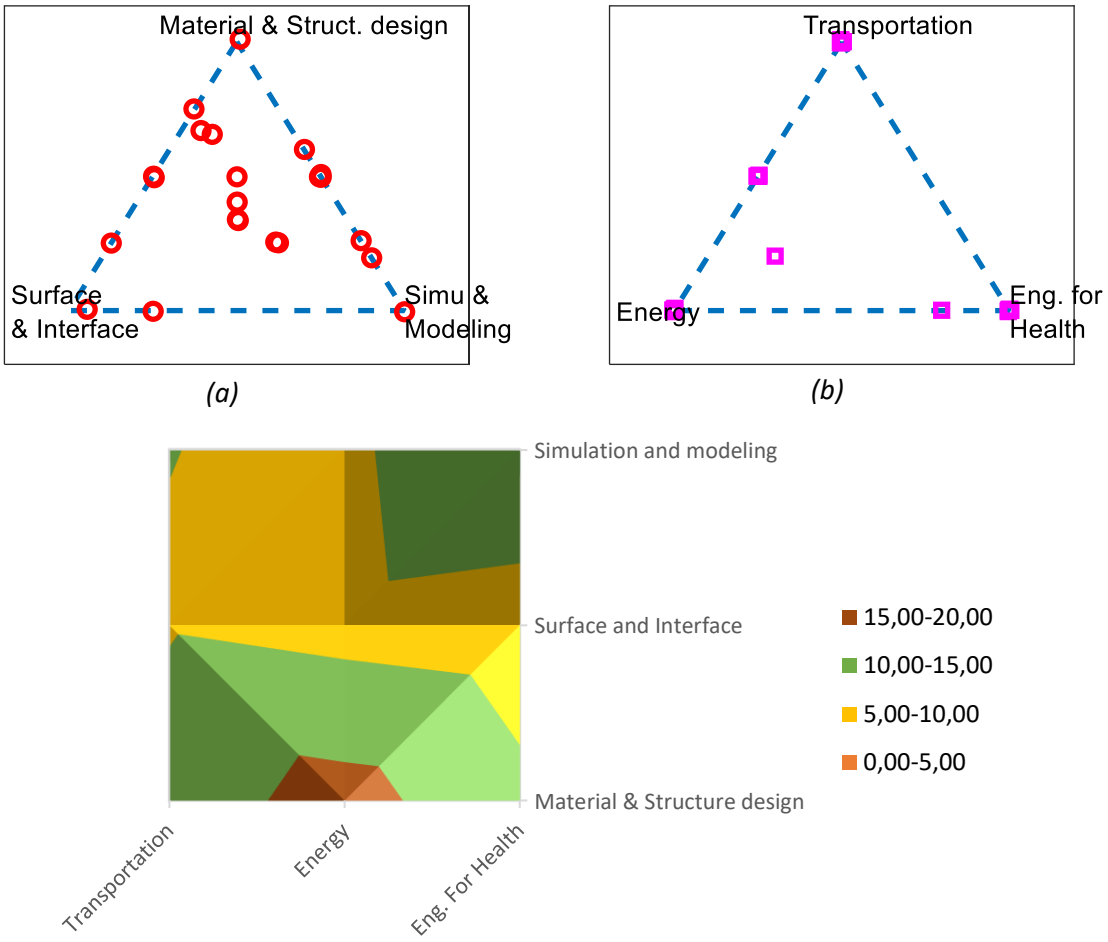
Journal papers		**Conferences**	
2024	**Total declared (running projects only)[14]**	**2024**	**Total declared (running projects only)[14]**
15	44	39	96

Table 6. Scientific communications (+1 patent).

The **positioning** of the IRN projects is still **well spread across the scientific thematic and applicative themes** (Figure 14), 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**, with some of the project emerging in the three topics. These observations highlight the relevancy of such organization. Finally, the general overview (Figure 14.c) shows a **quite homogeneous distribution**, that is more and more well distributed ("Energy" theme showed a slight prevalence before 2022).

Table 7 exposes the average **data for the projects**, along with a comparison with the last two year's data. The values are **rather stable**, with the following particular aspects:

- **Communications** (journal papers and conferences) **decreased between 2023 and 2024**, but remains **higher than in 2022** (2023 being an exceptional year for this indicator).
- **France to Japan stays decreased in 2024**. This could be explained by the fact that project members usually **do not declare the stay in Japan for the workshop**.
- **Japan to France stays** keep slightly increasing.
- Average project **participant increased,** but **workforce slightly decreased.**
- **Average budget** (for project declaring one) is **increasing**, notably through the obtention of **significant grants** potentially based on collaborations supported by ELyT over the last years.



(a) *(b)*

(c)

Figure 14: Repartition of projects (percentages): (a) by scientific topics; (b) by themes and (c) general overview.

	2022	2023	2024
Average number of participants	4.84	4.73	4.96
Task force	6.4 person-months	6 person-months	5.29 person-months
Average FR→JP stays	17 days (2022) / 48 days (total declared)	16 days (2023) / 51 days (total declared)	9.79 days (2024) / 42.1 days (total declared)
Average JP→FR stays	7.8 days (2022) / 57 days (total declared)	9.6 days (2023) / 62 days (total declared)	11 days (2024) / 60.8 days (total declared)
Average international journal paper	0.52 (2022) / 2.2 (total declared)	0.9 (2023) / 2.1 (total declared)	0.63 (2024) / 1.83 (total declared)
Average international conference	1.64 (2022) / 4.52 (total declared)	2 (2023) / 4.2 (total declared)	1.83 (2024) / 4 (total declared)
Average annual budget[16]	19.1 k€	34.2 k€	37.5 k€

Table 7. Average projects data.

[16] 13 projects declared budget. Hence, the average has been calculated on this number.

27 laboratories and research structures are represented in 2024 ELyT projects, which is decreasing compared to 2023 but identical to 2022. Among these, **14 are located in France[17], 10 in Japan[18], 1 (ELyTMaX) shared between France and Japan**, 1 in Greece (Table 8). To this list the participation of **large companies** (SKF Sweden) is a newcomer is the network, denoting a possible development of technology transfer facilitated by ELyT Global. **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 2024 **96 persons**, quite stable compared to 2023 (98 persons) after a significant increase in 2022 (71 in 2021 and 77 in 2020).

France		Japan	
Lab.	**Projects / Researchers**	**Lab.**	**Projects / Researchers**
MATEIS INSA-Lyon	8/15	IFS Tohoku	12/12
LTDS ECL	6/17	GSE Tohoku	8/13
LGEF INSA-Lyon	4/5	GSBE Tohoku	5/6
CREATIS INSA-Lyon	2/4	IMR Tohoku	2/3
LaMCoS INSA-Lyon	3/4	NICHe Tohoku	2/2
ILM UCBLyon1	3/3	FRIS Tohoku	1/1
Cancer Research Centre of Lyon	2/1	AIMR Tohoku	2/2
IPSB-Faculty of Pharmacy UCBLyon1	2/1	IFS Lyon Center Tohoku	1/2
LBTI UCBLyon1	1/2	Kyushu University, Fukuoka	1/1
LMFA INSA-Lyon	1/2	Smarttech-lab Tohoku	1/1
CEA Paris Saclay, Paris	1/1		
CETHIL INSA-Lyon	1/1		
IMP INSA-Lyon	1/1		
LMS Polytechnique, Paris	1/1		
Joint FR/JP			
Lab.			**Projects / Researchers**
ELyTMaX CNRS/Université de Lyon/Tohoku University			14/15
Other			
Lab.			**Projects / Researchers**
SKF (Sweden)			1/2
Aristotle University of Thessaloniki (Greece)			1/1

Table 8. Participating laboratories in 2024 projects.

[17] 12 from Lyon
[18] 9 from Tohoku

Interactions FR-JP			Japan									
			IFS Tohoku	*GSE Tohoku*	*GSBE Tohoku*	*IMR Tohoku*	*NICHe Tohoku*	*FRIS Tohoku*	*AIMR Tohoku*	*IFS Lyon Center Tohoku*	*Kyushu University, Fukuoka*	*Smarttech-lab Tohoku*
			(21)	(13)	(9)	(2)	(2)	(3)	(4)	(3)	(0)	(1)
France	*MATEIS INSA-Lyon*	(14)	4	4		2	1	1	1	1		
	LTDS ECL	(8)	3	3	1				1			
	LGEF INSA-Lyon	(7)	3				1	1	1	1		
	IPSB-Faculty of Pharmacy UCBLyon1	(5)	1	2	2							
	CREATIS INSA-Lyon	(4)	2	1	1							
	ILM UCBLyon1	(4)	2	1	1							
	IMP INSA-Lyon	(4)	1					1	1	1		
	CEA Paris Saclay, Paris	(3)	1	1	1							
	LaMCoS INSA-Lyon	(3)	2	1								
	Cancer Research Centre of Lyon	(2)			2							
	CETHIL INSA-Lyon	(1)	1									
	LBTI UCBLyon1	(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 15 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 **partial renewal of the IRN occurred in 2022**, with almost 50% of new projects. Since then, the total number of projects was rather constant.

Following **recommendation from institutions** and taking note of the **significant number of new projects since 2022**, a **pluri-annual individual project follow-up** has been established since this year, 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 16. In this case, I can be seen that the project follows a positive dynamic since 2019.

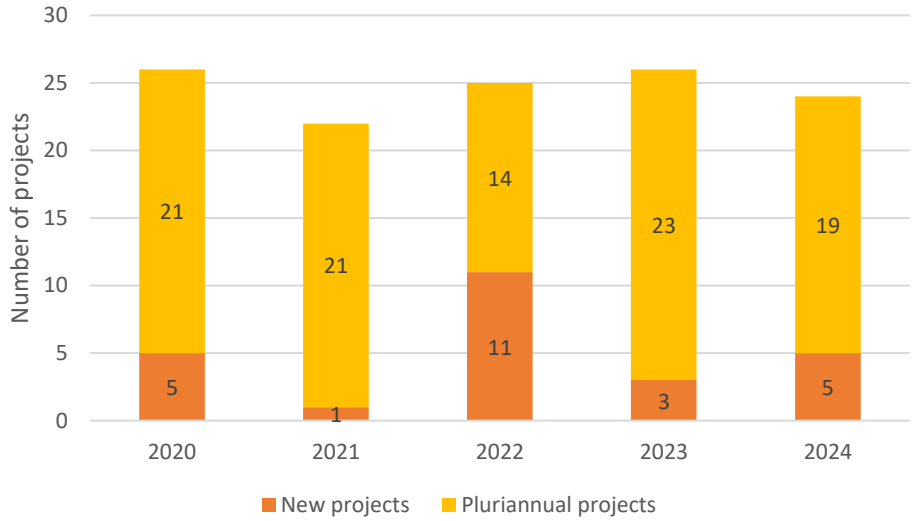


Figure 15: Number of projects since 2020.

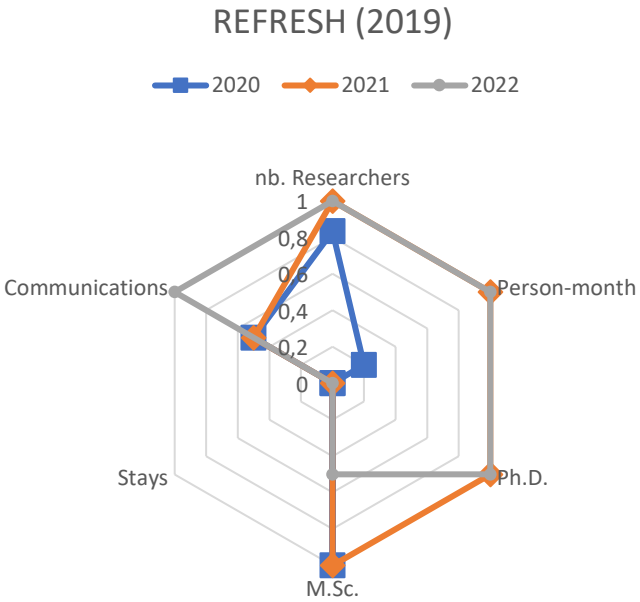


Figure 16: Example of pluri-annual project (REFRESH) follow-up chart (example from 2022).

Such a follow-up allows a **global view of the IRN liveliness** according to the chosen Key Performance Indicators, as demonstrated in Figure 17. It can be seen that the **number projects with positively evolving indicators is for each criterion greater than decreasing one**. Globally speaking, the IRN is **very healthy**, with more positive variations than negative ones.

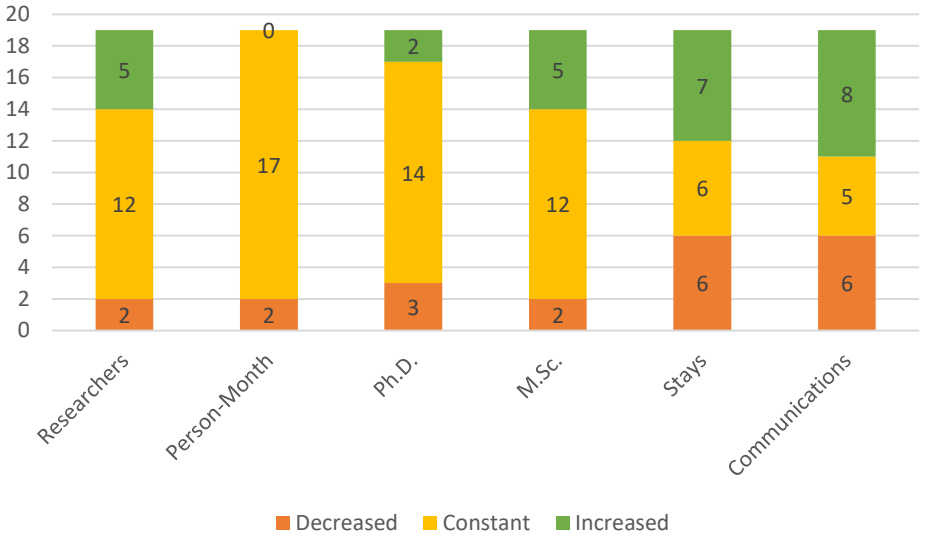


Figure 17: Global evolution of projects: number of projects with decreased, stable or increased KPI (excluding new projects).

List of active 2024 projects and project reports

Acronym	Name
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
FIESTA	Ferroelectric-ferroelectric transitions Induced by External STress for Applications in sensing and energy harvesting
FOCUS*	Ferromagnetic Objects: Carbide Uniformity and Segregation
FRIISE	Multi-scale elucidation of friction mechanisms in ice-rubber interfaces
MeCaT*	Mechano-Chemically-activated Tribofilm Growth at Nanoscale
MAGELLAN	Magnetorheological Elastomers: finite strain visco-elasto-plastic behavior under general loading conditions
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
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
SOLYDIC*	Surface degradatiOn acceLerated by hYdrogen Diffusion and trapping, case of lubrIcated rolling Contact
TEmPuRA	Theory for Electrostriction of PolymeRic Actuator
TFS	Touch feeling and Surface
TP-VIP*	Thermal Properties versus fiber core microstructure in Vacuum Insulation Pannels
VIVO CHIP*	Vascular Integration in Three-Dimensional Organoid-on-Chip Platform

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

BENTO

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

MAIN PARTICIPANTS

			
Tetsuya UCHIMOTO[a,c]	**Benjamin DUCHARNE[b,c]**	**Gael SEBALD[c]**	**Yves Armand TENE DEFFO[c]**

[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.

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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	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 (75 k€ since 2021)
Kakenhi kiban C (Inductance Spectroscopy)

Highlights & Outstanding achievements

_ 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.
_ 18 scientific papers have been published and more than 30 conference participations.
_ First OCEA prototype (electromagnetic non-destructive testing industrial setup for high value steel), autumn 2025.

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)*

Post-doc candidates:

_ Yves Armand Tene Deffo (2014-2026)

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	G. Diguet, B. Ducharne, S El Hog, F. Kato, H. Koibuchi, T. Uchimoto, HT Diep	Monte Carlo studies on geometrically confined skyrmions in nanodots: Stability and morphology under radial stresses	Computational Materials Science	243	113137	2024	https://doi.org/10.1016/j.commatsci.2024.113137
2	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
3	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
4	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
5	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

6	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
7	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
8	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
9	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
10	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
11	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

12	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
13	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
14	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
15	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
16	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

17	B. Zhang, B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto	Dynamic magnetic scalar hysteresis lump model, based on Jiles-Atherton quasi-static hysteresis model extended with dynamic fractional derivatives	IEEE Transactions on magnetics	54	6200204	2017	https://doi.org/10/1109/TMAG.2018.2773517
18	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

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	20 %		20 %
Simulation and modeling	5%		5 %

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

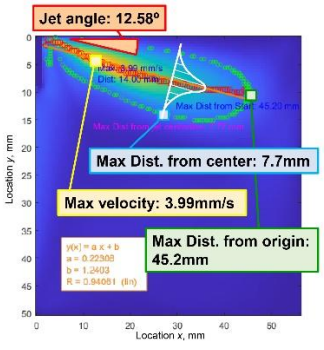
For main projects: Agency / year / name of project
- Collaborative Research Project of the Institute of Fluid Science, Tohoku University, 2024

Estimated annual budget: 500 k¥

Highlights & Outstanding achievements

- We have developed a precise measurement system of micro-scale protein mass transfer phenomenon.
- A local flow control system was developed by small-size Surface Acoustic Wave ultrasound transducer.
- A numerical simulation of ultrasound-induced flow was performed.
- A. Komiya gave an invited talk in September 2024.
- A. Komiya gave a keynote talk in December 2024.

Illustration



PROJECT DESCRIPTION

Background

The control of convector-diffusive mass transfer in tiny areas is a challenge encountered in many processes. Therefore, it is important to investigate methods to control the local flow and temperature/concentration boundary layer by natural convection or the other way. This study focuses on an active method thinning the thermal/concentration boundary layer using an ultrasound-induced flow. This method might be easy to install and control the boundary layers. Previous studies have proposed a method using impinging jet and vibrating ribbons providing mechanical perturbation. In this study, a new method was proposed for controlling the temperature or concentration fields. 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 controllability of convection heat/mass transfer by utilizing ultrasound-induced flow.

Key scientific question

How to make the boundary layers thinner using ultrasound induced flow?
What is the key factor for controlling the heat and mass transfer?

Research method

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 make a local flow and control the thickness of thermal/concentration boundary layer locally. 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 and specially designed ultrasound-inducer.

Research students involved

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

FR to JP (date, duration):

- V. Botton (September 2023, 11 days)

JP to FR (date, duration):

- R. Zhu (March 2024, 1 year)
- A. Komiya (February 2022, 8 days)
- A. Komiya (January 2025, 5 days)
- A. Komiya (March 2024, 5 days)
- A. Komiya (January 2024, 5 days)
- A. Komiya (May 2023, 7 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	N/A						

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	
3	Atsuki Komiya (Invited)	*Precise measurement of rapid and tiny heat and mass transport phenomena using high-speed phase-shifting interferometry*	Xi'an Jiaotong-Tohoku Joint Conference	18-19 Oct., 2024	Xi'an	China	
4	Atsuki Komiya, Ruiyao, Zhu, Valéry Botton, Sophie Miralles	*Enhancement of Protein Mass Transfer using Ultrasound Induced Flow and Macro-pore Membrane*	21st International Conference on Flow Dynamics	18-20 Nov.,2024	Sendai	Japan	
5	Atsuki Komiya (Keynote)	*Resonance-driven Heat Transfer Enhancement in a Natural Convection*	The Third Pacific Rim Thermal Engineering Conference	15-19 Dec., 2024	Honolulu	USA	
6	Ruiyao Zhu, Sophie Miralles, Samuel Margueron, Valéry Botton, Atsuki Komiya	*Towards the Control of Protein Mass Transfer via Ultrasound and Macro-porous Membranes*	ELyT Workshop 2025	19-21 Feb., 2025	Lyon, Annecy	France	

Project report 2024

BOSMA

Blood flOw Simulation for Medical Applications

MAIN PARTICIPANTS

				
Carole FRINDEL[a]	**Makoto OHTA[b]**	**Kevin TSE KOON[a]**	**Hitomi ANZAI[c]**	**Damien GARCIA[a]**

[a] CREATIS, INSA Lyon, Lyon Center IFS, Tohoku University
[b] ElyTMax, IFS, Tohoku University
[c] IFS, Tohoku University

Contact : carole.frindel@creatis.insa-lyon.fr, makoto.ohta@tohoku.ac.jp, tsevekoon@creatis.insa-lyon.fr, anzai@biofluid.ifs.tohoku.ac.jp, damien.garcia@creatis.insa-lyon.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			
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)*

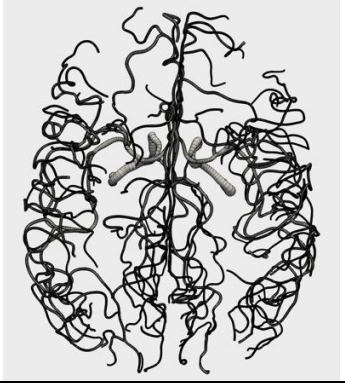
- Pack Ambition International from Région Auvergne-Rhône-Alpes, 2019-2022, SIMAVC
- INSA funding for PHD of Méghane Decroocq in the framework of ELyTMax
- Collaborative research project J22Ly15, IFS, Tohoku University since Oct. 2022

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
- Granted project from call INSERM/JSPS for common scientific seminar in 2024

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background

Recent advances in clinical measurement and computational modeling techniques introduce new capabilities for monitoring human cardiovascular dynamics. In this context, the integration of Computational Fluid Dynamics (CFD) and medical imaging offers a promising path toward the development of patient-specific vascular flow models. These models form the foundation of digital twins that aim to simulate individual hemodynamic profiles and derive novel imaging-based biomarkers for diagnosis, monitoring, and therapeutic planning in cerebrovascular diseases.

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):

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

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):

- Damien GARCIA (Oct. 31-Nov. 2, 2024, 3 days)
- Kevin TSE KOON (Oct. 31-Nov. 2, 2024, 3 days)
- 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)

Symposium organization *(gray color for previous years)*

- 8th International Conference on Computational and Mathematical Biomedical Engineering – CMBE2024 (24–26 June 2024), USA – co-organization of mini symposium on “modelling the anatomical variability of vascular systems”
- 7th International Conference on Computational and Mathematical Biomedical Engineering – CMBE2022 (27-29 June 2022), Italy – co-organization of mini symposium on “modelling the anatomical variability of vascular systems”

COMMUNICATIONS AND VALORIZATION

Journal publications *(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	
4	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	
5	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	
6	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	

7	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	
8	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)*

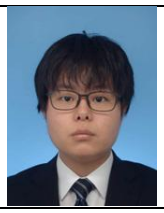
	People	**Event**	**Description**	**Date**
1	K. Yanagisawa, C. Frindel, D. Garcia, M. Ohta, H. Anzai	ELyT Workshop 2024	Oral presentation	11-13 March, 2024
2	Y. Kohata, H. Anzai, M. Decroocq, S. Rit, C. Frindel, M. Ohta	ELyT Workshop 2022	Oral presentation	16-18 November, 2022
3	Y. Kohata, H. Anzai, M. 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

Project report 2024

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: 2019 **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

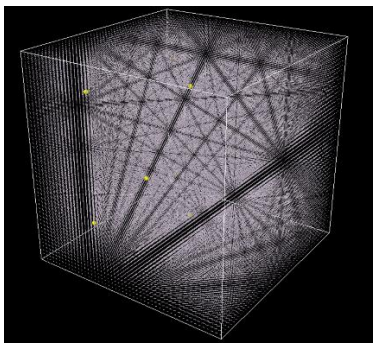
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: None

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

- We constructed the Fe-C system, which includes multiple carbon atoms, and simulate carbon electromigration under several electric field intensities.
- It is revealed that the drift velocity of carbon atoms does not follow the Nernst-Einstein relation, whose behavior exhibits nonlinearity with increasing electric field.
- The Ab Initio and Molecular Dynamics School was held from February 23rd to March 1st, 2025, at INSA Lyon in France.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Thermal treatments for metals using Joule heating from electricity generated by renewable energy have been attracting attention because no greenhouse gases are emitted during the processes. During the processes, additive elements move not only due to thermal vibration but also due to the influence of an electric field, a phenomenon known as electromigration. However, there is a lack of simulation-based knowledge because the physical phenomena exhibit complex behavior due to the combined effects of both thermal and electric factors, making analysis difficult. Until now, thermal vibration has been well studied, whereas electromigration has not been investigated sufficiently. Therefore, in this project, the coupled effects of thermal vibration and electromigration have been the main focus. As you know, carbon concentration strongly affects the microstructure of Fe-C alloys. Hence, the drift velocity of carbon atoms in a Fe crystal under an electric field was analyzed.

Key scientific question (2 lines max; Calibri 11)

Analyzing the drift velocity of carbon atoms under an electric field.
Elucidation of why the drift velocity does not follow the Nernst-Einstein relation.

Research method (8 lines max; Calibri 11)

Electromigration can be considered to depend on the microstructure (BCC structure, FCC structure, crystal grain boundaries, etc.). Therefore, microscale analysis was performed using molecular dynamics simulation. The Fe crystal was modeled using the embedded atom method (EAM) potential. To improve statistical accuracy, multiple carbon atoms were placed with a repulsive potential. Electromigration was simulated under several electric field intensities using this calculation system. The drift velocity of carbon atoms was calculated from the slope of carbon displacement in the direction of the electric field. Finally, the drift velocity was compared with the Nernst-Einstein relation.

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

Ph.D. candidates (years, institution):

- Ryuta Onozuka (2024-present, Double Degree Program Tohoku university-INSA Lyon)

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 (2025.2.19 – 2025.3.1)
- Takashi Tokumasu (2024.6.8 – 2024.6.10)
- Takashi Tokumasu(2023.6.20 – 2023.6.23)
- 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	Electric Field Dependence of Parameters Related to the C Diffusivity in Steel and Improvement of Previous Analytical Model	ELyT workshop 2025	19-21 Feb. 2025	Lyon/Annecy	France	
2	R. Onozuka, P. Chantrenne, T. Tokumasu	Molecular Analysis on Electric Field and Temperature Dependence of Electromigration in Fe-C Alloys	The Third Pacific Rim Thermal Engineering Conference 2024 (PRTEC2024)	15-19 Dec. 2024	Honolulu	USA	
3	R. Onozuka, P. Chantrenne, T. Tokumasu	Analysis of the Drift Velocity Variation of Carbon in Steel under Electric Field	ICFD2024	18-20 Nov. 2024	Sendai	Japan	
4	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	
5	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 Nov. 2022	hybrid	France	
6	Kairi Kita, Takuya Mabuchi, Sofia Molina-Montoya, Christophe Adessi, Patrice Chantrenne, Takashi Tokumasu	*Multiscale Simulation of Carbon Electromigration in Iron*	ICFD2021	27-29 Oct. 2021	online	Japan	
7	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	Demonstrator show	27th Sept. 2023
2	Takashi Tokumasu, Patrice Chantrenne, Kairi Kita	MD School @ IFS	Experiment demonstration	Oct. 11-12th, 2021

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

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

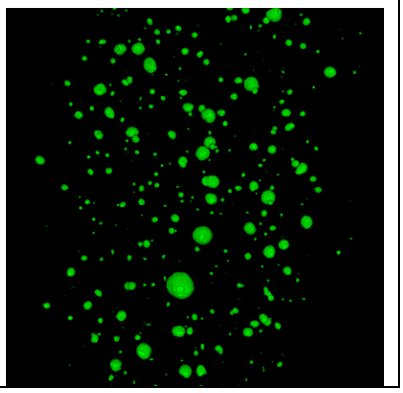
- JSPS, 2018-2022, Construction of electron beam 3D printing metallic materials

- Estimated annual budget:

Highlights & Outstanding achievements

- The influence of Carbon content on the microstructure of Co based alloys made by additive manufacturing process has been characterized
- We start again to work on the phase martensitic phase transformation of Ti alloys to improve the mechanical properties
- One paper published in Journal of the Japan Society of Powder and Powder Metallurgy

Illustration



PROJECT DESCRIPTION

Background

3D printing technologies is a key technology now to obtain complex structures on a wide range of alloys. However, the presence of defects is still a critical issue to widen the application for industrial parts. In this study, we evaluate the influence of initial defects in the powder on final parts as well as the influence of carbon content on the solidification procedure and thus mechanical properties. The second topic is based on former studies on the interest of metastable phase in Ti alloys for getting improved mechanical properties.

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. The other part of the project aimed at exploring thermal treatment on Ti alloys to obtain a microstructure able to form martensite during straining in order to improve the mechanical properties.

Research students involved

Master/Bachelor students (years):

- S. Aota (2019, Tohoku University)

Visits and stays

JP to FR (date, duration):

- S. Aota (Sept-Nov. 2017, 2 months)

COMMUNICATIONS AND VALORIZATION

Journal publications

	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

Conferences

	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]	**Noriko TSURUOKA**[5]	**Yoichi HAGA**[6]

[1] *CREATIS, Lyon, France*
[2] *IFS, Tohoku University, Sendai, Japan*
[3] *Elytmax, Sendai, Japan*
[4] *CEA, Paris-Saclay, France*
[5] *Graduate School of Engineering, Tohoku University, Sendai, Japan*
[6] *Graduate Shool of Biomedical Engineering, Tohoku University, Sendai, Japan*

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

Other:
Bio-medical device, magnetic sensors

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)*

- Giant-Magneto resistors of adequate size (>=300µm²) have been manufactured and characterized.
- GMR were integrated into a catheter.
- The feasibility of the method has been demonstrated in 1D.
- Setup build to experimental test the principle in 1D
- Setup in 2D coming.
- Simulation on 2D and 3D localization using Python and MagPyLib.

Illustration *(5x5 cm² max)*

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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 (2 lines max; Calibri 11)

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.
Assessing the system capability to compare with actual technologies

Research method (8 lines max; Calibri 11)

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)
- L, PAQUET (March 2025 – December 2025)

JP to FR (date, duration):

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
	Louis Paquet, Aurélie Solignac Kevin Tse-Ve-Koon, Makoto Ohta, Noriko Tsuruoka, Yoichi Haga, Claude M Fermon, Myriam Pannetier-Lecoeur, Benjamin Ducharne	Magnetic position determination with giant-magnetoresistance and moving field-free point in catheter	Sensors and Actuators A: Physical	383		2025	https://doi.org/10.1016/j.sna.2025.116199

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
	Louis Paquet, Aurélie Solignac Kevin Tse-Ve-Koon, Makoto Ohta, Noriko Tsuruoka, Yoichi Haga, Claude M Fermon, Myriam Pannetier-Lecoeur, Benjamin Ducharne	Magnetic position determination with giant-magnetoresistance and moving field-free point in catheter.	Intermag MMM2025	13-17/01/2025	New Orleans	USA	N/A

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			

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)*

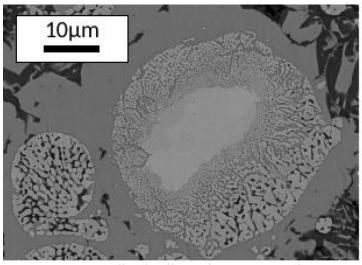
- none

Estimated annual budget: none

Highlights & Outstanding achievements

- Successful elaboration of porous Fe powders via liquid metal dealloying
- Development of a diffusion model for the NiCu-Ag system. Semi-quantitative agreement with experiments regarding kinetics and composition profiles in dealloyed structures was reached
- In operando monitoring of the dealloying reaction by X-ray diffraction using synchrotron radiation (FeNi-Mg system)
- Compression tests on single porous particles

Illustration



Partially dealloyed Invar powder – SEM-BSE cross-section

PROJECT DESCRIPTION

Background

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

Understanding of liquid metal dealloying kinetics and resulting morphology.
Application of porous powders elaborated via liquid metal dealloying for cold spray applications.

Research method

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).

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

Ph.D. candidates (years, institution):

Louis LESAGE (CNRS international Grant) 2021/11 - 2025/01

Master/Bachelor students (years):

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

FR to JP (date, duration):

Louis LESAGE: *2022/07 – 2023/01, 2023/10 – 2024/06 and 2024/11 - 2025/01*

Pierre-Antoine GESLIN: *2022/04 – 2022/10, 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	Acta Materialia	272	119908	2024	10.1016/j.actamat.2024.119908
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 in situ synchrotron X-ray diffraction	Materialia	36	102177	2024	10.1016/j.mtla.2024.102177

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	Processing of micro-porous metallic powders by liquid metal dealloying (Oral presentation)	JIM Annual Autumn meeting 2022	2022/09/23	Fukuoka	Japan	
2	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	
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	Thermodynamics of liquid metal dealloying: powders and bulk samples	4th International Symposium on Nanoporous Materials	2023/04/24	Nohfelden	Germany	

			by Alloy Corrosion				
5	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	
6	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	ElyT Workshop 2024	2024/03/12	Yamagata	Japan	
7	L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato	Thermodynamically controlled elaboration of porous powders by liquid metal dealloying *(Excellent oral presentation award)*	Spring meeting of the Japanese Society of Powder and Powder Metallurgy	2024/05/23	Tokyo	Japan	
8	L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato	Investigation of equilibrium conditions in liquid metal dealloying by in situ X-ray diffraction.	19th Meeting of Thermodynamics of Alloys	2024/09/25	Lyon	France	
9	L. Lesage, N. Mary, C. Le Bourlot, E. Maire, T. Wada, H. Kato, P.-A. Geslin	Elaboration of micro-porous powders by liquid metal dealloying.	Labex Manutech-Sise seminar	2024/10/16	Ecully	France	

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, beamline ID11)	Monitoring of liquid metal dealloying kinetics and phase transformations via *in situ* XRD and X-ray tomography	2023/04/18-21

Project report 2024

FIESTA

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

MAIN PARTICIPANTS

			
Mickaël Lallart[1,*]	**Gaël Sebald[2]**	**Benjamin Ducharne[2]**	**Hiroki Kuwano[3]**

Other contributors: Elie Lefeuvre, Ausrine Bartasyte, Takahito Ono

[1]*INSA Lyon, LGEF, UR682, 69621 Villeurbanne, France*
[2]*ELyTMaX IRL3757, CNRS, Univ. Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan*
[3]*New Industry Creation Hatchery Center (NICHe), Tohoku University, 6-6-10 Aramaki-Aoba, Aoba-ku Sendai, Miyagi 980-8579, Japan*
Contact: [*]*mickael.lallart@insa-lyon.fr*

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		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.

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, which however cover 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.

More recently, an investigation of energy harvesting on mechanical impacts was started. The objective is to explore the high level and high frequency regime of ferroelectrics

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):

- Alan Chales (May – September 2024, Master intern student)

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

FR to JP (date, duration):

- M. Lallart (Mar. 2024, 7 days)
- 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	Gaspard Taxil, Mickaël Lallart, Hung Hoang Nguyen, Benjamin Ducharne, Hiroki Kuwano, Takahito Ono, Gaël Sebald	Anisotropy breaking in high level piezoelectric energy harvesting	Scripta Materialia	261	116629	2025	https://doi.org/10.1016/j.scriptamat.2025.116629
2	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
3	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
4	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
5	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	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	
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	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	
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

FOCUS

Ferromagnetic Objects: Carbide Uniformity and Segregation

MAIN PARTICIPANTS

			
Bhaawan GUPTA[a]	**Terho SULKUPURO[a]**	**Tetsuya UCHIMOTO[b]**	**Benjamin DUCHARNE[c]**
			
Gael SEBALD[c]	**Yves Armand TENE DEFFO[c]**		

[a] *SKF, Gothenburg, Sweden*
[b] *IFS, Tohoku University, Sendai, Japan*
[c] *ELyTMaX, Tohoku University, Sendai, Japan*

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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	33 %		
Surfaces and interfaces	33 %		
Simulation and modeling	34 %		

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: ≈ 20 k€

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

This project aims to assess the feasibility of detecting carbide segregations and grinding burns in high-quality ferromagnetic steel parts using magnetic non-destructive testing (NDT) techniques. Initiated through a collaboration between SKF and the ELyTMaX laboratory, the study builds on ELyTMaX's expertise in magnetization mechanisms and high-resolution magnetic instrumentation. The main challenge lies in resolving the minimum detectable size of such defects. To address this, the project will explore several advanced methods including Barkhausen noise, magnetic incremental permeability, magnetic flux leakage using GMR sensors, and Faraday effect microscopy.

Key scientific question (2 lines max; Calibri 11)

_ What is the minimum detectable size and intensity of a carbide segregation with magnetic NDT?
_ How do different magnetization-based signals (e.g., Barkhausen noise, incremental permeability, magnetic flux leakage) correlate with the microstructural changes induced by carbide segregation and grinding burns?

Research method (8 lines max; Calibri 11)

The research will combine experimental characterization and signal analysis using a set of complementary magnetic NDT techniques. Custom millimetric sensors—including single- and double-coil probes, GMR sensors, and Barkhausen noise setups—will be deployed to scan steel specimens with controlled levels of grinding burns and carbide segregations. Measurements will be performed at various frequencies and magnetization modes to evaluate sensitivity and spatial resolution. Additionally, Faraday effect microscopy may be used to visualize surface magnetization patterns and support the interpretation of magnetic responses. The results will guide the selection of the most effective technique based on resolution and defect discrimination capability.

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)*

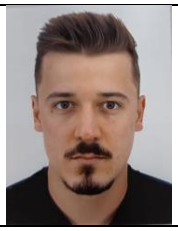
FR to JP (date, duration):

JP to FR (date, duration):

FRIISE

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

MAIN PARTICIPANTS (French side)

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

[a] *LTDS, Ecole Centrale de Lyon, Lyon, France*

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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)*

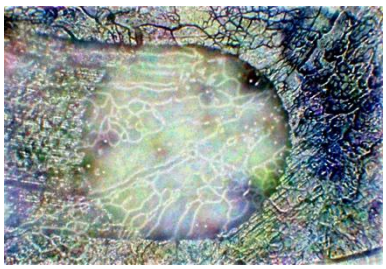
- ANR-CREST project, 2021-2025, FRIISE

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

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

- Combined friction measurements – real contact area visualization for a transparent ice/elastomer interface under controlled kinematics, to accurately estimate the interfacial shear stress during sliding.
- Influence of the elastomer viscoelasticity
- Identification of possible water presence during sliding

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(Prof Kurihara and Prof Mizukami) and Keio University (Prof Yasuda)

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 on 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.

On the Japanese side, a focus is made on the rubber/ice interface at a smaller scale using Resonance Shear Measurement experiments and Molecular Dynamics simulations to identify the presence and the properties of the quasi-liquid layer on ice.

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):

- 13th-15th of November 2024, 3 days

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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	In-situ Analysis of Rubber/Ice interface	FR/JP workshop on Nanomechanics, Multiscale Mechanics and Tribology	13-15 Nov. 2024	Ecully	France	
2	A. Dalavale Kaiser Pinto, J. Cayer-Barrioz, D. Mazuyer	Multi-scale Analysis of Ice-Rubber Sliding Interface	ITC Fukuoka 2023	19 - 30 Sept. 2023	Fukuoka	Japan	
	S. Hemette, D. Mazuyer, J. Cayer-Barrioz (invited)	Ice-rubber Friction Mechanisms	ACS Fall 2019	25-29 Aug. 2019	San Diego	USA	

MAGELLAN

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

MAIN PARTICIPANTS

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

[a] SmartTECH lab. Inc., MaSC Bldg., 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

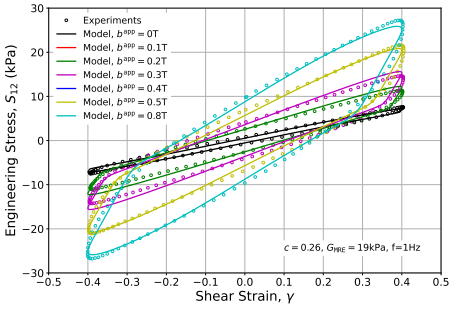
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: 5k€

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 *(5x5 cm² max)*



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)

7-21 April 2024 (L. Bodelot)

JP to FR (date, duration):

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Kostas Danas, Masami Nakano, Gaël Sebald	A continuum magneto-viscoelastic model for isotropic soft magnetorheological elastomers: experiments, theory and numerical implementation	*Mechanics of Materials*	200	105187	2025	10.1016/j.mechmat.2024.105187

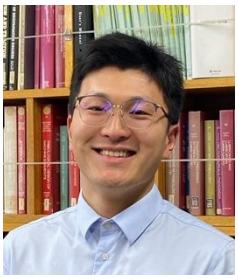
Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Kostas Danas, Gael Sebald, Masami Nakano	Visco-Elasto-Plastic Behaviour of Magnetorheological Elastomers under Shear Loading	Twenty-first International Conference on Flow Dynamics	November 18-20,2024	Sendai	Japan	

MeCaT

Mechano-Chemically-activated Tribofilm Growth at Nanoscale

MAIN PARTICIPANTS

			
Shaoli JIANG [a]	**Motoyuki MURASHIMA** [b]	**Jean Michel MARTIN** [c]	**Maria-Isabel De BARROS** [d]

[a,b] *Department of Mechanical Systems Engineering, Tohoku University, Sendai 980-8579,* ***Japan***
[c, d] *Ecole Centrale de Lyon, CNRS LTDS UMR5513, 69130 Ecully,* ***France***

Contact : jiang.shaoli.d1@tohoku.ac.jp, maria-isabel.de-barros@ec-lyon.fr

OVERVIEW

Starting year: 2024 **Current researchers** (permanent/non-permanent): 3 person-month/year

Positioning	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design	65 %		
Surfaces and interfaces	25 %		
Simulation and modeling	10%		

Include partner from ☐ Outside ELyT ☐ Industry

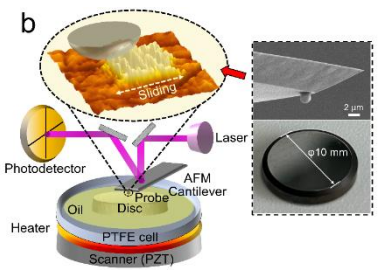
Main funding source(s)
☐ Public project(s) ☐ Industrial ☒ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

Highlights & Outstanding achievements

- *In lubro* AFM-based tribometry has been used to study boundary lubrication mechanisms of additives
- *ZDDP tribofilms have been growth successfully on steel samples using AFM nanoscale contact*
- *Analytical characterization is currently carried out to investigate chemical antiwear mechanism of ZDDP additive*

Illustration



PROJECT DESCRIPTION

Background

In general, the activation of chemical reactions requires energy, which is typically provided by heat, light or electrical potential. When mechanical contact generates a stress field at the interface between two surfaces, certain mechanically induced chemical reactions are initiated or accelerated. In the field of tribology, mechanochemical effects have been used to generate thin functional layers, well-known as tribofilms, on the surface of mechanical components, reducing wear and friction. In most tribological studies, these reactions are activated simultaneously at the tips of numerous microscopic asperities due to surface roughness, where locally distributed tribofilms form and eventually coalesce into a uniform layer. As a result, tribofilms rapidly develop on uncertain areas under unquantified pressures, making it difficult to independently interpret the genesis steps and growth kinetics of these tribofilms.

Key scientific question

Identification of the genesis steps and growth mechanisms of ZDDP tribofilms
Investigation of competitive and synergistic effects between additives at the sliding interface
Development of a novel analytical strategy to characterize tribofilms

Research method

As the most successful antiwear additive ever invented, zinc dialkyldithophosphate (ZDDP) is reported to decompose with physicochemical pathways, leading to protective tribofilm. However, there is no information on the evolution of their compositions and concentrations, as well as distribution within tribofilm. In this work, by mimicking sliding nanocontacts using atomic force microscopy (AFM), ZDDP tribofilms formation process was observed *in lubro*, starting with some tiny platelets that grow in height and further more platelet-like feature generation which is in agreement with the studies performed in macroscopic friction tests.

Subsequently, numerous additional characterizations were performed on the tribofilms developed using this approach. In particular, studies conducted using TEM/FIB coupled with EDS and AES show that these tribofilms have an amorphous structure with a chemical composition varying between the interfacial zone formed with steel and the bulk of the film. Understanding this structure will help better comprehend the ZDDP mechanism and optimize its performance for improved antiwear efficiency.

Project report 2024

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)*

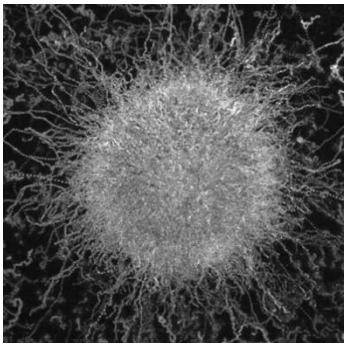
- IFS LyC project 2019-2023
- ANR SHAPE-Med Lyon1 2023-25 ORGANOX
- CNRS, Invited researcher positions for K. Funamoto (2 months in 2019; 1 month in 2023)

Estimated annual budget: 30 k€

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

- We developed several microfluidic devices to control heterogeneous oxygen concentration in a microenvironment.
- We have shown that *Dictyostelium* cells migrate toward oxygen-rich regions under the 0-2% O_2 only (aerotaxis), even in a starvation medium (paper in preparation).
- We have shown that *Acanthamoeba castellani*, an asocial amoeba, respond to oxygen gradients in 0-2% O_2 range as well (2 papers in preparation).
- 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 oxygen 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 into the oxygen 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 oxygen gradient as functions of gradient steepness and absolute oxygen level.

Key scientific question (2 lines max; Calibri 11)

The detection and sensing mechanisms for oxygen which lead to a directed migration of eukaryotic cells are still an enigma.

Research method (8 lines max; Calibri 11)

We have fabricated a very efficient microfluidic device enabling to control the oxygen 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 oxygen-sensing polymer film 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 oxygen gradients or uniform oxygen 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. YANAGITA (2024-now), Tohoku University
- J. HESNARD (Sep 2021-present, Université Claude Bernard Lyon 1)
- N. GHAZI (Oct 2021-Dec. 2024, Université Claude Bernard Lyon 1)
- S. HIROSE (2020-2023, Tohoku University)

Master/Bachelor students (years):

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

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

FR to JP (date, duration):

- J. P. Rieu (July 2024, 3 weeks + Nov 2024, 1 week) => total 4 weeks
- N. GHAZI (Nov 2023, 1 week)
- J.-P. RIEU (Oct-Nov 2022,20 days)
- J.-P. RIEU (Dec 2019,5 days)
- J.-P. RIEU (Jun 2019,5 days)
- J.-P. RIEU (Nov 2018, 5 days)

JP to FR (date, duration):

- K. FUNAMOTO (Mar 2024, 1 week)
- S. YANAGITA (Feb-Mar 2024, 5 weeks)
- K. FUNAMOTO (Dec 2023, 4 days)
- K. FUNAMOTO (June-Jul 2023, 1 month)
- S. HIROSE (Jan 2022-Jun 2022, 5 months)
- K. FUNAMOTO (Nov 2022, 4 days)
- S. HIROSE (Dec 2021, 1 month)
- K. FUNAMOTO (Feb 2020, 4 days)
- K. FUNAMOTO (Sep 2019, 2 months)
- S. HIROSE (Sep 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

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	N. Kawahara, S. Yanagita, S. Aratake, S. Hirose, J.-P. Rieu, N. Ghazi, K. Funamoto	Observation of cancer cells using four-chamber microfluidic device with different oxygen concentrations	The 18th International Conference on Biomedical Engineering (ICBME 2024)	10 Dec 2024	Singapore	Singapore	
2	J.-P. Rieu, K. Funamoto, N. Aznar	Monitoring Eukaryotic Cell Functions under Various Hypoxic Conditions with Microfluidic Based Oxygenators	LyonSE&N & ELyT Global workshop 2025	19 Feb 2025	Lyon	France	

3	N. Ghazi, N. Kawahara, S. Hirose, S. Yanagita, K. Funamoto, C. Anjard, J.-P. Rieu	Monitoring Eukaryotic Cell Functions under Various Hypoxic Conditions with Microfluidic Based Oxygenators	The 21st International Conference on Flow Dynamics (ICFD2024)	20 Nov 2024	Sendai	Japan	
4	N. Kawahara, S. Yanagita, S. Aratake, S. Hirose, N. Ghazi, J.-P. Rieu, K. Funamoto	Development of Four-Chamber Microfluidic Device for Generating Different Oxygen Conditions	The 21st International Conference on Flow Dynamics (ICFD2024)	19 Nov 2024	Sendai	Japan	
5	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)	The 20th International Conference on Flow Dynamics (ICFD2023)	Nov 2023	Sendai	Japan	
6	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	
7	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	
8	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	
9	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	
10	S. Hirose, J.-P. Rieu, K. Funamoto	Evaluation of motility enhancement of *Dictyostelium discoideum* by hypoxic exposure	The 33rd Bioengineering Conference Annual Meeting of	25 Jun 2021	On-line	Japan	

			Bioengineering Division, JSME (in Japanese)				
11	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 Advanced Fluid Information (AFI-2021)	28 Oct 2021	On-line	Japan	
12	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	
13	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	
14	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	

MIMECHAS

Microstructure and Mechanics of Aluminum - Steel welds

MAIN PARTICIPANTS

			
Kiyoaki SUZUKI[a]	**Benjamin LEFLON[a,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	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design	34 %		
Surfaces and interfaces	33 %		
Simulation and modeling	33 %		

Include partner from ☐ Outside ELyT ☐ Industry

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

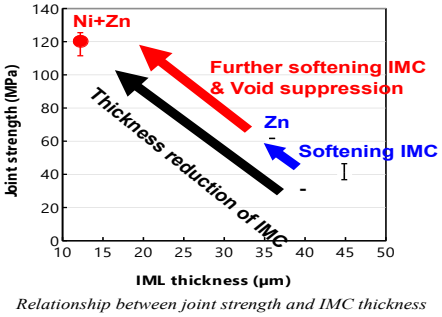
IFS CRP/LyC project? ☐ Yes X No

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

Estimated annual budget:

Highlights & Outstanding achievements

- The mechanisms of strength improvement in Al-steel TIG welds by alloying element addition were clarified (K. Suzuki PhD defense).
- An *in situ* synchrotron experiment was carried out at ESRF, Grenoble, to investigate IMC formation by X-ray diffraction and 3D imaging.
- Calibrated finite element simulations of the process allowed to explore temperature history in the weld over the full range of welding process parameters.



Relationship between joint strength and IMC thickness

PROJECT DESCRIPTION

Background

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

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

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. IMC formation is monitored by *in situ* synchrotron XRD.

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):

- Benjamin LEFLON (2022-present, DD Tohoku-INSA Lyon)
- Kiyoaki SUZUKI (2022-2025, JSD Tohoku-INSA Lyon, defended on 2025/02/13)

Master/Bachelor students (years):

- NA

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

FR to JP (date, duration):

- B. Leflon (Dec. 2024 – May. 2025, 6 months)
- B. Leflon (Oct. 2023 – Sept. 2024, 1 year)
- S. Dancette (Sept. 2022 – Aug. 2024, 2 years)

JP to FR (date, duration):

- K. Suzuki (April-June 2024, 3 months)
- 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.; Tatsumi, Y.; Dancette, S.; Sato, Y. S.	Improved strength and interfacial microstructure of dissimilar Al/steel weld via combined addition of Zn and Ni	Materials & Design	245		2024	10.1016/j.matdes.2024.113302
2	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	10.1016/j.matdes.2022.111444

International Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Sato, Y. S.; Suzuki, K. T.; Omura, S.; Tokita, S.	Control of interfacial microstructure of dissimilar weld of aluminum to steel	4th International Symposium on Computer-Aided Welding Engineering and Additive Manufacturing	Oct. 2024			
2	Suzuki, K. T.; Sato, Y. S.; Tokita, S.; Lachambre, J.; Dancette, S.	Hybrid Inverse Modeling Technique to Determine the Fracture Properties of Intermetallic Layer Formed at Al/Steel Dissimilar Weld Interface	The 30th International Conference on Computational & Experimental Engineering and Sciences	Aug. 2024	Singapore	Singapore	
3	Suzuki, K.T; Leflon, B.; Dancette, S.; Sato, Y.S.; Tokita, S.; Chaise, T.; Le Bourlot, C.; Mary, N.	Fe-Al welding - Experiments and simulations	ELyT Worshop 2024	March, 2024	Sendai	Japan	
4	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	Decembe r 2023	Sendai	Japan	
5	Leflon, B.; Dancette, S.; Chaise, T.; Le Bourlot, C.;	Coupled Numerical-Experimental Approach to Access Interfacial	PRICM11 - The 11th Pacific Rim International Conference on	Nov. 2023	Jeju	Korea	

	Mary, N.; Aoyama, Y.; Suzuki, K. T.; Sato, Y. S.	Temperature during Aluminum-Steel Dissimilar Arc Welding	Advanced Materials and Processing				
6	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	Nov. 2023	Jeju	Korea	
7	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	
8	Suzuki, K. T.; Dancette, S.; Adrien, J.; Sato, Y.S.	Fracture behavior of Al-Fe welds	ELyT Worshop 2022	Nov. 16, 2022	Lyon	France	
9	Suzuki, K. T.; Omura, S.; Tokita, S.; Sato, Y. S. Tatsumi, Y.	Strength Improvement in Dissimilar Al/steel Weld by Simultaneous Addition of Si and Ni	The 6th International Symposium on Visualization in Joining & Welding Science through Advanced Measurements and Simulation	Oct. 2022	Osaka	Japan	

Project report 2024

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 , zhixin.dong@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

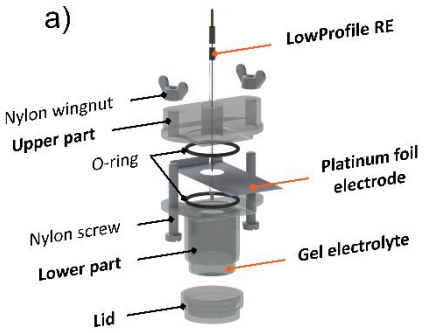
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

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):

- Z. Dong still at Tohoku and ElytMax from March 2024
- B. Normand, N. Mary, B. Ter-Ovanessian stay at Tohoku and ElytMax, March 2024 (1 week)
- 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

Conferences *(gray color for previous years)*

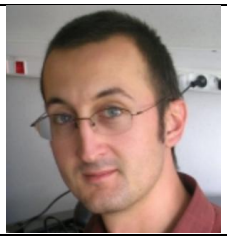
	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	Zhixin Dong, Benoît Ter-Ovanessian, Hiroshi Abe, Nicolas Mary , Yutaka Watanabe, Bernard Normand	Design of an EIS-based sensor for non-invasive in-field corrosion monitoring	Eurocorr 2024	01/09 - 05/09	Paris	France	
2	Zhixin Dong, Benoît Ter-Ovanessian, Hiroshi Abe, Nicolas Mary , Yutaka Watanabe, Bernard Normand	Design of an EIS-based sensor for non-invasive in-field corrosion monitoring	71st Japan Conference on Materials and Environments	11/11 - 13/11	Okinawa	Japan	

Project report 2024

MuORoD

Multi-Objective Robust Design

MAIN PARTICIPANTS

				
Hiroshi, SUITO[a]	**Koji SHIMOYAMA[b]**	**Frédéric GILLOT[c]**	**Sébastien BESSET[c]**	**Thanasak WANGLOMKLANG[c]**

[a] *Advanced Institute for Materials Research, Mathematical Science Group, Tohoku University, Japan*
[b] *Department of Mechanical Engineering, Kyushu University, Japan*
[c] *LTDS UMR CNRS 5513, DySCo Team, ECL, Lyon, France*

Contact: hiroshi.suito@aimr.jp; shimoyama@mech.kyushu-u.ac.jp, frederic.gillot@ec-lyon.fr, sebastien.besset@ec-lyon.fr, thanasak.wanglomklang@ec-lyon.fr

OVERVIEW *(keep within this page)*

Starting year: 2012**Current researchers** (permanent/non-per.): (4/1) 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

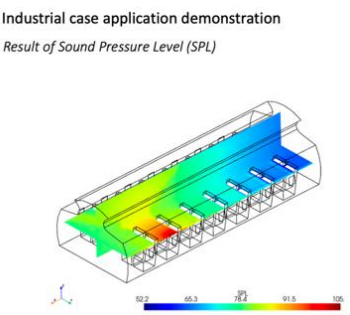
For main projects: Agency / year / name of project
- Rhône Alpes AAP grant awarded (2021 – 2024, 30keuros)
- JSPS Summer Grant 2022 and JSPS Short Term Post Doc, 1year, 05/2023 for Achille
- Short stay at AIMR (1 month, 05/2025) for Thanasak

Estimated annual budget: From institutions 35keuros

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

- Height journal papers have been accepted recently, two under review currently
- Ph.D. Student Pradeep has defended his Ph.D. for the Double Diploma in July 2021
- Ph.D. Student Achille received the JSPS Summer grant for summer 2022 / JSPS Short Term Post Doc in April 2023 for 1 year
- Ph.D. Student Thanasak has started his MNRT Ph.D. by October, 2023, one paper accepted by February, 2025

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Framework of our collaborative research studies concerns robust shape optimization of structures and systems under extremes conditions. Load involves in such conditions usually leads to non-linear behavior of structures, making figure of merits computationally costly and without accessible derivatives. As an applicative example, we have worked on a disc-pad system exhibiting vibro-acoustic properties arising from friction-induced vibration, commonly known as squeal noise. We are now designing cavities shapes w.r.t. inner noise level considerations, like what can be considered for cabin design of modern airplanes. The complex nature of those problems demands an efficient optimization strategy considering the computation cost. It is addressed through defining the expensive evaluation with a meta-model and using a dedicated Efficient Global Optimization (EGO) -liked search algorithms.

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 (2023-2026, 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):

- T. Wanglomklang (May 2025, 1 month)
- F. Gillot (Sept. 2023 – Aug. 2024, 1 year)
- A. Jacquemond (April 2023 – May 2024, 1 year)
- F. Gillot (May 2015, 1 month)
- F. Gillot (Sept. 2019-Aug. 2020, 1 year)
- P. Mohannasundaram (Sept. 2018 – Aug. 2019, 1 year)
- S. Besset (July 2019, 1 week)
- P. Mohannasundaram (Jan. 2021 – March. 2021, 3 months)
- A. Jacquemond (June 2022 – August 2022, 3 months)

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	Thansak Wanglomklang, Frédéric Gillot, Sébastien Besset	Hybrid method for energy flow in mid-high frequency acoustics: Applications in robust shape optimization for complex cavities	Journal of theoretical and applied acoustics				accepted Feb. 2025
2	Achille Jacquemond, , Frédéric Gillot, Sébastien Besset, and Koji Shimoyama.	Noisy Disc-brake squeal noise reduction through material selection and robust shape optimization	Noise Control Engineering Journal				accepted Feb. 2025
3	Achille Jacquemond, Frédéric Gillot, Sébastien Besset, and Koji Shimoyama	Noisy Kriging for robust shape optimization of mechanical systems with a nonlinear and gradient-free expensive black-box figure of merit	European Journal of Mechanics	111	105567	2025	
4	Achille Jacquemond, , Frédéric Gillot, Sébastien Besset, and Koji Shimoyama	Pareto optimal robust design combining isogeometric analysis and sparse polynomial chaos: brake squeal case study	Archive of Applied Mechanics				accepted 11/2024
5	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
6	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
7	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	
8	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	

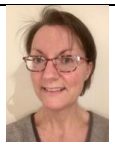
Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Wanglomklang, T., Gillot, F., Besset, S., K. Shimoyama, K.	Hybrid Method for Energy Flow for Complex Cavities Acoustic	WCSMO-16 2025	2025	Kobe	Japan	https://wcsmo2025.com/
2	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/
3	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
4	Jacquemond, A., Gillot, F., Besset, S., Shimoyama, K	Robustness Criteria Analysis for an Isogeometric-based Robust Shape Optimization Scheme of a Disc-pad System under Dynamical Criteria	WCCM-APCOM 2022	2022	Yokohama	Japan	https://www.wccm2022.org/dl/index/program_book.pdf
5	Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset	Iga based shape optimization under mechanical stability criteria	14th WCCM 2020	2020	Paris	France	
6	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	
7	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	
8	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]	**Shintaro SASAKI**[c,d]	**Ayami OMIYA**[c,d]	**Riko HASEGAWA**[c,e]	**Makoto OHTA**[c,f]

[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] *Graduate School of Biomedical Engineering, Tohoku University, Sendai, Miyagi, Japan*
[e] *Graduate School of Engineering, Tohoku University, Sendai, Miyagi, Japan*
[f] *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 PVaH 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. To achieve this, a hydrogel is synthesized by freezing a polyvinyl alcohol (PVA) solution with an adjusted concentration, allowing for tunable elasticity. 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):

- Guillaume Plet (2020-present, ECL)
- Jolan Raviol (2021-present, ECL)
- Riko Hasegawa (2024-present, TU)

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):

- Riko Hasegawa (16/11/2022-18/11/2022, 2/9/2024-11/6/2024)
- Ayami Omiya (19/2/2025-21/2/2025)

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	JMBBM	153		2024	https://doi.org/10.1016/j.jmbbm.2024.106469
2	R. Hasegawa, H. Kosukegawa, K. Yu, M. Shojima, K. Niizuma, N. Sakai, M. Ohta	Development of an arterial poly (vinyl alcohol) hydrogel model with lumen surface topography that mimics atherosclerosis feeling	BMEiCON			2023	https://doi.org/10.1109/BMEiCON60347.2023.10322009

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	S.Shintaro, M.Ohta, H.Kosukegawa, K.Yu	Study of vascular shape changes in response to helical stent deployment in PVA-H vascular models	JET2024	14-16 Jun. 2024	Fukuoka	Japan	
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	

Others *(gray color for previous years)*

	People	Event	Description	Date
1	A. Omiya	ElytWorkshop	Analysis of Guidewire Technique aiming for Reducing the Load on Vessels at the Internal Carotid Artery Bend	19-21 Feb. 2025
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	R. Hasegawa, H. Kosukegawa, K. Yu, M. Ohta	ElyTSchool	Development of a cerebral artery biomodel for surgery training	16-18 Nov. 2022
5	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

PREDOXCAN

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

MAIN PARTICIPANTS

				
Satoshi ARATAKE[a]	**Morgane ROINARD[B]**	**Jean-Paul RIEU[b]**	**Nicolas AZNAR[c]**	**Kenichi FUNAMOTO[a]**

[a] *Tohoku University, Sendai, Japan*
[b] *Université Claude Bernard Lyon 1, France*
[c] *Cancer Research Centre of Lyon, 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

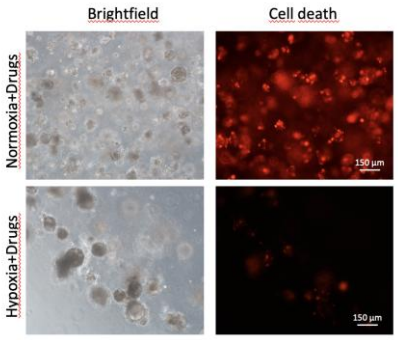
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- ShapeMed 2023-2025
- IFS LyC project 2022-2023
- IFS LyC projectS 2020-2021, 2021-2022

Estimated annual budget: 50 000€

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. Identification of specific gene signature associated with chemoresistance.
- Validation of gene signature and development of fluorescent probes to monitor resistant cells in CRC spheroids.
- We designed an innovative 3D cell culture system combined with oxygen gradient. Production and first tests with spheroid cultures.

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 O2 could impact cancer cell plasticity (CSCs properties)
Improve efficacy of conventional chemotherapy.

Research method (8 lines max; Calibri 11)

We recently identified a distinct CSC signature linked to chemotherapy resistance, along with specific CSC markers uniquely associated with hypoxic tumor regions. To investigate the influence of oxygen levels on CSC behavior, we generated colorectal cancer (CRC) patient-derived tumor organoids using our STEADY-STEM platform. These organoids were cultured under normoxic (21% O_2) and hypoxic (1% O_2) conditions to evaluate the effects of oxygen tension on tumor growth and CSC marker expression. Additionally, PDOs grown in both conditions were treated with 5-fluorouracil (5FU) to assess their resistance to standard chemotherapy. The next step will involve introducing fluorescent reporters for CSC markers to enable real-time tracking and evaluation of therapeutic strategies targeting these resistant cell populations.

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

Ph.D. candidates (years, institution):

- Satoshi ARATAKE (2022-2024, Sendai)

Master/Bachelor students (years):

- Minh Hoang BUI (2024-2025)
- Zhouxing SU (2022, Lyon)

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

FR to JP (date, duration):

- Nicolas AZNAR (CRCN CNRS, November 2024, 15 days)
- Jean-Paul Rieu (UCBL, November 2024, 7 days)
- Nicolas AZNAR (CRCN CNRS, November 2023, 20 days)
- Nicolas AZNAR (CRCN CNRS, November 2022, 20 days)
- Jean-Paul Rieu (UCBL, November 2022, 10 days)
- Zhouxing SU (Master student, April-June 2022, 3 months)

JP to FR (date, duration):

- Kenichi Funamoto (Assistant professor, Mars 2024, 4 days)
- 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

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	

Project report 2024

REFRESH

REFRigEration based on Solid-state cooling: Heat transfer mechanisms

MAIN PARTICIPANTS




Gaël SEBALD[a]	Atsuki KOMIYA[a,b]	Shihe XIN[c]	Gildas COATIVY[d]

[a] *ELyTMaX IRL3757, CNRS, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon, Tohoku University, 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*
**In memory of Professor Jacques Jay, a longstanding and active member of the REFRESH project and ELyT Global network, who passed away in November 2023.*

Contact: gael.sebald@insa-lyon.fr, komiya@tohoku.ac.jp, shihe.xin@insa-lyon.fr, gildas.coativy@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)*

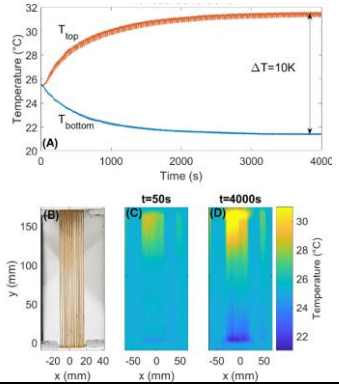
- ANR ECPOR (ANR-17-CE05-0016) 2017-2022
- JSPS Grant in Aid for Scientific Research Kiban C 19K04230 2019-2022

Estimated annual budget: 20k€

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

- 2025: Prize EDF Pulse AURA
- 2023: First functional experimental proof of concept of cooling system based on elastocaloric natural rubber
- 2023: Radio pitch of France culture on the experimental proof of concept
- 2021: Way Szu Xuen received the "Excellent Presentation Award" at the 21st Student Presentation of the Heat Transfer Society of Japan (Tohoku branch).
- 2020: "Editor's Pick" for an article in 2020, and was the subject of a "SciLight" (scientific highlight) by AIP.

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 spatial 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. Finally, the system may be reversed for low grade heat energy production.

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 and the reverse energy conversion possibility.

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

Ph.D. candidates (years, institution):

- Marianne Sion (2021-2025, CNRS, INSA Lyon – Tohoku University)

Master/Bachelor students (years):

- Oiri Takuma (2024-2026), Tohoku University
- Ishii Shun (2023-2025), 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):

- September 2024 – January 2025 (Marianne Sion)
- January 2024 – May 2024 (Marianne Sion)
- June 2022 – June 2023 (Marianne Sion)
- Dec. 2021: Giulia Lombardi started 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
1	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
3	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)*
1	Gael Sebald*, Giulia Lombardi, Marianne Sion, Gildas Coativy, Shihe Xin, Atsuki Komiya	Natural rubber for elastocaloric cooling and energy conversion from low grade heat: challenges and proof of concepts	Calorics 2024	Sept. 15-18, 2024	Cambridge	UK	
2	Marianne Sion, Jacques Jay, Gildas Coativy, Atsuki Komiya, Gael Sebald	Elastocaloric solid-state refrigeration device based on natural rubber: Single stage setup and analytical modelling	10th IIR Conference on Caloric Cooling and Applications of Caloric Materials	August. 21-24, 2024	Baotou	China	10.18462/iir.thermag2021.0003
3	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	
4	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

5	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	
6	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	
8	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	
9	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	
10	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	
11	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	
12	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		

13	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	Atsuki Komiya	Invited lecture	➢ Aug. 2024: Invited lecture in the Summer School of the Society of Rubber Science and Techonology, Japan	8 August, 2024
2	Atsuki Komiya	Invited lecture	➢ Feb. 2024: Invited lecture in the Technical Workshop of the Society of Rubber Science and Techonology, Japan	2 February, 2024
3	Gael Sebald	Radio pitch on France Culture	➢ Mar. 2023: Radio pitch on the elastocaloric cooling results ➢ In 2023, broad audience journal articles mentioning our work: (Liberation; L'Usine Nouvelle; Reporterre; The Telegraph…)	March 2023

Project report 2024

SOLYDIC

Surface degradatiOn acceLerated by hYdrogen Diffusion and trapping, case of lubrIcated rolling Contact

MAIN PARTICIPANTS

					
Gaël ZAVALETA[a]	**Ana C. PONTES RODRIGUES[a]**	**Nicolas MARY[b,c]**	**Tetsuya UCHIMOTO[d]**	**Fabrice VILLE[e]**	**Clotilde MINFRAY[a]**

[a] *Ecole Centrale de Lyon, Laboratory of Tribology and System Dynamics CNRS, UMR5513, Ecully, France*
[b] *Institut National des Sciences Appliqués de Lyon, Materials, engineering and science laboratory CNRS, UMR5510, Villeurbanne, France*
[c] *ELyTMaX IRL3757, CNRS, Univ Lyon, INSA Lyon, Centrale Lyon, Université Claude Bernard Lyon 1, Tohoku University, Sendai, Japan*
[d] *University of Tohoku, Institute of Fluid Science, Sendai, Japan*
[e] *INSA Lyon, CNRS, LaMCoS, UMR5259, 69621 Villeurbanne, France*

Contact: gael.zavaleta@ec-lyon.fr

OVERVIEW *(keep within this page)*

Starting year: 2025 **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	25 %	25 %	
Simulation and modeling			

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

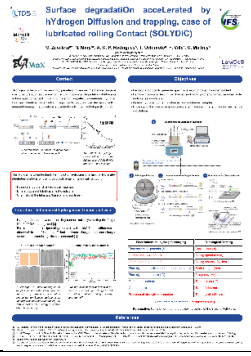
IFS CRP/LyC project? ☐ Yes ☒ No

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

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

- Poster presentation at 2025 ElyT Workshop

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

The industrial sector is developing new products less demanding in energy and resources. In the field of ground transportation, this is reflected in the development of electrical vehicles, whether the electricity is obtained via a battery or generated by a fuel cell. The use of lubricants is essential for the various systems present in this type of vehicle. They keep equipment running smoothly, limiting energy losses by minimizing friction and maximizing service life by controlling damage. Depending on the severity of the contact, the lubricant, made up of a base oil and various additives, can act in different ways: either by establishing an oil film separating the two rubbing surfaces or, in the most severe cases, by establishing a tribofilm. But how does hydrogen (H_2), increasingly present in this type of system, affect the tribological behavior of the steel part contacts? What is the influence of the lubricant's nature ? May the tribofilm act as a barrier to hydrogen diffusion?

Key scientific question (2 lines max; Calibri 11)

Understanding the impact of hydrogen charging of lubricated steel/steel contacts on the tribological behavior, considering structural changes, tribological test conditions and lubrication.

Research method (8 lines max; Calibri 11)

The first part of this work will concern the realization of controlled hydrogen charging of steel specimens by electrochemical means with two main objectives:

- to generate specimens with controlled hydrogen content for tribological testing.
- to further understand the interactions between the quantity of hydrogen trapped in steel and the mechanical-physical-chemical modifications induced.

The second part of the project will involve tribological tests using an experimental design that takes into account tribological test conditions (influence of rolling/slip rate, etc.), the quantity of hydrogen pre-charged, the composition of the lubricant, etc.

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

Ph.D. candidates (years, institution):

- G. Zavaleta (2025-present, DD Centrale Lyon - Tohoku University)

Master/Bachelor students (years):

-

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

FR to JP (date, duration):

- G. Zavaleta (2026, 1 year)

JP to FR (date, duration):

-

COMMUNICATIONS AND VALORIZATION

Others *(gray color for previous years)*

	People	Event	Description	Date
1	G. Zavaleta, N. Mary, T. Uchimoto, C. Minfray, A. C. P. Rodrigues	ElyT Workshop 2025	Poster presentation	Feb. 19-21th, 2025

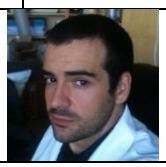
Project report 2024

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 [b,d,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 – INSA – ECLyon - UCBLyon - 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%)*	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)*

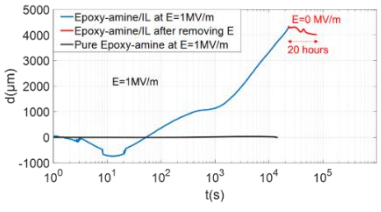
- BQR INSA 2023-2024

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 Maxwell stress tensor on COMSOL®.
- Fair agreement with a single set of parameters is obtained only with concentrated diffusion formalism (slow-down of diffusion when the ion concentration approaches its maximum value)
- In the case of Ionic liquid doped elastomers, 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 positive 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? What is the cause of the remnant deformation observed in ionic liquid doped elastomers.

Research method (8 lines max; Calibri 11)

New 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 have been characterized. Electrical (dielectric and bending spectroscopy under constant electric field), mechanical (mechanical spectroscopy) and structural (EDX, DRX, AFM) characterizations were performed 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.

Meanwhile simulations of ion segregation kinetics on PU by drift-diffusion of ions with slightly asymmetric mobility, then application of the local resulting Maxwell stress tensor enabled to monitor the bending kinetics on COMSOL®. Fortran drift-diffusion model is used to test hypothesis on diffusion, such as the slowing down of the diffusion process at high ion concentrations, viz. close to the electrodes, which was then also implemented on COMSOL® and enables to satisfactorily fir our reference experimental data on PU, for fields ranging from [2.10^6 - 10^7 V/m] with the same set of parameters.

Challenge for the coming years is (modelling) to transfer and adapt the modeling for epoxy-amine model samples and (experiments) to design ions the segregation of which can be traced by EDX on both anode and cathode. An ANR project has been submitted for that purpose and a joint PhD thesis projected.

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 March-August 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	Dec 2024	2 weeks
JY Cavaillé	Nov 2024	2 weeks
L Seveyrat	Nov 2024	2 weeks

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
JY Cavaillé	Oct-Nov 2019	2 weeks
JY Cavaillé	June-July 2019	2 weeks
JY Cavaillé	Feb-March 2019	1 week
JY Cavaillé	Apr-2019	2 weeks
K. Yuse	June-July 2019	1 week
K. Yuse	Oct-Nov 2019	1 week

JP to FR (date, duration):

Y. Akimoto	Dec. 2024	2 weeks
H. Takana	May-Jul. 2024	3 months
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	Axel Blain, Véronique Perrin, Laurence Seveyrat, Florent Dalmas, Sébastien Livi, Joël Courbon, Gildas Diguet, Hidemasa Takana, Jean-Yves Cavaillé, Gildas Coativy	Effect of ionic liquid on soft epoxy-amine electroactuators	Polymer	312	127601	2024	10.1016/j.polymer.2024.127601
2	Gildas Diguet, Jean-Yves Cavaillé, Gildas Coativy, Joel Courbon	Electric space charge threshold observation in polyurethane under high electric fields	Journal of Applied Physics	135	224101	2024	10.1063/5.0182679
3	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
4	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
5	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
6	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	D. Djoumoi, A. Blain, L. Seveyrat, V. Perrin, F. Dalmas, S. Livi, J. Courbon, H. Takana, G. Sebald, J.-Y. Cavaillé, G. Coativy	Ion-doped polymer actuators: experiments and modeling	ELyT Workshop	Febr. 2025	Annecy	France	
2	J. Courbon, H. Takana, G. Coativy, J.-Y. Cavaillé	Parametric Study of Ion Flow Through Polymer Strip Submitted to a High Voltage	21st ICFD	Nov. 2024	Sendai	Japan	
3	Djasma Djoumoi, Laurence Seveyrat, Véronique Perrin ,Florent Dalmas, Sébastien Livi, Joël Courbon,Hidemasa Takana, Jean-Yves Cavaillé, Gildas Coativy	Investigation of electric field induced bending of epoxy-amine elastomers doped with ionic liquids	21st ICFD	Nov. 2024	Sendai	Japan	
4	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	
5	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	
6	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	
7	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	

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
8	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	
9	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	
10	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	
11	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	
12	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
13	Kaori Yuse, Gildas Diguet, JY Cavaille	Electrical Conductivity Versus Electrostriction in Di-Block Polyurethane: New Insights	16th ICFD	2019 Nov. 6-8	Sendai	Japan	
14	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	
15	Gildas Diguet & Kaori Yuse	Seminar on Electrostriction	Morita's Lab	2019 July 8	Todai, Tokyo	Japan	
16	A. Suzuki, M. Miyano, R. Miura	Theoretical estimation of dielectrics constant of electroactive polymers	15th ICFD	2018 Nov 7-9	Sendai	Japan	

Project report 2024

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)*

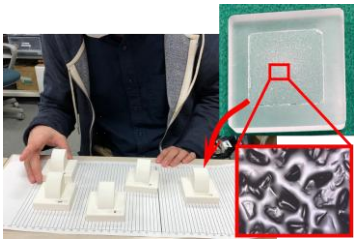
- International Society for Advanced Drawing Breakthrough project, 2021-2023, COMCOM
- ANR-JST project, 2016-2019, COMICA
- PHC, 2014-2016, Sakura

Estimated annual budget:

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

- 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 relationship among tactile perception, surface properties, and human characteristics

Research method (8 lines max; Calibri 11)

The purpose of this study is 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):

- 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	M. Takanari, T. Okuyama, C. Pailler-Mattei, M. Tanaka	Study on the relationship between the skin properties of the finger pad and vibration perception	The 20th International Conference on Precision Engineering	23-27 October 2024	Sendai	Japan	
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	

TP-VIP

Thermal Properties versus fiber core microstructure in Vacuum Insulation Pannels

MAIN PARTICIPANTS

				
G. FORAY[a]	**C. LE-BOURLOT**[a]	**P. DUMONT**[b]	**F. MARTOIA**[b]	**A. KOMIYA**[c]

[a] *INSA-Lyon, MatéIS, UMR CNRS 5510, 69621, Villeurbanne, France*
[b] *INSA-Lyon, LAMCOS, UMR CNRS 5559, 69621, Villeurbanne, France*
[b] *Institute of Fluid Science, Tohoku University, 980-8577, Sendai, Japan*

Contact: genevieve.foray@insa-lyon.fr, komiya@tohoku.ac.jp

OVERVIEW

Starting year: 2024 **Current researchers** (permanent/non-permanent): 4 person-month/year

Positioning	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design		75 %	
Surfaces and interfaces			
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

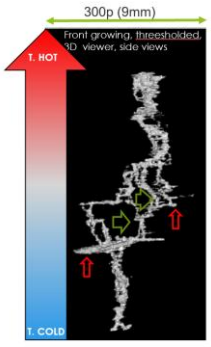
For main projects: Agency / year / name of project
Under construction :
- Ambassy budget, 2023-2025, Sakura 6 K€
- CNRS budget, 2025-2026, SMI, international mobility10 K€

Estimated annual budget: 25 k€

Highlights & Outstanding achievements

- We have demonstrated the reconstruction of a thermal bridge inside of insulator by using 3D tomography
- A series of numerical simulations considering radiative heat transfer was performed.
- New interdisciplinary research community was established.
- 1 Double-Degree student has participated in this project

Illustration



PROJECT DESCRIPTION

Background

Vacuum insulation panels (VIPs) are excellent insulators exhibit thermal conductivity down to 1-2 $mW \cdot m^{-1} \cdot K^{-1}$. The VIP market has boomed over the last decade and still expands requiring new core material source. VIPs are particularly well-suited for applications such as refrigerators and iso-thermal delivery boxes due to their low thickness. The VIPs thermal conductivity and internal pressure evolve over application time. Although their performance remains excellent compared to other materials, understanding the mechanisms is crucial to preserving our resources, increasing recyclability or promoting reversibility. In this project, we're aiming at the complete understanding of aging effect of VIP from the viewpoint of structure of inside thermal bridge and radiative heat transfer. Particularly, experimental and analytical approaches are applied in this project.

Key scientific question

How is the thermal conductivity of VIP affected over time?
How much is the contribution of radiative heat transfer inside VIP?

Research method

Our preliminary study focuses on VIPs with fibrous core materials, aiming to identify the intrinsic mechanisms within the core that contribute to aging. To this end, using our Double X-ray Tomography Emission (DLTE), we performed X-ray tomography measurement. We already know that these panels have experienced a change in thermal conductivity from 1.2 to 8.6 $mW \cdot m^{-1} \cdot K^{-1}$. Key question is how is the heat conduction affected by the time. So, in this study, we continuously measure the structure change of thermal bridges. Also, we will focus on the contribution of radiative heat transfer inside VIP using numerical simulation. Our scientific aim is to determine the changes the fibrous material and the porous network has undergone to better characterize it.

Research students involved

Ph.D. candidates (years, institution):

- Matéo Groux (2024-present, DD INSA Lyon – Tohoku University)

Master/Bachelor students (years):

- Ayuki Inokoshi (2023-2024, Tohoku University)

Visits and stays

FR to JP (date, duration):

- G. Foray ((March 2024, 7 days)

JP to FR (date, duration):

- A. Komiya (January 2025, 5 days)
- A. Komiya (February 2022, 8 days)

COMMUNICATIONS AND VALORIZATION

Conferences

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	M. Groux, C. Lebourlot, P. Dumont, F. Martoia, A. Komiya, G. Foray	*Thermal properties versus fibre core microstructure in Vacuum Insulation Panels, towards ageing understanding to ensure ecodesign*	ELyT Workshop 2025	19-21 Feb., 2025	Lyon, Annecy	France	
2	Ayuki Inokoshi, Atsuki Komiya	*Evaluation of the Influence of Radiation on the Thermal Properties of Foam Insulation Materials using the Guarded Hot Plate Method*	Symposium on 60th JSME Tohoku-branch	17 Mar., 2025	Sendai	Japan	

Project report 2024

VIVO-CHIP

Vascular Integration in Three-Dimensional Organoid-on-Chip Platform

MAIN PARTICIPANTS

				
Satoshi ARATAKE[a]	**Laetitia GEROSSIER[b]**	**Nicolas AZNAR[c]**	**Kenichi FUNAMOTO[a]**	**Minh Hoang BUI[b]**

[a] *Tohoku University, Sendai, Japan*
[b] *Université Claude Bernard Lyon 1, France*
[c] *Cancer Research Centre of Lyon, France*

Contact: Nicolas.aznar@cnrs.fr; funamoto@tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2024 **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)*

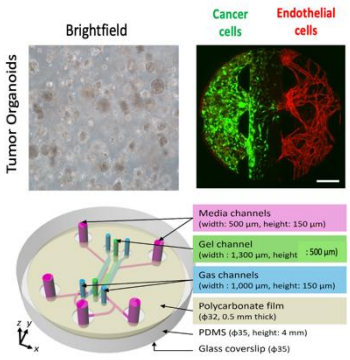
- IFS LyC project 2021-2022 ORGANOX project
- IFS LyC project 2022-2023 ORGANOX project
- IFS LyC project 2023-2024 VIVO-CHIP project

Estimated annual budget: 20 000€

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

- Optimization of patient-derived organoid (PDO) cultures from fresh tumors.
- Optimization of endothelial and cancer cells co-culture.
- We designed and developed an innovative three-dimensional (3D) cell culture chip integrating a fluidic system for enhanced functionality.

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 cancers. Developing more robust and relevant *in vitro* models is crucial to better recapitulate pathologies and improve the predictive power of preclinical studies. This project aims to develop an advanced organoid-on-chip platform to investigate the intricate interplay between organoids, different cell types, and vascularization processes within a physiologically relevant microenvironment. The study will focus on enhancing our understanding of the dynamic interactions between organoids and vascular networks, with potential applications in cancer modeling and drug screening.

Key scientific question (2 lines max; Calibri 11)

(1) Understand the impact of organoid-specific factors on spatiotemporal dynamics of vessel sprouting and morphology. (2) Improve efficacy of conventional chemotherapy.

Research method (8 lines max; Calibri 11)

Organoid Culture: Establish robust protocols for the culture of three-dimensional organoids representative of specific organ systems, ensuring cellular diversity and functionality. Utilize patient-derived organoids for cancer applications.

Endothelial Cell Incorporation: Integrate endothelial cells into the organoid culture to mimic the *in vivo* vascularization process. Optimize conditions for the co-culture of organoids and endothelial cells to promote vascular network formation and maturation.

Organoid-on-Chip Development: Design and fabrication of a microfluidic organoid-on-chip device that allows for precise control over the microenvironment, including nutrient supply, oxygenation, and waste removal. Implement microscale features to simulate physiological conditions and facilitate real-time monitoring.

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

Ph.D. candidates (years, institution):

- Satoshi ARATAKE (2022-2024, Tohoku University)

Master/Bachelor students (years):

- Minh Hoang BUI (2024, UCBL)

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

FR to JP (date, duration):

- Nicolas AZNAR (CRCN CNRS, November 2024, 20 days)

JP to FR (date, duration):

- Kenichi Funamoto (Professor, March 2024, 4 days)

COMMUNICATIONS AND VALORIZATION

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	Satoshi Aratake, Morgane Roinard, Zhouxing Su, Jean-Paul Rieu, Kenichi Funamoto, Nicolas Aznar	Investigation of a predictive therapeutic response under controlled oxygen condition in cancer patient-derived organoids	The 21st International Conference on Flow Dynamics (ICFD2024), OS14 Innovations in Oncology	Novembre 2024	Sendai	Japan	
2	Satoshi Aratake, Morgane Roinard, Zhouxing Su, Jean-Paul Rieu, Kenichi Funamoto, Nicolas Aznar	Investigation of a predictive therapeutic response under controlled oxygen condition in cancer patient-derived organoids	The 21st International Conference on Flow Dynamics (ICFD2024), OS25: IFS Lyon Center Collaborative Research Forum	Novembre 2024	Sendai	Japan	

Outlook

After several years marked by a unique situation due to health conditions, and follwoing the metamorphosis and renewal of the ELyT Global IRN in 2022 and 2023, 2024 is the year when things returned to normal, with operating conditions similar to those before COVID. The re-establishment of regular physical meetings significantly enhanced cohesion within the network, facilitated the emergence of new research synergies, and contributed to increased international visibility. All the indicators (numbers of researchers and labs, publications, involved students and early-career researchers…) are stable or slightly increasing, in average.

ELyT Global aims to further consolidate its role as a structuring platform for long-term, high-impact collaboration in Engineering Sciences between its partner institutions, in Japan and in France, together with other international partners. In 2025 and beyond, priority will be given to strengthening joint research programs, fostering interdisciplinary initiatives, and increasing the involvement of early-career researchers in multilateral projects. Particular attention will also be devoted to enhancing mobility schemes, facilitating co-supervised PhD projects, and encouraging the development of joint publications and coordinated responses to international calls for proposals.

At the strategic level, ELyT Global will continue to refine its governance and operational mechanisms to ensure agility, visibility, and sustainability in an evolving international research landscape. By consolidating joint research initiatives, and developing international projects, ELyT Global IRN is well positioned to expand its scientific impact and to reinforce its role as a flagship model of structured France–Japan collaboration in Engineering Sciences.

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 schools.

This document exposes main actions that have been achieved in the framework of the IRN for year 2024. 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 24 projects involving 27 laboratories and 96 researchers.

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