Annual Report 2022

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Executive Summary

This document exposes the actions of the ELyT Global IRN[1] during the year 2022. 2022 allowed an easing of the international exchanges along with the favorable evolution of the sanitary situation, allowing many events to take place as well as many new actions and collaborations in the framework of the IRN.

25 projects were running in 2022, including 11 new ones. 96 researchers from 27 labs (13 French, 10 Japanese, 1 joint FR/JP, 1 Chinese, 1 Indian and 1 Polish) were involved in these projects, representing 160 person-months in total. 2022 has seen a significant transformation, as the return to face-to-face meetings led to profound changes in collaborations, with some of them eventually stopped in the framework of ELyT Global, while new ones emerged. Overall, the IRN experienced a remarkable increase, with 3 more projects, a gain of 19 involved researchers and 6 labs, the restart of mobility since mid-2022 which in a little bit more than 6 months showed a similar number than a typical pre-Covid full year. New projects also permitted young people joining the IRN. On that aspect, projects involved 7 Master students, some performing research visits up to 6 months, and 25 Ph.D. students among which 12 are performing a Double Degree.

The easing of international travels since mid-2022 also allowed the organization of face-to-face meetings. Hence, ELyT workshop, held remotely in 2021, has been done on site in Lyon in 2022. Also, after 2 years of cancellation of the ELyT School (despite attempts to propose a remote event), it has finally been held on site in 2022, in conjunction with the ELyT workshop. This end of travel restriction also allowed performing numerous events to celebrate the collaborations (Doctor Honoris Causa, Alumni events…).

This report aims to expose the idea behind the ELyT initiative in general, and ELyT Global in particular. Then the actions performed in 2022 are reported, along with the detailed description of associated projects. Finally, some future opportunities and challenges are discussed.

[1] International Research Network

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The ELyT initiative

ELyT, namely "Engineering science Lyon-Tohoku" emerged more than 2 decades ago through collaborations between researchers from Tohoku and INSA-Lyon and ECL. 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 LIA (International Associated Laboratory), now **ELyT Global IRN** (International Research Network), 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 2021.
- ELyTMaX ("Material under eXtreme conditions) UMI (International Mixt Unit), now **ELyT MaX IRL** (International Research Laboratory), consisting of a classical independent laboratory, having premises both in Japan and 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 in 2020[2] and 2021.

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, INSA Lyon, ENISE, 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 UCB, 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 *LabEx 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

For more than 20 years, very close collaborations between two Lyon/France institutions (Ecole Centrale de Lyon and INSA Lyon, Université de 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 four 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

[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).

and Tokyo-Sendai December. Both in education and research, remarkable achievements had been 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, *i.e.,* 12 years ago. 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, 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 ELyT MaX 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).

[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.

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, 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, and 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 (with an engineer preparing a Ph.D. now in France).

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

[9] Institute of Fluid Science Lyon Center

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

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 LIA. The other point about this LIA was to broaden the collaboration at the University of Lyon level. 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 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 LIA/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 LIA/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 Ph.D.s such as with Michelin or Denso. Last year a new collaboration with Nippon Steel had emerged. An engineer from this company (Masato Taira) is now preparing for his Ph.D. in MATEIS Lab in INSA Lyon.

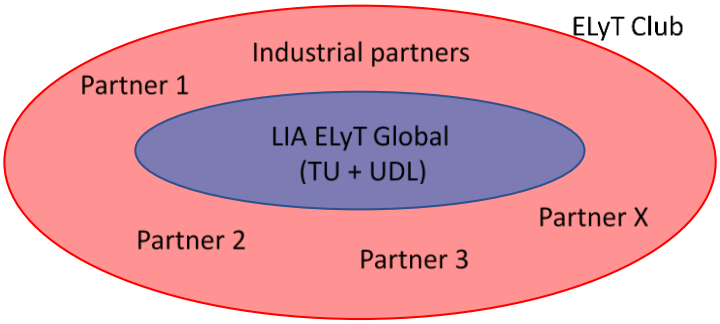


Figure 1: Scheme of the concept of ELyT Global and ELyT Club.

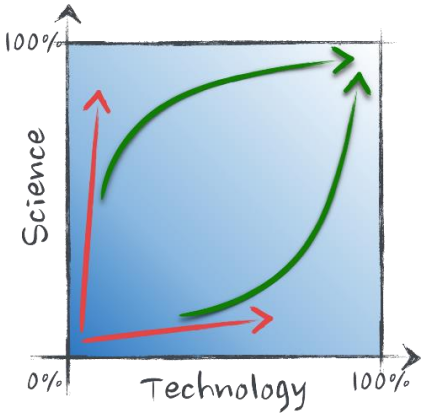


Figure 2: Schematic illustrating the paths towards mature technologies, based on the combination of science and technology. ELyT Global aims at following the green arrows, using science to improve technology.

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.

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 in 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.

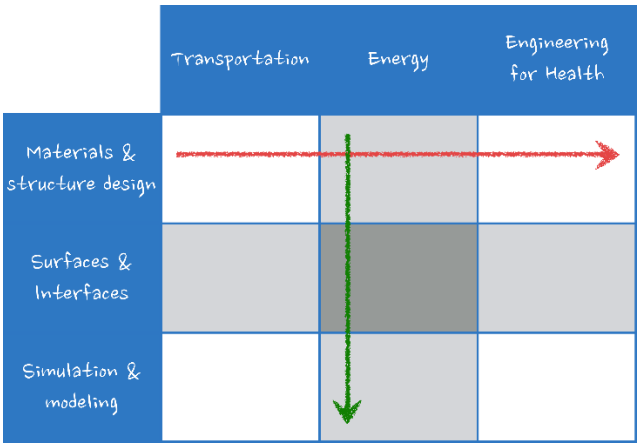


Figure 3: The 3 main themes (columns) and the three main topics (rows) of ELyT Global. Projects will belong either to a theme for application-oriented ones, or to a topic for science-oriented ones.

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.

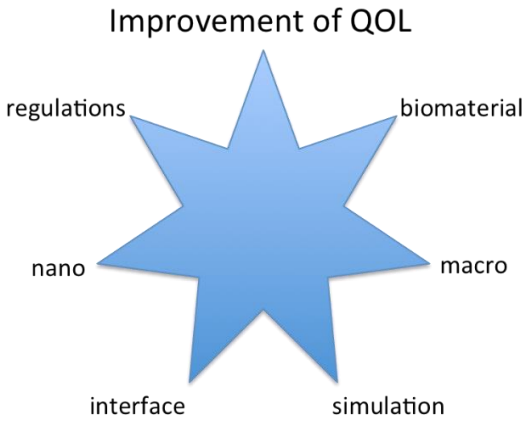


Figure 4: Schematic of the different challenges to address for improving quality of life (QOL).

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.

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 Lab 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 LIA/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 participants attend these meeting among them at least 40 come from abroad.

Education aspect – training through international research

ELyT Global 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 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.

Objectives

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

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

- 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 Lab (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 Lab 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 LIA/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	Dr. 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 evelyne.dorieux@insa-lyon.fr	Dr. FRIDRICI Vincent Ms NAVARRO Sylvie sylvie.navarro@ec-lyon.fr	Prof. UCHIMOTO Tetsuya

Table 1. ELyT workshop 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 three directors, potential members are:

- The Director of the CNRS Institute of Information and Engineering Sciences, or his 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 the 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. ELyT laboratories.

2022 activities

Forewords

2022 has seen a **significant release of the travel conditions** with respect to the sanitary situation. Such a significant changes compared to the last three years brought a **significant positive dynamic** to the network. Of course, such an expansion has been possible thanks to the **resilience of the network** during lockdown and restrictions of travel. Hence, the number of **involved researchers raised to 96** (+19 compared to 2021). The number of projects also increased from 22 in 2021 to **25 in 2022. 11 new projects** started thanks to the return to face-to-face meetings. On the other hand, this remarkable vigor in terms of project creation also means that 8 projects stopped in 2022 (or where transformed). This therefore demonstrates that the IRN has known, with this particular change in situation, a **metamorphosis** to some extent. This also applies for the involved lab, from 19 in 2021 to **27 in 2022**, hiding a slight turnover and extension but also with a strengthening of the core involved labs.

The relative freedom to travel since middle of May also allowed setting many events and celebrations face-to-face, starting with the **ELyT Workshop** and **ELyT School**, along with other **numerous activities** as detailed below.

ELyT workshop

2022 edition of the ELyT workshop was held in a face-to-face format in Lyon, on November 16th to 18th. Over two and a half days, researchers from ELyT and beyond exposed their latest research advances in the framework of Lyon-Tohoku collaborations or as basis for future collaborations. The workshop gathered **84 participants**, with **40 presentations** including **4 invited talks** (Valéry Botton - INSA Lyon -, Anne-Lise Cristol & Yannick Desplanques - Centrale Lille -, Ausrine Bartasyte - Université de Franche-Comté – and Kostas Danas - Ecole Polytechnique), 3 of them being outside the Lyon area. The workshop also included a **dedicated symposium on the Core-to-Core project on ammonia combustion**, showing the strong partnership concluded with Lyon, as well as a **Double Degree Ph.D. round table**, exposing the benefit, both at personal and professional levels, of pursuing such a cursus. The detailed program of the workshop is given in Table 3.

Wednesday, November 16th

INSA - Rotonde / Agora

8:30	9:00	Welcome coffee
9:00	11:10	Doctor Honoris Causa ceremony for **Professor Toshiyuki Takagi** Round table Picture
11:10	11:30	Opening of the workshop
11:30	13:30	Cocktail
13:30	14:10	Flows driven by ultrasounds in liquids in a wall mass transfer enhancement perspective **Valéry Botton** *et al.* (INSA Lyon)
14:10	14:30	Kinetics of Polyurethane Bending over Long Times under Electric Field (TEmPuRA) **Gildas Coativy** *et al.* (INSA Lyon)
14:30	14:50	Thermodynamic modelling of liquid metal dealloying **Pierre-Antoine Geslin** *et al.* (INSA Lyon)
14:50	15:10	Fracture behavior of Al-Fe welds **Kiyoaki Suzuki and Sylvain Dancette** (TU and INSA Lyon)
15:10	15:30	Tensile properties of silk fibers obtained from silkworms fed cellulose nanofibers **Hiroki Kurita** *et al.* (TU)
15:30	15:50	NDT based on the magnetization mechanisms: last progress in the frame of BENTO **Benjamin Ducharne** *et al.* (INSA Lyon)
15:50	16:10	Coffee break
16:10	16:30	Making cool with elastocaloric polymers: progress of the ELyT Global REFRESH project **Gaël Sebald** *et al.* (TU)
16:30	16:50	Modelling of elastocaloric polymers-based heat pump: heat transfer analysis & improved design **Giulia Lombardi** *et al.* (TU)
16:50	17:10	Analysis of energy conversion potentials of Metglas 2605SA1 for energy harvesting applications by measuring Ericsson cycle **Yuanyuan Liu** *et al.* (INSA Lyon)
17:10	17:30	Calibration of an in vivo biomechanical characterisation device for unruptured cerebral aneurysms: first results on polymeric phantom arteries **Guillaume Plet** *et al.* (ECL)
17:30	17:50	Design of a polymeric cerebral aneurysm based on numerical modelling for the development of an aneurysm mechanical characterisation device **Jolan Raviol** *et al.* (ECL)
17:50	18:10	Observation of endothelial cell response to various stenting deployment in an *in vitro* flow system **Hanif Saifurrahman** *et al.* (TU)
18:10	18:30	Nd^{3+}-doped $20Al(PO_3)_3$-80LiF glass : a promising VUV scintillator material for high-counting-rate fast neutron detection **Georges Boulon** *et al.* (Univ. Lyon 1 UCBL)

Thursday, November 17th

Ecole Centrale de Lyon - Building W1 / Amphi 3

7:40		Bus departure from INSA to ECL (in front of La Rotonde)
9:00	9:40	Wear and emissions of highly dissipative rubbing systems: how to learn from experiment? **Anne-Lise Cristol, Yannick Desplanques** *et al.* (Centrale Lille)
9:40	10:00	Atomic structure of bulk metallic glasses investigated by transmission electron microscopy, synchrotron-radiation X-ray diffraction, scanning tunneling microscopy and ab-initio molecular dynamics simulation **Dimitri Louzguine** (TU)
10:00	10:20	Skyrmion stabilization by geometric confinement and uniaxial strain **Hiroshi Koibuchi** (National Institute of Technology (KOSEN), Ibaraki College)
10:20	10:40	Coffee break
10:40	11:00	Evaluation of the thermal gradient of in-flight polymer particles during cold spray process **Chrystelle Bernard** *et al.* (TU)
11:00	11:20	EDOT polymerization in an emulsion by plasma enveloped bubble **Kazuhiko Otake** *et al.* (TU)
11:20	11:40	Electrochemical- and gaseous hydrogen monitoring system for thermodynamic equilibrium state using hydrogen-permeable Pd tubes **Helmut Takahiro Uchida** *et al.* (Tokai University)
11:40	12:00	Diffusion of water in epoxy ionic liquid composite polymer cured and its effect on dielectric and mechanical properties **Lucas Ollivier-Lamarque** *et al.* (TU)
12:00	14:00	Lunch and poster session
14:00	14:40	$LiNbO_3$ films for acoustic filters and vibrational energy harvesting **Ausrine Bartasyte** (Université de Franche-Comté)
14:40	15:00	Flow structure extraction related to the noise generation in a subsonic free jet by using mode decomposition methods **Shota Morita** *et al.* (TU)
15:00	15:20	Sensitivity analysis to investigate the secondary structure from atmospheric shear flow **Ryoichi Yoshimura** *et al.* (TU)
15:20	15:40	Superlubricity of a-C/Si_3N4 contact in presence of castor oil **Maria-Isabel de Barros Bouchet** *et al.* (ECL)
15:40	16:00	Multi-scale elucidation of friction mechanisms in ice-rubber interfaces **Anderson Dalavale Kaiser Pinto** *et al.* (ECL)
16:00	17:00	Coffee break and poster session
17:00	17:20	Introduction of synthetic artery data **Kazuyoshi Jin** *et al.* (TU)
17:20	17:40	Blood flow simulations in cerebrovascular models from BraVa database **Yutaro Kohata** *et al.* (TU)
17:40	18:00	Robust shape optimization of a disc-brake system under dynamical criterion **Frédéric Gillot, Achille Jacquemond** *et al.* (ECL)
20:00	23:00	**Banquet** On board Hermès II (13 bis quai Rambaud - 69002 Lyon)

Friday, November 18th

INSA - Building H. Lamarr / Amphi Chappe

9:00	11:00	JSPS Core-to-Core symposium 1. Introduction of core to core by Pr. Takashi Tokumasu (online) 2. Introductions of ammonia utilization and combustion by Pr. Akihiko Hayakawa 3. Ammonia : possible free-carbon fuel for energy and transport applications, Invited talk by Pr. Christine Mounaïm-Rousselle
11:00	12:00	Double-degree PhD Round table
12:00	13:30	Lunch
13:30	14:10	Recent advances in the study of magnetorheological elastomers (MREs) **Kostas Danas** *et al.* (Ecole Polytechnique)
14:10	14:30	Material design for corrosion and stress corrosion cracking management in nuclear applications **Hiroshi Abe** (TU) and **Benoît Ter-Ovanessian** (INSA Lyon)
14:30	14:50	Hypoxia triggers collective aerotactic spreading of eukaryotic cells **Nasser Ghazi** *et al.* (Univ. Lyon 1 UCBL)
14:50	15:10	Cancer cell migration under oxygen concentration gradients **Kenichi Funamoto** *et al.* (TU)
15:10	15:30	Effect of wall elasticity on flow instability and wall shear stress of a full-scale, patient-specific phantom in middle cerebral artery **Ryuhei Yamaguchi** *et al.* (TU)
15:30	15:50	Coffee break
15:50	16:10	Effect of difference wall stiffness between single-segment models and two-segments models on velocity map **Daibo Kotaro** *et al.* (TU)
16:10	16:30	Modeling of Olsen cycle for pyroelectric energy harvesting and assessment of abnormal electrocaloric effect in ferroelectric single crystals **Gaspard Taxil** *et al.* (INSA Lyon)
16:30	16:50	Thermal processes in thermomagnetic energy generators **Joel Joseph** *et al.* (Karlsruhe Institute of Technology)
16:50	17:10	Radiative cooling of solar cells: detailed optoelectro-thermal modeling and influence of surface structuring **Mohamed Amara** *et al.* (INSA Lyon)
17:10	17:30	Ferromagnetic alloys for integrated electrical protection circuits **Mickaël Lallart** *et al.* (INSA Lyon)
17:30	17:50	Thermodynamic Analysis of a New Electric Environmental Control System **Takahiro Adachi** (Akita University)
17:50	18:10	CarboEDiffSim :Molecular Theory Analysis of Carbon Diffusion in Iron which is Happened Phase Transformation under Electric Field **Patrice Chantrenne** *et al.* (INSA Lyon)
18:10	18:30	Closing session **Toshiyuki Takagi** (TU)

Table 3. ELyT WS schedule.

Education through research

ELyT School

After 3 years with limited international exchanges due to covid pandemy, ElyT school is back. The easing of travel in the second part of 2022 allowed the ELyT School to finally take place, in **a face-to-face** format, at the **same time than the workshop** (November 16th to 18th). Thus, **25 students** including **10 from the University of Tohoku**, from various scientific backgrounds, were able to travel to Lyon to discuss in a friendly atmosphere. In conjunction with ELyT workshop, ELyT School allowed students to **discover labs in Lyon**, as well as **intercultural aspects** through dedicated activities.

As the school was held at the **same time than the ElyT workshop**, which brought together researchers around collaborative projects, ElyT School therefore only took place over **3 days**, a shorter format but which allowed students discussing at length and attending **presentations by the researchers** supervising them along with **participation to round tables**, thus giving them a **good overview of the research professions**.

The various activities offered to the students were a great success. After a warm welcome around a meal at Ninkasi on the first evening, the students met for a presentation session allowing them to know each other better and to understand the **specificities of teaching and student life in the foreign country**.

These three days together also gave them the opportunity to **visit the laboratories of INSA and the Ecole Centrale**. The **testimonies of expatriate researchers or students** under joint supervision were not forgotten and **two round tables** were organized, during which many questions were answered.

The detailed timetable of the ELyT School is provided in Table 4.

Ab Initio and Molecular Dynamics School

In February 2020 the first Molecular Dynamics school was organized in Sendai within the Elyt Global framework. It gathered students from Tohoku University (TU) and INSA. This **second school** was still organized within the Elyt Global Framework, but is enlarged to **a new partner**, Aristotle University of Thessaloniki (AUTH). Held on March 4th-11th 2022 **in Lyon** in a hybrid format, it gathered students from TU, INSA, and AUTH. The topic of the school is also **enriched since Molecular Dynamics but also Ab Initio** simulations will be parts of the program.

The number of research topics linked with atomic scale simulations are increasing, either for research on nanostructured materials and systems or to understand the physical phenomena leading to material microstructure during material processing. Despite many cursi are available to learn basics of physics, nano-sciences and nano-technologies, too few students have already experienced the use of Ab Initio (AI) and Molecular Dynamics (MD) **simulation tools**.

The goals of this school were:

- To give students the **principles and basis** of AI and MD simulations,
- To taught them **how to use softwares** for AI and MD simulations (SIESTA, LAMMPS, Quantum expresso)
- To work on a **simulation project**.

Start FR	End FR	Day 1, Nov. 16th (WED)	Day 2, Nov. 17th (THU)	Day 3, Nov. 18th (FRI)
08:30	09:00	**Opening ELyT School - Rothonde Agora**	**7:40: Bus departure from la Doua to ECL**	**INSA-Lyon (Amphitheater Chappe, bât. H. Lamarr)**
09:00	09:20	Doctor Honoris Causa ceremony for Professor Toshiyuki Takagi *(INSA - Rotonde/Agora)*	Invited talk, Yannick Despnaques (Lille) et AnneLise Cristol (ECL), Tribology	JSPS Core-to-Core symposium 1. Introduction of core to core by Pr Tokumasu 2. Ammonia world by Pr Hayakawa 3. Invited talk by Pr Christine Mounaïm-Rousselle
09:20	09:40			
09:40	10:00			
10:00	10:20		Student presentations (10 students (5-10 min/student))	
10:20	10:40			
10:40	11:00			
11:00	11:20	Alumni event with Japanese Consulate *(INSA - Rotonde/Agora)*	Lab visit LMFA /visite campus (2 groupes)	Double-degree PhD Round table *(Amphitheater Chappe, bât. H. Lamarr)*
11:20	11:40			
11:40	12:00			
12:00	12:20	Cocktail *(INSA - Rotonde/Agora)*	Lunch	Lunch *(Amphitheater Chappe, bât. H. Lamarr)*
12:20	12:40			
12:40	13:00			
13:00	13:30			
13:30	13:40	Invited Talk, Valery Bottom, INSA, Flows driven by ultrasounds in liquids in a wall mass transfer enhancement perspective		Invited Talk, Kostas Danas (Ecole polytechnique), Magnetism, Smart Materials (Amphitheater Chappe, bât. H. Lamarr)
13:40	14:10			
14:10	14:20	Presentation of ELyT activities and ELyT School- Buiding Ada Lovelace - Room Goodyear 125	Invited Talk, Austine Bartasyte (Univ Franche Comté), Materials integration	Norio Mihara "new era of multiculturalism" Buiding Ada Lovelace - Room Georges Charpy n°132
14:20	14:40			
14:40	15:00			
15:00	15:20	Student presentations (10 students (5-10 min/student)) - Buiding Ada Lovelace - Room Goodyear 125	Lab visit LTDS + AMPERE (2 groupes)	
15:20	15:40			
15:40	16:00			
16:00	16:20		Poster session (ELyT Lab Symposium)	Cheese (and wine) discovery 16-18h - DRI -3rd floor - building Charlotte Perriand
16:20	16:40			
16:40	17:00	ELyT-Lab and MATEIS visit		
17:00	17:20			
17:20	17:40			
17:40	18:00			
18:00	18:20			
18:20	18:40			Closing: 18:00-18:30
18:40	19:00	Dinner betwwen students: Ninkasi La Doua		
19:00	19:20			
19:20	19:40			
19:40	20:00			
20:00	20:20		Banquet (on the boat HermesII on Saone river, 20:00 but be in advance!)	
20:20	20:40			
20:40	21:00			
21:00	21:20			
21:20	21:40			
21:40	22:00			

Table 4. ELyT School schedule.

Alumni event

A round table organized jointly with the **Japan consulate office in Lyon regarding expatriation to and from Japan** was the occasion, during the numerous events held on Nov. 16th-18th, of exchanging wonderful experiences of **Japanese people working in France and conversely**. The round table (Figure 5) consisted in testimonies and cross-exchanges with the audience from **three researchers from Tohoku University** (Atsuki KOMIYA, Professor, Hiroki KURITA, assistant professor, and Yutaro KOHATA, Double Degree Ph.D. student) and two people **from France** (M. Eric FILIPPI, Director of the Lyon Japan Space - "Espace Lyon Japon"– and M. Florian LE COZ). The discussions emphasized **the great knowledge and open mindedness**, as well as **opportunities**, brought by such experiences.

Figure 5: Alumni event.

DD Ph.D. student round table

Following the successful organization, in a remote condition, of a Double Degree Ph.D. students webinar in September 2021, an **on-site round table regarding the opportunities and personal development offered by DD Ph.D. curricula** has been organized on Nov. 18th. During one hour, **testimonies from French and Japanese DD Ph.D. students and alumni** allowed pointing out all the benefits brought by such a path. They also shared their own experience of this cursus, providing significant and precious advice to **undergraduate students interested by this program**. This was then followed by **fruitful discussions** between DD Ph.D. (students and alumni) and the audience, giving precious information to serenely enroll in this way and how to valorize it.

Inauguration of the Japan Room @ ECL

As an additional demonstration of the strong links between Lyon and Tohoku, the inauguration of the **Japan Room @ ECL** was a supplementary achievement. Such a space will be a privileged area for the **short- and medium-term visits** from Japanese colleagues and students to promote the bilateral collaboration.

Figure 6: Japan Room@ECL.

Doctor Honoris Causa of Prof. TAKAGI

In recognition of his impressive **contribution to the scientific community** on electromagnetic nondestructive testing and evaluation, as well of his wonderful **involvement in the construction of Tohoku-Lyon partnership**, it was a great delight and honor to **award Prof. Toshiyuki TAKAGI the Doctor Honoris Causa** title from Prof. Frédéric FOTIADU, president of INSA Lyon, under the honorary chairmanship of Gabriele FIONI, Deputy Rector for Higher Education, Research and Innovation of the Auvergne-Rhône-Alpes academic region, Frank DEBOUCK, President of the University of Lyon, Kenji KURATOMI, Consul , Head of the Japanese Consular Office in Lyon, Frédéric FOTIADU, President of INSA and Marie-Christine BAIETTO, Vice-President of Research and Development in INSA Lyon (Figure 7).

Official visits and partnerships

2022 also provided strengthening of the links with supporting institutions but also with diplomatic representatives. Hence, **a visit of Mr Kuratomi Kenji, Consul** – chef du Bureau Consulaire du Japon à Lyon - on February 16th, 2022, established **strong links with the ELyT initiative** (Figure 8). From example, it triggered the establishment of Alumni round table previously described) during the celebrations of Nov. 16th, 2022.

Figure 7: Doctor Honoris Causa ceremony for Prof. Takagi.

Figure 8: visit of Mr Kuratomi Kenji, Consul.

Researcher long-term mobility and master student exchange

Although 2022 has seen a release in the travel, this easing has only been active since mid-2022. Hence, long-term mobilities have still been impaired this year. Yet, **three long term visits** (>2 months), 2 from France to Japan and 1 from Japan to France, has been performed (not counting DD Ph.D. student and researchers in delegation).

Master exchange, notably in the framework of a PAI program LyonSE&N Welcome (including ELyT but broader), also restarted. Hence, **7 Master students** from Japan have been visiting labs in Lyon in the framework of collaborative research between French and Japanese laboratories. They stayed in French lab for an **average period of 2,5 months**, and **up to 6 months**. This number, keeping in mind that travels were allowed only from mid-2022, demonstrates that the restart of the program initiated in 2019 is successful. Within ELyT Global, **5 M. Sc. students** were involved in the declared projects in 2022.

Double Degree Ph.D.

Thanks to the highly positive dynamic of 2021, **12 students were performing Double Degree Ph.D.** curriculum in 2022. In particular, 2022 has seen the re-opening of the flux **from Japan to France**, with 2 newly enrolled Ph.D. students. In total, **29 Double Degree Ph.D. students** have been graduated or are pursuing their Ph.D. studies in the framework of the IRN. Additionally, **13 single degree Ph.D. students** are also involved in ELyT Global projects.

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 in 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**. Hence, **13 projects** involving researchers from the ELyT IRN and contributing to the network activities have been granted in 2022.

Collaborative scientific activities in the framework of ELyT Global

2022 projects

With the release of sanitary condition since mid-2022, ELyT Global projects have undergone a profound metamorphosis. This significant change led the project investigators to perform an assessment of their collaborations. This led to the stopping of several projects, along with the transformation of other ones (e.g., combination of several project). Yet, the return to face-to-face meetings yielded **11 new projects**. 2022 therefore witnesses **25 projects**, yielding 3 more than in 2021.

Thanks to the easing of travels, researchers and students-researchers mobility has significantly increased, with a total of more than **600 days cumulatively**, including **3 long stays** of more than 1 month and **1 very long stay** greater than 6 months (Table 5). This level is still slightly less than the pre-CoVid period, especially in terms of long to very long stays, but it should be kept in mind that travels were allowed again since mid-2022 and that long to very long stays need time for preparation. Additionally, new projects allowed the introduction of **young people within the network** ensuring the next generation to be involved in the IRN.

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

FR→JP		JP→FR	
2022	**Total declared (running projects only)[14]**	**2022**	**Total declared (running projects only)[14]**
425 days (incl. 1 very long stay > 6 months and 1 long stay > 1 month)	1626 (incl. 2 long stays > 1 month and 5 very long stays > 6 months)[15]	193 days (incl. 2 long stays > 1 month)	1426 (incl. 8 long stays > 1 month)[15]

Table 5. 2022 visits and total declared in project forms (excluding Double Diploma students). Numbers are given in days.

The significant positive dynamic in terms of Double Degree (DD) Ph.D. students in 2021 **allows 11 DD Ph.D. students** to be involved in the IRN in 2022. Furthermore, in 2022, a **remarkable increase of the whole Ph.D. student pool** (single and double degree) is observed, going from **15 in 2021 to 24 in 2022** (Table 6). Again, this demonstrates the liveliness of the network **to attract a new generation of early stage researchers**.

In terms of scientific communication (Table 7), a **slight drop** in terms of Journal paper is observed, with **13 publications** in 2022 (17 in 2021), but a **huge increase of conference**s, with **41 communications** (vs. 27 in 2021), can be denoted. Such changes are not only explained by the previous **pandemic situation impairing the progress** of collaborative work, but also by the **important number of new projects**, and for which journal papers may take some time to be submitted, accepted, and published. Interestingly, the action undertaken by the IRN projects denoted a will of **technology transfer**, with **2 new patents** in 2022.

Ph.D. students		M.Sc. students	
2022	**Total (running projects only)[14]**	**2022**	**Total declared (running projects only)[14]**
24 (incl. 11 Double Degree students)	28	5	18

Table 6. Students involved in the projects.

Journal papers		Conferences	
2022	**Total declared (running projects only)[14]**	**2022**	**Total declared (running projects only)[14]**
13	55	41	113

Table 7. Scientific communications (+3 patents).

[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 Masters students, DD Ph.D students and researchers in delegation.

The **positioning** of the IRN projects is still **well spread across the scientific thematic and applicative themes** (Figure 9). It can be noted that for the applicative theme, some projects place themselves in a **transdisciplinary fashion** at the interface between transportation and energy. For the scientific topics, the projects are **well distributed within the subjects**, highlighting the relevancy of such organization. Finally, the general overview (Figure 9.c) still shows a significant place of the "Energy" theme. However, compared to the previous years, a **more homogeneous distribution** of the projects can be observed.

Table 8 exposes the average date for the projects. 16 projects out of 25 declared a budget associated with the collaboration, with a **total budget of 306 k€**, which is **more than halved** compared to 2021. While the number of average **number of participants decreased** (by less than 1 person) compared to 2021, the **task force significantly increased** by 1,8 person-month. Hence, this denotes a **better involvement** of researchers. **Stays significantly increased of course in 2022** because of the end of travel restriction, although on the overall project life, a decrease of a few days is observed. Consistent with the previous analysis of Table 7, a **slight drop in average journal paper** and a **huge increase in conference communication** appear. The **decrease of some indicators** can however be attributed to the numerous **new projects**, that are at the **early stage of their development**.

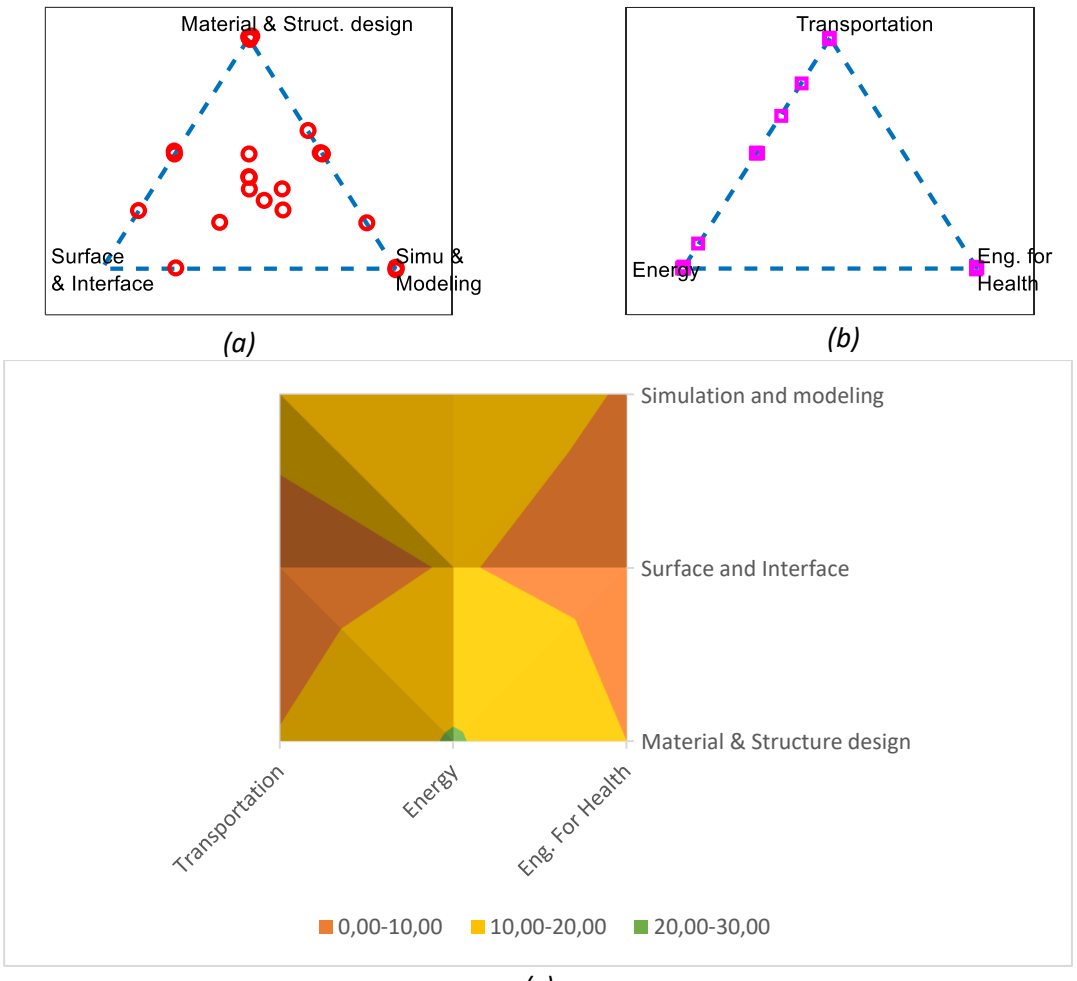


Figure 9: Repartition of projects (percentages): (a) by scientific topics; (b) by themes and (c) general overview.

Average number of participants	4,84
Task force	6,4 person-months
Average FR→JP stays	17 days (2022) / 48 days (total declared)
Average JP→FR stays	7,8 days (2022) / 57 days (total declared)
Average international journal paper	0,52 (2022) / 2,2 (total declared)
Average international conference	1,64 (2022) / 4,52 (total declared)
Average annual budget[16]	19,1 k€

Table 8. Average project data.

In 2021, 24 laboratories (including 9 from France and 10 for Japan) participated in the projects. This number experienced an increase, with **27 laboratories involved in the** IRN (**13 from France, 10 from Japan, 1 joint France/Japan**, 1 in India, 1 in China and 1 in Poland**). Cross-collaborations and interactions**, exposed in Table 10, have also undergone a **significant positive development**., 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 2022 **96 persons**, largely surpassing the previous years (71 in 2021 and 77 in 2020).

France		Japan	
Lab.	**Projects /researchers**	**Lab.**	**Projects /researchers**
MATEIS INSA-Lyon	8/16	IFS Tohoku	13/21
LTDS ECL	4/12	GSE Tohoku	8/12
LGEF INSA-Lyon	7/9	IMR Tohoku	4/6
ILM UCBLyon1	2/2	AIMR Tohoku	1/1
LMFA ECL	2/2	FRIS Tohoku	3/2
IMP INSA-Lyon	2/1	NICHe Tohoku	2/4
LaMCoS INSA-Lyon	1/2	ILE Osaka	1/1
LTDS ENISE	1/2	µSIC Tohoku	1/1
Cancer Research Centre of Lyon	1/1	GSBE Tohoku	1/1
CETHIL INSA-Lyon	1/1	Ishinomaki Senshu University	1/1
CREATIS INSA-Lyon	1/1		
IPSB-Faculty of Pharmacy UCBLyon 1	1/1		
LIRIS ENISE	1/1		
Joint FR/JP			
Lab.	**Projects /researchers**		
ELyTMaX CNRS/Université de Lyon/Tohoku University	14/23		
Other			
Lab.	**Projects**		
IIT Dhanbad (India)	1		
Southwest Jiaotong University (China)	1		
University of Wroclaw (Poland)	1		

Table 9. Participating laboratories in 2021 projects.

[16] 17 projects declared budget. Hence, the average has been calculated on this number.

Interactions FR-JP			Japan									
			IFS Tohoku	*GSE Tohoku*	*FRIS Tohoku*	*IMR Tohoku*	*AIMR Tohoku*	*GSBE Tohoku*	*NICHe Tohoku*	*µSIC Tohoku*	*ILE Osaka*	*Ishinomaki Senshu University*
			(17)	(9)	(5)	(5)	(3)	(2)	(2)	(1)	(1)	(1)
France	*MATEIS INSA-Lyon*	(17)	4	5	3	3	1			1		
	LGEF INSA-Lyon	(9)	3	1	1		1		2			1
	LTDS ECL	(5)	2	1		1		1				
	IMP INSA-Lyon	(4)	2		1		1					
	IPSB-Faculty of Pharmacy UCBLyon 1	(3)	1			1					1	
	LMFA ECL	(3)	2	1								
	ILM UCBLyon1	(2)	2									
	LTDS ENISE	(2)		1				1				
	Cancer Research Centre of Lyon	(1)	1									
	CETHIL INSA-Lyon	(1)	1									
	CREATIS INSA-Lyon	(1)	1									
	LaMCoS INSA-Lyon	(1)		1								
	LIRIS ENISE	(1)	1									

Table 10. FR-JP lab interactions (without ELyTMaX, the lab being both JP and FR).

Pluri-annual project follow-up

Following **recommendation from institutions** and taking note of the **significant number of new projects in 2022**, a **pluri-annual individual project follow-up** has been established. 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 is shown in Figure 10. In this case, I can be seen that the project follows a positive dynamic since 2019.

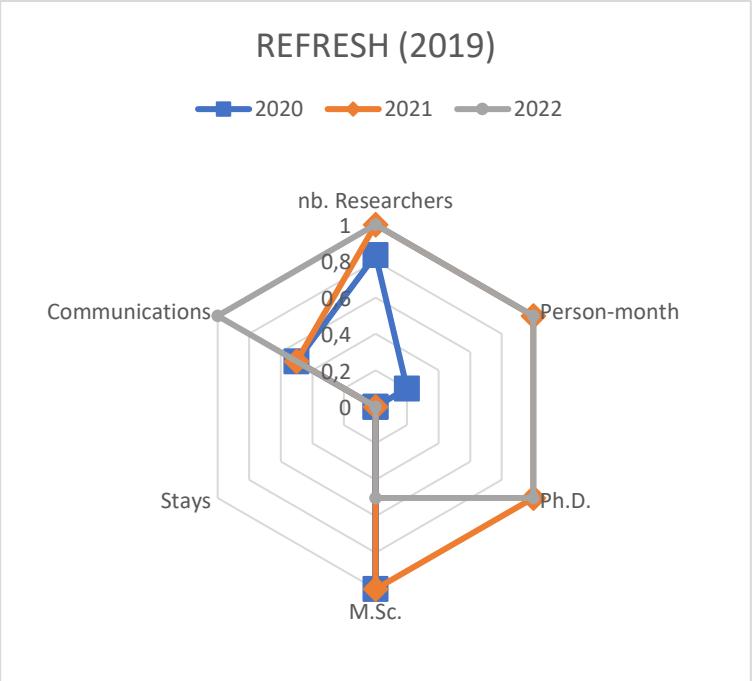


Figure 10: Example of pluri-annual project (REFRESH) follow-up chart.

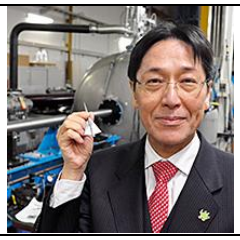
List of active 2022 projects and project reports

Acronym	Name
AATIGSA*	Atmospheric Aircraft Turbulence Investigated by Global Stability Analysis
BENTO	Nonlinear and dynamic micromagnetic Behavior modeling and characterization for Non-Destructive Testing techniques optimization
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
EPOPEE*	Elaboration of POrous Powders by liquid mEtal dEalloying
ESANSHSJN*	Extraction and sensitivity analysis of noise sources of high-speed subsonic jet noise
FIESTA	Ferroelectric-ferroelectric transitions Induced by External STress for Applications in sensing and energy harvesting
FRIISE*	Multi-scale elucidation of friction mechanisms in ice-rubber interfaces
MARECO	MAgneto-Rheological elastomers for Energy COnversion
MATSURI	MAgneToStrictive coUpling for eneRgy harvestIng
MicroCell	Microsystems for Cell Engineering
MIMECHAS*	Microstructure and Mechanics of Aluminum - Steel welds
MOREOVER*	MOdelling of the long-term coRrosion bEhaviOr from detailed analysis of excaVated anciEnt cultural aRtifact
MuORoD	Multi-Objective Robust Design
PIARR*	Prognosis of intracranial aneurysm rupture risk
PolymColdSprayCoat	Resilient Polymeric Cold Spray Coating
POMADE	POlymer-Metal-fiber Adhesions DElamination control
PREDOXCAN*	Investigation of a predictive therapeutic response under controlled oxygen condition in spheroids and cancer patient-derived organoids.
REFRESH	REFRigEration based on Solid-state cooling: Heat transfer mechanisms
ScinGlass*	Scintillator Glasses
T2 TRIBOCHEM*	Syperlubricity of a ta-C/Si3N4 contact in presence of castor oil
TATAMI	Thermal AcTuation and energy hArvesting using MultIphysic alloys
TEmPuRA	Theory for Electrostriction of PolymeRic Actuator
TFS*	Touch feeling and Surface

Table 11. Active projects (: new projects).*

Atmospheric Aircraft Turbulence Investigated by Global Stability Analysis

MAIN PARTICIPANTS

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

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

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

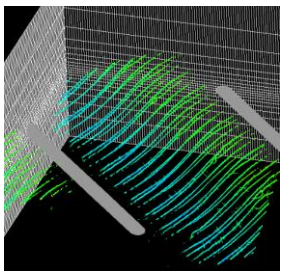
- JSPS 2020-2024 Fund for the Promotion of Joint International Research (Fostering Joint International Research (A))

Estimated annual budget: 14,000 euro

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

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

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

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

FR to JP (date, duration):

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

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

Conferences *(gray color for previous years)*

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

BENTO

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

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

Positioning *(Multiple selection allowed – total 100%)*

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

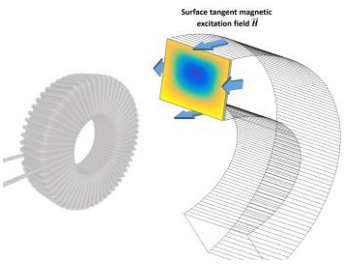
IFS CRP/LyC project? ☒ Yes ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
JSPS Grant-in-aid for scientific research (B) (2018 – 2020)
Estimated budget: 17 000 000 ¥
Lyc project (2017 – 2020)
Estimated annual budget: 20 k€

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

- B. Gupta received the best Ph.D. award of 2019 by INSA under the category "Transports: Structures, infrastructures et mobilitié".
- A simulation tool has been developed.
- More than 100 k€ in Industrial collaborations.
- More than 14 scientific papers have been published and more than 30 conference participations.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

Identification of structural defects or degradation through electromagnetic signatures.

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

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

FR to JP (date, duration):

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

JP to FR (date, duration):

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	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
2	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
3	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
4	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
5	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
6	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
7	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
8	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	Journal of magnetism and magnetic materials	486	165250	2019	https://doi.org/10.1016/j.jmmm.2019.165250

		on simulation of magnetic incremental permeability					
9	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
10	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
11	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
12	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
13	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
14	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

BOSMA

Blood flOw Simulation for Medical Applications

MAIN PARTICIPANTS

			
Carole FRINDEL[a]	**Makoto OHTA[b]**	**Guillaume LAVOUE[c]**	**Hitomi ANZAI[d]**
[a] CREATIS, INSA Lyon, Lyon Center IFS, Tohoku University **[c] LIRIS, ENISE Saint-Etienne, Ecole Centrale de Lyon**		**[b] ElyTMax, IFS, Tohoku University** **[d] IFS, Tohoku University**	

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☒ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

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

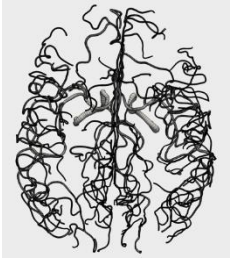
- Pack Ambition International from Région Auvergne-Rhône-Alpes, 2019-2022, SIMAVC
- INSA funding for PHD of Méghane Decroocq in the framework of ELyTMax
- **Collaborative research project J22Ly15, IFS, Tohoku University since Oct. 2022**

Estimated annual budget:10 K€

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

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

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

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

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

FR to JP (date, duration):

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

JP to FR (date, duration):

- Yutaro KOHATA (June 2022-June 2023, 1 year)
- Yutaro KOHATA (Sept-Oct. 2019, 2 months)

COMMUNICATIONS AND VALORIZATION

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	N. Debs, M. Decroocq, T.-H. Cho, C. Frindel	Patient-Specific Hemodynamic Simulation for Stroke Lesion Prediction	17th International Conference of Flow Dynamics	28-30 Oct. 2020	Sendai	Japan	
5	M. Decroocq , C. Frindel, M. Ohta, G. Lavoue	Meshing Arterial Networks from Manually Extracted Centerlines	17th International Conference of Flow Dynamics	28-30 Oct. 2020	Sendai	Japan	
6	M. Decroocq , C. Frindel, M. Ohta, G. Lavoue	Structured meshing of large vascular networks for computational fluid dynamics	Virtual Physiological Human	24-28 Aug. 2020	Paris	France	
7	Y. Kohata, H. Anzai, M. Ohta, M. Decroocq, C. Frindel, S. RIT	A study on Optical Flow Method for Hemodynamics Estimation	2nd International Symposium on Computational Biofluid	16 Dec. 2020	Johor	Malaysia	

Others *(gray color for previous years)*

	People	Event	Description	Date
1	Y. Kohata, H. Anzai, M. Decroocq, S. Rit, C. Frindel, M. Ohta	ELyT Workshop 2022	Oral presentation	16-18 November, 2022
2	H. Anzai, M. Ohta, S. Mugikura, N. Mori, N. Juchler, S. Hirsch, C. Frindel and M. Oshima	7th International Conference on Computational and Mathematical Biomedical Engineering, Milano, Italy	Mini-symposium organization	27-29 June 2022
3	Y. Kohata, H. Anzai, M. Decroocq, S. Rit, C. Frindel, M. Ohta	ELyT Workshop 2021	Oral presentation	21-25 June, 2021
4	M. Decroocq, E. Maury, G. Lavoué, C. Frindel, M. Ohta	ELyT Workshop 2021	Oral presentation	21-25 June, 2021
5	M. Decroocq, C. Frindel, M. Ohta, G. Lavoue	ELyT Workshop 2020	Oral presentation	17-19 Feb., 2020
6	Y. Kohata, H. Anzai, M. Ohta, M. Decroocq, C. Frindel, S. Rit	ELyT Workshop 2020	Poster presentation	17-19 Feb., 2020
7	M. Decroocq, C. Frindel, M. Ohta, G. Lavoue	ELyT Workshop 2019	Oral presentation	9-12 March, 2019
8	M. Decroocq, C. Frindel	ELyT Seminar	Oral presentation	6 June, 2018

CarboEDiffSim

Simulation of Carbon electro diffusion in Iron with phase change

MAIN PARTICIPANTS




Takashi TOKUMASU[a]	Patrice CHANTRENNE[b]	Takuya MABUCHI[a,c]	Ryuta ONOZUKA[a,d]

[a] *Institute of Fluid Science, Tohoku University, Japan*
[b] *MATEIS, INSA-Lyon, France*
[c] *Frontier Research Institute for Interdisciplinary Science, Tohoku University, Japan*
[d] *Graduate School of Engineers, Tohoku University, Japan*

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OVERVIEW *(keep within this page)*

Starting year: 2017 **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

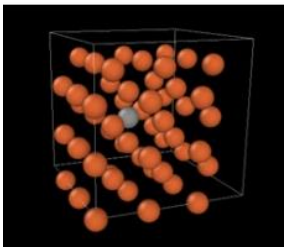
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: None

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

- We constructed a calculation system introducing the ABO potential as an interatomic potential that can simulate the correct phase transformation temperature of iron.
- We found a time step, satisfying the conservation of energy law.
- To verify that we used the interatomic potentials correctly, we compared our results with previous studies. Specifically, we calculated dissolution energy. (The calculation system is shown on the right figure.)
- Organization of the next Ab initio and Molecular Dynamics school in March 2023 in Greece

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

- None

Master/Bachelor students (years):

- Ryuta Onozuka (2022, IFS)

COMMUNICATIONS AND VALORIZATION

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Ryuta Onozuka, Takuya Mabuchi, Patrice Chantrenne, Takashi Tokumasu	CarboEDiffSim :Molecular Theory Analysis of Carbon Diffusion in Iron which is Happened Phase Transformation under Electric Field	ELyT workshop 2022	16-18 November 2022	hybrid	France	
2	Kairi Kita, Takuya Mabuchi, Sofia Molina-Montoya, Christophe Adessi, Patrice Chantrenne, Takashi Tokumasu	Multiscale Simulation of Carbon Electromigration in Iron	ICFD2021	27-29 October 2021	online	Japan	
3	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

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				

Others *(gray color for previous years)*

	People	Event	Description	Date
1	Takashi Tokumasu, Patrice Chantrenne, Kairi Kita	MD School @ IFS	Teachers and students	27th Sept. 2020

DECCOBABA

DEvelopment and Characterization of New CO BAsed alloys for Biomedical Applications

MAIN PARTICIPANTS

			
Akihiko CHIBA[a]	**Kenta YAMANAKA[a]**	**Damien FABREGUE[b]**	

[a] *Deformation Processing lab, IMR, Tohoku University*
[b] *MATEIS, INSA Lyon*

Contact: a.chiba@imr.tohoku.ac.jp, k_yamanaka@imr.tohoku.ac.jp, damien.fabregue@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			100 %
Surfaces and interfaces			
Simulation and modeling			

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☐ No

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

Estimated annual budget: 12000 euros/year

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

- We have demonstrated the influence of the method of powder fabrication on the porosity after 3D printing on Co based alloys
- The paper has been published

Illustration *(5x5 cm² max)*

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Co based alloy are already used for various biomedical application combined with additive manufacturing technique. One of their problem can be limited mechanical properties due to porosity after fabrication. We have studied the influence of the starting powder porosity (depending on the method of fabrication) on the porosity after 3D printing.

Key scientific question (2 lines max; Calibri 11)

Optimization of the alloys for biomedical applications
Interest of the additive manufacturing

Research method (8 lines max; Calibri 11)

Powder elaboration techiques
3D printing (EBM)
3D Xray characterization

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

Ph.D. candidates (years, institution):

Master/Bachelor students (years):

- A. Numata : October 2019 – March 2020 (4 months)
- S. Aota : February-August 2018 (6 months)

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

FR to JP (date, duration):

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

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Kenta Yamanaka, Manami Mori, Kazuo Yoshida, Sandra Balvay, Daniel Hartmann, Damien Fabrègue, Akihiko Chiba	Preparation of high-strength Co− Cr−Mo alloy rods via hot-caliber rolling	Materialia	12	100729	2020	https://doi.org/10.1016/j.mtla.2020.100729

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year

Others *(gray color for previous years)*

	People	Event	Description	Date

EPOPEE

Elaboration of POrous Powders by liquid mEtal dEalloying

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

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

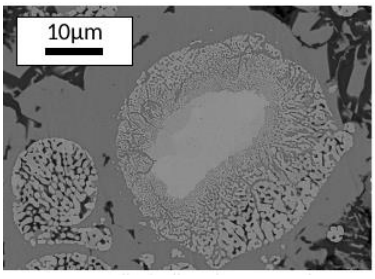
- none

Estimated annual budget: none

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

- Porous Fe powders were successfully elaborated via the liquid metal dealloying process

Illustration *(5x5 cm² max)*



Partially dealloyed Invar powder – SEM-BSE cross-section

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

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

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

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

FR to JP (date, duration):

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

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

JP to FR (date, duration):

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato	Thermodynamic modelling of liquid metal dealloying of NiCu alloys dealloyed in Ag	In preparation				

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	L. Lesage, P.-A. Geslin, N. Mary, E. Maire, C. Le Bourlot, T. Wada, H. Kato	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 by Alloy Corrosion	2023/04/24	Nohfelden	Germany	
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 (upcoming)	Frankfurt	Germany	

Others *(gray color for previous years)*

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

Extraction and sensitivity analysis of noise sources of high-speed subsonic jet noise

MAIN PARTICIPANTS

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

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

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

Estimated annual budget: 100,000 yen

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

- We have founded that the flow structures related to the jet noise and flow instability through the Mode Decomposition Method
- We have developed the new sensitivity analysis to clarify the relationship between acoustic waves and jet flow instability
- Based on above achievements, three conferences and workshops has been attended

Illustration *(5x5 cm² max)*

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

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

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

Key scientific question (2 lines max; Calibri 11)

Clarification of a subsonic jet noise mechanism

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

- No

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

FR to JP (date, duration):

- None

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	Flow Structure Extraction Related to the Noise Generation in A Subsonic Free Jet by Using Mode Decomposition Methods	ElyT workshop 2022	16-18 Nov., 2022	Lyon	France	
2	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	*Flow Structure Analysis Related to the Acoustic Wave Generation in Subsonic Free Jet Using Dynamic Mode Decomposition*	WCCM-APCOM 2022(15th World Congress on Computation Mechanics & 8th Asian Pacific Congress on Computation Mechanics)	31 Jul.-5 Aug., 2022	Yokohama (Online)	Japan	
3	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	*Modal Approach for Extracting Flow Structure Related to the Subsonic Jet Noise Generation*	ICFD2022(Nineteenth International Conference on Flow Dynamics)	9-11 Nov.,2022	Sendai	Japan	
4	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	*Flow Structure Analysis Related to the Acoustic Wave Generation in Subsonic Free Jet using the Mode Decomposition Method*	JSASS northern Branch 2022 (Japanese name:日本航空宇宙学会北部支部 2023 年講演会ならびに第 4 回再使用型宇宙輸送系シンポジウム)	17-19 Mar. 2022	Sendai (Online)	Japan	
5	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	*Mode Decomposition Method for Extracting Characteristic Structures Related to*	Eighteenth International Conference on Flow Dynamics(ICFD2021)	27-30 Apr. 2021	Sendai (Online)	Japan	

		the Subsonic Jet Noise Generation					
6	S.Morita, A. Yakeno, C. Bogey and S. Obayashi	*Modal approach for extracting flow structure related to the subsonic jet noise generation*	ELyT workshop 2021	25 Jun. 2021	Sendai (Online)	Japan	

Patents *(gray color for previous years)*

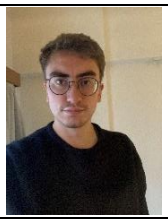
Others *(gray color for previous years)*

Project report 2022

FIESTA

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

MAIN PARTICIPANTS






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

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

Other contributors: Elie Lefeuvre, Ausrine Bartasyte, Merieme Ouhabaz, Jhordan Chavez, Takahito Ono
Contact: **mickael.lallart@insa-lyon.fr*

OVERVIEW *(keep within this page)*

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

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

Include partner from ☐ Outside ELyT ☐ Industry

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

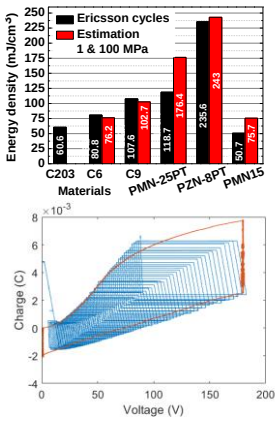
IFS CRP/LyC project? ☐ Yes ☑ No

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

Estimated annual budget: 70 000 euros

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

- Investigation and characterization of different ferroelectric materials under high excitation levels for energy harvesting with Ericsson cycle.
- Theoretical investigation of optimal phase transition in different oriented ferroelectric single crystal for pyroelectric energy harvesting
- Theoretical and experimental study of ideal temperature of work of Ericsson cycle for energy harvesting. Identification of the best polarization mechanisms and phase transition 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 are considered as the sources for electromechanical energy harvesting using ferroelectric materials. Researchers in the world are curious on what maximum energy could be converted. In the past decade, many efforts have been made to investigate the energy conversion capability of ferroelectric materials by Olsen or Ericsson cycles. Besides the intrinsic nature of ferroelectric materials, there are three main external influences (stress, temperature and electric field) which make change in the polarization of ferroelectric materials, hence affecting the energy conversion performance. In this research, these three parameters will be investigated to find out the optimal conditions to reach the maximum energy conversion capability of ferroelectric materials.

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 with Ericsson cycle under high excitations levels have been characterized. Investigations particularly focus on PMN-25PT and PZN-8PT single crystals which present high energy densities. Landau-Devonshire phenomenological approach has been used and experimental characterization of Ericsson cycle at different temperatures allowed to identify ideal polarization mechanisms and phase transitions. The next step was to develop a real device which support high values of stress and electric field. A smart tile was developed with the associated electrical interface (Bennet doubler). High energy output was obtained with PZT stacks. 320 mJ per cycle was extracted which is nearly two orders of magnitude above the state-of-the art.

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

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

FR to JP (date, duration):

- G. Taxil (May 2022, 18 months)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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
2	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	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	
2	G. Taxil, M. Lallart & G. Sebald & al	Phase transition in ferroelectric materials for pyroelectric energy harvesting	IWPMA 2022	24-26 October 2022	Online	Online	
3	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	
4	G. Taxil, M. Lallart, G.Sebald & al	Modeling ferroelectric phase transitions for energy harvesting	ELyTWorkshop	21-25 July., 2021	Online	Online	

FRIISE

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

MAIN PARTICIPANTS

A. Dalavale Kaiser Pinto	J. Cayer-Barrioz	D. Mazuyer	
ECL LTDS CNRS UMR5513			

OVERVIEW *(keep within this page)*

Starting year: 2022

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			
Simulation and modeling			

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☐ No

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

Estimated annual budget:

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

-

Illustration *(5x5 cm² max)*

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

During the first 18months of the FRIISE project, Anderson Dalavale Kaiser Pinto (ADKP) was hired (2021/04/15) in order to improve the capacities of the KORI tribometer and to perform the first macroscopic friction experiments between rubber and ice. All the goals have been successfully realized.

The following steps were performed:

- To understand the functioning of the KORI Tribometer, ADKP was fully trained and he has developed new experimental protocols. For example:
  - In the new ice protocol, the temperature as well as the humidity and the pressure inside the freezer are now controlled during the whole process (environment temperature, Peltier/bottom temperature, heater/upper temperature).
  - The duration time of the ice machining has been extended to provide better results in terms of ice surface topography.
- ADKP has analyzed all the steps of the process, searching for optimization, and he has proposed additional developments of the ice making structure and of a new cooling chamber.
  - The new cooling chamber has arrived. The goal is to reach temperatures lower than -20°C.
- The new rubber samples provided by Michelin were characterized in terms of concentricity.
- and roughness. A new mold was designed and is under fabrication at Michelin Nihon.
- In order to enhance the visualization of the static rubber/ice contact, the Leica microscope used on the KORI tribometer was cleaned and realigned. The possible light sources were also investigated and a new camera was acquired.
  - This leads to a much better in situ contact visualization allowing one to perfectly measure the contact area during sliding. A new version of the phantom code is in development and should be ready for the beginning of next year. The goal is to reduce the time to analyze each image (it currently takes almost 1 day to analyze 1 sliding experiment).
- A few static and dynamic experiments were performed in a range of temperatures going from 0°C to -18°C for different rubber samples.

The JKR experiments were performed using rubber samples with two types of surface texture (smooth and rough) and two colors (white and black), in contact with either a glass disc or ice. The analysis of the results shows the impact of the curvature radius of the samples, confirming the importance of reducing the concentricity default.

The friction results were analyzed and are in very good agreement with the ones obtained by Dr. Hemette during his PhD Thesis, confirming the reproducibility of the friction experiments. These first results confirm the experimental strategy proposed by the LTDS to tackle the friction dissipation of a sliding ice/rubber contact.

Future steps are considered:

- To increase the range of temperature during sliding experiments;
- To investigate the effect of material viscoelasticity and of the rubber surface topography on JKR and friction experiments;
- To analyze the friction data in the context of the developed theoretical friction model [1, 2]

[1] S. Hemette. Rubber-Ice Friction: A multi-scale and multi-physical approach. PhD thesis, 2019

[2] Chernyak YB, Leonov AI. On the theory of the adhesive friction of elastomers. Wear 1986

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

Ph.D. candidates (years, institution):

- A. Dalavale Kaiser Pinto

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1							

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				

Others *(gray color for previous years)*

	People	Event	Description	Date

Project report 2022

MARECO

MAgneto-Rheological elastomers for Energy COnversion

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

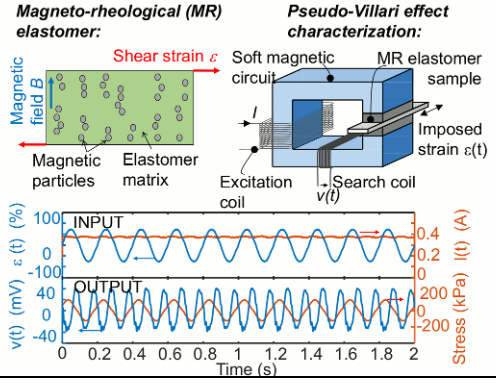
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: 10k€

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

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

Illustration[17] *(5x5 cm² max)*



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

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

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

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

Ph.D. candidates (years, institution):

Master/Bachelor students (years):

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

FR to JP (date, duration):

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

JP to FR (date, duration):

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

Conferences *(gray color for previous years)*

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

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

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year

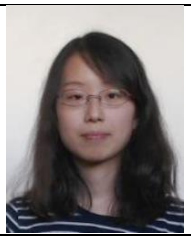
Others *(gray color for previous years)*

	People	Event	Description	Date

MATSURI

MAgneToStrictive coUpling for eneRgy harvestIng

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

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

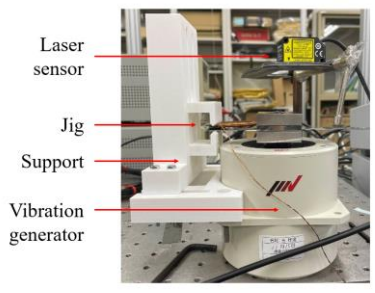
- MESRI, 2020-2023, Magnetostrictive materials and systems for energy harvesting

Estimated annual budget: 30 k€

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

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

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

-

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

FR to JP (date, duration):

- Yuanyuan LIU (May 2022 - Present)

JP to FR (date, duration):

- Yuanyuan LIU (November 2022, 10 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Yuanyuan LIU, Benjamin DUCHARNE, Gaël SEBALD, Kanjuro MAKIHARA, Mickaël LALLART	Analysis of energy conversion potentials of Metglas 2605SA1 for energy harvesting applications by measuring Ericsson cycle	Elyt workshop 2022	Nov 16-18	Lyon	France	
2	Yuanyuan LIU, Benjamin DUCHARNE, Gaël SEBALD, Kanjuro MAKIHARA, Mickaël LALLART	Magnetic characterization of Metglas under tensile stress for energy harvesting applications	Elyt workshop 2021	June 21-25	Virtual		
3	Yuanyuan LIU, Benjamin DUCHARNE, Gaël SEBALD, Kanjuro MAKIHARA, Mickaël LALLART	Low-frequency Induction heating of ferromagnetic catheter for the varicose veins treatment: a study of the feasibility	IEEE Intermag 2021	April 26-30	Lyon	France	

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				
2				

Others *(gray color for previous years)*

	People	Event	Description	Date
1				

Project report 2022

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)*

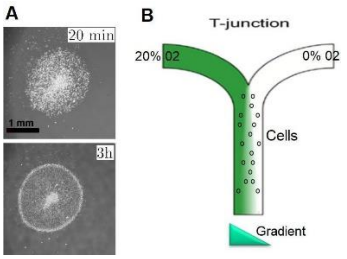
- IFS LyC project 2019-2022
- CNRS, MITI, APP Modélisation du Vivant 2019-2020, HFSP 2021-2024
- CNRS, Invited researcher position for K. Funamoto (2 months in 2019) another invitation is scheduled for 2023

Estimated annual budget: 30 k€

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

- We developed a microfluidic device to control heterogeneous oxygen concentration in a microenvironment.
- We have shown that Dictyostelium (Dicty) cells enhances their cell migration under a low oxygen concentration (aerokinesis) and migrate toward an oxygen-rich regions under the 0-2% O_2 only (aerotaxis) and that ROS are not involved in aerotaxis.
- We have shown that Acanthamoeba castellani, an asocial amoeba, respond to O_2 gradients in any range of O_2 concentration.
- A research paper was published in Processes in 2022, another was submitted to Frontiers in Cell and Developmental Biology.
- S. Hirose pre-defended her PhD in Tohoku University in Nov. 2022.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

We have fabricated a very efficient microfluidic device enabling to control the O_2 concentration in the range of 0.3-20% within 15 min with two gas channels positioned just above the media channels where cells were cultured. An O_2-sensing polymer films was also developed and utilized to monitor the oxygen condition inside the device. Dicty cells 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 Dicty cells. We showed that cell respond to relative oxygen gradients in the 0-2% range and that secondary ROS or nitric oxide gradients are not involved in the aerotaxis mechanism.

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

- S. HIROSE (2019-2020, Tohoku University)
- J. HESNARD (2020-2021, Université Claude Bernard Lyon 1)
- N. GHAZI (2020-2021, Université Claude Bernard Lyon 1)

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

FR to JP (date, duration):

- J.-P. Rieu (Oct-Nov 2022,20 days)
- J.-P. Rieu (Dec 2019,5 days)
- J.-P. Rieu (June 2019,5 days)
- J.-P. Rieu (Nov 2018, 5 days)

JP to FR (date, duration):

- S. Hirose (Jan 2022-June 2022, 5 months)
- K. Funamoto (Nov 2022, 4 days)
- S. Hirose (Dec 2021, 1 month)
- K. Funamoto (Feb 2020, 4 days)
- K. Funamoto (Sept 2019, 2 months)

- S. Hirose (Sept 2019, 2.5 months)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	S. Hirose, J.-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
2	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
3	A. Shirai, Y. Sugiyama, J.-P. Rieu	Differentiation of neutrophil-like HL-60 cells strongly impacts their rolling on surfaces with various adhesive properties under a pressing force	Technology and Health Care	26(1)	93-108	2018	doi: 10.3233/THC-171052

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	N. Ghazi, 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	
2	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	
3	S. Hirose, J.-P. Rieu, K. Funamoto	Migration characteristics of *Dictyostelium discoideum*	The 11th Asian-Pacific Conference on	4 Dec 2021	On-line	Japan	

		depending on oxygen environment	Biomechanics (AP Biomech 2021)				
4	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	
5	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	
6	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	
7	S. Hirose, J.-P. Rieu, K. Funamoto	Evaluation of motility enhancement of *Dictyostelium discoideum* by hypoxic exposure	The 33rd Bioengineering Conference Annual Meeting of Bioengineering Division, JSME (in Japanese)	25 Jun 2021	On-line	Japan	
8	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	
9	S. Hirose, J.-P. Rieu, K. Funamoto	*Motility analysis of Dictyostelium discoideum under oxygen gradient by microfluidic device*	The 31th JSME Conference on Frontiers in Bioengineering (in Japanese)	12-13 Dec 2020	On-line	Japan	

10	S. Hirose, J.-P. Rieu, K. Funamoto	*Evaluation of Dictyostelium migration under oxygen concentration gradient*	The 17th International Conference on Flow Dynamics (ICFD2020)	30 Oct 2020	On-line	Japan	
11	O. Cochet-Escartin, S. Hirose, K. Funamoto, C. Anjard, J.-P. Rieu	*Hypoxia triggers collective aerotactic migration in Dictyostelium discoideum*	The 20th International Symposium on Advanced Fluid Information (AFI2020)	28 Oct 2020	On-line	Japan	
12	K. Funamoto, J.-P. Rieu	*Microfluidic Tools to Study Aerotaxis in Eukaryotic Cells*	Elyt Workshop	17-19 Feb 2020	Vogüé	France	
13	O. Cochet-Escartin, M. Demircigil, S. Hirose, K. Funamoto, C. Anjard, V. Calvez, J.-P. Rieu	*Hypoxia triggers collective aerotactic migration in Dictyostelium discoideum*	CNRS MITI, AAP Modélisation du Vivant	13 Feb 2020	Paris	France	

Patents *(gray color for previous years)*

	Inventors	**Title**	**PCT #**	**Year**

Others *(gray color for previous years)*

	People	**Event**	**Description**	**Date**
1				

Project report 2022

MIMECHAS

Microstructure and Mechanics of Aluminum - Steel welds

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

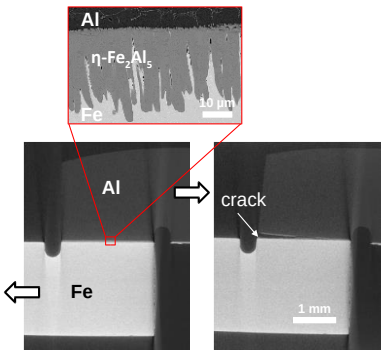
IFS CRP/LyC project? ☐ Yes X No

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

Estimated annual budget:

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

- Two PhD students started on the project.
- Al-steel and AlNi-steel TIG welds were produced with a reproducible intermetallic interfacial layer.
- An X-ray tomography setup was developed to monitor the mechanical behavior of the welds *in situ* under tensile shear.



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

Tailor the formation of the intermetallic compound and characterize its microstructure.
Measure and model the fracture behavior of the welds.

Research method (8 lines max; Calibri 11)

Welds are produced by TIG welding with a low carbon steel sheet and an aluminum alloy of controlled chemical composition. Thermal cycle measurement during welding is being developed, to be compared to finite element simulation of the process. The influence of alloy composition and process parameters on the weld and IMC microstructure is analyzed.
The fracture properties of the welds are measured, including *in situ* 3D monitoring of the tests by X-ray tomography. Then they are discussed with respect to the weld microstructure and finite element simulation of damage during the tests.

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

Ph.D. candidates (years, institution):

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

Master/Bachelor students (years):

- NA

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

FR to JP (date, duration):

- S. Dancette (Sept. 2022 - today, 1 year)

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	K.T Suzuki, S. Dancette, J. Adrien, Y.S. Sato	Fracture behavior of Al-Fe welds	ELyT Worshop 2022	Nov. 16, 2022	Lyon	France	

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year

Others *(gray color for previous years)*

	People	Event	Description	Date

MOREOVER

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

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

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

Estimated annual budget:

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

- New project started in November 2022

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):

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

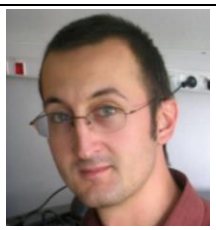
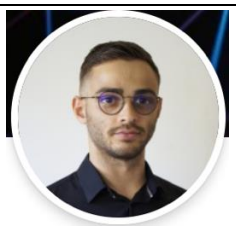
Conferences *(gray color for previous years)*

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

MuORoD

Multi-Objective Robust Design

MAIN PARTICIPANTS

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

[a] *IFS, Tohoku University, Sendai, Japan*
[b] *LTDS UMR CNRS 5513, DySCo Team, ECL, Lyon, France*

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

OVERVIEW *(keep within this page)*

Starting year: 2012 **Current researchers** (permanent/non-permanent): (3/1) 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 *(up to 3, past projects in gray)*

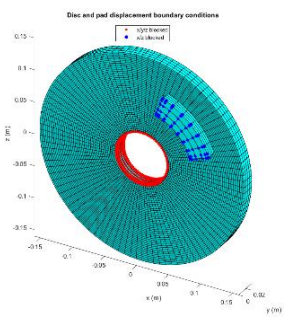
- 2 MNRT funds for Ph.D., 2016-2021 + 2021-2024
- Mega Ph.D.School funds for 3 months grant, 2020
- Rhône Alpes AAP grant awarded (2021 – 2024, 30keuros)
- JSPS Summer Grant 2022 for Achille

Estimated annual budget: From institutions 35keuros

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

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

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Post-doc (years, institution):

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

Ph.D. candidates (years, institution):

- Pradeep Mohanasundaram (2016-2021, MNRT)
- Achille Jacquemond (2021-2024, 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):

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

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Mohanasundaram, P., Gillot, F., Besset, S., Shimoyama, K.	“Modelling friction-induced dynamic instability dedicated for Isogeometric formulation”	Shock and Vibration			accepted 2022	
2	Mohanasundaram, P., Gillot, F., Besset, S., Shimoyama, K.	“Multi-references acquisition strategy for shape optimization of disc-pad-like mechanical systems.”	Struct Multidisc Optim	64,	1863–1885	2021	https://doi.org/10.1007/s00158-021-02947-7
3	Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset	"Shape optimization of a disc-pad system under squeal noise criteria."	SN Applied Sciences	2(4)	1-15	2020	
4	Troian, Renata, Koji Shimoyama, Frédéric Gillot, and Sébastien Besset	"Methodology for the design of the geometry of a cavity and its absorption coefficients as random design variables under vibroacoustic criteria."	Journal of Computational Acoustics	24(02)	1650006	2016	

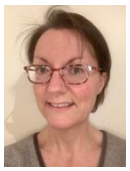
Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	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
2	Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset	Iga based shape optimization under mechanical stability criteria	14th WCCM 2020	2020	Paris	France	
3	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	
4	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	
5	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]	Ryuhei YAMAGUCHI[c,d]	Riko HASEGAWA[c,d]	Kotaro DAIBO[c,d]	Makoto OHTA[c,d]

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

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

OVERVIEW

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

Positioning *(Multiple selection allowed – total 100%)*	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design			50 %
Surfaces and interfaces			0 %
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. 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)

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):

- Makoto OHTA (14/11/2022-19/11/2022)
- Ryuhei YAMAGUCHI (14/11/2022-19/11/2022)
- Kotaro DAIBO (14/11/2022-19/11/2022)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1			I				

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	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	
2	G.Plet, J.Raviol, H.Magoariec, C.Pailler-Mattei	Design of an *in vivo* biomechanical characterization device for unruptured intracranial aneurysms: calibration study on phantom arteries	ESB	26-29 Jun. 2022	Porto	Portugal	

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				

Others *(gray color for previous years)*

	People	Event	Description	Date
1	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
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

Project report 2022

PolymColdSprayCoat

Resilient Polymeric Cold Spray Coating

MAIN PARTICIPANTS

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

[a] *Tohoku University, GSE, FRRI, Sendai, Japan*
[b] *ELyTMaX UMI3757 -CNRS-TU-UdL, Sendai Japon*
[c] *Tohoku University, FRIS, Sendai, Japan*
[d] *INSA Lyon – CNRS, MATEIS, Villeurbanne, France*
[e] *Indian Institute of Technology Dhanbad, Indian*
[f] *IFS, Tohoku University, Sendai, Japan*
[g] *µSIC, Tohoku University, Sendai, Japan*

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OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

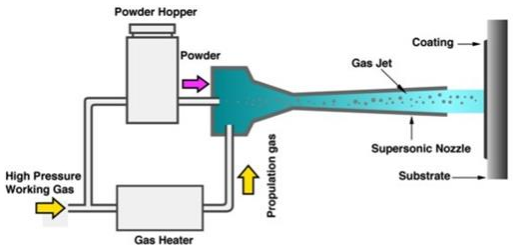
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

- CRP–IFS, 2021-2022, J21Ly08
- TI-FRIS, 2021-2026
- CRP-IFS, 2022-2023, J22Ly09

Estimated budget: 400,000 yen/year

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

- Understanding and improving the formation of polymer coating on metallic substrates by Cold Spray
- Modelling the flow dynamics inside the nozzle and the particles' thermal gradient
- In total, 10 publications in peer-review journals (1 paper submitted, several in preparation), 1 patent, 6 awards



PROJECT DESCRIPTION

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

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

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

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

FR to JP (date, duration):

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

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
10	C.A. Bernard, H. Takana, O. Lame, K. Ogawa, J.-Y. Cavaillé	*Influence of the nozzle inner geometry on the particle history during cold spray process*	*Journal of Thermal Spray Technology*,	31	1776	2022	doi.org/10.1007/s11666-022-01407-y
9	CA Bernard, O Lame, T Deplancke, JY Cavaillé, K Ogawa	From rheological to original three-dimensional mechanical modelling of semi-crystalline polymers: application to a wide strain rate range and large deformation of Ultra-High Molecular Weight semi-crystalline polymers	Mechanics of Materials	151	103640	2020	doi.org/10.1016/j.mechmat.2020.103640
8	CA Bernard, H Takana, G Diguet, K Ravi, O Lame, K Ogawa, JY Cavaillé	Thermal gradient of in-flight polymer particles during cold spraying	Journal of Materials Processing Technology	286	116805	2020	doi.org/10.1016/j.jmatprotec.2020.116805
7	W Lock Sulen, K Ravi, C Bernard, Y Ichikawa, K Ogawa	Deposition Mechanism Analysis of Cold-Sprayed Fluoropolymer Coatings and Its Wettability Evaluation	Journal of Thermal Spray Technology	29	1643-1659	2020	doi.org/10.1007/s11666-020-01059-w
6	W Lock Sulen, K Ravi, C. Bernard, N Mary, Y. Ichikawa, K Ogawa	Effects of nano-ceramic particle addition for cold sprayed fluoropolymer coatings	Key Engineering Materials	813	141-146	2019	doi.org/10.4028/www.scientific.net/KEM.813.141
5	K Ravi, W Lock Sulen, C Bernard, Y Ichikawa, K Ogawa	Fabrication of micro-/nano-structured super-hydrophobic fluorinated polymer coatings by cold-spray	Surface and Coatings Technology	373	17-24	2019	doi.org/10.1016/j.surfcoat.2019.05.078
4	K Ravi, T Deplancke, O Lame, K Ogawa, JY Cavaillé, F Dalmas	Influence of nanoceramic interlayer on polymer consolidation during cold-spray coating formation	Journal of Materials Processing Technology	273	116254	2019	doi.org/10.1016/j.jmatprotec.2019.116254
3	K Ravi, T Deplancke, K Ogawa, JY Cavaillé, O Lame	Understanding deposition mechanism in cold sprayed ultra high molecular weight polyethylene coatings on metals by isolated particle deposition method	Additive Manufacturing	21	191-200	2018	doi.org/10.1016/j.addma.2018.02.022

2	K Ravi, Y Ichikawa, K Ogawa, T Deplancke, O Lame, JY Cavaille	Mechanistic Study and Characterization of Cold-Sprayed Ultra-High Molecular Weight Polyethylene-Nano-ceramic Composite Coating	Journal of Thermal Spray Technology	25	160-169	2016	doi.org/10.1007/s11666-015-0332-1
1	K Ravi, Y Ichikawa, T Deplancke, K Ogawa, O Lame, JY Cavaille	Development of ultra-high molecular weight polyethylene (UHMWPE) coating by cold spray technique	Journal of Thermal Spray Technology	24	1015-1025	2015	doi.org/10.1007/s11666-015-0276-5

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
9	C. A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé	Evaluation of the thermal gradient of in-flight polymer particles during cold spray process	ELyT Worshop 2022	November 2022	Lyon	France	
8	C.A. Bernard, H. Takana, G. Diguet, O. Lame, K. Ogawa, J.-Y. Cavaillé	Evolution of the polymer particle thermal history during cold spray process	ICFD2022	November 2022	Sendai	Japan	
7	C.A. Bernard, H. Takana, G. Diguet, O. Lame, J.-Y. Cavaillé, K. Ogawa	In-flight thermal gradient of polymer particles during cold-spray process	ICFD2021	Oct. 27-29, 2021	Sendai	Japan	
6	Y. Kaneko, W. Lock Sulen, C. Bernard, H. Saito, Y. Ichikawa, K. Ogawa	Progressive improvement in deposition efficiency for cold sprayer fluoropolymer coatings	ELyT Workshop 2021	June 21-24, 2021	online		
5	C. A. Bernard, H. Takana, O. Lame, K. Ogawa, J.-Y. Cavaillé	Nozzle design for polymer coating by cold spray process	ELyT Workshop 2021	June 21-24, 2021	online		
4	W. Lock Sulen, H. Saito, C.A. Bernard, Y. Ichikawa, K. Ogawa	Extremely high deposition efficiency of robust and super-hydrophobic fluoropolymer coating on a metallic intermediate layer by low-pressure cold spray	International Thermal Spray Conference 2021	May 24-28, 2021	online		
3	W Lock Sulen, H Saito, C Bernard, S Onodera, J Ishizaki, N Mary, Y Ichikawa, K Ogawa	Improvement of Deposition Efficiency and Adhesion by Laser Surface Texturing for Cold Sprayed Fluoropolymer Coating	10th Asian Thermal Spray Conference	Nov. 1st-3rd, 2020	Ningbo	China	

2	CA Bernard, H Takana, O Lame, K Ogawa, JY Cavaillé	Computational simulation on particle-laden flow during polymer cold-spray process	ICFD2020	Oct. 28-30, 2020	Sendai	Japan	
1	CA Bernard, H. Takana, G Diguet, K Ravi, O Lame, K Ogawa, JY Cavaillé	Polymer coating by cold-spray: a review	ElyT Workshop 2020	Feb. 17-19, 2020	Vogüé	France	

Patents *(gray color for previous years)*

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

Others *(gray color for previous years)*

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

Project report 2022

POMADE

POlymer-Metal-fiber Adhesions DElamination control

MAIN PARTICIPANTS

Tetsuya Uchimoto[a]	Nicolas Mary[b]	Sebastien Livi[C]	Benoit Ter-ovanessian[d]
Bernard Normand[d]	Sabrina Marcelin[d]		

[a] *Tohoku Univ.IFS, Sendai, Japan*
[b] *CNRS-UdL-Tohoku Univ. - ELyTMaX, Sendai, Japan*
[c] *INSA Lyon-CNRS, IMP@INSA, Villeurbanne, France*
[d] *INSA Lyon-CNRS, MATEIS, Villeurbanne, France*

Contact: uchimoto@ifs.tohoku.ac.jp ; nicolas.mary@insa-lyon.fr

OVERVIEW *(keep within this page)*

Starting year: 2017 **Current researchers** (permanent/non-permanent): 4 / 1

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)*

- none

Estimated annual budget: €10,000

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

- New polymer epoxy-Ionic Liquid materials showed high water uptake resistance.
- Ratio between epoxy and ionic liquids tunes the physical and chemical properties of the polymer.
- Water uptake change the coating permittivity which can be investigated by either capacitive of electrochemical impedance measurements

Illustration *(5x5 cm² max)*

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Epoxy-Amine coatings are widely used for corrosion protection of metallic surfaces in industry. However, their mechanical behaviors need to be improved in order to increase their range of applications. Thus, fibers (glass, carbon, etc.) can be injected in the polymer layer. Their presences create new heterogeneities, in volume and also at the internal interface between the coating and the substrate. All of them affect the overall corrosion behavior of the structure during static or dynamic loads. To optimize coatings and adhesion properties, additional knowledges are required in term of corrosion propagation and delamination mechanism at the material/polymer or polymer/fiber interfaces. Our aim is to combine complementary nondestructive measurements such as electrochemical impedance spectroscopy and eddy currents methods, to better understand the delamination processes that occurs at all interfaces heterogeneities in order to develop new hydride polymer/fiber coatings.

Key scientific question (2 lines max; Calibri 11)

How to tune epoxy ionic liquid materials to optimize water uptake.
Identification of the water uptake mechanism to enhance coating performances.

Research method (8 lines max; Calibri 11)

In 2017/2018, at MATEIS & IMP, coating material were prepared during the stay of L. Ollivier-Lamarque. This time only epoxy polymer coatings were made. At IFS/ELyTMaX, water uptake during immersion tests were followed by NDE (capacitive sensor) and impedance measurements. Results comparisons with results obtained by Dr Marcelin at MATEIS with electrochemical technics are ongoing.
From 2018, optimization of the capacitive measurement on polymer disc were performed. In parallel, a coplanar sensor was developed in 2021. Coplanar sensor was tested on polymer materials after immersion and promising results were obtained.
Analyze of results are ongoing at this date. A work has been also performed on the modeling of the capacitance based on the modification of the permittivity of the coating when water penetrate. Mr L. Ollivier-Lamarque has been enrolled as DD PhD student from April 2019 in TU and December 2019 at INSA Lyon. He defended his PhD in Japan and in France in 2022.

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

Ph.D. candidates (years, institution):

- L. Ollivier-Lamarque (2019-2022, DD INSA/TU)

Master/Bachelor students (years):

- L. Ollivier-Lamarque (2017-2019, DD INSA/TU)

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

FR to JP (date, duration):

- S. Livi (Assoc. Prof) stay at ELyTMaX and IFS (TU), January 2020 (1 week).

JP to FR (date, duration):

- L. Ollivier-Lamarque (DD Master), stay at ELyTMaX@Lyon, November 2018 (1 week)
- L. Ollivier-Lamarque (DD Master), stay at IMP (INSA-Lyon), July 2018 (1 week)
- L. Ollivier-Lamarque (DD Master), stay at MATEIS (INSA-Lyon), July 2018 (1 week)
- L. Ollivier-Lamarque (DD Master), stay at MATEIS (INSA-Lyon), July 2018 (1 week)
- L. Ollivier-Lamarque (DD PhD), stay at MATEIS (INSA-Lyon), October 2018 (10 days)
- T. Uchimoto (Prof.), stay at MATEIS (INSA-Lyon) & ELyTMAX@Lyon, November 2018 (1 week)
- N. Mary (Assoc. Prof.), stay at MATEIS (INSA Lyon), November 2018 (1 week)

- T. Uchimoto (Prof.), stay at MATEIS (INSA-Lyon) & ELyTMAX@Lyon, July 2018 (1 week)
- N. Mary (Assoc. Prof.), stay at MATEIS (INSA Lyon), September 2019 (1 week)
- Ollivier-Lamarque (DD PhD), stay at IMP (INSA-Lyon), October 2021 (15 days)
- N. Mary (Assoc. Prof.), stay at MATEIS (INSA Lyon), September 2022 (1 week)
- Ollivier-Lamarque (DD PhD), stay at IMP (INSA-Lyon), july 2022 (15 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	L. Ollivier-Lamarque, S. Livi, T. Uchimoto, N. Mary	Water Uptake in Epoxy Ionic Liquid Free Film Polymer by Gravimetric Analysis and Comparison with Nondestructive Dielectric Analysis	nanomaterials	12	651	2022	**10.3390/nano12040651**
2	L. Ollivier-Lamarque*, M. Lallart, T. Uchimoto, N. Mary, S. Livi, S. Marcelin, H. Miki	Dielectric analysis of water uptake in polymer coating using spatially defined Fick's law and mixing rule	Progress in Organic Coatings	148	105846	2020	10.1016/j.porgcoat.2020.105846

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	L. Ollivier-Lamarque, N. Mary, T. Uchimoto, S. Livi, S. Marcelin.	Methodology to detect water uptake in polymer materials using non contact capacitor sensor. Sendai (Japon).	Eighteenth International Conference on Flow Dynamics (ICFD2021)	10/2021	Sendai	Japan	*Best presentation award*
2	L. Ollivier-Lamarque*, T. Uchimoto, M. Lallart, N. Mary, S. Marcelin, S. Livi	Water Uptake Monitoring in Epoxy-amine Polymer by Combining Dielectric and Gravimetric Analysis	Seventeenth International Conference on Flow Dynamics (ICFD2020)	10/2020	Sendai	Japan	
3	L. Ollivier-Lamarque*, M. Lallart, T. Uchimoto, N. Mary, S. Livi, S. Marcelin, H. Miki	Water Uptake Assessment in Polymer Coating from Dielectric measurements Using Local Mixing Rule Coupled with Cole-Cole Equation	Eurocorr2020	09/2020	Brussel	Belgium	
4	l. Ollivier-Lamarque, T. Uchimoto, N. Mary, S. Livi, S. Marcelin, B. Ter-Ovanessian	Evaluation of Water Uptake in Ionic Liquid Composite Polymer Coating: Comparison between Gravimetric and Capacitance Measurements. And	Sixteenth International Conference on Flow Dynamics (ICFD 2019),	06/11/2019-08/11/2019	Sendai	Japan	

		Polymer metal fiber adhesions delamination control.					
5	L. Ollivier-Lamarque*, T. Uchimoto, N. Mary, S. Livi, S. Marcelin, B. Normand, B. Ter-Ovanessian	Water Uptake in anti-corrosion polymer coating: development of capacitive measurement methods	Eurocorr2019.	09/09/2019 – 13/09/2019	Seville	Spain	
6	L. Ollivier-Lamarque, T. Uchimoto, N. Mary, S. Livi, S. Marcelin, B. Normand	*Evaluation of Water Uptake in Anti-Corrosion Polymer Coating by Capacitance Measurement*,	15th International Conference on Flow Dynamics	November 7-9, 2018	Sendai	Japan	
7	L. Ollivier-Lamarque, T. Uchimoto, N. Mary, S. Livi,	*Development of electromagnetic non-desctructive testing on polymer-ionic liquid composite coating for corrosion protection*,	23rd International Workshop on Electromagnetic Nondestructive Evaluation (ENDE2018)	September 10-13, 2018	Detroit	USA	

PREDOXCAN

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

MAIN PARTICIPANTS

Mr. Satoshi ARATAKE
Tohoku University, Sendai, Japan

Prof. Jean-Paul RIEU
Université Claude Bernard Lyon 1, France

Assoc. Prof. Nicolas AZNAR
Cancer Research Centre of Lyon, France

Assoc. Prof. Kenichi FUNAMOTO
Tohoku University, Sendai, Japan

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☒ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

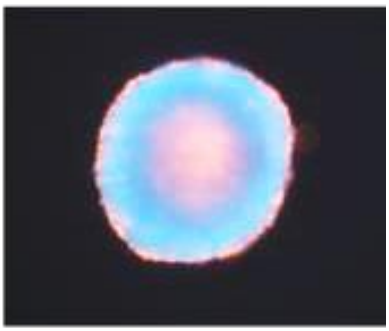
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- IFS LyC project 2021-2022

Estimated annual budget: 20 000€

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

- We validated 3D cell culture spheroid conditions for cancer stem cell markers expression.
- Hypoxic condition decreases spheroid growth.
- Hypoxic condition confers resistance of spheroids to drugs.
- Optimization of CRC patient-derived organoid cultures from fresh tumors.
- We designed an innovative 3D cell culture system combined with oxygen gradient.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Although some cancers are effectively treated through the standard strategy of surgery, radiation and/or chemotherapy, some patients have a recurrence of their cancer. Despite decades of research, we are still unable to predict which cancers will be efficiently treated and which are likely to spread, thus there is an urgent need to find new or better treatment alternatives for colorectal cancers (CRC). Cancer stem cells (CSC) located within the tumor constitute a key medical issue. Due to their high plasticity, this particular cancer cell population is extremely resistant to conventional therapy and responsible for the recurrence of the disease in patients. Therefore, identify novel mechanisms regulating cancer cell plasticity and targeting those CSCs is a prerequisite to open novel therapeutic avenues. The main goal of this project is to study how oxygen (O_2) concentration influence CSC plasticity and their response to anti-cancer therapies.

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

Ph.D. candidates (years, institution):

- Satoshi ARATAKE (2022-present, Sendai)

Master/Bachelor students (years):

- Zhouxing SU (2022, Lyon)

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

FR to JP (date, duration):

- Zhouxing SU (Master student, April-June 2022, 3 months)
- Nicolas AZNAR (CRCN CNRS, November 2022, 20 days)

JP to FR (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	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	
2							

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				
2				

Others *(gray color for previous years)*

	People	Event	Description	Date
1				
2				

Project report 2022

REFRESH

REFRigEration based on Solid-state cooling: Heat transfer mechanisms

MAIN PARTICIPANTS






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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

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

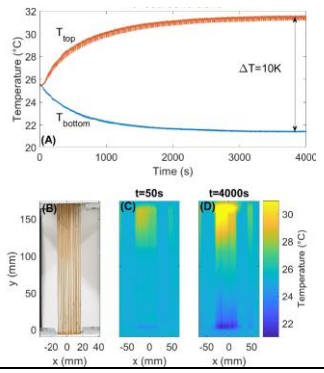
- ANR ECPOR (ANR-17-CE05-0016) 2017-2022
- JSPS Grant in Aid for Scientific Research Kiban C 19K04230 2019-2022

Estimated annual budget: 20k€

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

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

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

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

When driven cyclically, such a material exhibits time oscillations of temperature, and the conversion of it into a 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.

Key scientific question (2 lines max; Calibri 11)

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

Research method (8 lines max; Calibri 11)

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

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

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

Ph.D. candidates (years, institution):

- Marianne Sion (2021-2014, CNRS, INSA Lyon – Tohoku University)

Master/Bachelor students (years):

- 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):

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

JP to FR (date, duration):

-

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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
2	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	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	
2	Gael Sebald*, Giulia Lombardi, Atsuki Komiya, Gildas Coativy, Jacques Jay, Laurent Lebrun	Elastocaloric rubber based system for new refrigeration solutions	Nineteenth International Conference on Flow Dynamics (ICFD2022)	November 9-11, 2022	Sendai	Japan	
3	G. Sebald*, A. Komiya, J-M. Chenal, L. Chazeau, F. Dalmas, M. Vigouroux, F. Rousset, M. Boutaous, J. Jay, B. Garnier, M. Rammal, A. O. El Moctar, H. Haissoune, G. Coativy, L. Seveyrat, K. Yuse, L. Lebrun	Main key points for developing environmental friendly solid state cooling system based on the elastocaloric effect in rubber	2020 European Materials Research Society (E-MRS) Fall Meeting	September 16th – 19th, 2019	Warsaw	Poland	

4	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		
5	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**

Project report 2022

SCINTILLATOR GLASSES

New VUV scintillator glasses for fast neutron detection

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

Starting year: 2017 **Current researchers** (permanent/non-permanent): 4 person-month/year

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

Other:

Include partner from ☒ Outside ELyT ☐ Industry

Main funding source(s)

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

IFS CRP/LyC project? ☐ Yes ☒ No

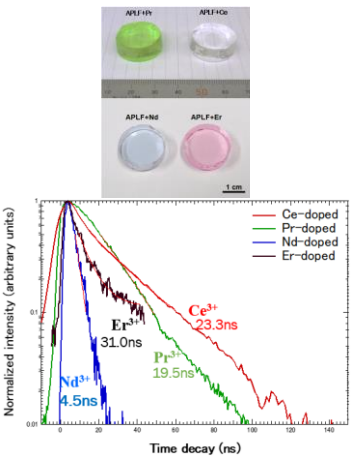
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

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

- High-quality crystals that are required for most radiation detection applications are difficult to produce because of the high production costs and slow growth processes.
- We have developed the complex fluorophosphate glass, $20Al(PO_3)_3$-80LiF (APLF) as a host material for RE^{3+} (rare earth ions)-doped neutron fast scintillators.
- APLF contains aluminum metaphosphate [$Al(PO_3)_3$] more stable to moisture than other metaphosphates and also containing a lithium (Li) of 31.6 mmol cm^{-3} comparable to that of a commercial Ce^{3+}-activated Li aluminosilicate glasss cintillator.
- RE^{3+}=Ce^{3+}, Nd^{3+}, Pr^{3+} take advantage of the electric-dipole allowed interconfigurational $4f^{n-1}5d \rightarrow 4f^n$ transitions with fast emission decays.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Available rare earth ion dopants are largely analyzed in the $4f^n$ configuration, which lies from the UV to the near-infrared regions (200 nm to 1500 nm), but rarely in the $4f^{n-1}5d$ configuration, which lies in the vacuum UV (VUV) region (170 nm to 400 nm). Although absorption and emission properties in the VUV region are always difficult to measure due to the spectral limit of many devices, most of the host materials are not suitable for detecting 270 keV fast neutrons because they lack of Li or have insufficient ^6Li content making them less sensitive to the neutrons. The most important property of these RE^{3+}-doped APLF glasses is that they exhibit electric-dipole allowed $4f^{n-1}5d \rightarrow 4f^n$ broadband emissions detectable in VUV-UV and a fast decay time comparable to that of a glass conventional scintillator, KG2 (36.0 mmol cm^{-3}) from Saint-Gobain.

Key scientific question (2 lines max; Calibri 11)

Making rare earth ions-doped APLF glasses to be ranked as advanced potential scintillator materials in time-of-flight detectors for high-counting-rate fast neutron detection of few ns.

Research method (8 lines max; Calibri 11)

The objectives of SCINTILLATOR GLASSES encompass glass science, optical properties and especially spectroscopic properties of 4f←→5d parity-allowed transitions with short decay of Pr^{3+}, Ce^{3+}, Nd^{3+}, Er^{3+}, trivalent rare earth dopants. Doped-APLF glasses are researched instead of doped-crystals for scintillators having many advantages (larger sizes, more flexible, mass-produced compared to crystal scintillators). APLF glasses contain ^6Li density of 31.6 mmol/cm^3, the maximum amount in the conventional ^6Li glass scintillator which has a high cross section fit for scattered neutron detection discriminated from X-ray signals and primary neutrons and developed in ILE(Osaka). $^6Li + n \rightarrow T + \alpha$ (4.8 MeV) reaction contributes to high scintillation light yield. Finally, emission spectra and decays analysis are performed to evaluate each type of glass. Nd^{3+}-doped APLF glass is the most promising one.

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

Ph.D. candidates (years, institution):

- Keito Shinohara (2021-present, ILE Osaka)

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

FR to JP (date, duration):

- G. Boulon (iLM lyon)-IMR Sendai October 24-November 11, 2021, 2 weeks)
- G. Boulon (iLM lyon)-IMR Sendai October 26-November 7, 2022, 2 weeks)

JP to FR (date, duration):

- Melvin Empizo (ILE Osaka)-iLM Lyon September 19, 2018, 1 day
- Melvin Empizo (ILE Osaka)-iLM Lyon June 5-6, 2019, 2 days
- Nobuhiko SARUKURA (ILE Osaka)-iLM Lyon June 5-6, 2019, 2 days
- Melvin Empizo (ILE Osaka)-iLM Lyon December 2-17, 2019, 2 weeks
- Melvin Empizo (ILE Osaka)-iLM Lyon February 27-March 17, 2020, 3 weeks
- Akira Yoshikawa (IMR sendai)-iLM Lyon July 27-28, 2022, 2 days
- Melvin Empizo (ILE Osaka)-iLM Lyon Sept10-21 2022, 11 days
- Keito Shinohara (ILE Osaka)-iLM Lyon Sept10-21 2022, 11 days

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Keito Shinohara, Melvin John F. Empizo, Marilou Cadatal-Raduban, Kohei Yamanoi, Toshihiko Shimizu, Masashi Yoshimura, Nobuhiko Sarukura, Takahiro Murata, Mayrene A. Uy, Hitoshi Abe, Akira Yoshikawa, Georges Boulon, Christophe Dujardin	Radiation resistance of praseodymium-doped aluminum lithium fluorophosphate scintillator glasses for laser fusion experiments	Japanese Journal of Applied Physics	62	010613	2023	https://doi.org/10.35848/1347-4065/aca0d4
2	Melvin John F. Empizo, Yuki Minami, Kohei Yamanoi, Toshihiko Shimizu, Masashi Yoshimura, Nobuhiko Sarukura, Takahiro Murata, Akihiro Yamaji, Akira Yoshikawa, Malgorzata Guzik, Yannick Guyot, Georges Boulon, Marilou Cadatal-Raduban	Investigations on the electric-dipole allowed $4f^2 5d \rightarrow 4f^3$ broadband emission of Nd^{3+}-doped $20Al(PO_3)_3$-80LiF glass for potential VUV scintillator application	Journal of Alloys and Compounds	856	158096	2021	https://doi.org/10.1016/j.jallcom.2020.158096
3	Yuki Minami, Jacque Lynn, Gabayno, Verdad Canila Agulto, Youwei Lai, Melvin John F. Empizo, Toshihiko Shimizu, Kohei Yamanoi, Nobuhiko, Sarukura, Akira Yoshikawa, Takahiro Murata, Malgorzata Guzik, Yannick Guyot, Georges Boulon, John A. Harrison, Marilou Cadatal-Raduban	Spectroscopic investigation of praseodymium and cerium co-doped 20Al(PO3)3-80LiF glass for potential scintillator applications	Journal of Non-Crystalline Solids	**521**	119495	2019	https://doi.org/10.1016/j.jnoncrysol.2019.119495
4	Melvin John F. Empizo, Marilou Cadatal-Raduban, Takahiro Murata, Yuki Minami, Keisuke Kawano, Kohei Yamanoi, Toshihiko Shimizu, Nobuhiko Sarukura, Malgorzata Guzik, Yannick Guyot, Georges Boulon	Spectroscopic properties of Pr^{3+}-doped 20Al(PO3)3-80LiF glasses as potential scintillators for neutron detection	Journal of luminescence	193	13-21	2018	https://doi.org/10.1016/j.jlumin.2017.06.029

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, Nobuhiko, Yoshikawa &al	Nd^{3+}-doped $20Al(PO_3)_3$-80LiF glass : a promising VUV scintillator material for high-counting-rate fast neutron detection	ELyT Workshop 2022	16-18 Nov., 2022	Villeurbanne	France	
2	Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, Sarukura, Akira Akira Yoshikawa,	The choice of 5d□4f UV emission of Ce^{3+}/Pr^{3+}-doped $20Al(PO_3)_3$-80LiF glasses as fast scintillators for neutron detection	The XVII International Feofilov Symposium on Spectroscopy of Crystals Doped with rare Earth and transition Metal ions	23-28 Sept 2018	Ural Federal University Ekaterinburg	Russia	
3	Georges Boulon, Yannick Guyot, Malgorzata Guzik, Melvin John F. Empizo, Nobuhiko Sarukura, Akira Yoshikawa, &al	Pr^{3+}-doped $20Al(PO_3)_3$-80LiF glass as potential scintillator for neutron detection	The Phosphor Safari and The Sixth International Workshop on Advanced Spectroscopy and Optical Materials (PS- IWASOM'17)	9-14 July 2017	Gdansk University	Poland	

T2 TRIBOCHEM

Syperlubricity of a ta-C/Si_3N_4 contact in presence of castor oil

MAIN PARTICIPANTS

			
Maria Isabel DE BARROS BOUCHET	**Jean Michel MARTIN**	**Yang Wang**	**Momoji KUBO**

Maria Isabel De Barros Bouchet LTDS Ecole Centrale de Lyon 69134, Ecully, **France**.
Jean Michel Martin LTDS Ecole Centrale de Lyon 69134, Ecully, **France**.
Yang Wang Research Institute of Frontier Science, Southwest Jiaotong University, 610031, Chengdu, **China**
Momoji Kubo IMR Tohoku University2-1-1 Katahira, Aoba-ku Sendai 980-8577, **Japan**

Contact: maria-isabel.de-barros@ec-lyon.fr, momoji@imr.tohoku.ac.jp

OVERVIEW *(keep within this page)*

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

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

Other: Energy saving

Include partner from ☒ Outside ELyT ☐ Industry

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

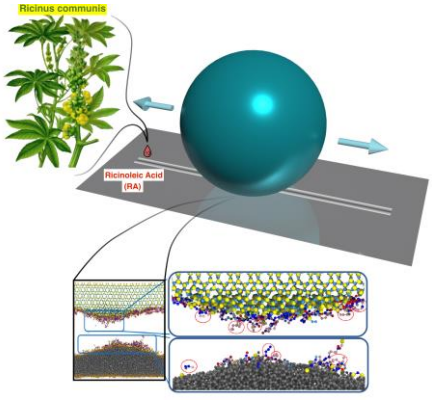
IFS CRP/LyC project? ☐ Yes ☒ No

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

Estimated annual budget:

Highlights & Outstanding achievements

- We have demonstrated a new superlubricious system operating with a green lubricant, hydrogen-free DLC/Si3N4 contact lubricated by castor oil.
- Superlow friction is related to the in situ formation of graphitic/graphenic species but also to the presence of OH- and –(CH2–CH2)n–oligomers on the surface.
- Through tailoring initial sp2-hybridized carbon content at the ta-C surface, friction can be governed.
- A publication has been accepted in the Journal “Friction“ (IF=5.4).



PROJECT DESCRIPTION

Background

To meet the surging needs in energy efficiency and eco-friendly lubricants, a novel superlubricious technology using an unsaturated fatty acid and ceramic materials is proposed. By using amorphous carbon coatings with a selected fraction of sp^2 and sp^3-hybridized carbon in presence of a commercially available silicon nitride bulk ceramic, castor oil provides superlubricity although the liquid oil film in the contact is at the nanometer scale. Local tribochemical reactions between contacting asperities are essential to maintain superlubricity at low speeds. High local pressure and shear activate chemical degradation of castor oil generating graphitic/graphenic-like species on top of asperities, thus helping both the chemical polishing of surface and its chemical passivation by H- and/or OH- species. For the first time, formation of alkane and alkene surface oligomers have been evidenced to play a major role in the friction reduction in the superlow regime.

Key scientific question

Developing new superlubricious lubricated systems for energy saving
Developing green superlubricants derived from vegetable oils

Research method

Computer simulation unveils that formation of chemical degradation products of castor oil on friction surfaces are favored by the quantity of sp^2-hybridized carbon atoms in the amorphous carbon structure. Moreover, short alkene chains are found to terminate the tribofilm on Si_3N_4 Hence, tuning sp^2-carbon content in hydrogen-free amorphous carbon, in particular, on the top layers of the coating, provides an alternative way to control superlubricity achieved with unsaturated fatty acids.

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

Ph.D. candidates (years, institution):

- Yun LONG (PhD student at LTDS, 2017-2019)

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

FR to JP (date, duration):

JP to FR (date, duration):

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Yun LONG, Yang WANG, Volker WEIHNACHT, Stefan MAKOWSKI, Momoji KUBO, Jean Michel MARTIN, Maria-Isabel DE BARROS BOUCHET	Mechanism of superlubricity of a DLC/Si3N4 contact in the presence of castor oil and other green lubricants	Friction	10(10)	1693–1706	2022	*https://doi.org/10.1007/s40544-022-0601-1*

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year

Others *(gray color for previous years)*

	People	Event	Description	Date
1	Maria-Isabel DE BARROS BOUCHET	ELyT workshop 2022		November 16th - 18th, 2022 - Lyon, France

Project report 2022

TATAMI

Thermal AcTuation and energy hArvesting using MultIphysic alloys

MAIN PARTICIPANTS

		
Mickaël LALLART[a]	**Hiroyuki MIKI[b]**	**Gaël SEBALD[c]**

[a] *Univ. Lyon, INSA-Lyon, LGEF EA 682, F-69621, France*
[b] *Faculty of Science and Engineering, Ishinomaki Senshu University, Ishinomaki 980-8580, Japan*
[c] *ELyTMaX UMI 3757, CNRS – Université de Lyon – Tohoku University, International Joint Unit, Tohoku University, Sendai, Japan*

Contact: mickael.lallart@insa-lyon.fr, hiroyuki.miki.k6@isenshu-u.ac.jp, gael.sebald@insa-lyon.fr

OVERVIEW *(keep within this page)*

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

Positioning *(Multiple selection allowed – total 100%)*	Transportation	Energy	Eng. for Health
Materials and structure design		20%	
Surfaces and interfaces		50%	
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 (TATAMI) ☐ No

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

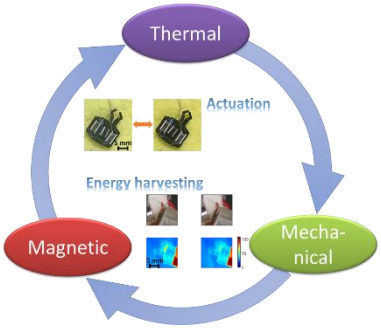
- IFS LyC, 2020-2021, 2021-2022 & 2022-2023, Collaborative Research Project
- JSPS, 2019-2020, invitational fellowship

Estimated annual budget: 10 k€

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

- Materials with thermomagnetic properties are considered
- Applications in the field of energy harvesting and actuation are developed
- A patent application is pending

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

TATAMI project aims at providing alternatives to thermoelectric modules for thermal to electrical energy conversion and to conventional SMA and magnetic devices for actuation. To this end, the project consists in the development of structures using magnetothermal coupling. TATAMI proposes innovative routes for thermo-mechano-electrical and electro-thermo-mechanical energy conversion systems. The project will propose designing systems in the framework of energy harvesting and actuation. Specifically, TATAMI aims at an innovative global approach driven by "material and device by design" philosophy. The general outcomes of TATAMI encompass material and systems aspects, through theoretical and experimental investigations, with the development of innovative small-scale demonstrators. In this framework, new pyro-based heat engines and innovative electrical breakers have been proposed.

Key scientific question (2 lines max; Calibri 11)

How to efficiently convert electrical energy in mechanical energy and conversely via thermomagnetic coupling? What is the globally optimized energy conversion chain in a full device?

Research method (8 lines max; Calibri 11)

Benefiting from the excellent knowledge and complementarities of the partners and using as basis such previous collaborations, TATAMI aims at going beyond current results. To achieve the project's goals, a global and interconnected approach, driven by the "material and system by design", is proposed.

Activities done in 2022 mainly focuses on further developing actuation devices using ferromagnetic materials. In particular, better understanding and optimization of an innovative electrical breaker allowing the combination of thermal and magnetic protection at a small-scale has been conducted.

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):

- M. Lallart (nov. 2022, 1 week)
- M. Lallart (Sept. 2019-July 2020, 10 months)
- L. Yan (Sept. 2019-Sept. 2020, 13 months)

JP to FR (date, duration):

-

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	M. Lallart, L. Yan, H. Miki, G. Sebald, G. Diguet, M. Ohtsuka and M. Kohl	Heusler Alloy-Based Heat Engine using Pyroelectric Conversion for Small-Scale Thermal Energy Harvesting	Applied Energy	288	116617	2021	https://doi.org/10.1016/j.apenergy.2021.116617
2	M. Lallart, H. Miki, L. Yan, Linjuan, G. Diguet, M. Ohtsuka	Investigation of Low Field Response of Metamagnetic Heusler Alloys as MultiPhysic Memory Alloys	J. Phys. D: Appl. Phys.	53	345002	2020	https://dx.doi.org/10.1088/1361-6463/ab8c7c

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	M. Lallart, G. Sebald and H. Miki	Ferromagnetic Alloys for Integrated Electrical Protection Circuits	ELyT Workshop 2022	November 16-18, 2022	Lyon	France	
2	M. Lallart, G. Sebald and H. Miki	Ferromagnetic-based Actuation for Electrical Protection	Nineteenth International Conference on Flow Dynamics (ICFD 2022)	November 9-11, 2022	Sendai	Japan	
3	M. Lallart, H. Miki, L. Yan, G. Sebald, G. Diguet, M. Ohtsuka and M. Kohl	Heusler Alloy Based Heat Engine with Pyroelectric Energy Conversion	Eighteenth International Conference on Flow Dynamics (ICFD 2021)	October 27-29, 2021	Sendai	Japan	
4	M. Lallart, H. Miki, L. Yan, G. Sebald, G. Diguet, M. Ohtsuka, M. Kohl	Heat engine based on MultiPhysic Memory Alloys and pyroelectric conversion for thermal energy harvesting	ELyT Workshop 2021	June 21-25, 2021	online	online	

Patents *(gray color for previous years)*

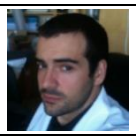
	Inventors	Title	PCT #	Year
1	M. Lallart, G. Sebald and H Miki	*Overcurrent Protection Device Based on Thermomagnetically-Shiftable Material*	PCT/EP2022/067948 (pending)	2022

Project report 2022

TEmPuRA

Theory for Electrostriction of PolymeRic Actuator

MAIN PARTICIPANTS

					
G. COATIVY[a]	H. TAKANA[b]	G. DIGUET[c]	K. YUSE[a,d]	L. SEVEYRAT[a]	V. PERRIN[a]
					
F. DALMAS[e]	S. LIVI[f]	J. COURBON[e]	C. BERNARD[g]	JY CAVAILLE[h]	

[a] *LGEF, EA 682,INSA Lyon, Univ. Lyon*
[b] *IFS, Tohoku University*
[c] *AIMR, Tohoku University*
[d] *IFS Lyon Center, Tohoku Univ. & LGEF, INSA Lyon*
[e] *MATEIS, UMR 5510, CNRS INSA Lyon, Univ. Lyon*
[f] *IMP, UMR 5223, INSA Lyon, Univ. Lyon*
[g] *Frontier Research Institute for Interdisciplinary Sciences, Tohoku*
[h] *ELyTMaX, IRL 3757, CNRS - Univ. Lyon - Tohoku Univ.*

Contact: jean-yves.cavaille@insa-lyon.fr, takana@tohoku.ac.jp, gildas.coativy@insa-lyon.fr

OVERVIEW *(keep within this page)*

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

Positioning *(Multiple selection allowed – total 100%)*

	Transport ation	Energy	Eng. for Health
Materials and structure design		50%	
Surfaces and interfaces			
Simulation and modeling		50%	

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

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

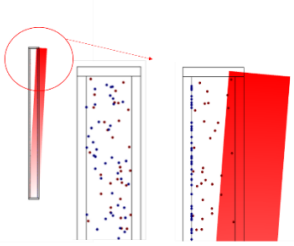
- BQR INSA 2023-2024

Estimated annual budget: 10k€

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

- We have demonstrated that in polyurethane, electrostatic pressure and polarization body forces cannot explain the strong electromechanical behavior. Our hypothesis is that electrical charge drift and their Coulombic interactions are the main mechanisms. This might explain both the slow mechanical response (over 10^5 s) and large deformation, as well as the bending observed on homogeneous films.
- 4 peer reviewed co-authored articles
- In 2022, we elaborated model elastomer materials containing various types of ionic liquids and started to study their bending under high electric field.
- As far as the simulation tasks are concerned, the mechanical and electrical modules of COMSOL® were successfully linked and a correct description of the bending curves was obtained, although a global optimization is still needed to take into account the multi-scale effects and the large number of electrical charges.

Illustration *(5x5 cm² max)*



Simulation of the bending resulting from the accumulation of charges near the electrodes

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). Because of the lack of theoretical guideline, they result from a time-consuming systemic screening. The project aims at providing a complete model accounting for 3 contributions, (i) electrostatic surface forces coming from the two interacting electrodes, (ii) possible body forces resulting from dielectric interactions between dipoles and local electric field gradients and (iii) interactions between mobile electric charges. This needs theoretical approaches and numerical simulations at a mesoscale to compare our model with experimental data (thickness changes, bending, etc.). Most of our works were performed on polyurethane and now we start to test some model materials doped with a control amount of ionic liquids to study the impact of the presence of charge carriers on the electro-actuation of elastomers.

Key scientific question (2 lines max; Calibri 11)

What physical mechanisms are responsible for the temporal deformation of soft polymers under electric field? How to model them?

Research method (8 lines max; Calibri 11)

So far, we have studied the electromechanical behavior of polyurethanes under an electric field in compression and more recently in bending in a controlled environment (temperature and humidity). In parallel, a numerical simulation was carried out at the meso scale in order to capture the short- and long-term time dependence of the bending. As the material studied was industrial with an uncontrolled amount and type of impurities, it was difficult to further our understanding of the electroactuation mechanism of elastomers. We therefore started to develop and characterize model epoxy-amine networks doped with a controlled amount of different ionic liquids to study the impact of the size and amount of electric charge carriers on the electroactuation of elastomers. Our materials will be studied electrically (dielectric spectroscopy and in bending under constant electric field), mechanically (mechanical spectroscopy) and structurally (SAXS, TEM) to obtain data to feed our numerical simulation.

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

Ph.D. candidates (years, institution):

Master/Bachelor students (years):

- Axel Blain (M2 stay at IMP/LGEF/MATeIS/Elytmax) March-September 2023
- N. Boucida (M2 stay at IFS/ELyTMaX), April-September 2016
- Zhouyang He (M2 student of INSA, Mat. Sc. and Eng.)

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

FR to JP (date, duration):

K. Yuse	June-July 2019	1 week
K. Yuse	Nov-2019	1 week
JY Cavaillé	Feb-March 2019	2 weeks
JY Cavaillé	Apr-2019	1 week
JY Cavaillé	June-July 2019	2 weeks
JY Cavaillé	Oct-Nov 2019	2 weeks
JY Cavaillé	November 2022	2 weeks
J. Courbon	Feb-Aug-2023	6 months
JY Cavaillé	April 2023	2weeks

JP to FR (date, duration):

H. Takana	September 2022	2 weeks
H. Takana	March 2023	2 weeks

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	G Coativy, K Yuse, G Diguet, V Perrin, L Seveyrat, F Dalmas, S Livi, J Courbon, H Takana and J Y Cavaillé,	Role of charge carriers in long-term kinetics of polyurethane electroactuation	Smart Materials and Structures	31	125019	2022	10.1088/1361-665X/aca12e
2	Gildas Diguet, JY Cavaille, Gael Sebald, Toshiyuki Takagi, Hiroshi Yabu, Ai Suzuki, and Ryuji Miura	Physical behavior of electrostrictive polymers. Part 1: Polarization forces	Computational Materials Science	190	110294	2021	10.1016/j.commatsci.2021.110294
3	M.H. Jomaa, L. Roiban, D. Dhungana, J. Xiao, J.-Y. Cavaillé, L. Seveyrat, L. Lebrun, G. Diguet, K. Masenelli-Varlot	Quantitative Analysis of grafted CNT dispersion and of their stiffening of polyurethane (PU)	Composites Science and Technology	171	103-110	2019	10.1016/j.compscitech.2018.12.012
4	M.H. Jomaa, L. Seveyrat, L. Perrin, L. Lebrun, K. Masenelli-Varlot, G. Diguet, J.-Y. Cavaillé,	Difference between electrostriction kinetics, and mechanical response of segmented polyurethane-based EAP	Smart Materials and Structures	26	035049	2017	10.1088/1361-665X/aa5c4b

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	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	

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
2	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	
3	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	
4	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	
5	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	
6	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	
7	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
8	Kaori Yuse, Gildas Diguet, JY Cavaille	Electrical Conductivity Versus Electrostriction in Di-Block Polyurethane: New Insights	16th ICFD	2019 Nov. 6-8	Sendai	Japan	

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
9	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	
10	Gildas Diguet & Kaori Yuse	Seminar on Electrostriction	Morita's Lab	2019 July 8	Todai, Tokyo	Japan	
11	A. Suzuki, M. Miyano, R. Miura	Theoretical estimation of dielectrics constant of electroactive polymers	15th ICFD	2018 Nov 7-9	Sendai	Japan	
12	A. Suzuki, R. Miura, N. Hatakeyama, J.-Y. Cavaille, G. Diguet, G. Sebald	Multiscale Modeling of Electromechanical Coupling in Electroactive Polymers	14th ICFD	2017 Nov. 1-3	Sendai	Japan	
13	Nazim Boucida, Jean-Yves Cavaillé, Jean-Marc Chenal, Gildas Diguet, Gael Sebald	Nano-structured polymer based materials for energy conversion and actuation,	ISMANAM	2016 July 3-8	Nara	Japan	Invited lecture

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year
1				

Others *(gray color for previous years)*

	People	Event	Description	Date

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]**

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)*

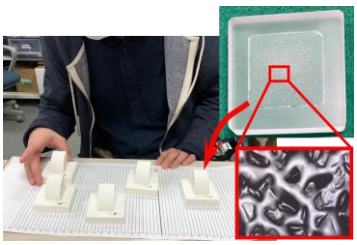
- International Society for Advanced Drawing Breakthrough project, 2021-2023, COMCOM
- ANR-JST project, 2016-2019, COMICA
- PHC, 2014-2016, Sakura

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):

-

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*

Patents *(gray color for previous years)*

	Inventors	Title	PCT #	Year

Others *(gray color for previous years)*

	People	Event	Description	Date

Outlook

Following years of particular situation due to the sanitary conditions, 2022 has been a year of **metamorphosis and renewal** of the ELyT Global IRN. Although travel restrictions have been only released on mid-2022, the number of stays and events have been **at least as important as pre-Covid period**. This therefore demonstrates the remarkable **liveliness of the network**, and the **strong will and relevance of collaborations**. For sure, this extraordinary dynamic has been significantly helped by the **strong resilience** of the network during the pandemic period.

Also, **numerous new projects** have been proposed, which largely compensate the end of others. Almost **all the indicators** (numbers of researchers and labs, staying time, involved students and early stage researchers…) have been **increasing**, with the exception of journal papers, which is explained by the number of new projects denoting **emerging collaborations** (also indicated by the increasing number of conference communications). Considering the number of new projects as well as the recommendation of the steering committee, project management has also evolved, with the implementation of a new indicator for **pluri-annual project follow-up**.

In summary, 2022 has been a particular year with **many changes** mostly triggered by the end of travel restrictions. This has led to a first review of previous projects by researchers involved in them, potentially leading to **project transformations** (e.g., merging) or simply their ending, while **face-to-face meetings and events** yielded numerous exchanges notably resulting in **many new collaborations emerging within the networks**, and to some extent to a **rebalance of their positioning** (also confirming the relevancy of the IRN themes and topics). Due to these deep transformations, particular attention will have to be placed on IRN activities, in particular regarding **new projects**, by **providing tools and supports for the productive development** of the network and its outcomes.

ELyT Global ("**E**ngineering sciences **Ly**on-**T**ohoku") is an International Research Network (IRN) aiming at promoting and supporting collaborating research between Lyon and Tohoku. The purpose of the IRN is to provide a framework to top-level collaborations between French and Japanese researchers on three main scientific topics ("Materials and structure design", "Surface and interfaces" and "Simulation and modeling") associated to three socio-economical themes ("Transportation", "Energy", "Engineering for Health"). ELyT Global also proposes training through research to students and researchers, through summer school and thematic spring schools.

This document exposes main actions that have been achieved in the framework of the IRN for year 2022. 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 25 projects involving 27 laboratories and 96 researchers.

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