Annual Report 2020

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

Executive Summary

This document reports the activity undertaken in the LIA[1]/IRN[2] ELyT Global framework during the year 2020. Despite the sanitary situation, research groups and people involved in the network have made outstanding efforts so that collaborative, networking, and promotion actions were still ongoing at a very high rate. In addition to the specific research topics within each project, the structuration of the French-Japanese collaboration at the scale of Japan and the Lyon/St-Etienne site has been initiated as a first step of the IRN opening.

New initiatives have completed the successful past actions. A thematic school on Molecular Dynamics or continuous support for welcoming Japanese Master students to perform a research stay in France (the France to Japan flow having been successfully implemented for many years by now) are some examples. 2020 shows a steady number of 26 actions (same as 2019) despite the sanitary situation. 77 researchers from 21 labs (9 French, 9 Japanese, 1 joint FR/JP, 1 German, and 1 Indian) are involved in these projects, representing 120 person-months in total with approx. 600 days of visits and exchanges for the sole year of 2020. Publication rate showed an impressive rise of +58% (27 Journal papers), while the sanitary situation yielded a drop in international conferences. In support to some of these research projects, 7 ongoing joint Double Degree (INSA/ Tohoku or ECL/Tohoku) Ph.D. students participate in the collaboration.

Hence, this report aims to expose the idea behind the ELyT initiative in general, and ELyT Global in particular. Then the actions performed in 2020 are reported, along with the detailed description of associated projects. Finally, some future opportunities and challenges are discussed.

[1] International Associated Laboratory

[2] 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 2020.
- ELyT MaX ("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, ELyT MaX 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[3].

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.

[3] 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)[4] , and (iii) dedicated experimental platforms (such as “Material, Mechanical and Tribological measurements”[5], “High-Tech equipment for microscopy”[6], “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), 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 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

[4] 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.

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

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

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 with CNRS recognition in 2008, has officially started in January 2009, *i.e.,* 11 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 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).

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

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

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

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

The IFS LyC[9]

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

The Lyon Center was established in Université de Lyon in April 2018 by Tohoku University's Institute of Fluid Science. At this center, fluid science researchers from the IFS and other Japanese institutions will 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 we will operate an international research unit, do collaborative research utilizing the strengths of each party, and promote world-leading human resources development.

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. ELyTGLobal 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 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.

[9] Institute of Fluid Science Lyon Center

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

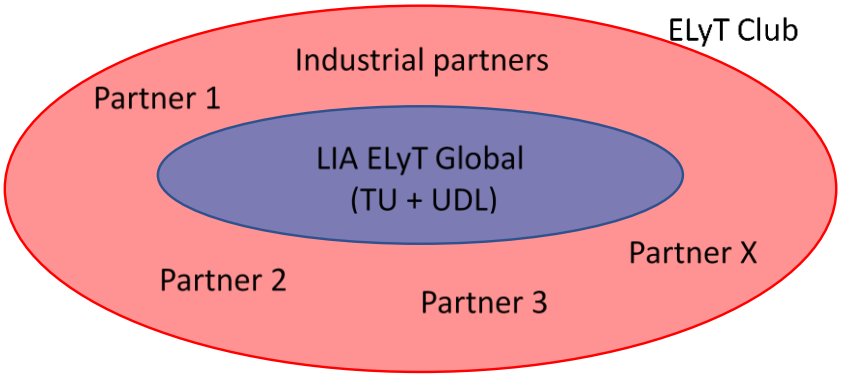


Figure 1: Scheme of the concept of ELyT Global and ELyT Club.

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 Project (PYRAMID) and a KAKENHI project have been obtained from the French and the Japanese government**. 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 IRL objectives are to strengthen the underway actions with financial supports. Simultaneously, it encourages and facilitatess 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.

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:

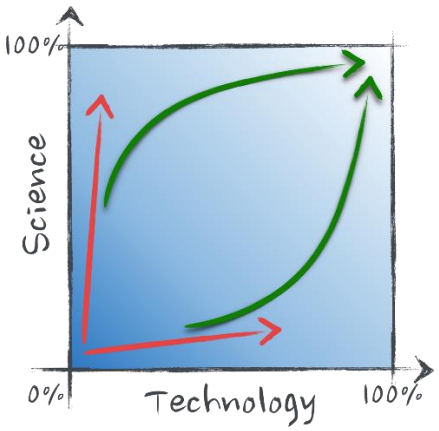


Figure 2: Schematic illustrating the paths towards mature technologies, based on the combination of science and technology. ELyT Global aims at following the green arrows, using science to improve technology.

- 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.

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).

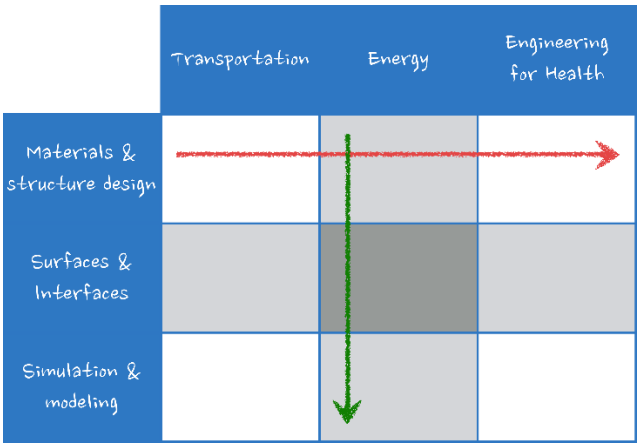


Figure 3: The 3 main themes (columns) and the three main topics (rows) of ELyT Global. Projects will belong either to a theme for application-oriented ones, or to a topic for science-oriented ones.

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 (traditional and new materials, structural materials, surface treatments, coatings, composites…), and lubricants. Mechanics of materials is then an essential field of research, together with tribology and manufacturing processes.

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

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

Energy

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

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

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

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

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

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

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

Engineering for Health

Challenges of engineering for Health are maintaining health (involving anti-aging) and curing patients less invasively. Recent research activities focus only on a single discipline, which means developments are performed with a single viewpoint. However, health needs a multi-disciplinary approach (Figure 4),

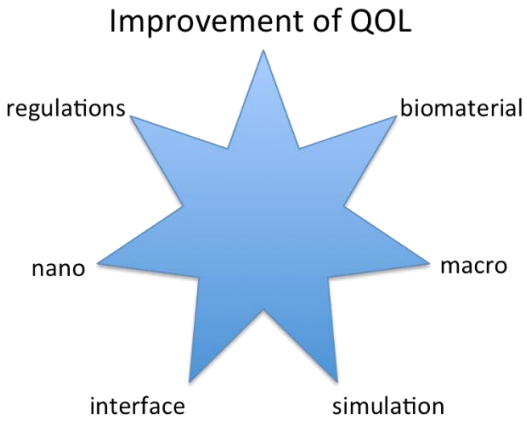


Figure 4: Schematic of the different challenges to address for improving quality of life (QOL).

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, in Europe will soon be voted a new regulation focused on MD's safety and performances. For instance, the 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 (MD, QCMD…), 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 life-time, 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 mechano-chemical polishing, the origin of mecano-chemical 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.

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:

- 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.

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

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, 18 students were involved, but only one from Tohoku University to Lyon. 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 *(since 2021)* mickael.lallart@insa-lyon.fr Prof. FABREGUE Damien *(until 2020)*	Dr. FONTAINE Julien julien.fontaine@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. TAKAGI Toshiyuki Prof. UCHIMOTO Tetsuya uchimoto@ifs.tohoku.ac.jp
Financial aspects	Mrs. SECOND Jalila erika.sattler@insa-lyon.fr	Mrs. SCHOCH Helene helene.schoch@ec-lyon.fr	Prof. UCHIMOTO Tetsuya
ELyT School	Dr. FAVE Alain alain.fave@insa-lyon.fr Dr. JOLY POTTUZ Lucile	Dr. FRIDRICI Vincent vincent.fridrici@ec-lyon.fr	Prof. UCHIMOTO Tetsuya
Annual workshop	Prof. FABREGUE Damien Mrs. SECOND Jalila jalila.second@insa-lyon.fr	Dr. FONTAINE Julien Mrs. 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.

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 / UdL
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.

2020 activities

Forewords

The pandemic situation in the world has put international collaborations into trouble. However, the strength of historical collaborations in ELyT activities' framework has shown particular resilience facing this unprecedented circumstance. Hence, exchanges have still been possible, mostly relying on long-term visits. Projects and associated advances and valorization (*e.g.*, publication) also showed **comparable amounts than previous years**, some indicators even increasing (Journal publications). Also, **new initiatives** have been launched, and **structuring actions** and projects successfully applied and implemented. Such resilience is explained by the strong roots of the collaboration and natural interactions between French and Japanese researchers in the framework of ELyT.

LyonSE&N

Following a strong will to **structure actions and develop the network outside the founding partners**, an Université de Lyon initiative driven by some of the ELyT key members started in 2018. **Called LyonSE&N (Lyon/St-Etienne & Nippon)**, this action, divided into three distinct thematics (“Energy”, “Health” and “Urbanism”) and a transverse one (“Data Science and AI”) representing scientific strengths and societal needs of both countries, has allowed developing new insights, both in terms of collaborative actions and involved partners. One key program consisted of STARMAJ action, consisting of **providing grants for Master students to perform research activities in a network's foreign laboratory**. For the first time, it allowed welcoming **20 Japanese Master students**[12] (including 11 in the framework of ELyT activities) for stays of **several months** (from 2 to 6), who are usually very prudent regarding international experiences. Through research, this training is a strong base for initiating or strengthening collaborations between Japanese and French permanent researchers.

ELyT and LyonSE&N workshop[13]

The 11th edition of the ELyT workshop was held from **February 17 to 19th, 2020, in Domaine Lou Capitelle, Vogüé, Ardèche, France**. It gathered **65 participants**, including 36 participants from Japan. 36 talks were given, and 11 posters were presented. For the first time and following the LyonSE&N initiative to structure the collaboration and widen the network, **the workshop was extended to activities in the framework of global Lyon/St-Etienne/Japan collaboration**.

ELyT School

Due to the worldwide sanitary situation, and despite significant effort to find solutions (postponement, …), the 12th edition of ELyT School, initially planned to be held in Sendai in September 2020, has been **canceled**. It is **rescheduled for September 2021** in Sendai.

Molecular Dynamics school

In 2020 a new initiative for training through research was implemented in a **spring school dedicated to Molecular Dynamics**, representing a common field of expertise with **very good complementarities between Lyon, Tohoku University, and Todai**. The school was successfully held from February 23rd to March, 1st 2020. It gathered **12 attendees**, ranging from B3 students to assistant professors. Thanks to innovative pedagogical methods, such an extensive range of levels was well managed to ensure that all participants would understand while gaining knowledge. The success and mutual interest in this action yielded preliminary **planification of future editions**.

[12] According to the Japanese curriculum, Master students are much closer to researcher than conventional students.

[13] https://www.elyt-lab.com/en/content/elyt-workshop-2020

International Ambition Pack "LyonSE&N Welcome"

To support LyonSE&N actions, a project proposal has been **granted by Auvergne-Rhône Alpes** region to support the cost of **Japanese Master student-researcher[14] long-term research stays** in French laboratories of Lyon/St-Etienne site, as well as, to some extent, visit of their Japanese supervising professors (15 k€/year for 3 years). Therefore, such a project targets settling **new collaborations**, potentially with laboratories outside Lyon but deeply involved in the collaboration, as well as **strengthening existing ones**. By providing more attractive grants to students, we expect further increasing the number of exchanges and also attracting top-level Master student-researchers to be involved in the collaborations, ultimately providing a **premium pool for Double Degree Ph.D. students**, and, in a medium/long-term sight, potential contributors at academic and industrial levels once these students will be in their professional life.

Cross-appointed professor & associate professor positions

To further strengthen the already well-established cooperation, Tohoku University in agreement with INSA Lyon, employs since 2019 on a **part-time basis ("cross-appointment") three assistant professors as well as a professor emeritus from INSA-Lyon** to facilitate welcoming foreign staff, with support at the administrative, life and scientific contact levels. These positions has been **renewed in 2020**, with discussions to **extend this initiative to other researchers** strongly involved in the cooperation.

Tohoku IFS LyC

Tohoku Institute of Fluid Science proposes each year project grants (CRP - "Collaborative Research Projects"), with some dedicated to international collaborations. In 2020, IFS reconducted a call **specifically addressed to Tohoku-Lyon collaboration through IFS LyC**. Hence, **8 ELyT Global projects** beneficiated from this support. While such projects are mainly dedicated to travel and visits, 2020 projects were allowed to spend all of the budget for furniture and consumable – possibly delivered to the French partner - due to COVID-19 pandemic.

JSPS fellowships

Demonstrating the Tohoku involvement but also the global national support from Japan to the collaboration, JSPS[15] fellowships have been granted in the framework of ELyT Global. In 2019-2020, **two researchers beneficiated from long-term fellowships**. One consisted of **a long-term invitational** position (10 months, Sept. 2019-June 2020) and the second one of a **post-doc** position (13 months). For the last fellowship, the application was done through CNRS.

Other Japanese counterparts

In addition to the actions undertaken mentioned above, it is also important to note that many actions and grants are also found on the Japanese side. For example, Tohoku University welcomes **French Master students for Double Diploma program, with grants from Japanese institutions** (JASSO, MEXT…). Typically **10 French Master students are simultaneously involved** in this program (5 new every year, 2-year program).

Collaborative scientific activities in the framework of ELyT Global

As previously underlined, the pandemic situation has severely restricted short-term travels and visits but ultimately had little impact on collaborative aspects thanks to resilient collaborations built on a long history and factual bases. Hence, in 2020, **26 projects** were active, corresponding to the same

[14] Due to the strong presence of laboratory research activity in the Japanese Master curriculum, the term "student-researcher" is more adapted here than just "student".

[15] Japanese Society for the Promotion of Science.

number as 2019. As an image of the network's liveliness, **5 new projects** entered the list, and 5 terminated or put on standby.
While short-term travels and visits significantly dropped, the increasing number of long-term stays allowed maintaining significant researcher exchanges (Table 3). These promising numbers also apply to co-supervision (Table 4), with funding source being more and more diversified (MESRI, ANR…) but still efforts to be performed to enroll Japanese students, and publications (Table 5 - + 10 journal papers compared to 2019).

FR→JP		**JP→FR**	
2020	**Total declared (running projects only)[16]**	**2020**	**Total declared (running projects only)[16]**
464 (incl. 3 very long stays > 6 months)	1104 (incl. 8 long stays > 1 month and 3 very long stays > 6 months)	130 (incl. 4 long stays > 1 month)	1324 (incl. 18 long stays > 1 month)

Table 3. 2020 visits and total declared in project forms (excluding Double Diploma students). Numbers are given in days.

Ph.D. students		**M.Sc. students**	
2020	**Total**	**2020**	**Total declared (running projects only)[16]**
11 (incl. 7 Double Degree students)	22	8	14

Table 4. Students involved in the projects.

Journal papers		**Conferences**	
2020	**Total declared (running projects only)[16]**	**2020**	**Total declared (running projects only)[16]**
27	71	27	75

Table 5. Scientific communications (+1 patent).

Regarding ELyT Global scientific positioning, projects are quite well dispatched among the scientific topics and themes (Figure 5). However, energy scientific topic shows over-representation because of its transdisciplinary nature (for instance, there is no project mixing Transportation and Engineering for Health).
The average data for the projects are given in Table 6. It can be noted that 17 projects out of 26 declared budget associated with their projects, for a total amount of 881 k€. The total number of participants in all the projects is 77 (for a total workforce of 120 person-month in 2020), from 21 laboratories (9 French, 9 from Tohoku, 1 joint FR/JP, 1 German and 1 Indian). Participating laboratories are given in Table 7.

[16] "Total declared" refers to the whole project duration for those still running in 2020. Former projects are not taken into account, so that global numbers for all ELyT projects since the beginning of the initiative is much higher.

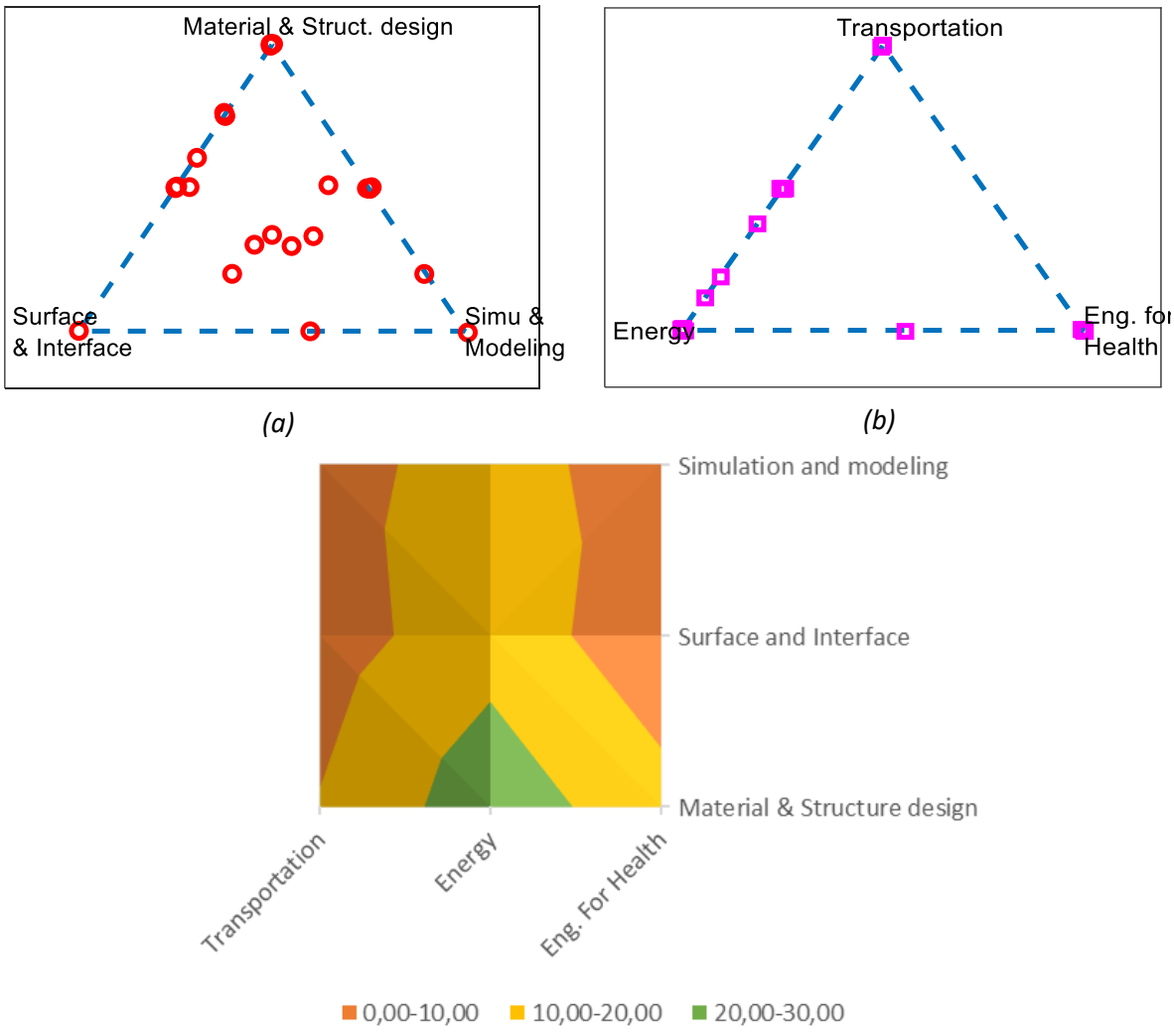


Figure 5: Repartition of projects (percentages): (a) by scientific topics; (b) by themes and (c) general overview.

Average number of participants	4,3
Task force	4,6 person-months
Average FR→JP stays	17,8 days (2020) 42,5 days (total declared)
Average JP→FR stays	5 days (2020) 50,9 days (total declared)
Average international journal paper	1,04 (2020) 2,73 (total declared)
Average international conference	1,04 (2020[17]) 3,92 (total declared)
Average annual budget[18]	51,82 k€

Table 6. Average project data.

[17] Worldwide COVID-19 pandemic had a significant impact on workshops, symposia and conferences.

[18] 17 projects declared budget. Hence, the average has been calculated on this number.

France		Japan	
Lab.	**Nb. projects**	**Lab.**	**Nb. projects**
LTDS ECL	12	IFS Tohoku	19
MATEIS INSA-Lyon	12	GSE Tohoku	5
LGEF INSA-Lyon	5	NICHe Tohoku	4
CETHIL INSA-Lyon	3	IMR Tohoku	3
ILM UCBLyon1	3	Space Structure Lab. Tohoku	2
CREATIS INSA-Lyon	1	FRIS Tohoku	1
IMP INSA-Lyon	1	GSMS Tohoku	1
LIRIS ENISE	1	GSSE Kindai	1
LVA INSA-Lyon	1	IMRAM Tohoku	1
Joint FR/JP			
Lab.			**Nb. projects**
ELyTMaX CNRS/Université de Lyon/Tohoku University			17
Other			
Lab.			**Nb. projects**
IMT KIT (Germany)			3
IIT Dhanbad (India)			1

Table 7. Participating laboratories in 2020 projects.

List of active 2020 projects and project reports

Acronym	Name
BENTO	Nonlinear and dynamic micromagnetic Behavior modeling and characterization for Non-Destructive Testing techniques optimization
BoneDrill	Development and Friction Characterization of Biomodels of Bones
BOSMA*	Blood flOw Simulation for Medical Applications
CarboEDiffSim	Simulation of Carbon electro diffusion in Iron with phase change
CODOMO	COrrosion Degradation of cOld spray coating by electrocheMical analysis at the lOcal Scale
CombAmmOpt	Elucidation of fundamental COMBustion characteristics of AMMOnia blended fuels to develop and OPTimize the design of low carbon gas turbines for power plants
CONCORD*	Corrosion friction stir welDing
COSMIC	COmpression-Shearing Method – understanding Interfaces in metal Composites
DECCOBABA	DEvelopment and Characterization of New CO BAsed alloys for Biomedical Applications
ELiceTrib	Tribology of elastomer/ice contact from nm to mm scale
INTELUM	Materials and structure design
LASMAT	Nd3+/Yb3+rare earth ions-doped transparent laser ceramics by Spark Plasma Sintering method. Comparison with single crystals
lofDIAMS	Low and ultralow friction of microcrystalline diamonds films towards smart and tribo-resistant coatings
MARECO	MAgneto-Rheological elastomers for Energy COnversion
MATSURI*	MAgneToStrictive coUpling for eneRgy harvestIng
MicroCell	Microsystems for Cell Engineering
MISTRAL	MIniature-Scale Energy GeneraTion by Magnetic Shape MemoRy Alloys
MuORoD	Multi-Objective Robust Design
OPSCC	Optimizing surface finish to Prevent SCC initiation in energy industries
PolymColdSprayCoat	Resilient Polymeric Cold Spray Coating
POMADE	POlymer-Metal-fiber Adhesions DElamination control
PYRAMID	Piping sYstem, Risk management based on wAll thinning MonItoring and preDiction
REFRESH*	REFRigEration based on Solid-state cooling: Heat transfer mechanisms
SIAEROSIM	Simulation of Silica aerogels
TATAMI*	Thermal AcTuation and energy hArvesting using MultIphysic alloys
TEmPuRA	Theory for Electrostriction of PolymeRic Actuator

Table 8. Active projects (: new projects).*

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]**	**Toshiyuki TAKAGI[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 – Université de Lyon – Tohoku University, International Joint Unit, Tohoku University, Sendai, Japan.

Contact: tetsuya.uchimoto.c7@tohoku.ac.jp, benjamin.ducharne@insa-lyon.fr, gael.sebald@insa-lyon.fr, toshiyuki.takagi.d4@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

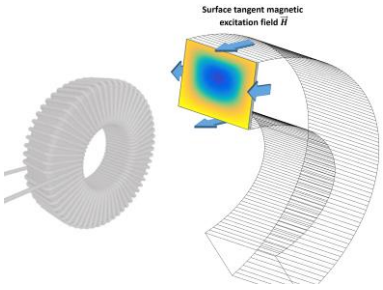
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- JSPS Grant-in-aid for scientific research (B) (2018 – 2020)
- Estimated budget: 17 000 000 ¥
- Lyc project (2017 – 2020)

Estimated annual budget: 20 k€E

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

- B. Gupta received the best Ph.D. award of 2019 by INSA under the category "Transports: Structures, infrastructures et mobilité".
- A simulation tool has been developed.
- More than 10 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 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)

Master/Bachelor students (years):

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*
- *Kita, Sep 2019, 2 months*
- *S. Zhang, Sep 2019, 3 months*
- *T. Matsumoto, May 2018, 3 months*
- *T. Uchimoto, Jul 2019, 2 weeks*
- *T. Uchimoto, Nov 2019, 1 week*

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	B. 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			2020	
2	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
3	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
4	B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto, T. Miyazaki, T. Takagi	Physical interpretation of the microsctructure for aged 12 Cr-Mo-VW steel creep test samples based on simulation of magnetic incremental permeability	Journal of magnetism and magnetic materials	486	165250	2019	https://doi.org/10.1016/j.jmmm.2019.165250
5	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
6	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
7	T. Matsumoto, B. Ducharne, T. Uchimoto	Numerical model of the Eddy current magnetic signature (EC-	AIP advances	9	035045	2019	https://doi.org/10.1063/1.5079995

		MS) non-destructive micro-magnetic technique					
8	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
9	B. Ducharne, B. Gupta, Y. Hebrard, J.B. Coudert	Phenomenological model of Barkhausen noise under mechanical and magnetic excitation	IEEE Transactions on magnetics	54	6202606	2018	https://doi.org/10/1109/TMAG.2018.2833419
10	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
11	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

BoneDrill

Development and Friction Characterization of Biomodels of Bones

MAIN PARTICIPANTS

				
Makoto OHTA[a, b]	**Vincent FRIDRICI[c]**	**Yuta MURAMOTO[a, c]**	**Gaëtan BOUVARD[c]**	**Philippe KAPSA[c]**

[a] *Institute of Fluid Science, Tohoku University, Sendai, Japan*
[b] *ELyTMaX, UMI 3757, CNRS, Université de Lyon, Tohoku University, Sendai, Japan*
[c] *LTDS, UMR 5513, CNRS, Ecole Centrale de Lyon, Ecully, France*

Contact: makoto.ohta@tohoku.ac.jp, vincent.fridrici@ec-lyon.fr

OVERVIEW

Starting year: 2011 **Current researchers** (permanent/non-permanent): 5 person-month/year

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

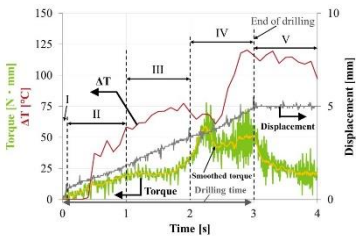
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- Labex MANUTECH-SISE / 2017-2020 / BoneDrill project

Estimated annual budget: 5 k€

Highlights & Outstanding achievements

- Double degree Ph.D. defenses of Yuta MURAMOTO in Tohoku University and in Ecole Centrale de Lyon.
- Development of engineered materials with controlled tribological properties in drilling for application in dentistry (training of students and surgeons, standardization, characterization for development of tools and prostheses).
- Development of tribological test methodology for determining friction properties during drilling of bones and biomodels.
- Yuta went back to Japan just before lockdown!!! and could start working for an implant company in Japan.

Illustration



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

The objective of this project is to develop bones biomodels with drilling characteristics similar to the ones of natural bones. These biomodels could be used for the training of doctors or development / evaluation of medical devices. Important characteristics are mechanical properties (hardness, elasticity modulus) and friction between the biomodel and a drill, in order to give to the doctors the same feeling as with natural bones for the drilling of the bones.

In the last years, this project was supported by the works of Yuta Muramoto, first as a TU master student (with a 1-year stay at ECL) and then as a double degree PhD student between TU and ECL, with final defense in the beginning of 2020.

Key scientific question (2 lines max; Calibri 11)

Characterizing friction properties during drilling

Developing materials with similar properties in drilling than bone.

Research method (8 lines max; Calibri 11)

Different composite materials, based on PMMA, have been developed and characterized (in mechanical tests and drilling tests), in order to understand the effects of different types of additives on hardness, elastic modulus, thrust force, maximum friction torque, drilling speed… This project focuses on the relationships between these parameters and the materials' microstructure, by taking into account temperature, lubrication and chips shape during drilling. Validation of the newly developed composites is performed by drilling tests realized by surgeons to rank developed composites, already existing bone biomodels and natural bones, in terms of feeling during drilling.

Research students involved

Ph.D. candidates (years, institution):

- Yuta Muramoto (2017-2020, Tohoku University – Ecole Centrale de Lyon)

Master/Bachelor students (years):

- Yuta Muramoto (2014-2017, Tohoku University with 1 year-stay at ECL)

Visits and stays *(from 2017)*

FR to JP (date, duration):

- V. Fridrici (September 2019, 1 week)
- V. Fridrici (March 2019, 4 days)
- V. Fridrici (August–September 2018, 10 days)
- V. Fridrici (November 2017, 5 days)

JP to FR (date, duration):

- M. Ohta (February 2020, 4 days)
- M. Ohta (October 2019, 4 days)
- M. Ohta (November 2018, 3 days)
- M. Ohta (October 2018, 2 weeks)
- M. Ohta (July 2018, 3 days)
- M. Ohta (February–March 2018, 5 weeks)
- M. Ohta (February 2017, 3 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Y. Muramoto, V. Fridrici, Ph. Kapsa, G. Bouvard and M. Ohta	Effects of temperature increase during surgical drilling in acrylic resin	Technology and Health Care	28(4)	369-380	2020	10.3233/THC-191870 https://content.iospress.com/articles/technology-and-health-care/thc191870

Conferences *(gray color for previous years) (from 2017)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Y. Muramoto, V. Fridrici, M. Ohta, P. Kapsa, G. Bouvard	Tribological characterization of acrylic composite materials for bone biomodel: the effects of alumina cement on drilling haptics	Lyon Saint Etienne & Nippon Scientific Network Engineering sciences Lyon Tohoku LyonSE&N – ELyT Workshop 2020	Feb. 17-19, 2020			
2	Y. Muramoto, V. Fridrici, P. Kapsa, G. Bouvard, M. Ohta	Drilling properties of acrylic composite materials for modeling of bone drilling in dry conditions	International Tribology Conference (ITC)	Sept. 17-21, 2019			
3	Y. Muramoto, V. Fridrici, P. Kapsa, G. Bouvard, M. Ohta	The effects of additive amount of acrylic composite materials on drilling properties towards development of bone biomodels	46th Leeds-Lyon Symposium on Tribology	Sept. 2-4, 2019			
4	Y. Muramoto, G. Bouvard, V. Fridrici, P. Kapsa, M. Ohta	Drilling of PMMA-based bone biomodel: The effects of temperature elevation during drilling	8th World Congress of Biomechanics	July 8-12, 2018	Dublin	Ireland	
5	Y. Muramoto, G. Bouvard, M. Ohta, V. Fridrici, P. Kapsa	Fabrication, Observation and Tribological Characterization of Acrylic Composite Materials for Bone Biomodel for Surgical Drilling	30èmes Journées Internationales Francophones de Tribologie (JIFT2018)	May 16-18, 2018	Sophia Antipolis	France	
6	Y. Muramoto, G. Bouvard, V. Fridrici, Ph. Kapsa, F. Lundell, M. Ohta	Research of high speed contact with medical devices	International Conference on Flow Dynamics - ICFD 2017	Nov. 1-3, 2017	Sendai	Japan	

7	Y. Muramoto, V. Fridrici, P. Kapsa, G. Bouvard, F. Lundell, M. Ohta	Drilling of PMMA-based bone biomodel: effect of additives	World Tribology Congress 2017	September 17-22, 2017	Beijing	China	

Others *(gray color for previous years)*

	People	Event	Description	Date
1	Yuta Muramoto	Tohoku University, President award	Special Recognition Award	

BOSMA

Blood flOw Simulation for Medical Applications

MAIN PARTICIPANTS

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

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

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

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☒ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☒ Yes ☐ No

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

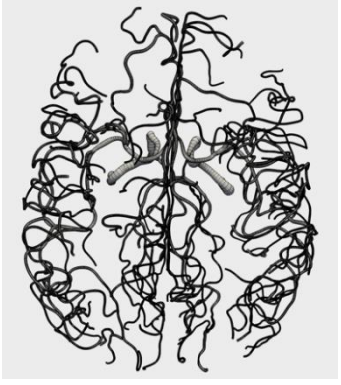
- Pack Ambition International from Région Auvergne-Rhône-Alpes, 2019-2022, SIMAVC
- INSA funding for PHD of Méghane Decroocq in the framework of ELyTMax

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-present, Directors: FRINDEL, LAVOUE and OHTA)

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 (January-December 2021, 1 year)
- Méghane DECROOCQ (November 2019, 1 month)
- Méghane DECROOCQ (Oct.2018-March 2019, 6 months)

JP to FR (date, duration):

- 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	N. Debs, M. Decroocq, T.-H. Cho, C. Frindel	Patient-Specific Hemodynamic Simulation for Stroke Lesion Prediction	International Conference of Flow Dynamics	28-30 Oct. 2020	Sendai	Japan	
2	M. Decroocq , C. Frindel, M. Ohta, G. Lavoue	Meshing Arterial Networks from Manually Extracted Centerlines	International Conference of Flow Dynamics	28-30 Oct. 2020	Sendai	Japan	
3	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	
4	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 2020	16 Dec. 2020	Johor	Malaysia	

Others *(gray color for previous years)*

	People	Event	Description	Date
1	M. Decroocq, C. Frindel, M. Ohta, G. Lavoue	ELyT Workshop 2020	Oral presentation	17-19 Feb., 2020
2	Y. Kohata, H. Anzai, M. Ohta, M. Decroocq, C. Frindel, S. Rit	ELyT Workshop 2020	Poster presentation	17-19 Feb., 2020
3	M. Decroocq, C. Frindel, M. Ohta, G. Lavoue	ELyT Workshop 2019	Oral presentation	9-12 March, 2019
4	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]	Kairi KITA[c]

[a] *Institute of Fluid Science, Tohoku University, Japan*
[b] *MATEIS, INSA-Lyon, France*
[c] *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

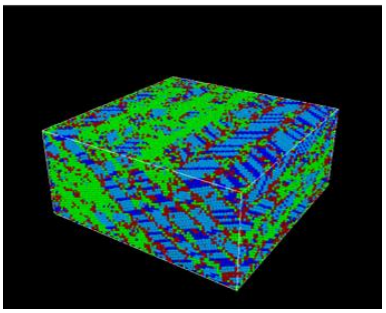
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget: None

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

- We have made a simulation code to estimate the diffusion coefficient of carbon in iron without phase change.
- We have made a method to evaluate the phase change point by thermodynamic integration. (right figure)
- The diffusion coefficient of carbon obtained by mean square displacement is different from that obtained by the velocity of carbon induced by electrical field.
- We have a school for molecular dynamics at IFS.

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)*

Master/Bachelor students (years):

- Kairi Kita (2020, IFS)

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

FR to JP (date, duration):

- P. Chantrenne (Feb 2020, 7 days)

JP to FR (date, duration):

- Takashi Tokumasu (Jun.-Jul. 2020, 2 months)
- Naoya Uene (Jun.-Jul. 2020, 2 months)
- Kyohei Ishikawa(Oct.-Nov. 2020, 2months)
- Koki Nakajima(Oct.-Nov. 2020, 2months)

COMMUNICATIONS AND VALORIZATION

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	K. Kita, T. Mabuchi, P. Chantrenne, T. Tokumasu	Molecular Dynamics Study of carbon diffusion inside iron under an electric field	The 34th Symposium on Computational Fluid Dynamics	21-23 Dec., 2020	Okinawa	Japan	https://dx.doi.org/sd.3432/0522-4530/de3c1f

Others *(gray color for previous years)*

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

CODOMO

COrrosion Degradation of cOld spray coating by electrocheMical analysis at the lOcal Scale

MAIN PARTICIPANTS

Nicolas MARY[a]	Kazuhiro Ogawa[b]	Bernard Normand[c]	Sheng Yuan[c]

[a] *ELyTMaX UMI3757 -CNRS-TU-UdL, Sendai Japon*
[b] *Tohoku University, GSE, FRRI, Sendai, Japan*
[c] *INSA Lyon – CNRS, MATEIS, Villeurbanne, France*

Contact: nicolas.mary@insa-lyon.fr, kogawa@rift.mech.tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2016 **Current researchers** (permanent/non-permanent): 4/0

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)*

- Allocation MESRI Ph.D.

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

-

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

CODOMOs aims to provide new criteria for the cold spray layer behaviors taking corrosion processes as the driving force for their degradation. To fully understand the corrosion initiation and propagation at the microstructure scale, local electrochemical measurements will be performed to characterize the particles' reactivity's modifications before and after their impacts on the substrates. Based on these mechanical, microstructural and electrochemical characterizations, the corrosion scheme will update. This knowledge will be used to evaluate new surfaces or additional treatments, such as UV Laser, to promote coating resistances.

Key scientific question (2 lines max; Calibri 11)

Origin of cold spray coating adhesion properties.
Relation between coating metallurgy and corrosion initiation/propagation

Research method (8 lines max; Calibri 11)

In 2016-2017, at INSA Lyon, E. Lapushkina performed High-pressure cold spray experiments on Zinc base powder (with Pr Normand and Dr Yuan). After a process optimization, several coatings were studied firstly by corrosion tests to correlate the metallurgical defects to the dissolution kinetic of the anodic coating.
During her stay in TU in 2017-2018, E. Lapushkina performed Low-pressure cold spray experiments on Al base powder (with Pr Ogawa and Dr Mary). As the one studied in Lyon (e.g., Zinc), this material is a sacrificial coating for corrosion protection. She completed coating with particle reinforcements to improve the hardness and compactness of the structure. First surface laser treatments were done and evaluated in terms of corrosion sensitivity. No metallurgical modification was found at the macroscopic/mesoscopic scale; however, a slight improvement in corrosion resistance was observed.
Another work was performed on Zn coating. The proposition of the experimental plan (Doehlert method) was done to limit the number of trial tests. Output parameters were: the coating thickness (dealing with coating durability), coating porosity (dealing with the corrosion propagation). Results showed the necessity to find a compromise since optimization can not solve all the parameters simultaneously.
Finally, E. Lapushkina completed her Ph.D thesis in 2020, July.

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

Ph.D. candidates (years, institution):

- E. Lapuskina (2016-2020)

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

FR to JP (date, duration):

- B. Normand (Prof.), stay at GSE/ELyTMaX (TU), November 2017 (1 week)

JP to FR (date, duration):

- N. Mary (Assoc. Prof.), stay at MATEIS (INSA-Lyon), March 2017 (1 week)
- N. Mary (Assoc. Prof) stay at MATEIS (INSA-Lyon), Sept. 2019 (1 week)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	E. Lapushkina, S. Yuan, N. Mary, K Ogawa, B. Normand	Contribution in optimization of Zn Cold-sprayed coating dedicated to corrosion applications	Surface and Coatings Technology	400	126193	2020	https://doi.org/10.1016/j.surfcoat.2020.126193

Project report 2020

CombAmmOpt

Elucidation of fundamental COMBustion characteristics of AMMOnia blended fuels to develop and OPTimize the design of low carbon gas turbines for power plants

MAIN PARTICIPANTS

			
Hideaki KOBAYASHI[a]	**Dany ESCUDIE[b]**	**Cedric GALIZZI[b]**	**Sophie COLSON[a]**

[a] *IFS, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai, 980-8577, Japan*
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Contact: kobayashi@ifs.tohoku.ac.jp, dany.escudie@insa-lyon.fr, cedric.galizzi@insa-lyon.fr, colson.sophie@tohoku.ac.jp

OVERVIEW

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			
Surfaces and interfaces		40%	
Simulation and modeling		60%	

Other: Environment

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/2018-2019/Priority Collaborative Research Project
- IFS/2020/LyC Collaborative Research Project
- JSPS/2020-2022/Grant-in-Aid for Scientific Research (B)

Estimated annual budget: 4,000,000 JPY

Highlights & Outstanding achievements

- Ammonia/methane combustion chemistry was investigated for large ammonia content in the fuel, highlighting the main process of production and consumption of NO as well as the interactions between the two fuels.
- Extinction stretch rate was obtained for both premixed and non-premixed ammonia/methane flames, and existing kinetic modeling evaluated based on those experimental results, and way of improvement suggested.
- The stabilization domain of ammonia/methane jet flames was characterized, highlighting some specific behavior under the combined effect of air coflow velocity and ammonia content.
- Interaction flame-burner were clarified showing the evolution of the aero-thermo-chemical coupling occurring at the burner rim when gradually introducing ammonia in the flame.
- Results of this work were published in two papers in an international journal (Combustion Science and Technology).

Illustration

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

The study of low-carbon fuels, such as ammonia, is essential in the context of global warming. However, its combustion is challenging, particularly regarding flame stabilization and NOx emission. One solution to overcome the stabilization issues is to use a mixture of ammonia with another fuel. The aim of this work is the analysis of the fundamental combustion characteristics of an ammonia-methane mixture, which remains merely investigated in the literature. The objective is to understand the kinetic mechanisms leading to the formation of pollutants and the mechanisms controlling stabilization. This work thus focuses on the combustion chemistry of these mixtures, flame fundamental properties experimental characterization, detailed chemistry mechanisms evaluation as well as the detailed study of flame stabilization and flame burner interaction.

Key scientific question (2 lines max; Calibri 11)

What are the key processes leading to NOx production in ammonia/methane flames?
How is flame stabilization affected by ammonia introduction in fuel mixture?

Research method (8 lines max; Calibri 11)

The research method combines experiment and numerical simulation on ammonia/methane flame. Observation of fundamental flame properties (extinction stretch rate, radical and intermediate species profiles) was done by combining experiments (PIV, PLIF) and numerical simulations. The flame chemistry analysis involves the use of numerical simulations to perform reaction path analysis, heat release rate analysis… The flame stabilization study corresponded to global parameter observation in a first stage, combined to shadowgraph imaging measurements, CH* chemiluminescence imaging to track the flame tip as well as temperature measurements to characterize the transition between each regime as well as the flame-burner interactions.

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

Ph.D. candidates (years, institution):

- Sophie COLSON (2017-2020, DD INSA Lyon - TU)

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

FR to JP (date, duration):

- Dany ESCUDIE (August 2018, 1 week)
- Cedric GALIZZI (August 2018, 1 week)

JP to FR (date, duration):

- Sophie COLSON (January 2020, 1 month)
- Hideaki KOBAYASHI (December 2018, 1 week)
- Sophie COLSON (October 2018 – September 2019, 1 year)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Colson, S., Hirano, Y., Hayakawa, A., Kudo, T., Kobayashi, H., Galizzi, C., & Escudié, D.	Experimental and Numerical Study of NH3/CH4 Counterflow Premixed and Non-premixed Flames for Various NH3 Mixing Ratios.	Combustion Science and Technology	In press.	In press.	2020	https://doi.org/10.1080/00102202.2020.1763326
2	Colson, S., Kuhni, M., Galizzi, C., Escudié, D., & Kobayashi, H.	Study of the Combined Effect of Ammonia Addition and Air Coflow Velocity on a Non-premixed Methane Jet Flame Stabilization.	Combustion Science and Technology	In press.	In press.	2020	https://doi.org/10.1080/00102202.2020.1830276

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Colson, S., Kuhni, M., Galizzi, C., Escudie, D., Kobayashi, H.	Effect of Ammonia Addition on a Non-premixed Methane Jet Flame Expanding in an Air Coflow	58th Japanese Symposium on Combustion	2-4 Dec., 2020	online	Japan	Oral presentation Paper ID 189q (Presentation C312)
2	Colson, S., Kuhni, M., Galizzi, C., Escudie, D., Kobayashi, H.	Study of the Effect of Ammonia Addition on the Stabilization of a Non-premixed Methane Jet Flame in an Air Coflow	International Conference on Fluid Dynamics ICFD2020	28-30 Oct., 2020	Sendai (online)	Japan	Oral presentation Paper ID5287-1 (Presentation OS20-11)
3	Colson, S., Hirano, Y., Hayakawa, A., Kudo, T., Kobayashi, H., Escudie, D., Galizzi, C.	*Experimental analysis and 1D modeling of counterflow ammonia-methane flames*	9th European Combustion Meeting	14-17 Apr., 2019	Lisboa	Portugal	Poster Presentation (Poster No. S1_All_18)
4	Colson, S., Hirano, Y., Kudo, T., Hayakawa, A., Kobayashi, H., Escudie, D., Galizzi, C.	*Investigation of methane-ammonia chemistry from premixed and diffusion flame structures using a counterflow configuration*	37th International Symposium on Combustion	29 July – 3rd Aug., 2018	Dublin	Ireland	Poster Presentation Poster 16339 (2P151)

Others *(gray color for previous years)*

	People	Event	Description	Date
1	S. COLSON	TU – KAUST online meeting	Oral presentation	3th Sept. 2020
2	S. COLSON	CETHIL PhDay	Oral presentation	March 14th 2019
3	S. COLSON	French Combustion Doctor Student Day (Journee Lacas)	Oral presentation	Jan. 22th, 2019

CONCORD

Corrosion friction stir welDing

MAIN PARTICIPANTS

Yutaka SATO[a]	Nicolas MARY[b]	Sabrina MARCELIN[b]	Bernard NORMAND[b]

[a] *Graduate school of Material Science, Tohoku University, Japan*
[b] *MATEIS – UMR CNRS, INSA Lyon, Villeurbanne*

Contact: ytksato@material.tohoku.ac.jp; nicolas.mary@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	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)*

- not yet

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

In many commercial applications, welding is inevitable. However, fusion welding processes often results in some problems with hot cracking in fusion zone due to segregation of alloying elements (Inconel alloy as example) or formation of intergranular Cr-rich carbides in the heat affected zone (as for austenite stainless steel). These metallurgical modifications affect the corrosion properties of the materials, consequently. To alleviate these microstructural problems, careful control of the weld metal composition and temperature are often required during welding.

Friction stir welding (FSW) achieved satisfactory products with better mechanical properties and better cost efficiencies than conventional fusion welding techniques. FSW is a solid-state joining process with low heat inputs, leading to the formation of fine grains, low distortion and no macro segregation. For 304 stainless steel, moreover, FSW leads to a relatively low degree of sensitization in the HAZ. Therefore, the corrosion resistance of the fusion weld could be improved with the subsequent friction stir processing (FSP) on the fusion zone of austenitic stainless steels.

Key scientific question (2 lines max; Calibri 11)

How stir welding affects the local electrochemical behavior of stirred zone?

Research method (8 lines max; Calibri 11)

To better understand improvement of the corrosion resistance of the join zone and its surrounding in the fusion zone by FSP, local electrochemical analysis will be carried out to correlate the metallurgical state of the material, the passive film properties and the pitting sensitivity of the surface. These characterizations will help to optimize next FSW join to better resist to aggressive environments, and to expand use of FSP as the surface modification method to improve performance of austenitic stainless steel weld.

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

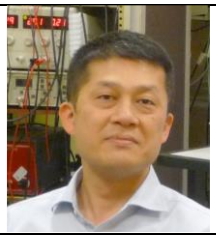
Master/Bachelor students (years):

- Mr. Naru Kawauchi

COSMIC

COmpression-Shearing Method – understanding Interfaces in metal Composites

MAIN PARTICIPANTS

				
Julien FONTAINE[a]	**Hiroyuki MIKI**[b]	**Takamichi MIYAZAKI**[c]	**Matthieu GUIBERT**[a]	**Sho TAKEDA**[b]

[a] *Laboratoire de Tribologie et Dynamique des Systèmes, École Centrale de Lyon, Écully cedex, France*
[b] *Institute of Fluid Science Tohoku University, Sendai, Japan*
[c] *School of Engineering, Tohoku University, Sendai, Japan*

Contact: julien.fontaine@ec-lyon.fr, hiroyuki.miki.c2@tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2016 **Current researchers** (permanent/non-permanent): 5 person-month/year

Positioning *(Multiple selection allowed – total 100%)*	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design	5 %	50 %	
Surfaces and interfaces	15 %	30 %	
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)*

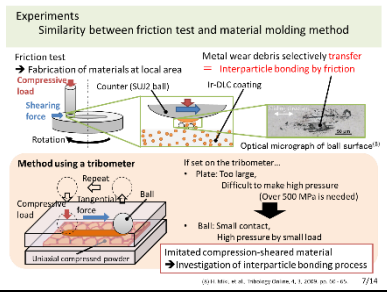
- JSPS, 2019-2022, Grant-in-Aid for Challenging Research
- JSPS, 2015-2020, Grant-in-Aid for Scientific Research
- Frontier Research Institute for Interdisciplinary Sciences, TU/2016-2018/ International Collaborative Research Project

Estimated annual budget: 10,000 EUR

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

- A double degree student (Sho Takeda) took a degree from TU.
- Two publication has been accepted in Tribology Online.
- Project have been partly granted from JSPS.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

In recent years, requirements for the material property such as a high strength and/or high toughness are increasing with development of machine and mechanical system. Materials processing is one of the important techniques to improve those properties. Many scientists are working in this field and several processing for manufacturing metal and composite such as casting, and powder metallurgy have been proposed. Our research group has been focusing on a novel powder molding technique, COmpression Shearing MEthod at Room Temperature (COSME-RT) as the method to consolidate metal powder into thin plate directly. In this method, dissolving at high temperature is not required and metal plate can be formed without coarsening of crystal grain and making compound. Consolidated metal plates indicate high mechanical strength according to refined crystal grains.

Key scientific question (2 lines max; Calibri 11)

Development of new molding technique using solid-phase bonding of powder material.
Research on the principle of local solid-phase bonding on metals, etc.

Research method (8 lines max; Calibri 11)

COSME-RT has attracted attention as the novel method of solidifying metal powder. The metal powders are solidified by the enforced plastic flow, and external heating is not required. In this project, the possibility of compacting the metal powder and the composite between metal and other material, polymer, ceramics and compound etc., using COSME-RT will be investigated, to clarify the interparticle bonding of powder particles during the compression and shearing process. With development of this technique, we would like to form the multifunction material which shows the good electrical and friction properties by a simple solidifying process as a practical material.

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

Ph.D. candidates (years, institution):

- Sho Takeda (2015-2018, DD TU-ECL)

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

FR to JP (date, duration):

- J. Fontaine (CR CNRS), Stay at IFS (TU, September 2019 (2 days)
- J. Fontaine (CR CNRS), Stay at FRIS (TU, January 2018 (2 days)
- J. Fontaine (CR CNRS), Stay at FRIS (TU, October-November 2017 (1 week)

JP to FR (date, duration):

- H. Miki (Assoc. Prof.), Stay at LTDS (ECL), December 2018 (4 days)
- S. Takeda (DD PhD), Stay at LTDS (ECL), December 2018 (2 weeks)
- S. Takeda (DD PhD), Stay at LTDS (ECL), February-March 2018 (6 weeks)
- H. Miki (Assoc. Prof.), Stay at LTDS (ECL), September 2017 (1 week)
- H. Miki (Assoc. Prof.), Stay at LTDS (ECL), June 2017 (1 week)
- S. Takeda (DD PhD), Stay at LTDS (ECL), April-July 2017 (3 months)
- H. Miki (Assoc. Prof.), Stay at LTDS (ECL), January 2017 (1 week)
- S. Takeda (DD PhD), Stay at LTDS (ECL), January-March 2017 (2 months)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	S. Takeda, H. Miki, J. Fontaine, M. Guibert, H. Takeishi, T. Takagi	Interparticle Bonding of Cu Powder under Repetitive Unidirectional Friction	Tribology Online	13(2)	43-49	2018	doi: 10.2474/trol.13.43
2	S. Takeda, H. Miki, J. Fontaine, H. Takeishi, T. Takagi	Role of MoS_2 Addition in the Consolidation of Metal from Powder to Plate by the Compression Shearing Method at Room Temperature	Tribology Online	13(1)	15-19	2018	doi: 10.2474/trol.13.15

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Sho TAKEDA, Hiroyuki MIKI, Julien FONTAINE, Matthieu GUIBERT, Hiroyuku TAKEISHI, Toshiyuki TAKAGI	*Transition of Solid-phase Dynamic Alloying Behavior of Powder Particles under Repetitive Tangential Force*	ELyT Workshop 2019	10 March 2019	Osaki	Japan	
2	Sho TAKEDA, Hiroyuki MIKI, Julien FONTAINE, Matthieu GUIBERT, Noboru NAKAYAMA, Hiroyuku TAKEISHI, Toshiyuki TAKAGI	*Solid-phase interparticle bonding of pure cu powder particles under repetitive unidirectional friction experiment*	The 5th Asian Symposium on Materials and Processing (ASMP2018)	7 Dec. 2018	Bangkok	Thailand	
3	S. Takeda, H. Miki, J. Fontaine, M. Guibert, N. Nakayama, H. Takeishi, T. Takagi	*Transition of Dynamic Elasto-plastic Contact Behavior of Pure Cu Powder*	15th International Conference on Flow Dynamics	7-9 Nov. 2018	Sendai	Japan	
4	S. Takeda, H. Miki, J. Fontaine, M. Guibert, T. Miyazaki, T. Takagi	*Mechanism of interparticle bonding of metal powder by repetitive unidirectional friction process, Conference on Material Mechanics*	Conference on Material Mechanics M&M2017	9 Oct. 2017	Sapporo	Japan	
5	S. Takeda, H. Miki, J. Fontaine, M. Guibert, T. Miyazaki, T. Takagi	*Interparticle Bonding of Metal Powder under Repetitive Unidirectional Friction Force*	14th International Conference on Flow Dynamics	1-3 Nov. 2017	Sendai	Japan	

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

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

- A 4 months stay in France for a Japanese master student
- A new paper published

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Co based alloys are already widely used for various biomedical applications. Moreover, more and more parts are made through additive manufacturing techniques. Thus, there is now some efforts to make to develop new alloys permitting to obtain optimized microstructure and mechanical properties at the end of the elaboration process for being used in biomedical applications.
Thus, this project will address that topic. Some thermodynamic calculations will be carried out to predict the equilibrium phases. Bulk materials will be casted and some additive manufacturing experiments (when the powder can be elaborated) will be realized varying the different process parameters. Microstructural characterization as well as mechanical ones will be done to evaluate the in-use properties of the new alloys. Damage characterization and biocompatibility will be assessed to have a complete picture of the potentiality of these new designed alloys.

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)

The objectives of COMIC encompass material science, tribology and electrical physics. The material is obtained from commercial ink, with incorporation of graphene nano objects made electrically non-neutral through triboelectric process. The inclusion of the particles in the ink matrix is obtained through solution casting method with ultrasonic dispersion. A particular attention is paid to the charged ink and paper interface to ensure that bonding properties are kept while maintaining a viscosity level sufficient for graphene particle movements. Finally, dielectric analysis is performed to evaluate the polarizability and electromechanical coupling of the embedded nano particles.

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

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)*

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

ELiceTrib

Tribology of elastomer/ice contact from nm to mm scale

MAIN PARTICIPANTS

				
Kazue KURIHARA[a]	**Masashi MIZUKAMI[a]**	**Motohiro KASUYA[b]**	**Denis MAZUYER[c]**	**Juliette CAYER-BARRIOZ[c]**

[a] *New Industry Creation Hatchery Center, Tohoku University, Japan*
[b] *Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Japan*
[c] *LTDS, ECL, CNRS UMR5513, France*

Contact: kazue.kurihara.e7@tohoku.ac.jp, denis.mazuyer@ec-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	30%		
Surfaces and interfaces	40%		
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

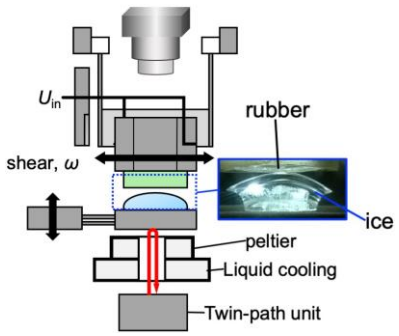
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

- ANR-JST project, 2020-2026, Multi-scale elucidation of friction mechanisms in ice-rubber interfaces
- Nihon Michelin Tire Co. collaboration research fund, 2015-2018, Rubber-water-glass resonance shear measurement.

Estimated annual budget: 260,000 Euro/year
(32,000,000 yen/ year)

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

- Ice-rubber friction was investigated using a low temperature surface forces apparatus/resonance shear measurement (LowT-SFA/RSM) which we developed.
- Viscosity of ice-premelting layer was evaluated for the first time as functions of temperature and sliding velocity.
- Ice-rubber friction was modified by the ice premelting layer and the viscoelasticity of the rubber in complex manners.
- Ice-rubber(with fillers) friction was dominated by the viscoelasticity of rubber and influenced by roughness at –13 ˚C.



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Driving on ice can be slippery and leads to poor road safety, therefore, improving the grip of tire on ice is important. The energy loss due to the tire friction also needs to be minimized, requiring complex adjustment of tire materials, one of typical elastic soft materials. In order to achieve sustainable technology and safer society, there is an increasing interest to elucidate and control the interaction between ice and rubber.

Several mechanisms govern the tribological behavior of ice-rubber, such as premelting and melting of ice, rubber viscoelasticity and adhesion of ice-rubber interface. In addition, these mechanisms are known to depend both on temperature (T) and shear velocity (V). These dynamic properties and their coupling result in the complicated friction behavior of ice-rubber interfaces.

Key scientific question (2 lines max; Calibri 11)

Understanding of governing factors of ice-rubber friction and its mechanisms.

Establish a guideline to design innovative rubber materials to optimize friction and energy saving.

Research method (8 lines max; Calibri 11)

LowT-SFA/RSM will be used for characterizing the ice premelting layer, adhesion, and the viscoelasticity of styrene butadiene rubbers (SBRs) surfaces with various T_g and SBRs with fillers. The contribution of each factor and their coupling effect on the ice-rubber friction will be evaluated.

KORI tribometer, developed by ECL, will be used for visualizing the multi-contact spots of macroscopic ice-rubber interfaces, evaluating friction heat as well as adhesion and viscoelastic properties of rubber affect the ice-rubber friction.

The obtained results will be integrated in the predictive friction model, and will be utilized to establish a guideline to molecular design of innovative rubber materials.

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

Ph.D. candidates (years, institution):

- Sylvain HEMETTE (2016 -2019, ECL and Tohoku University)

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

FR to JP (date, duration):

- Denis MAZUYER (Dec. 2015, 3 days; Oct. 2016, 3 days; April 2017, 1 week)
- Juliette CAYER-BARRIOZ (Dec 2015; April 2017, 1 week)

JP to FR (date, duration):

- Kazue KURIHARA and Motohiro Kasuya (Nov. 2017, 2 days)
- Masashi MIZUKAMI and Motohiro KASUYA (June 2019, 3 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	F. Lecadre, M. Kasuya, S. Hemette, A. Harano, Y. Kanno and K. Kurihara	Ice premelting layer of ice–rubber friction studied using resonance shear measurement	Soft Matter	16	8677-8682	2020	DOI: 10.1039/d0sm00478b
2	F. Lecadre, M. Kasuya, Y. Kanno and K. Kurihara	Ice Premelting Layer Studied by Resonance Shear Measurement (RSM)	Langmuir	35	15729-15733	2019	DOI: 10.1021/acs.langmuir.9b02451
3	S. Hemette, M. Kasuya, F. Lecadre, Y. Kanno, D. Mazuyer, J. Cayer-Barrioz and K. Kurihara	Viscoelasticity of Rubber–Ice Interfaces Under Shear Studied Using Low-Temperature Surface Forces Apparatus	Tribology Letters	67	234156	2019	https://doi.org/10.1007/s11249-019-1187-2
4	M. Mizukami, S. Hemette and K. Kurihara	Mechanical model analysis for resonance shear measurement	Review of Scientific Instruments	90	055110	2019	doi: 10.1063/1.5084117
5	F. Lecadre, M. Kasuya, A. Harano, Y. Kanno and K. Kurihara	Low-Temperature Surface Forces Apparatus to Determine the Interactions between Ice and Silica Surfaces	Langmuir	34	11311-11315	2018	DOI: 10.1021/acs.langmuir.8b01902
6	S. Hemette, J. Cayer-Barrioz and D. Mazuyer	Friction setup and real-time insights of the contact under controlled cold environment: The KORI tribometer for rubber-ice contact application	Review of Scientific Instruments	89	123903	2018	https://doi.org/10.1063/1.5048844

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	K. Kurihara	Resonance Shear Measurement for Studying Contact Mechanics	International Tribology Conference 2019	16-21 Sep., 2019	Sendai	Japan	
2	K. Kurihara, F. Lecadre, S. Hemmette, M. Kasuya, Y. Kanno	*Low-temperature Surface Forces Apparatus*	International Conference on Active Materials	3-8 Nov. 2019	Okinawa	Japan	
3	S. Hemette, J. Cayer-Barrioz, D. Mazuyer	*A multi-physical and scale approach to tackle rubber/ice friction mechanisms*	International tribology Conference 2019	17-21 Sept. 2019	Sendai	Japan	

4	S. Hemette, D. Mazuyer, J. Cayer-Barrioz (Invited talk	*Ice-Rubber Friction Mechanisms*	Fall 2019 American Chemical Society National meeting	25-29 Aug. 2019	San Diego	USA	
5	S. Hemette, J. Cayer-Barrioz, D. Mazuyer	*A multi-physical and Scale analysis of Rubber/ice Friction Mechanisms*	STLE Tribology Frontier Conference 2018	28-31 Oct 2018	Chicago	USA	

INTELUM

Advanced scintillating fibres and Cerenkov fibres for new hadron and jet calorimeters for future colliders

MAIN PARTICIPANTS

		
Kheirreddine LEBBOU[a]	**Georges BOULON**[a]	**Akira YOSHIKAWA**[b]

[a] *ILM, UCBLYON1, Villeurbanne, France ;* [b] *IMR, Tohoku,Sendai, Japan ;* [c]*University of Wroclaw, Poland ;* [d] *Institut NEEL, CNRS/UGA UPR2940 and ESRF, Grenoble, France;* [e]*CERN-EP-CMX, Geneva, Switzerland;* [f]*Institute of Physics, Prague;*

Y. GUYOT[a], **C.DUJARDIN**[a], **K. KAMADA**[b], **S.KUROSAWA**[b], **J. PECHAL**[b], **M. GUZIK**[c], **G. DANTELLE**[d], **D. TESTEMALE**[d], **E. AUFFRAY**[e], **P. LECOQ**[e], **M. NIKL**[f]

Contact: georges.boulon@univ-lyon1.fr, yoshikawa@imr.tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2016 **Current researchers** (permanent/non-permanent): 5 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: European project, Intelum Rise2020. International and intersectoral mobility
Intelum is an European Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE) agreement No 644260 (Intelum), under Grant Agreement no. 654168 (aida 2020).ERC Advanced Grant no. 338953 (TICAL), by ASCIMAT project under Grant agreement no. 690599 and by COST Action TD1401 (FAST)

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

- Raw powders from several producers were tested and many tens of fibres of both Ce^{3+}-doped $Lu_3Al_2Al_3O_{12}$ (LuAG:Ce) /$Y_3Al_2Al_3O_{12}$ (YAG:Ce) (Length up to 1 m; 1-2 mm Φ round-shaped; 2x2 mm square fibres) have been delivered to CERN.
- The feasibility of producing between 20-200km of fibres with degradation of their optical properties below 10% at 1 MGy level and well defined production costs, has been demontrated.
- A novel optimization concept, related to the development of based on Mg^{2+} or Li^{+} codoping of Ce-doped garnets (LuAG,YAG and novel GAGG hosts) provided a new technological way to obtain faster scintillation response and higher light yield.
- We were mainly involved by the growth and the optical and XANES basic characterizations of Ce^{4+} in Ce^{3+}, Mg^{2+}-co-doped $Gd_3Al_2Ga_3O_{12}$ garnet crystals.

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Currently, new concepts are being considered for hadron and jet calorimetry in high energy physics experiments, in order to improve the energy resolution of these detectors by a factor of at least two. This is a prerequisite for future studies at the high luminosity, large hadron collider as well as at future electron and proton colliders: from LHC Large Hadron Collider (2008) to HL-LHC (2026). High Luminosity- Large Hadron Collider Amongst the few concepts being proposed, scintillating and Čerenkov fibres are considered very promising candidates. The collaboration between Lyon and Sendai is focused on the academic exchanges to develop micro-pulling-down crystal growth and other new types of fibre technology.

This project was completed in 2020. Another one has been launched with IMR-Tohoku and ILE (Institute of Laser Engineering) in Osaka on fast scintillators to detect neutrons.

Key scientific question (2 lines max; Calibri 11)

-demonstrate feasibility of producing crystalline fibres with consistent quality and defined costs
-demonstrate sufficient radiation hardness of the fibres

Research method (8 lines max; Calibri 11)

Commun research activities of both (ILM) at UCBLyon1 and IMR & NICHe of Tohoku University are based on engineering process, developments and applications in the field of scintillators and crystal growth. The teams are now two leading groups in both, crystal growth fibres and shaped crystals using micro-pulling down (µ-PD) and Czochralski techniques, structural and spectroscopic characterizations as well as mechanism analysis in scintillating crystals. The two teams have created novel or improved materials based on Ce^{3+}-doped $Y_3Al_5O_{12}$ (YAG), Ce^{3+}-doped $Lu_3Al_5O_{12}$ (LuAG) and Ce^{3+}, Mg^{2+}-co-doped $Gd_3Al_2Ga_3O_{12}$ garnets that match the challenging requirement specifications informed by CERN in view of the use in high energy. The project also lead to important impacts in other domains such as functional medical imaging and homeland security.

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

Ph.D. candidates (years, institution):

- Bouita Rekia iLM, UCBL (2016-2019)

Post-Doc:

- Omar BENAMARA (iLM, UCBL) (2018)
- Guillaume ALLOMBERT-GOGET (iLM, UCBL) (2018)

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

FR to JP (date, duration):

- K.Lebbou (DR CNRS) July 14 to August 14 2018 (one month)
- P.Veber (IR CNRS) August 2018 (one month)
- G. Boulon (Pr UCBL) Feb 2016, Feb 2017, Feb 2018, March 2019, Oct 2019, (3 weeks)

JP to FR (date, duration):

- Yoshikawa (Pr) (IMR) one week Feb 2017
- N. Sarukura (Pr) (ILE-Osaka) two weeks Nov 2017
- M. Empizo (Ass. Pr.ILE-Osaka) two weeks Nov 2017, Nov 2018, June 2019, one month Feb 2020

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	G. Dantelle, G. Boulon, Y. Guyot, D. Testemale, M. Guzik, S. Kurosawa, K. Kamada, A. Yoshikawa	Research of efficient fast scintillators. Evidence and XANES characterization of Ce^{4+} in Ce^{3+}, Mg^{2+}-co-doped $Gd_3Al_2Ga_3O_{12}$ garnet crystals	Physica Status Solidi B	257 n°8	1900510 (7 pages)	2020	DOI: 10.1109/TNS.2018.2840160
2	M. Yoshino, K. Kamada, V.Kochurikhin, M. Ivanov, M. Nikl, S. Okumura, S. Yamamoto, J. Yeol Yeom Y. Shoji , S. Kurosawa, Y. Yokota, Y. Ohashi, A. Yoshikawa	Li^+, Na^+ and K^+ co-doping effects on scintillation properties of $Ce:Gd_3Ga_3Al_2O_{12}$ single crystals	Journal of Crystal Growth 491, 1–5	491	1-5	2018	https://doi.org/10.1016/j.jcrysgro.2018.03.004
3	C. Dujardin, E. Auffray, E.Bourret, P. Dorenbos, P. Lecoq, M. Nikl, A. N.Vasil'ev, A. Yoshikawa, Ren-Yuan Zhu	Trends and Advances in Inorganic Scintillators,	IEEE Transactions on Nuclear Science	65(8)	1977	2018	https://doi.org/10.1002/pssb.20190051
4	K. Kamada, Y. Shoji, V. Kochurikhin, A. Nagura, S. Okumura, S. Yamamoto, J. Yeom, S. Kurosawa, J. Pejchal, Y. Yokota, Y. Ohashi, M. Nikl, M. Yoshino, A. Yoshikawa	Large Size Czochralski Growth and Scintillation Properties of Mg2+ Co-doped Ce:Gd3Ga3Al2O12	IEEE Trans. Nucl. Sci.	*63(2)*	443	2016	DOI: 10.1109/TNS.2016.2521399

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	G. Boulon,G.Dantelle, Y. Guyot, D. Testemale, M. Guzik, S. Kurosawa, K. Kamada, A. Yoshikawa	Ce4+ evidence in the fast scintillation mechanism of Ce3+, Mg2+-co-doped garnet crystals	International Conference on Scintillating Materials and their Applicationsl SCINT 2019, Sendai, Japan - *Plenary lecture*	26 Sept - 9 Oct, 2019	Sendai	Japan	http://www.scint2019.imr.tohoku.ac.jp/
2	G. Boulon,G.Dantelle, Y. Guyot, D. Testemale, M. Guzik, S. Kurosawa, K. Kamada, A. Yoshikawa	Evidence of Ce4+ ions by XANES spectroscopy in the new fast scintillator crystal: Ce3+, Mg2+-co-doped Gd3Al2Ga3O12 garnet	8th International workshop (PRE) :Photoluminescence in Rare Earths: Photonic Materials and Devices	4-6 Sept 2019	Nice	France	https://pre19.sciencesconf.org/
3	G. Boulon,G.Dantelle, Y. Guyot, D. Testemale, M. Guzik, S. Kurosawa, K. Kamada, A. Yoshikawa	XANES evaluation of Ce4+ ions in Ce3+-doped YAG and Ce3+/ Ce3+-Mg2+/ Ce3+-Li+-doped either Lu3Al5O12 or Gd3Ga3Al2O12 garnet crystals for scintillators	8th Symposium on Optical Materials (IS-OM8) - *Honorary Chair*	9-14 June 2019	Wroclaw	Poland	https://is-om8.chem.uni.wroc.pl/

Project report 2020

LASMAT

Nd3+/Yb3+rare earth ions-doped transparent laser ceramics by Spark Plasma Sintering method. Comparison with single crystals

MAIN PARTICIPANTS

Georges BOULON[a]	Akira YOSHIKAWA[b]

[a] *ILM, UCBLYON1, Villeurbanne, France ;* [b] *IMR, Tohoku,Sendai, Japan ;* [c]*University of Wroclaw Poland ;* [d]*National Institute of Optics-CNR 50019 Sesto Fiorentino,Italy*

Y. GUYOT[a], K. KAMADA[b], S.KUROSAWA[b], J. PEJCHAL[b], V. KOCHURIKHIN[b], T. GOTO[b], M. GUZIK[c], G. TOCI[d]

Contact: georges.boulon@univ-lyon1.fr, yoshikawa@imr.tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2014 **Current researchers** (permanent/non-permanent): 2 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:

LASMAT project is now completed. However we continue to work on these refractory materials grown by the new technique of bulk crystal growth from the melt in the cold crucible at IMR (Sendai) and for ceramics fabricated by SPS and HIP techniques at MATEIS, INSA-Lyon.

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

- We have grown single crystals of Nd^{3+}/Yb^{3+}-doped Lu_2O_3 by µ-PD technique
- We have fabricated transparent ceramics of Nd^{3+}/Yb^{3+}-doped Lu_2O_3 by SPS technique.
- The spectroscopic properties of the two C_2 and C_{3i} sites occupied by Nd^{3+} or Yb^{3+} of the sesquioxide lattice have been characterized.
- Laser outputs have been measured for all samples.

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Nd^{3+}/Yb^{3+}-doped Lu_2O_3 refractory single crystals show the highest thermal conductivity (12.5 W/m/K) and are very promising as high power laser application. We are here at the frontier of materials science with a melting point of 2510°C so that successful growths of high crystal quality is a challenge. Indeed, instead to grow single crystals, it should be much easier to fabricate Lu_2O_3 into a ceramic structure -solid-state reaction process- because the sintering temperature is about 700 °C lower than its melting point and no expensive crucible is required. Nd^{3+}/Yb^{3+}-doped Lu_2O_3 single crystals have been grown by the Micro-Puling Down (µ-PD) in Yoshikawa's group at IMR and transparent ceramics by the non-conventional and fast Spark Plasma Sintering (SPS) method in Goto's group at IMR.

Key scientific question (2 lines max; Calibri 11)

Growth of Nd^{3+}/Yb^{3+}-doped Lu_2O_3 single crystals by µ-PD and now from the melt in the cold crucible at IMR, Sendai.

Fabrication of Nd^{3+}/Yb^{3+}-doped Lu_2O_3 transparent ceramics by SPS and now by HIP at MATEIS, INSA-Lyon.

Research method (8 lines max; Calibri 11)

We have mainly grown single crystals and transparent ceramics from IMR, analysed the spectroscopic properties at iLM-UCBLyon1 and laser outputs at Firenze (Italy). Especially the spectroscopy of the two C_2 and C_{3i} sites of the cubic Lu_2O_3 sesquioxides have been characterized. **The project is completed**. However, after retirement of Prof. Goto at Tohoku two years ago, we improve the homogeneity of nanometric sizes of raw materials with Dr Malgorzata Guzik at the University of Wroclaw (Poland) in order to fabricate now transparent ceramics by SPS and HIP methods at MATEIS (INSA-Lyon). We experiment the fabrication of transparent ceramics by comparing with cubic Y_6MoO_{12} molybdate under study with another grant. Also, Yoshikawa'group at IMR works on the improvement of the crystal quality of single crystals by creating the new technique of bulk crystal growth from the melt in the cold crucible.

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

Master students (years):

M. Sobota and P. Sobota (iLM-UCBLyon1 and MATEIS INSA-Lyon (2018-19)

Post-Doc: Guillaume Allombert-Goget (iLM, UCBL) (2015-2018)

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

FR to JP (date, duration):

G. Boulon (Pr UCBL) Feb 2016, Feb 2017, Feb 2018, March 2019, Oct 2019, (3 weeks)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	P. Sobota, M. Guzik, V. Garnier, G. Fantozzi, M. Sobota, E. Tomaszewicz, Y. Guyot, G. Boulon	The challenge of fabrication of optical transparent ceramics from cubic nano-crystals Y_6MoO_{12} molybdate	Ceramics International	46 Issue 4	4619-4633	2020	https://doi.org/10.1016/j.ceramint.2019.10.192,
2	M. Sobota, P. Sobota, M. Bieza, M. Guzik, E. Tomaszewicz, Y. Guyot and G. Boulon	Influence of synthesis route and grain size on structural and spectroscopic properties of cubic Nd^{3+}-doped Y_6MoO_{12} nano and micro-powders as optical materials	Optical Materials	90,	300-314	2019	https://doi.org/10.1016/j.optmat.2019.02.021
3	Y. Guyot, M. Guzik, G. Alombert-Goget, J. Pejchal, A. Yoshikawa, A. Ito, T. Goto	Spectroscopy of C_{3i} and C_2 sites of Yb^{3+}-doped Lu_2O_3 sesquioxide either as ceramics or crystal	J. of Luminescence	170	513-519	2016	https://doi.org/10.1016/j.jlumin.2015.04.017
4	M. Guzik, G. Alombert-Goget, Y. Guyot, J. Pejchal, A. Yoshikawa, A. Ito, T. Goto	Spectroscopy of C_{3i} and C_2 sites of Nd^{3+}-doped Lu_2O_3 sesquioxide either as ceramics or crystal	J. of Luminescence	169	606-611	2016	https://doi.org/10.1016/j.jlumin.2014.12.063
5	G. Alombert-Goget, Y. Guyot, M. Guzik, G. Boulon, A. Ito, T. Goto, A. Yoshikawa, M. Kikuchi	Nd^{3+}-doped Lu2O3 transparent sesquioxide ceramics elaborated by the Spark Plasma Sintering (SPS) method. Part 1: structural, thermal conductivity and spectroscopic characterization	Optical Materials	41	3-11	2015	https://doi.org/10.1016/j.optmat.2014.10.014
6	G. Toci,, M. Vannini, M. Ciofini, A. Lapucci, A. Pirri,A. Ito, T. Goto, A. Yoshikawa, A. Ikesue, G. Alombert-Goget, Y. Guyot, G. Boulon	Nd^{3+}-doped Lu2O3 transparent sesquioxide ceramics elaborated by the Spark Plasma Sintering (SPS) method. Part 2: First laser output results and comparison with Nd3+-doped Lu2O3 and Nd3+-Y2O3 ceramics elaborated by a conventional method.	Optical Materials,	41	12–16	2015	https://doi.org/10.1016/j.optmat.2014.09.033

7	Malgorzata Guzik, Milosz Siczek, Tadeusz Lis, Jan Pejchal, Akira Yoshikawa, Akihiko Ito, Takashi Goto, Georges Boulon	Structuralinvestigations of un-doped Lu_2O_3 as Single Crystal and Polycrystalline Transparent Ceramic	Crystal Growth and Design,	14	3327−3334	2014	https://doi.org/10.1021/cg500225v
8	*Shunsuke Kurosawa, Liqiong An, Akihiro Yamaji, Akira Suzuki, Yuui Yokota, Kenji Shirasaki, Yamamura Tomoo, Akihiko Ito, Takashi Goto, Georges Boulon and Akira Yoshikawa*	Scintillation Properties of Nd^{3+}-Doped Lu_2O_3 Ceramics in the Visible and InfraRed Region	IEEE Transactions On Nuclear Science	61	316-319	2014	**DOI:** 10.1109/TNS.2013.2290554

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	G. Boulon, G. Alombert-Goget, Y. Guyot, M. Guzik, J. Pejchal, A. Yoshikawa, A. Ito, T. Goto, A. Ikesue, G. Toci	A challenge for laser materials Nd^{3+}-doped Lu_2O_3 ceramics/crystals .	CIMTEC, 14th International Ceramics Congress - *Invited*	4-8 June 2018	Perugia	Italy	
2	G. Boulon	Achievements, progress and issues in laser ions-doped optical transparent ceramics.	International School of Atomic and Molecular Spectroscopy - *Invited*	20 July-4 Aug 2017	Erice (Sicily)	Italy	
3	G. Boulon, A. Yoshikawa, M. Guzik, G. Toci	A challenge: Nd^{3+}-doped Lu_2O_3 ceramics. Fabrication by the SPS and HIP techniques, spectroscopic characterization and laser output.	12th Laser Ceramics Symposium. International Symposium on Transparent Ceramics for Photonic Applications Le FORUM – *Invited*	28 Nov. – 2 Dec. 2016	Saint-Louis	France	

lofDIAMS

Low and ultralow friction of microcrystalline diamonds films towards smart and tribo-resistant coatings

MAIN PARTICIPANTS

	
Hiroyuki MIKI [a]	**Michel BELIN**[b]

[a] *Institute of Fluid Science Tohoku University, Sendai, Japan*
[b] *Laboratoire de Tribologie et Dynamique des Systèmes, École Centrale de Lyon, Écully cedex, France*

Contact: hiroyuki.miki.c2@tohoku.ac.jp, michel.belin@ec-lyon.fr

OVERVIEW *(keep within this page)*

Starting year: 2016 **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 %	30 %	
Surfaces and interfaces	15 %	30 %	
Simulation and modeling	5 %		

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

IFS CRP/LyC project? ☐ Yes ☒ No

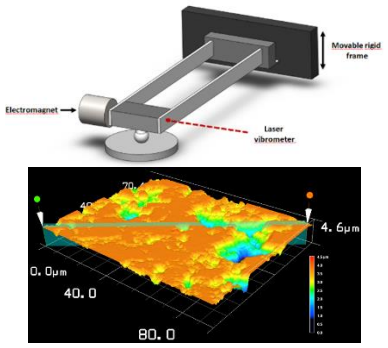
For main projects: Agency / year / name of project
- Institut Carnot I@L, France
- Frontier Research Institute for Interdisciplinary Sciences, Tohoku University/2016-2018/ International Collaborative Research Project

Estimated annual budget: N/A (2020)

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

- Succeeded in developing a measurement system.
- One publication has been accepted in Tribology Online.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

A project has started, concerning low and ultralow friction of carbon-based coatings. It is related to “Superlubricity”. The objective is to describe the low friction behavior of partially-polished microcrystalline diamond films. The goal is to depict and precisely quantify the different contributions to friction (velocity-dependent and Coulomb-type contributions), in different contact conditions. Experimental work is involving mainly 1) coating elaboration in TU, 2) and the “oscillating relaxation tribometer” technique in LTDS. Those films will be applied as the smart and tribo-resistant coatings, especially to the bearings under extreme environments.

Key scientific question (2 lines max; Calibri 11)

Characterization of the low-friction behavior for the tribosystem.
Try to quantify the "solid-type friction" and "velocity-dependent" contribution in friction.

Research method (8 lines max; Calibri 11)

Friction characterization has been achieved thanks to the oscillating relaxation tribometer, developed at LTDS, in order to measure the kinematic friction between two sliding surfaces. This technique is based on the study of the dynamic free-response of a single degree-of-freedom mechanical oscillator, in which the sliding contact acts as a damper. It has been beneficially used to determine the velocity-independent and velocity-dependent friction contributions, with no need for any direct friction force measurement. The samples of the diamond coatings were deposited by the Hot Filament CVD method on SiC ceramics substrate. Deposited microcrystalline diamond films were then carefully polished, inducing surface topography changes.

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

FR to JP (date, duration):

- M. Belin (IR CNRS), stay at IFS (TU), September 2019 (1 day)
- M. Belin (IR CNRS), stay at IFS and FRIS (TU), February 2018 (1 week)

JP to FR (date, duration):

- H. Miki (Assoc. Prof.), stay at LTDS (ECL), December 2018 (4 days)
- H. Miki (Assoc. Prof.), stay at LTDS (ECL), February 2017 (4 days)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	M. Belin, H. Miki and T. Takagi	*Friction laws determination of random-textured surface of microcrystalline diamond coatings, using the oscillating tribometer technique*	Tribology Online	14(3)	109-114	2019	doi:10.2474/trol.14.109

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	Hiroyuki MIKI, Michel BELIN	*Low and ultralow friction of microcrystalline diamonds films ~ towards smart and tribo-resistant coatings*	ELyT Workshop 2019	12 March, 2019	Osaki	Japan	
2	M. Belin, H. Miki, T. Takagi	*Low-friction characterization of random-textured surface of microcrystalline diamond coatings, thanks to the relaxation tribometer technique*	6th World Tribology Congress	17-22 Sep. 2017	Beijing	China	

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 UMI 3757, CNRS – Université de Lyon – Tohoku University International joint Unit, 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

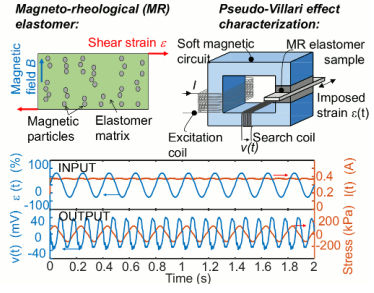
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

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[19] *(5x5 cm² max)*



[19] *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 2020, the work focused mostly on (i) an energy harvesting proof of concept, and (ii) a new class of smart material using elastomer foam.

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

FR to JP (date, duration):

- 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)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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
2	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
3	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
4	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)*

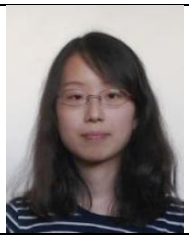
	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	G. Diguet, G. Sebald, M. Nakano, M. Lallart, J. Y. Cavaille	Experimental and Theoretical Investigation on the Influence of the Volume Fraction of the Particles on MR and Villari Effect	Sixteenth International Conference on Flow Dynamics	November 6 – 8, 2019	Sendai	Japan	
2	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)	15 – 18 September 2019	Nanjing	China	
3	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	Smart Fluids & Soft Matters and Their Advanced Applications, at 15th International Conference on Flow Dynamics	November 7-9, 2018	Sendai	Japan	

4	G. Diguet, J.-Y. Cavaille, G. Sebald, M. Nakano. M. Lallart	Magnetic saturation in anisotropic Magneto-rheological Elastomers, the limiting factor of efficiency?	Smart Fluids & Soft Matters and Their Advanced Applications, at 15th International Conference on Flow Dynamics	November 7-9, 2018	Sendai	Japan	
5	G. Diguet, G. Sebald, M. Nakano, M. Lallart, J.-. 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	
6	G. Diguet, G. Sebald, M. Nakano, M. Lallart	MR Elastomers for Energy Harvesting System	INTERMAG 2018	April 23-26, 2018	Singapore	Singapore	
7	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	
8	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	
9	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	

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 – Université de Lyon – Tohoku University, International Joint Unit, Tohoku University, Sendai, Japan*

Contact: mickael.lallart@insa-lyon.fr, makihara@ssl.mech.tohoku.ac.jp

OVERVIEW *(keep within this page)*

Starting year: 2020 **Current researchers** (permanent/non-permanent): 3/12 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)*

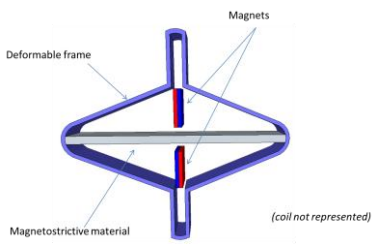
- MESRI, 2020-2023, Magnetostrictive materials and systems for energy harvesting

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

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 electromagnetic approach. Still, intrinsic mechanisms of the physical operations of such materials have still received little attention, and their realistic application in energy conversion devices, both at the structural and electrical aspects, is still 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 aspect) 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, (2) structure and (3) electrical interface, ultimately providing (4) an unified and global approach in terms of system development. The methodology will consist of taking the scientific essence of socio-economical stakes mainly related to Energy, Transportation and Civil Engineering, which are the most suitable fields for the deployment of self-powered sensors.

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

Ph.D. candidates (years, institution):

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

Project report 2020

MicroCell

Microsystems for Cell Engineering

MAIN PARTICIPANTS



Jean-Paul RIEU [a]	Kenichi FUNAMOTO [b]	Atsushi SHIRAI [b,c]

[a] *Institut Lumière Matière, Université Claude Bernard Lyon 1, Villeurbanne, France*
[b] *Institute of Fluid Science, Tohoku University, Sendai, Japan*
[c] *Department of Robotics / Graduate School of System Enginnering, Kindai University, Hiroshima, Japan (since April 2018)*

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

OVERVIEW *(keep within this page)*

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			75 %
Surfaces and interfaces			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)*

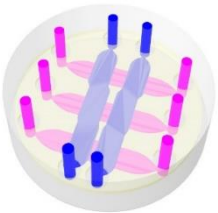
- CNRS, MITI, APP Modélisation du Vivant 2019-2020
- IFS LyC project 2019-2020
- CNRS, Invited researcher position for K. Funamoto (2 months in 2019)

Estimated annual budget: 30 k€

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

- We have designed a microfluidic device to control oxygen gradients
- We have shown that Dicty cells migrate toward rich O_2 regions (aerotaxis) within the 0-2% region only.
- A publication has been submitted to Elife
- We have published a work on the rolling of neutrophil-like cells on biomimetic endothelium

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 outward of the hypoxia 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 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)

Design a new device to study aerotaxis adapted from Funamoto's microfluidic devices for observations of cancer and endothelial cells [Funamoto, Lab Chip, (2012), Integr. Biol., (2017)].

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 0.5-20% within 15 min with gas channels positioned just above the media channel with cells. An effort was made to include O_2-sensing polymer films inside the device. The device was fabricated in NanoLyon facility during a two-month stay of Funamoto and Hirose at iLM in 2019. Then, it was successfully tested with Dicty during that stay. Dicty cells responded to the 0-2% range of O_2 concentration. This is extremely low O_2 concentration and indicates a very efficient O_2 detection mechanism for those cells.

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

Ph.D. candidates (years, institution):

- S. HIROSE (2020-present, Tohoku University)

Master/Bachelor students (years):

- S. HIROSE (2019-2020, Tohoku University)

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

FR to JP (date, duration):

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

JP to FR (date, duration):

- K. Funamoto (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	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 (under review)			2020	https://www.biorxiv.org/content/10.1101
2	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	K. Funamoto, J.-P. Rieu	Microfluidic Tools to Study Aerotaxis in Eukaryotic Cells	Elyt Workshop	17-19 Feb 2020	Vogüé	France	
2	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	
3	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	
4	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	
5	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	

MISTRAL

MIniature-Scale Energy GeneraTion by Magnetic Shape MemoRy ALloys

MAIN PARTICIPANTS


Lena SEIGNER[a]


Joel JOSEPH[a]


Linjuan YAN[b, c]


Mickaël LALLART[d, b, c]


Hiroyuki MIKI[b]


Manfred KOHL[a]

[a] *Institute of Microstructure Technology (IMT), Karlsruhe Institute of Technology (KIT), Germany*
[b] *Institute of Fluid Science, Tohoku University, Sendai, Japan*
[c] *ELyTMaX UMI 3757, CNRS – Université de Lyon – Tohoku University, International Joint Unit, Tohoku University, Sendai, Japan*
[d] *Univ. Lyon, INSA-Lyon, LGEF EA 682, F-69621, France*

Contact: manfred.kohl@kit.edu, hiroyuki.miki.c2@tohoku.ac.jp, mickael.lallart@insa-lyon.fr

OVERVIEW *(keep within this page)*

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

Positioning *(Multiple selection allowed – total 100%)*	Transportation	Energy	Eng. for Health
Materials and structure design		20 %	30 %
Surfaces and interfaces		5 %	5 %
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

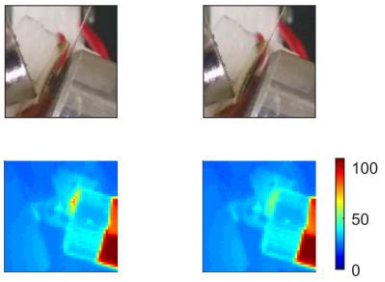
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- DFG Germany, 2019-2022, THERVESTII
- JSPS, 2019-2020, invitational fellowship

Estimated annual budget: 50 k€

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

- Scaling performance of heat transfer dynamics during resonant self-actuation and effect of film thickness and device footprint on power and efficiency
- Electrical power per footprint increases with film thickness by a factor of 3.4 (50 µW/cm² at a temperature change of 3 °C)
- Multifunctional energy conversion (e.g., incl. pyroelectric)
- Publication: J. Joseph, M. Ohtsuka, H. Miki, M. Kohl, Upscaling of Thermomagnetic Generators Based on Heusler Alloy Films, (2020) to be published in Joule 4, Dec 16. DOI:10.1016/j.joule.2020.10.019
- JSPS invitational and post-doc fellowships (10+13 months)

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

MISTRAL aims at providing new routes for electrothermal energy conversion, for instance providing alternatives to thermoelectric modules that exhibit large thermal conductivity that prevents energy entering within the device.

Progress in development of films that exhibit large abrupt changes in magnetization such as NiMnGa films and rapid heat transfer unclose the development of thermodynamically efficient thermomagnetic generators.

Local vibrations and time-domain temperature variations can be converted into electricity by electroactive materials. Pyroelectric elements for conversion of local temperature change with time showed a magnification of the output power.

Key scientific question (2 lines max; Calibri 11)

Understanding heat transfer dynamics in thermomagnetic generators

Improving power output and efficiency

Research method (8 lines max; Calibri 11)

Detailed experiments and lumped element simulations for the case of Heusler alloy film Ni-Mn-Ga show that scaling of film thickness and device footprint oppositely affect power output. Based on this understanding, we could increase the electrical power per footprint by a factor of 3.4 for increasing film thickness from 5 to 40 µm reaching values of 50 µW/cm² at a temperature change of only 3 °C. These results pave the way for the development of advanced generators consisting of parallel architectures with tailored footprint and films operating well below 100 °C that open up waste heat recovery near room temperature. Also, including as much electroactive materials as possible, exploiting the maximum amount of energy sources permits increasing the power density.

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

Ph.D. candidates (years, institution):

- Joel Joseph (2019-present, KIT)

Master/Bachelor students (years):

- Lena Seigner (2020, KIT)

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

FR to JP (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	J. Joseph, M. Ohtsuka, H. Miki, M. Kohl	Upscaling of Thermomagnetic Generators Based on Heusler Alloy Films	Joule	*In press*		2020	DOI:10.1016/j.joule.2020.10.019
2	M. Lallart, H. Miki, L. Yan, 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
3	H. Miki, E. Abe, S. Takeda, M. Ohtsuka, M. Kohl	Metamagnetic Shape Memory Alloy Thin Plates Consolidated by Compression Shearing Method at Room Temperature for Thermal Energy Harvesting Device	Sensors and Materials	32(8)	2867-2875	2020	https://myukk.org/SM2017/article.php?ss=2938
4	M. Gueltig, F. Wendler, H. Ossmer, M. Ohtsuka, H. Miki, T. Takagi, and M. Kohl	High-Performance Thermomagnetic Generators Based on Heusler Alloy Films	Adv. Energy Mater.	7	1601879	2016	DOI: 10.1002/aenm.201601879.
5	M. Gueltig, M. Ohtsuka, H. Miki, K. Tsuchiya and M. Kohl	Thermomagnetic actuation in low hysteresis metamagnetic Ni-Co-Mn-In films	Materials Today: Proceedings,	2	S883–S886	2015	https://doi.org/10.1016/j.matpr.2015.07.423
6	M. Gueltig, H. Ossmer, M. Ohtsuka, H. Miki, K. Tsuchiya T. Takagi and M. Kohl	High Frequency Thermal Energy Harvesting Using Magnetic Shape Memory Films	Adv. Energy Mater.	4	1400751	2014	https://doi.org/10.1002/aenm.201400751

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	M. Lallart, H. Miki, L. Yan, G. Diguet, M. Ohtsuka and G. Sebald	Low-Field Modeling of Heusler MultiPhysic Memory Alloys	The 17th International Conference on Flow Dynamics (ICFD2020)	October 28 - 30, 2020	Sendai	Japan (online)	
2	L. Seigner, J. Joseph, M. Lallart, H. Miki and M. Kohl	Upscaling of a Thermomagnetic Generator Based on Magnetic Shape Memory Alloys	ELyT Workshop 2020	Feb. 17-19, 2020	Vogüé	France	
3	H. Miki, M. Kohl, M. Lallart and L. Yan	Future prospects in the MISTRAL (Miniature-Scale Energy Generation by Magnetic Shape Memory Alloys) project	ELyT Workshop 2019	March 10-12, 2019	Osaki	Japan	
4	M. Kohl, H. Miki, M. Lallart, M. Gueltig, M. Ohtsuka	MIniature-Scale Energy GeneraTion by Magnetic Shape MemoRy Alloys	ELyT Workshop 2018	March 6-8, 2018	Satillieu	France	
5	H. Miki, K. Tsuchiya, E. Abe, S. Takeda, M. Ohtsuka, M. Gueltig, M. Kohl and T. Toshiyuki Takagi	Improvement in Magnetic Properties of Metamagnetic Shape Memory Alloy Processed by Compression Shearing Method at Room Temperature	The 14th International Conference on Flow Dynamics (ICFD2017)	Nov. 1-3, 2017	Sendai	Japan	

MuORoD

Multi-Objective Robust Design

MAIN PARTICIPANTS

			
Koji SHIMOYAMA[a]	**Sébastien BESSET[b]**	**Frédéric GILLOT[b,c]**	**Pradeep MOHANASUNDARAM[a,b,c]**

[a] *IFS, Tohoku University, Sendai, Japan*
[b] *LTDS UMR CNRS 5513, DySCo Team, ECL, Lyon, France*
[c] *ELTYMAX, UMI CNRS 3757, Tohoku University, Sendai, Japan*

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

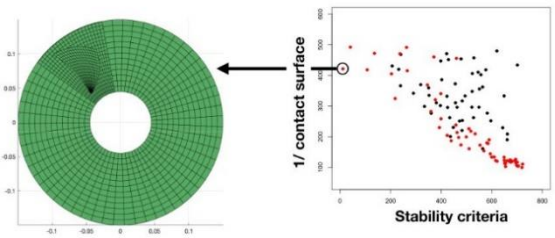
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- MNRT fund for a Ph.D., 2016-2020
- Mega Ph.D.School funds for 3 months grant, 2020

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
- One journal paper has been accepted recently, one under review and one submitted soon
- Ph.D. Student Pradeep has been awarded the Mega Ph.D. School grant for short research stay in Pr. Shimoyama's Lab

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.

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-present, 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):

- P. Mohannasundaram (Jan. 2021 – March. 2021, 3 months)
- F. Gillot (Sept. 2019-Aug. 2020, 1 year)
- S. Besset (July 2019, 1 week)
- P. Mohannasundaram (Sept. 2018 – Aug. 2019, 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, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset	Shape optimization of a disc-pad system under squeal noise criteria	SN Applied Sciences	2, no. 4	1-15	2020	
2	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, no. 2	1650006	2016	

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
	Mohanasundaram, Pradeep, Frédéric Gillot, Koji Shimoyama, and Sébastien Besset	Iga based shape optimization under mechanical stability criteria	14th WCCM 2020	11-15 January 2021	Paris	France	
	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	
	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	
	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	

OPSCC

Optimizing surface finish to Prevent SCC initiation in energy industries

MAIN PARTICIPANTS

Hiroshi ABE[a]	**Benoît TER-OVANESSIAN[b]**	**Kathleen JAFFRE[b,c]**	**Nicolas MARY[b,c]**
Takamichi MIYAZAKI[a]	**Bernard NORMAND[b]**	**Yutaka WATANABE[a,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: hiroshi.abe.c3@tohoku.ac.jp , benoit.ter-ovanessian@insa-lyon.fr (Project leaders)

OVERVIEW *(keep within this page)*

Starting year: 2017 **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		100%	
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

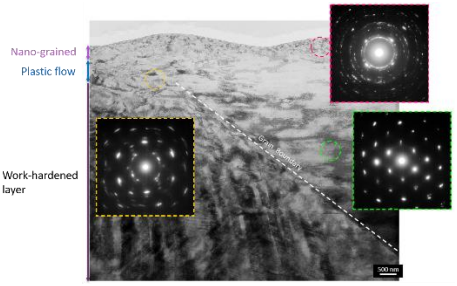
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

Estimated annual budget:

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

- Development of a new methodology to characterize semiconductive properties of passive layer
- Evidence of the modification of the electronic properties of passive film due to affected surface state by dry grinding
- Transposition of the methodology to oxide layer formed in representative environment
- Evidence of the correlation between the subsurface modification due to dry grinding and the oxide film chemistry, structure and properties

Illustration *(5x5 cm² max)*



TEM image with electron diffraction patterns of the top surface of the grinder-finished specimen.

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

It has been recently recognized that surface finish has strong impact on SCC susceptibility of alloys in various kinds of environments, including boiling water reactor coolant, primary water of pressurized water reactors, and chloride containing water. Industry needs appropriate surface finish procedures to reasonably minimize SCC susceptibility of alloys. To achieve an effective answer to this demand, we need to know the following items as a function of surface treatment:

- Physical metallurgy of alloy surface (micro- and nano-structure of surface).
- Electrochemical properties, in particular, stability of passivity.
- SCC initiation dynamics (embryo formation and repassivation, coalescence of micro-cracks).

All those properties need to be linked to each other to understand the effect of surface finish on SCC susceptibility of alloys.

Key scientific question (2 lines max; Calibri 11)

Discriminate the effect of subsurface modification on the reactivity of SS
Correlate the change in surface reactivity to SCC susceptibility

Research method (8 lines max; Calibri 11)

In 2017-2018, passive film characterizations have been performed at MATEIS on material provided by GSE-TU. The film properties (capacitance, resistance, number of defect) were evaluated for several surface preparation that will be used for SCC experiments in GSE-TU.
In 2018-2019, detailed characterizations of the work hardened surface layers formed on austenitic stainless steels with different surface finish methods (grinder, emery paper, and colloidal silica) were carried out using a TEM and an EBSD technique.
In 2019-2020, Electrochemical analysis for passive films formed in several environments including high temperature water were also carried out.

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

Ph.D. candidates (years, institution):

- Kathleen JAFFRE (2017-present, DD INSA-LYON/ TOHOKU)
  (INSA: October 2017 - December 2018 and December 2019 –present)
  (TOHOKU: January 2019- December 2019)

Master/Bachelor students (years):

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

FR to JP (date, duration):

- K. Jaffre (Ph.D. candidate), stay at QSE (Tohoku), January 2019 (1 year)

JP to FR (date, duration):

- H. Abe (Senior Assist. Prof.), stay at MATEIS (INSA-Lyon), March 2018 (1 week)
- N. Mary (Assoc. Prof.), stay at MATEIS (INSA-Lyon), November 2017 (1 week)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	K. Jaffré, B. Ter-Ovanessian, H. Abe, N. Mary, Y. Watanabe, B. Normand	Effect of dry grinding on the surface microstructure and passive behavior of stainless steel 304L	Applied Surface Science	-	-	submitted	-

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	K. Jaffré, B. Normand B. Ter-Ovanessian, , N. Mary, Y. Watanabe, H. Abe	*Effect of surface finishing on the corrosion of austenitic stainless steel 304L in simulated BWR and PWR environments*	Eurocorr 2020	6-10 Sept. 2020	Virtual	Virtual	
3	K. Jaffré, B. Normand B. Ter-Ovanessian, , N. Mary, Y. Watanabe, H. Abe	*Influence of mechanical surface finishing on the properties of passive film formed on stainless steel using electrochemical impedance spectroscopy measurements*	Eurocorr 2019	9-13 Sept. 2019	Sevilla	Spain	
3	K. Jaffré, B. Ter-Ovanessian, B. Normand, N. Mary, Y. Watanabe, H. Abe	*Influence des traitements mécaniques de surface sur les propriétés du film passif formé sur les aciers inoxydables des internes de cuve*	Matériaux 2018	19-23 Nov. 2018	Strasbourg	France	

PolymColdSprayCoat

Resilient Polymeric Cold Spray Coating

MAIN PARTICIPANTS

				
Kazuhiro Ogawa[a,b]	**Chrystelle Bernard[b,c]**	**Olivier Lame[d]**	**Jean-Yves Cavaillé[b]**	**Kesavan Ravi[e]**

[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

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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

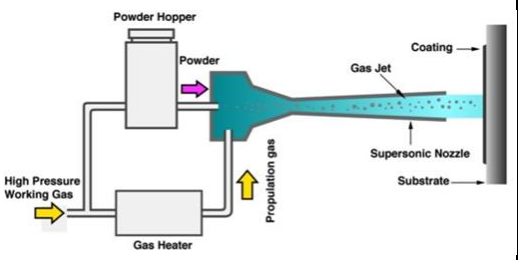
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

- CRP–IFS 2020-2021, J20Ly03
- CRP–IFS, 2019-2020, J19Ly01
- CRP–IFS, 2018-2019, J18I061
- Kakenhi A, JSPS, 2017-2021, Solid-phase film formation …

Estimated annual budget: 400,000 yen/an

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

- Understanding of the formation of UHWMPE powder on metallic substrates
- Modelling of the flow dynamics inside the nozzle and investigation of the particles' thermal gradient
- In total,
  - 9 publications in peer-review journals directly.
  - 1 patent
  - 5 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.
And also, the other polymer materials, such as fluoropolymer and polyimide coatings have been studying. It is successful to make the coatings by low pressure cold spray system.

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

Ph.D. candidates (years, institution):

- 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, 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, September 2019	1 week
• C. Bernard	Stay at University of Grenoble, September – October 2018	2 months

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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
2	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
3	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		Accepted.	2020	
4	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
6	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
7	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

8	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
9	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)*
1	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	1st-3rd Nov. 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	
3	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	
4	W L.ock Sulen, K Ravi, C Bernard, N Mary, Y Ichikawa, K Ogawa	Effects of Nano-Ceramic Particle Addition for Cold Sprayed Fluoropolymer Coatings	33rd Conference on Surface Modification Technologies	June 26, 2019	Naples	Italy	
5	W Lock .Sulen, K Ravi, Y Ichikawa, K Ogawa	Development of fluoropolymer coating using low pressure cold spray	International Thermal Spray Conference 2019	May 28, 2019	Yokohama	Japan	

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
1	CA Bernard	The 2nd Caterpillar STEM Award	Special Recognition Award	Feb.2020
2	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
4	K Ravi	6th Asian Thermal Spray Conference (ATSC) 2014	Best Poster Award	Nov.2014
5	K Ravi, W Lock Sulen, S Gao, Y Ichikawa, K Ogawa	The 15th "Challenge Cup" International Students Technology Innovation Carnival	Grand Prize	Nov.2017

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.

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 and adhesion 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.
In 2018/2019, optimization of the capacitive measurement on polymer disc were performed. In parallel, a coplanar sensor was developed. 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.

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

Ph.D. candidates (years, institution):

- L. Ollivier-Lamarque (2019-2021, 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)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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*, 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	
2	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 Polymer metal fiber adhesions delamination control.	Sixteenth International Conference on Flow Dynamics (ICFD 2019),	06/11/2019-08/11/2019	Sendai	Japan	
3	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	
4	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	
5	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	

PYRAMID

***P**iping s**Y**stem, **R**isk management based on w**A**ll thinning **M**on**I**toring and pre**D**iction*

MAIN PARTICIPANTS

		
Toshiyuki Takagi[a]	**Philippe Guy**[b]	**Tetsuya Uchimoto**[a]

[a] *IFS Tohoku University, Sendai, Japan*
[b] *LVA, INSA de Lyon, Villeurbanne, France*

Contact : philippe.guy@insa-lyon.fr , uchimoto@ifs.tohoku.ac.jp

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			75 %
Surfaces and interfaces			25 %
Simulation and modeling			

Other:

Include partner from x Outside ELyT x Industry

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

IFS CRP/LyC project? ☐ Yes x No

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

- ANR-JST project PRCI, 17-CE08-0046

Estimated annual budget: 325k€

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

- Mass flux and mass transfer coefficient evaluation method through a diffusion-controlled limiting current measurement under flow by using a rotating cylinder electrode has been developed.
- Solid-liquid two-phase flow evaluation (CFD calculation) : three-dimensional solid-liquid two-phase flow calculations around elbow were conducted with a solid-particle simulation model. Flow drift and separation around the elbow were compared with the experiment described above, and the qualitative agreement was validated. As a result, we have found that the flow velocity profile and mass transfer
- Online wall thinning EMAT evaluation have been carried out during controlled electrochemical corrosion tests. A good agreement between the ultrasonic evaluation and the profilometer measurements have been found. From these preliminary results, a new corrosion cell is under development.
- Prototype point focus transducers were fabricated, and it was confirmed that incident beams were successfully focused, observing the sound field experimentally.
- Development and validation of simulation tools to support the optimal design of EMAT and EMAR probes
- Risk Evaluation: a probabilistic evaluation method of future damage was proposed.

PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

From a recent NACE report, cost of corrosion in US is estimated to reach 2.5 trillion US$, which is equivalent to 3.4% of Gross Domestic Product. It is estimated that an available corrosion control practices could be save 15 and 35% of this cost. Because this value can be extend to other country, it can be concluded that a project focused on corrosion monitoring is relevant for economy and environment. The inspection and maintenance of piping systems in harsh conditions has been evocated as a crucial issue in many industrial domains such as nuclear plants, chemical storage and transport. In Japan there is a great need to develop quickly NDT methods able to be deployed in very harsh environments, and especially in the objective of Fukushima Dai-ichi nuclear plant decommissioning.

Moreover the performance of the flow damage of carbon steel pipes in power generating plant has cause considerable concern. Carbon steels are the principal coolant pipe materials in nuclear and other fuel power plants. Erosion-corrosion induced wall thinning of pipe bores by the radiation, humidity, high temperature, velocity and pressure water flow has required structural evaluation of these pipes to allow integrity of these piping systems to be maintained.

A safe process for disassembling complex piping systems, requires new tools and techniques to detect and quantify wall thinning due to Flow Accelerated Corrosion (FAC). This is very important to evaluate if the piping system will resist to the multiple drainings of a polluted tank for instance. The corrosion phenomena associated to erosion are expected to be very complex, and highly influenced by the presence of particles into the liquid flow.

Key scientific question (2 lines max; Calibri 11)

Flow Accelarated Corrosion FAC, understanding and modelling.

EMAT for guided waves devices and simulations and Risk Managment tools development

Research method (8 lines max; Calibri 11)

The mass flux and mass transfer coefficient evaluation method through a diffusion-controlled limiting current measurement under flow by using a rotating cylinder electrode has been developed. Permanent dialog between partners and comparison of experimental and simulated results, both for the electrochemichal aspects of FAC and NDT methods aimig at feeding the risk management model to be developed.

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	Hiroyuki Nakamoto, Philippe Guy, Toshiyuki Takagi	Corrosion Induced Roughness Characterization by Ultrasonic Attenuation Measurement	E-Journal of Advanced Maintenance			2020	http://www.jsm.or.jp/ejam/Vol.11 No.4/AA/AA167/AA167.html
2	H. Sun, R.Urayama, T. Uchimoto, T. Takagi, M. Hashimoto	Small electromagnetic acoustic transducer with an enhanced unique magnet configuration	NDT & E International	110	102205	2020	10.1016/j.ndteint.2019.102205
3	H. Sun, T. Uchimoto, T. Takagi	New Combination of Magnet and Coil of Electromagnetic Acoustic Transducer for Generating and Detecting Rayleigh Wave	IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control	67	832 - 839	2020	10.1109/TUFFC.2019.2956711
4	H. Sun, R. Urayama, T. Uchimoto, L. Udpa, T. Takagi, K. Kobayashi	Data processing method for thickness measurement using electromagnetic acoustic resonance	Electromagnetic Nondestructive Evaluation XXII, Studies in Applied Electromagnetics and Mechanics	44	1-6	2019	10.3233/SAEM190002
5	T. Takagi, H. Sun, R. Urayama, T. Uchimoto	Electromagnetic acoustic resonance method for thickness measurement of metals	Reprinted from The Reports of the Institute of Fluid Science, Tohoku University, Sendai, Japan	31	15-27	2019	

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Coun-try	DOI *(if applicable)*
1	T. Takagi, P. Guy, Y. Watanabe, H. Abe, S. Ebara, T. Uchimoto, T. Aoki, M. Hashimoto, R. Urayama, H. Sun, T. Monnier, J. Antoni, B. Normand, N. Mary, R. Morita, S. Watanabe, A. Iwasaki, H. Nakamoto, C. Reboud, P. Calmon, E. Demaldent, V. Baronian, X. Artusi, S. Chatillon, A. Lhemery	Progress of PYRAMID project -Piping system, risk management based on wall thinning monitoring and prediction-	第 4 回福島第一廃炉国際フォーラム	2019/8/5	Iwaki	Japan	

2	P. CALMON, C. REBOUD, E. DEMALDENT	Advanced simulation tools for nondestructive assessment of corrosion affecting steel pipes	ElyT Workshop 2019	2019/3/11	Sendai	Japan	
3	P. GUY, B. NORMAND, H. NAKAMOTO, et al.	Recent advances in PYRAMID project : EMAT experimental results for corrosion characterization	ElyT Workshop 2019	2019/3/11	Sendai	Japan	
4	T. TAKAGI, P. GUY	Piping system, risk management based on wall thinning monitoring and prediction	ElyT Workshop 2019	2019/3/11	Sendai	Japan	
5	A. TEZUKA, T. TAKAGI, et al.	Development of Point Focusing Electromagnetic Acoustic Transducer Aiming at the Local Pipe Wall Thinning Measurement	14th International Conference on Flow Dynamics	2018/11/8	Sendai	Japan	
6	T. TAKAGI, et al.	International Joint Project for Risk Management of Piping Systems Based on Monitoring and Predicting Wall Thinning during Decommissioning of Fukushima Daiichi Nuclear Power Plant	14th International Conference on Flow Dynamics	2018/11/5	Sendai	Japan	
7	H. Sun, R. Urayama, T. Uchimoto, L. Udpa, T. Takagi	Thickness measurement of uneven specimen using frequency domain signal of pulse echo by electromagnetic acoustic transducer	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	
8	S. WATANABE and R. MORITA	Piping system, risk management based on wall thinning monitoring and prediction -Numerical evaluation of flow structure of liquid-solid two phase flow-	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	
9	T. TAKAGI, P. GUY, Y. WATANABE, et al.	Piping system, risk management based on wall thinning monitoring and prediction	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	
10	A. IWASAKI	Bayesian Evaluation of Damage Risk from Monitoring Data	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	

11	H. NAKAMOTO, P. GUY and T. TAKAGI	Corrosion Induced Roughness Characterization by Ultrasonic Attenuation Measurement	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	
12	Christophe REBOUD, Sylvain CHATILLON, Pierre CALMON, et al.	Advanced simulation tools for nondestructive assessment of corrosion affecting steel pipes	The 4th ICMST-Tohoku 2018	2018/10/23	Sendai	Japan	
13	Ryota NAKAGAWA, Hiroshi ABE, Yutaka WATANABE	Evaluation of Mass Transfer Coefficient for Prediction of Pipe Wall Thinning Rate in Solid-Liquid Multiphase Flow	4th International Conference on Maintenance Science and Technology (The 4th ICMST-Tohoku 2018)	2018/10/23	Sendai	Japan	
14	A. TEZUKA, T. TAKAGI, et al.	Development of thickness gauging method for pipe wall thinning inspection with Point Focusing EMAT	The 23rd International Workshop on Electromagnetic Nondestructive Evaluation	2018/9/11	Detroit, Michigan	USA	
15	H. Sun, R. Urayama, T. Uchimoto, L. Udpa, T. Takagi, K. Kobayashi	Data processing method for thickness measurement using electromagnetic acoustic resonance	The 23nd International Workshop on Electromagnetic Nondestructive Evaluation	2018/9/11	Detroit, Michigan	USA	10.3233/SAEM190002
16	T. Takagi, H. Sun, T. Uchimoto, R. Urayama	Electromagnetic acoustic resonance method and its application to pipe wall thinning measurement	Materials Service Performance in Nuclear Power Plants (MSPNP 2018)	2018/8/5			
17	T. Takagi P. Guy	Piping sYstem, Risk management based on wAll thinning MonItoring and preDiction	ELyT Workshop 2018	2018/3/7	Satillieu, Ardèche	France	
18	P. Guy H. Nakamoto	Study of the surface roughness measurement by ultrasonic scattering on a carbon steel block	ELyT Workshop 2018,	2018/3/6	Satillieu, Ardèche	France	

Project report 2020

REFRESH

REFRigEration based on Solid-state cooling: Heat transfer mechanisms

MAIN PARTICIPANTS

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

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[b] *Institute of Fluid Science, Tohoku University, 980-8577, Sendai, Japan*
[c] *Univ. Lyon, CNRS, INSA-Lyon, CETHIL, UMR5008, F-69621, Villeurbanne, France*
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OVERVIEW *(keep within this page)*

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

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

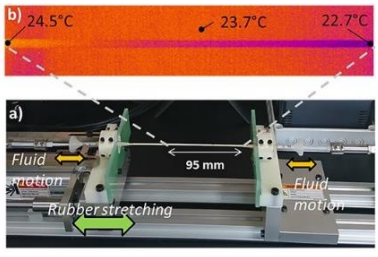
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- ANR ECPOR (ANR-17-CE05-0016) 2017-2022
- JSPS Grant in Aid for Scientific Research Kiban C 19K04230

Estimated annual budget: 20k€

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

- We have developed a proof of concept of refrigeration based on elastocaloric natural rubber
- A model with analytical solutions was developed
- A publication was accepted in a special issue of the Journal of Applied Physics, and received distinction of "Editor's Pick", and was the subject of a "SciLight" (scientific highlight) by the American Institute of Physics.

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.

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 proof of concept, along with adequate modeling. Although 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 proof of concept helps (i) verifying the model assumptions, (ii) proving the refrigeration capability of the system.

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

Master/Bachelor students (years):

- Alban Duval (2020, INSA Lyon)
- Way Szu Xuen (2020-2023, Tohoku University)

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	G. Sebald, A. Komiya, J. Jay, G. Coativy, L. Lebrun	Regenerative cooling using elastocaloric rubber: analytical model and experiments	Journal of Applied Physics	127	094903	2020	doi: 10.1063/1.5132361

Conferences *(gray color for previous years)*

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

SIAEROSIM

Simulation of Silica aerogels

MAIN PARTICIPANTS

			
Patrice CHANTRENNE[a]	**Takashi TOKUMASU**[b]	**Julien MORTHOMAS**[a]	**Aikaterina KIOURTZIDOU**[a]

[a] *MATEIS INSA de Lyon, France*
[b] Quantum Nanoscale Flow Systems Laboratory, Novel Battery Nanoscale Flow Laboratory, *IFS, Tohoku University, Sendai, Japon*

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OVERVIEW *(keep within this page)*

Starting year: 2019 **Current researchers** (permanent/non-permanent): 9 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 ☐ 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: 0

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

- Creation of Silica aerogel with OH group on its surface using reactive interatomic potential.
- Definition of the strategy to simulate heat transfer.

PROJECT DESCRIPTION

Background

Silica aerogel are highly porous materials, more than 90% porosity. The characteristic size of the pores is few nanometers. Due to these characteristics, silica aerogels have a thermal conductivity which is lower than the thermal conductivity of air. Even if the production cost is expensive, they are used in each case the insulating volume and mass has to be minimized (transportation, housing…). Silica aerogels are good candidate to help reducing energy consumption.

However, material aging is an issue since in building the material properties should not vary during several tens of years. Silica aerogels present two drawbacks: low mechanical properties and an increase of the thermal conductivity with time. This is due to the high porosity of the material:

- The higher the porosity, the lower the thermal conductivity at the expense of the mechanical properties.
- The nanostructure of silica aerogel increases the specific area of the material and surface reactivity. Silica reacts with water vapor which leads to the thermal conductivity increase.

Mechanical and thermal properties of silica aerogel depend on the atomic structure of the material. Their predictions thus require the atomic scale simulation of silica aerogels. It is done using Molecular Dynamics simulations. During his PhD (2013-2016), W. Gonçalves choose and studied an interatomic potential to predict mechanical properties of pure silica aerogels [1,2]. Within this framework, Morthomas et al. [3] proposed a strategy to predict the thermal properties of pure silica aerogel. W. Kassem as part of a post doc (AURA region funding, Pack Ambition project) studies the adequate interatomic potentials for realistic simulation considering the surface chemistry of silica aerogels.

Key scientific question

The goal of the project is to use another kind of interatomic potential that account of the surface chemical reactivity in order to:

- Predict the thermal conductivity of realistic silica aerogel considering surface chemistry. This study may allow optimizing the production process.
- Study the influence of water vapor on the modification of the nano structuration of the aerogel and then the influence on the thermal conductivity and mechanical properties.

Research method

The research method is based on Molecular dynamics simulation of a silica aerogel system on which OH group have been added on the surface.

The use of reactive interatomic potential leads to a drastic reduction of the number of atoms compared to previous simulations. So only silica nanowires are considered.

The simulation strategy consist first to create the silica nanowires and then to add OH group on it.

Then the news nanowires are submitted to mechanical and heat transfer test to predict the influence of the OH group on their mechanical and thermal properties.

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

Bachelor student:

- Aikaterina Kiourtzidou, from Aristotle University, Thessalonique, Greece. Intern at MATEIS from October 2019 to April 2020. Aikaterina Kiuortzidou presented a poster during the ElyT Workshop 2020.

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

JP to FR (date, duration):

- T. Tokumasu
  - Feb. 20 , 2020
  - March 9-10, 2020
  - Nov. 18-20, 2020

COMMUNICATIONS AND VALORIZATION

Conferences *(gray color for previous years)*

	Authors	**Title**	**Conference**	**Date**	**City**	**Country**	**DOI** *(if applicable)*
1	Takashi Tokumasu, Patrice Chantrenne and Aikaterini Kiourtzidou	Prediction of thermal and mechanical properties of Silica Aerogel using atomic scale simulations	LyonSE&N – ELyT – IARI Workshop 2020 – 11th annual workshop	February 17th -19th, 2020	Vogüé, Ardèche	France	

Project report 2020

TATAMI

Thermal AcTuation and energy hArvesting using MultIphysic alloys

MAIN PARTICIPANTS

				
Mickaël LALLART[a, b, c]	**Hiroyuki MIKI[b]**	**Linjuan YAN[b]**	**Gaël SEBALD[c]**	**Gildas DIGUET[b,c]**

[a] *Univ. Lyon, INSA-Lyon, LGEF EA 682, F-69621, France*
[b] *Institute of Fluid Science, Tohoku University, Sendai, Japan*
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OVERVIEW *(keep within this page)*

Starting year: 2020 **Current researchers** (permanent/non-permanent): 3 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 ☐ No

For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- IFS LyC, 2020-2021, 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 microgripper demonstrator driven by thermoelectric modules (heating/cooling) has been fabricated
- JSPS invitational and post-doc fellowships granted (10+13 months)

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.

Key scientific question (2 lines max; Calibri 11)

How to efficiently convert electrical energy in mechanical energy and conversely.
What is the globally optimized energy conversion chain.

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, declined into tightly interacting work packages as follow:

- WP1 - material selection, fabrication and optimization
- WP2 - modeling and characterization
- WP3 - energy harvesting device
- WP4 - actuation system

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

FR to JP (date, duration):

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

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

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

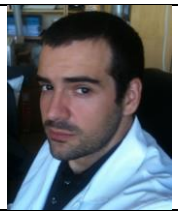
Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	M. Lallart, H. Miki, L. Yan, G. Diguet, M. Ohtsuka and G. Sebald	Low-Field Modeling of Heusler MultiPhysic Memory Alloys	The 17th International Conference on Flow Dynamics (ICFD2020)	October 28 - 30, 2020	Sendai	Japan (online)	

TEmPuRA

Theory for Electrostriction of PolymeRic Actuator

MAIN PARTICIPANTS

					
Ai SUZUKI[a]	**Gildas DIGUET[b]**	**Kaori YUSE[c]**	**Gildas COATIVY[d]**	**Sébastien LIVI[e]**	**Florent DALMAS[f]**

[a] *NICHe, Tohoku University*
[b] *ELyTMaX, UMI 3757, CNRS - Univ. Lyon - Tohoku Univ., International Joint Unit*
[c] *IFS Lyon Center, Tohoku Univ. & LGEF, INSA Lyon*
[d] *LGEF, EA 682,INSA Lyon, Univ. Lyon*
[e] *IMP, UMR 5223, INSA Lyon, Univ. Lyon*
[f] *MATEIS, UMR 5510, CNRS INSA Lyon, Univ. Lyon*

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Other participants: Nozomu HATAKEYAMA, Ryuji MIURA, Akihira MIYAMOTO (NICHe), Hiroshi YABU (AIMR, TU), Tetsuya UCHIMOTO (IFS), Gael SEBALD (ELyTMaX), Jean-Marc CHENAL (MATEIS), Jean-Fabien CAPSAL, Laurence SEVEYRAT, Veronique PERRIN (LGEF), Jean-Yves CAVAILLE (ELyTMaX@INSA)

OVERVIEW *(keep within this page)*

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

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

Other:

Include partner from ☐ Outside ELyT ☐ Industry

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

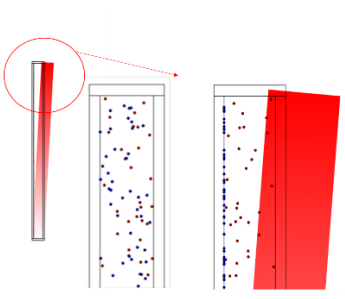
IFS CRP/LyC project? ☐ Yes ☒ No

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)*

- We have demonstrated that in polyurethane, electrostatic pressure and polarization body forces cannot explain the strong electromechanical behavior.
- Our hypothesis is that electrical charge diffusion and their Coulombic interactions are the main mechanisms
- This might explain both the slow mechanical response and large deformation, as well as the bending observed on homogeneous films.
- 3 peer reviewed co-authored articles



PROJECT DESCRIPTION

Background

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 electrodes interactions, (ii) possible body forces resulting from dielectric interactions between dipoles and local electric field gradients and (iii) interactions between electric charges able to diffuse. This needs theoretical approaches and numerical simulations by (i) molecular dynamics (thanks to the NICHe team) and (ii) at a mesoscale to compare with experimental data (thickness changes, bending, etc.). Most or our works were performed on polyurethane and from now we plan to test some model materials with given internal architecture and well-known electrical and mechanical properties.

Key scientific question

Physical mechanisms at the origin of soft polymer deformation observed under electric fields, and their time dependence. Numerical simulation of the observed behavior on given polymers.

Research method

Up to now, we worked on polyurethane, which is known to exhibit a strong deformation under electric field. In order to understand better the mechanisms of these behaviors, we will develop new model materials, fully characterized from both macroscopic and microscopic point of view (viscoelastic and dielectric responses, conductivity under high electric field, electromechanical responses, microscopy and SAXS observations). In parallel, we aim at testing several hypothesis involving electrical charges diffusion, in relation with the deformation kinetics and amplitudes, as determined with our experimental set-up.

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

Master/Bachelor students (years):

- N. Boucida (M2 stay at IFS/ELyTMaX), April-September 2016
- Zhouyang He (M2 student of INSA, Mat. Sc. and Eng.), possible stay at TU (2021)

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

FR to JP (date, duration):

•	K. Yuse	June-July 2019	8 days
•	K. Yuse	Nov-2019	5 days
•	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	Decembre-2019	1 week

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	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				Under revision
2	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	doi: 10.1016/j.compscitech.2018.12.012
3	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	doi: 10.1088/1361-665X/aa5c4b

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

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

5	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	
6	Gildas Diguet & Kaori Yuse	Seminar on Electrostriction	Morita's Lab	2019 July 8	Todai, Tokyo	Japan	
7	A. Suzuki, M. Miyano, R. Miura	Theoretical estimation of dielectrics constant of electroactive polymers	15th ICFD	2018 Nov 7-9	Sendai	Japan	
8	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	
9	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	Japn	Invited lecture

Outlook

2020 has been a particular and tough year regarding international collaborations due to the pandemic situation. Still, the resilience of the collaboration allowed by strong history and exchanges allowed to successfully overcome this condition, by keeping all the typical events (except ELyT School) and number of collaborative projects within the IRN. This year even saw a significant increase of associated Journal paper publications (+59%) and new actions successfully launched in the framework of the collaboration (Master student mobility JP→FR for researcher visit, Molecular Dynamic School). In a strong will of IRN development and opening as well as global structuration of the collaboration, ELyT Global has been an active actor of the LyonSE&N initiative, aiming at providing common action between Japan and Lyon/St-Etienne site. In that framework, the first common edition of ELyT and LyonSE&N workshop was successfully held. This success will there be thus renewed in the next years. For instance, the next common workshop is planned for May 2021, with the support of the French Embassy in Japan in the framework of the French-Japan year.

These actions will be further developed thanks to the renewal of ELyT Global in 2021. Hence, the renewed IRN ELyT Global will be different from the former one by the fact that **other partners coming from French institutions will be part of the project**, while keeping the core management at founding institutions. The idea here is to permit to have more people deeply involved in this collaboration and that the IRN could have, as an additional role (but still strongly promoting the other well-established actions and objectives), a hub for the IRL ELyTMaX. By proposing light structure and agility in the development of new research projects as well as short stays in Japan, we hope that we will also **motivate new people to be part of the collaboration and to stay for longer periods**. Our strategy for getting newcomers is first to elaborate new collaborations through the network of the two schools involved (Centrale Lyon and INSA Lyon). Indeed, these two schools benefit from two strong networks (Centrale School network and Groupe INSA) representing a strong task force in terms of research and education. Some contacts have thus been already taken with labs of the network (for example SCR / C-Met of INSA Rennes) to be involved in the collaboration with Tohoku and to develop new research topics related to the themes already tackle in the IRN. The second part of our strategy relies on promoting and favor the **inclusion in medium to large French projects** (EU, ANR or Region for instance) or even **to Japanese projects** (JSPS, Tohoku IFS CRP) **partners outside the original core** of ELyT Global, in order to demonstrate the excellence of the network and **attract outside researchers**. Finally, **promoting young talented researchers in the ELyT network** is another key to ensure long-term cooperation and possible mobility to feed the ELyT network. Hence, actions targeting these researchers will be taken, for instance in the form of grants for collaborative research.

These exciting and promising actions, both undertaken since a long time or under consideration, yet require the same outstanding support from institutions but also sufficient funding. In particular, in 2021 the stop of IDEXLyon project will have a significant impact on the IRN budget, and seeking and securing funds for replacing this loss will be of particular importance. In that view, the opening of the network may bring new opportunities. Additionally, although the collaborations have shown impressive resilience with respect to the pandemic situation, particular attention should be placed on the effect of prolongated emergency situation to ensure the production of common results.

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 2020. This is decomposed into a general presentation of the IRN and the ecosystem it belongs to (ELyT initiative), networking and promotion activities (workshops, schools, students and researcher exchanges) as well as scientific research projects performed in the framework of the IRN, which regroups 26 projects involving 21 labs and 77 researchers.

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