Matrix Effects on Lipid Preservation and Extraction from Archaeological Ceramics

Program : Chemical & Materials engineering - M-IRMAE

Description

The analysis of organic residues, particularly lipids, extracted from archaeological ceramics provides valuable information on ancient subsistence practices, exchange networks, and ritual activities. While the influence of ceramic porosity on lipid preservation is recognized, the influence of the matrix composition, most notably calcium carbonate, has only recently become the focus of systematic investigation. The presence of calcium carbonate may affect lipid retention and extraction efficiency, potentially introducing biases that influence the interpretation of archaeological datasets.

The objective of the master thesis will be to systematically investigate the influence of calcium carbonate on lipid extraction from archaeological artefacts. Samples from Sicilian calcitic ceramic wares will be characterised in terms of porosity, elemental and mineral composition (XRF, XRD). Lipids will be extracted using two standard solvent extraction protocols. The extracted lipids will be analyzed and characterized by GC-MS. Extraction protocols will be optimized to take the nature of the ceramic matrix into consideration

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Kristin BARTIK (Kristin.bartik@ulb.be)

Co-supervisor : Alicia Van Ham-Meert (alicia.van.hammert@ulb.be)

Sustainable iron metal production by direct electroreduction of iron ore

Program : Chemical & Materials engineering - M-IRMAE

Description

Steel production accounts for more than 8% of global emissions and sustainable steel production is key to achieve a decarbonized economy. The direct electroreduction of iron oxide to produce metallic iron (ULCOS project) is truly a fascinating field of research and offers a breakthrough alternative to the existing status quo of blast furnace based iron production. The reaction happens in alkaline media and the mechanism of electroreduction -ie, solid state direct reduction is yet to explored in detail. Furthermore, a lot of other sources such as bauxite residue can be directly used to produce metallic iron via this method. The student will work on firstly understanding the fundamental reaction mechanism of direct electroreduction of iron from iron oxide in alkaline media.

Promotor: Prakash Venkatesan (Prakash.venkatesan@ulb.be)

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCBS, M-IRCNE
Number of topics	2

Supervision

Supervisor : Prakash Venkatesan (prakash.venkatesan@ulb.be)

Analysis of Heat and Mass Transport During Hydrogen Bubble Growth in Water Electrolysis

Program : Chemical & Materials engineering - M-IRMAE

Description

Hydrogen can be produced by splitting water through electrochemical reactions in electrolysis. Although the process is overall endothermic, additional heat can be generated locally, most notably through Joule heating at the electrode surface. This localized heating modifies the temperature field near the growing hydrogen bubble, creating temperature gradients that induce thermocapillary (Marangoni) flows along the bubble interface.
In addition to thermal effects, concentration gradients of surface active species such as ions or dissolved gases can also alter surface tension, resulting in solutal Marangoni convection. These interfacial flows strongly affect bubble growth, shape, and detachment dynamics. Understanding these coupled effects requires the ability to accurately resolve the local temperature and concentration fields around the bubble. However, measuring both fields at the same time remains a significant experimental challenge.
Previous studies have demonstrated that at high applied potentials, Joule heating dominates, and thermocapillary effects become the primary drivers of interfacial motion, while solutal effects can often be neglected. Various optical techniques such as Schlieren imaging, laser induced fluorescence, and interferometry have been used to study these fields.
Mach Zehnder interferometry stands out as a noninvasive and calibration free technique for resolving instantaneous temperature fields with high sensitivity.
This thesis will focus on hydrogen bubble dynamics on a microelectrode in acidic electrolysis, using two complementary experimental techniques:

- Mach Zehnder Interferometry, to quantify the temperature field near the electrode and at the base of the bubble, especially when concentration variations are negligible.
- High speed visualization, to qualitatively capture the bubble inception, growth, and detachment processes.
- Complementary Schlieren imaging may be used for qualitative validation as done in the previous study [1].

Methodology

1. Literature survey

The student will begin by familiarising themselves with the topic. A thorough review of recent literature, especially on interferometric and visualisation techniques applied to gas-evolving electrodes, will help define the research scope and objectives.

2. Experimental set-up

The student will work with the existing electrolysis cell, Mach Zehnder interferometer, and high-speed imaging system available at the TIPS laboratory. This phase will involve hands-on training with laser alignment, optical adjustments, electrode handling, and system calibration. The student will also participate in test runs to optimise measurement conditions and gain confidence in operating the setup independently.

3. Measurement campaign and data analysis

The student will conduct experiments to visualise hydrogen bubble growth on microelectrodes using high-speed imaging and Mach Zehnder interferometry. Interferometric data will be analysed to extract local temperature fields, while high-speed recordings will be used to characterise bubble shape, growth, and detachment dynamics. Post-processing and analysis will be carried out using MATLAB. If numerical simulation results are available, they will be compared with the experimental data. In parallel, the student will measure the refractive index, density, and viscosity of the electrolyte across different concentrations and temperatures, using the available facilities at the TIPs laboratory, ULB.

4. Reporting

- Weekly meetings with the supervisor(s) to define tasks and discuss outcomes and practicalities.
- Monthly meeting with the team to verify the progress and discuss follow-up
- Final presentation

References

[1]. A. Babich, A. Bashkatov, X. Yang, G. Mutschke, and K. Eckert, “In-situ measurements of temperature field and Marangoni convection at hydrogen bubbles using schlieren and PTV techniques,” Int. J. Heat Mass Transf., vol. 215, p. 124466, 2023.

[2]. J. Massing, G. Mutschke, D. Baczyzmalski, S. S. Hossain, X. Yang, K. Eckert, and C. Cierpka, “Thermocapillary convection during hydrogen evolution at microelectrodes,” Electrochimica Acta, vol. 297, pp. 929–940, 2019.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	2

Supervision

Supervisor : Pierre Colinet (pierre.colinet@ulb.be)

Co-supervisor : Senthil Kumar Parimalanathan (senthil.parimalanathan@ulb.be)

Unraveling the degradation of applied brocades in the Van Eyck's brothers' "Adoration of the Mystic Lamb" Altarpiece: synthesis and multi-analytical characterization of Sn(II) metal soaps

Program : Chemical & Materials engineering - M-IRMAE

Description

The iconic "Adoration of the Mystic Lamb" altarpiece, painted by the Van Eyck brothers in the XVth century, presents a severe alteration of its applied brocades, an ancient decorative technique involving a complex superposition of numerous materials. Previous analysis of samples taken from the altarpiece suggest the degradation of the brocades' tin foils occurs through the formation of metal soaps that have not been yet described in the scientific literature. Considering the as-obtained results as well as the materiality of the applied brocades' tin foils, Sn(II)-based soaps are suspected to be one of the main degradation products formed. Nonetheless, the lack of Sn-soap references hinders their identification as well as a refined understanding of the brocades' degradation mechanism. The project currently seeks to clearly identify such mechanisms to propose better conservation-restoration solutions that ensure their preservation.

The project aims to define a reproducible synthetic pathway allowing to obtain a Sn(II) metal soap which will have to be characterized using numerous (micro)analytical techniques (ATR-FTIR, SEM-EDX, Raman, pXRPD, XPS, ToF-SIMS and NMR). Once obtained, a novel reflection FTIR analytical methodology will be developed to identify and localize such soaps in mock-ups and samples taken from the altarpiece, thus improving our understanding of the applied brocade's degradation phenomena.

The work will be carried in collaboration with the Royal Institute for Cultural Heritage in Brussels (KIK-IRPA), more specifically in the Materials Science for Conservation Research (MatCoRe) unit which is dedicated to the study of the molecular phenomena involved in the degradation of historical oil paintings.The main techniques that will be used in this project are: ATR-FTIR, Raman, NMR, SEM-EDX, XPS, ToF-SIMS.

Prerequisites

- Spectroscopy
- Organic Chemistry

Link : https://www.kikirpa.be/fr/presse/restauration-agneau-mystique

For more information, please contact Dr. Francisco Mederos-Henry (francisco.mederos@kikirpa.be) or Kristin Bartik (Kristin.bartik@ulb.be).

Language	EN (english)

Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

Supervisor : Kristin BARTIK (kristin.bartik@ulb.be)

Co-supervisor : Francisco Mederos-Henry (Francisco.Mederos-Henry@ulb.be)

Topics offered to students by other master's programs

TARGET PROGRAM

Chemical engineering

Material Screening for Laser-Ablation Micropropulsion Using a Torsional Pendulum Thrust Balance

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally compare candidate materials for laser-ablation micropropulsion using a torsional pendulum thrust or impulse balance. Laser propulsion refers to concepts in which laser radiation transfers momentum to a spacecraft or target. In laser-ablation propulsion, laser energy is absorbed by a material surface, causing rapid heating, vaporization, plasma formation, or material ejection. The recoil from the ejected material produces a small impulse, making this approach relevant for micropropulsion, attitude control, precision positioning, and possibly remote momentum transfer to small objects or debris.

The work will build on an existing torsional pendulum setup previously developed for laser-propulsion studies. The main objective is to determine how material properties such as composition, rigidity, porosity, optical absorption, surface roughness, and internal structure influence the impulse generated by pulsed laser ablation. The student will first review the principles of laser propulsion, pulsed laser ablation, micropropulsion, and impulse measurement, with attention to key quantities such as impulse bit, momentum coupling coefficient, laser fluence, ablation threshold, repeatability, and surface degradation.

Experimentally, small material samples will be mounted on the torsional pendulum and irradiated by a laser under controlled conditions. The recoil impulse produced by each laser pulse will induce an angular displacement or oscillation, from which the impulse can be estimated using the pendulum calibration, geometry, torsional stiffness, damping, and moment of inertia. The first phase will focus on calibration and validation of the measurement system, including sensitivity, noise floor, repeatability, damping behaviour, and uncertainty.

The second phase will test standard reference materials such as aluminium, copper, graphite, polymers, black coatings, adhesive tapes, or commercial absorptive films. These results will provide baseline data on how optical absorption, thermal conductivity, melting or vaporization behaviour, and surface morphology affect impulse generation. A third phase will investigate custom or engineered materials, such as porous materials, composites with carbon or metallic fillers, multilayer coatings, polymer matrices, foams, aerogels, or surface-treated samples. Laser parameters such as pulse energy, spot size, repetition rate, incidence angle, number of pulses, and target position will be controlled as carefully as possible.

The analysis will compare impulse bit, impulse as a function of laser energy or fluence, estimated momentum coupling coefficient, repeatability over multiple shots, and surface degradation after irradiation. The expected outcome is a calibrated comparative assessment of materials for laser-ablation micropropulsion. The thesis should rank candidate materials according to propulsion-relevant performance metrics and provide recommendations for future vacuum-compatible laser-propulsion experiments.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervisor

Axel Coussement (axel.coussement@ulb.be)

Co-supervisor

Carlo Iorio (carlo.iorio@ulb.be)

Master’s program offering the topic : Architectural engineering - M-IRARE

Incorporating Sustainability in the design process of products, processes and businesses.

Description

How to design products that have a better impact on environment, social and economy? This thesis starts with a state of art review of methods for 'Design for Sustainability'. What are methods to decision on sustainability and what are the remaining challenges and pitfalls? The aim of the thesis is to formulate a novel way to embed sustainability in the decision process of companies and link it to existing methods for corporate sustainability reporting.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCNE, M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Messagie Maarten (maarten.messagie@vub.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Redox-Active Hydrogel Scaffolds for Nanoparticle Encapsulation and Controlled Manganese Release in Postoperative Anticancer Applications

Description

Hydrogel-based biomaterials are increasingly explored as localized platforms for improving postoperative cancer treatment by enabling the encapsulation and sustained release of therapeutic nanomaterials. In this context, manganese dioxide (MnO_2) nanoparticles offer redox-responsive properties and the ability to release manganese ions, which can induce oxidative stress and contribute to cancer cell cytotoxicity. This thesis proposes the development of MnO_2 nanoparticle–embedded photocrosslinkable hydrogels as systems for nanoparticle encapsulation and controlled, sustained manganese release for in vitro anticancer evaluation.

Two hydrogel matrices, Gelatin Methacryloyl (GelMA) and Carboxymethyl Cellulose Methacrylate (CMCMA), will be investigated in a comparative study. GelMA provides a biomimetic and biocompatible environment, while CMCMA offers enhanced mechanical stability and potential printability. The study will focus on the fabrication and mechanical characterization of MnO_2-loaded hydrogels, evaluating key properties including rheological behavior, compressive strength, swelling ratio, degradation rate, gel fraction, and porosity. These parameters will be correlated with the hydrogel's ability to encapsulate nanoparticles and regulate their sustained release.

The cumulative release of manganese species will be monitored using UV–Vis spectrophotometry and colorimetric manganese detection assays, enabling analysis of MnO_2 degradation and Mn^{2+} ion release kinetics. The biological effects of released manganese species will be assessed using in vitro cancer cell models, with cell viability evaluated via the CellTiter-Glo® 3D assay (Promega) and Live/Dead staining to visualize cell survival and membrane integrity.

By correlating hydrogel structure, nanoparticle encapsulation, release behavior, and cellular response, this work aims to establish MnO_2-loaded hydrogels as effective platforms for localized and controlled nanomaterial delivery in postoperative anticancer applications.

Langue	EN (english)

Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Dynamically Tunable Hydrogels for Vascular Stiffness Modulation

Description

Hydrogel-based matrices are widely used to model the physical microenvironment of cells in engineered tissues. However, most current systems rely on static materials with fixed mechanical properties, limiting the ability to study how cells respond to mechanical changes over time. In native tissues, extracellular matrix properties such as stiffness evolve dynamically, influencing cell behavior, barrier function, and mechanotransduction.
In this project, you will develop phenol-modified hydrogels with controllable crosslinking and stiffness. Phenol-functionalized polymers enable enzymatic crosslinking reactions that allow the degree of crosslinking, and therefore the mechanical properties of the hydrogel, to be adjusted over time. By tuning crosslinking conditions, the material can undergo controlled stiffening after gel formation, creating a dynamic matrix whose mechanical properties can be programmed during experiments.
Some tasks will involve:

- Tune enzymatic crosslinking conditions to control gelation and stiffness.
- Characterize hydrogel mechanical properties using rheology or mechanical testing.
- Develop protocols for inducing controlled stiffness changes over time.
- Test compatibility of the hydrogels with endothelial cell culture and perfused channel systems.

The resulting platform will enable dynamic control of the mechanical microenvironment, which can be used to study how vascular cells respond to changes in matrix stiffness. Such systems may also serve as in vitro models to investigate processes associated with arterial stiffening, which are difficult to capture using conventional static materials.

See - R. Schnellmann et al.,Stiffening Matrix Induces Age-Mediated Microvascular Phenotype Through Increased Cell Contractility and Destabilization of Adherens Junctions, Advanced Science, 2026
J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

Langue	EN (english)

Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Development of a realistic and easy-to-use mucus simulant

Description

Context: Over the last years, the respiratory drug delivery has drawn a strong interest due to the large surface area of the airway mucosa, providing an easy access to the blood. In particular, nasal sprays intending to treat non-local disorders, like migraine or hypoglycaemia, have appear. Compared to oral medicines, they are easier to use, act faster and can be given to unconscious patients [1]. However, the current characterisation techniques for spray are still lacking. Cutting-edge methods, such as experimental and digital models of the nose aims to bridge this gap but further development is still needed to reproduce adequately spray deposition in the nose. In particular, the interactions between the spray particles and the mucus lining the interior of the nose governs the final deposition site of the spray.

Objective: This thesis aims to develop a realistic and easy-to-use fluid replicating the nasal mucus. This simulant needs to reproduce the rheological characteristics of the biological mucus [2] and must be coated easily into nasal replicas. This mucus simulant will then be used to assess the influence of its properties (viscoelasticity, viscoplasticity, surface tension,...) on the trajectories of impacting particles. These results would strengthen the current understanding of the mucus-particles interactions and help to validate advanced simulation models.

Langue	EN (english)
Ouvert à d'autres masters	yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Light-Responsive Sacrificial Hydrogels for 3D Bioprinting Applications

Description

Three-dimensional (3D) bioprinting enables the fabrication of complex biological structures with spatial control over materials and cells. However, creating perfusable channel networks within these constructs remains a major challenge. Sacrificial hydrogels offer a promising solution by acting as temporary templates that can be removed after printing to form hollow structures.

This project focuses on the development of light-responsive sacrificial hydrogels that can be processed under mild conditions and selectively dissolved upon external stimulation. The material system can be tuned to function either as a support bath for embedded printing or as a printable sacrificial filament, enabling flexible fabrication strategies. The student will investigate how formulation and processing affect mechanical properties, printability, and removal behavior, and will demonstrate the fabrication of simple perfusable structures.

The objective of this project is to design and evaluate a tunable hydrogel system for use as a sacrificial material in 3D bioprinting. This includes understanding how material composition influences gel formation, mechanical behavior, and responsiveness to light-based triggering, as well as demonstrating its applicability in creating defined structures and channels.

Tasks

- Chemical preparation and modification of polymer-based hydrogels
- Formulation optimization to tune mechanical properties (soft vs. structured gels)
- Rheological characterization (viscosity, gel strength, recovery behavior)
- Development of support bath systems for embedded 3D printing
- Extrusion-based 3D printing experiments (filaments, simple structures)
- Evaluation of light-triggered material removal
- Fabrication of hollow channels and perfusion testing
- Basic biocompatibility assessment (cell viability assays)

Methods & Techniques

- Hydrogel synthesis and preparation
- Rheometry and mechanical testing
- 3D bioprinting (extrusion-based)

- Optical/light-based triggering experiments
- Microscopy and image analysis
- Cell culture and viability assays

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Food and house dust mite allergens

Description

Allergy represents an important public health problem. On the one hand, we are developing bioinformatics tools to predict whether a protein corresponds to a food allergen. Such tools are
very important for the development of new food products. On the other hand, we are studying
certain structural and dynamic properties of house dust mite allergens.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS
Nombre de sujets	1

Supervision

Supervisor : Gilis Dimitri (dimitri.gilis@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Improved adenoid hypertrophy treatment through nasal replicas

Description

Context: Adenoid hypertrophy is the pathologic enlargement of the tonsils at the back of the nose. It is one of the most common no-infectious ENT affection in children with a prevalence of about over 30%. Nowadays, the first-line treatment of adenoid hypertrophy is corticosteroid nasal sprays. While half of the patients shows improvement with this treatment, it is ineffective for the other half [1]. One issue may be that the current treatments aim for maximum coverage of the nasal cavity and not maximal penetration. Consequently, only a small part of the medicine reaches directly its site of action. New medication strategies, combining adapted devices, formulations and administration procedures [2], could increase the success of corticosteroid treatment and decrease the use of surgery in children.
Objective: This thesis aims to maximise the amount of drug reaching the pharyngeal tonsils. The fraction of drug reaching the site of action will be determined using a 3D-printed nasal replica of a child anatomy. The main goal is to combine the characteristics of the spray (viscosity, surface tension) and the administration procedure (instillation angle, inspiration) to increase the amount of drug reaching the back of the nasal cavity. Correlations between the characteristics of the sprays and the deposition in the nose should also be drawn to provide simple guidelines for future medicine development.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Modular Volumetric Bioprinted Vascular Models to Study Cell–Flow Interactions

Description

Understanding how geometry and flow conditions influence cellular behavior is crucial for studying vascular biology, disease development, and tissue engineering. Recent advances in volumetric bioprinting enable the rapid fabrication of complex hydrogel structures with precisely defined internal geometries. These structures can be used as model systems to investigate how physical cues affect cell responses in engineered microenvironments.
In this project, you will develop modular hydrogel building blocks containing internal channel geometries that can be linked together to form artificial vessel-like networks. Using volumetric printing, these building blocks will be fabricated with features such as constrictions, angles, and porous regions that create distinct flow regimes (e.g., altered shear stress, recirculation zones, or diffusion-dominated regions).
Some tasks will involve:

- Design and volumetrically print modular hydrogel blocks with embedded channels.
- Assemble these blocks into customizable artificial vascular systems.
- Introduce cells into the channels and apply controlled perfusion flow.
- Investigate how channel geometry, flow patterns, and shear stress influence cell behavior such as adhesion, morphology, migration, and proliferation.
- Analyze how porous or structured regions affect diffusion and cell–material interactions.

The project combines advanced biofabrication, microfluidics, and cell biology, providing a platform to systematically study how physical microenvironmental parameters regulate cellular responses. It will help to uncover fundamental principles governing cell behavior in vascular-like environments.

See - J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

Langue	EN (english)
Ouvert à d’autres masters	Yes

Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Master thesis in microfluidics

Description

Several research topics related to microfluidics and lab-on-a-chip: droplets, bubbles, capsules, antibubbles, double emulsions, flow crystallisation, cell encapsulation, cell sorting, giant unilamelar vesicles, confined Leidenfrost, coalescence, subretinal injection, blood testing by elastocapilarity, organoid encapsulation, ...

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	2

Supervision

Supervisor : Scheid Benoit (Benoit.Scheid@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Construction of Bacterially in Situ Generated Cellulose-Based Tannic Acid Nanozyme and Investigation of Its Enzymatic Performance Study

Description

Nanozymes, as synthetic nanomaterials with enzyme-like catalytic activities, have attracted significant attention in biosensing, catalysis, and antibacterial applications. Among them, metal–polyphenol networks (MPNs), especially tannic acid (TA)-based nanozymes, exhibit excellent catalytic efficiency, biocompatibility, and drug-loading capacity due to the inherent antioxidant and anti-inflammatory properties of polyphenols. Bacterial cellulose (BC), biosynthesized by microorganisms such as Komagataeibacter xylinus, is a highly pure, mechanically robust, and biocompatible nanofibrous material, making it a promising candidate for tissue engineering and functional materials. Integrating nanozymes with BC can impart multifunctionality to the composite system. However, conventional approaches typically rely on in vitro incorporation of nanozymes into preformed BC, which often results in uneven distribution and weak interfacial interactions. To address these limitations, this study proposes an in-situ biosynthesis strategy, in which TA-based nanozymes are directly introduced into the bacterial fermentation system, enabling the simultaneous formation of BC and nanozymes. This approach is expected to achieve uniform distribution and strong interfacial integration. Furthermore, the interaction mechanisms between nanozymes, BC fibers, and bacterial behavior will be systematically investigated, providing fundamental insights into the bio-fabrication of engineered living materials (ELMs).

Research points:
A) Construction of in situ BC complexes by co-culturing bacteria with TA nanozymes
B) Investigation of the interaction mechanisms between nanozymes and BC fibers through comprehensive material characterization.
C) Evaluation of multi-enzyme activities in the composite system and investigation of the effects of BC matrix on catalytic activity stability, reaction kinetics, and pH adaptability.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH

Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Development of a Bioactive HAMA/GelMA Hydrogel for Volumetric Printing of Biomimetic Structures

Description

Volumetric 3D printing is an emerging approach in biofabrication that enables the rapid production of complex three-dimensional structures. Unlike layer-by-layer printing techniques, this method allows an entire volume of photosensitive resin to be polymerized in a matter of seconds. However, its use in tissue engineering remains limited by the small number of compatible bioinks, which must both possess suitable optical properties for printing and maintain a biologically favorable environment for cells.

This project aims to develop and characterize a new bioactive hydrogel formulation based on a GelMA (gelatin methacryloyl) and HAMA (hyaluronic acid methacrylate) mixture for volumetric printing. The goal is to design a resin that enables both efficient polymerization during printing and a supportive environment for cell viability. The potential addition of PEGDA may also be explored to fine-tune mechanical properties and crosslinking kinetics.

The first work axis will focus on material formulation and characterization. HAMA will be synthesized, and different molecular weights may be investigated. Methacrylation will be analyzed (by NMR if possible, or by FTIR for qualitative estimation). These polymers will then be incorporated into GelMA/HAMA hydrogel formulations at various ratios, optionally complemented with polyethylene glycol diacrylate (PEGDA) to adjust mechanical properties and crosslinking. Simple UV photopolymerization tests will be conducted to assess the reactivity of the formulations, followed by mechanical characterization of the resulting hydrogels (Young’s modulus and storage modulus).

The second project axis will address the compatibility of the formulations with volumetric printing. The optical properties of the resin (refractive index, absorbance) will be measured to verify their suitability for the printing technique. Volumetric printing polymerization tests and light-dose adjustments will be carried out to determine the conditions required to produce stable and well-defined hydrogel structures, with the ultimate goal of creating more complex structures, such as those containing microchannels.

Finally, in parallel, a third axis will focus on evaluating the biological activity of the hydrogels. Cell viability assays (MTT or Alamar Blue) will be performed using fibroblasts or endothelial cells. Cell morphology will also be studied using fluorescent labeling to assess the interactions between cells and the different formulations (HAMA molecular weight and

ratios). These tests can be conducted on hydrogel discs.
This project will thus explore the potential of HAMA/GelMA hydrogels as bioinks for volumetric printing and provide insights into how formulation affects the mechanical, optical, and biological properties of the material.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Artificial intelligence methods to design ligands for olfactory receptors

Description

The olfactory system relies on protein receptors expressed by olfactory neurons. These olfactory
receptors belong to the family of G protein-coupled membrane receptors (GPCR). The relationships between odorant molecules, targeted olfactory receptors and odour perception are
complex and not yet well understood. In addition, it has been shown that some olfactory receptors are expressed in tissues other than the olfactory epithelium and may have a physiological or potentially therapeutic role.
This project consists in developing artificial intelligence approaches, allowing (1) to predict the
olfactory receptor(s) targeted by an odorant molecule, and (2) to design de novo a molecule able
to activate a given olfactory receptor. It is carried out in collaboration with the group of Prof. I.
Langer (Faculty of Medicine), which experimentally characterises these systems.
The master thesis topics related to this project can be entirely bioinformatics or include an experimental part.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS
Nombre de sujets	1

Supervision

Supervisor : Gilis Dimitri (dimitri.gilis@ulb.be)

Master’s program offering the topic : Chemical & Materials engineering - M-IRMAE

Process parameter optimization for 3D printing of Functionally Graded rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

Rocket nozzles need FGMs to withstand extreme thermal and mechanical stresses by gradually transitioning from heat-resistant materials at the throat to tougher structural metals, improving durability, reducing thermal mismatch, and preventing failure. This is why rocket nozzles are manufactured with a graded transition from 316L or Inconel to copper as shown on Fig. 2-3.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October 2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and doesn't rely yet on the FGM technology.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. When printing FGMs, these parameters increase in number and must be actively tuned during the build as the material transitions from one type to another. The results of the manufacturing of the miniature FGM rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping, crack formation, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

The aim of this master thesis will be to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores, cracks, or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : Chemical & Materials engineering - M-IRMAE

Plasmonic nanoparticles inside PNIPAM hydrogel for light-driven soft actuators using femtosecond laser writing

Description

Context: Soft matter can serve as an actuator in microrobotics by deforming under external stimuli (light, heat, or pH…) and producing mechanical outputs like force or displacement. At the microscale, these smart materials can be 3D printed without assembly. In our lab, we use two-photon polymerization (2PP) to fabricate soft actuators from a thermo-responsive pol-ymer, poly(N-isopropylacrylamide) (pNIPAM). This material swells below its lower critical solution temperature (LCST) by absorbing water and shrinks above the LCST by expelling it. Recently, we fabricated 50 µm × 50 µm × 50 µm active cubes capable of bending, contract-ing, twisting, or shearing in heated water [1]. To achieve precise, multidirectional motion control, multiple actuators could be combined and selectively triggered by different wave-lengths of light. This is possible by doping them with photothermal nanomaterials that lo-cally convert light into heat [2]. Metallic nanostructures like gold (Au) and silver (Ag) nano-particles or nanorods have been used to actuate PNIPAM-based hydrogels [3]. However, they are usually dispersed uniformly, preventing spatial control. An alternative approach uses a tightly focused femtosecond laser in a PNIPAM hydrogel swollen with silver nitrate, locally forming Ag nanoparticles by multiphoton reduction [4]. Applying this method to our actuators would enable spatially selective nanoparticle patterning, allowing localized, pre-cise activation.
Objective: The aim of this thesis is 3D print photosensitive nanoparticles inside PNIPAM hydrogels with the 2PP machine. After printing, light will be used to illuminate the actuators and will be converted into heat by the nanoparticles. The generated heat will trigger actuator mo-tion by shrinking the hydrogel.
Methods: Literature review. Hydrogel fabrication (with 2PP printing). Printing of Ag/Au nanoparti-cles i.e., tune the printing parameters to obtain nanoparticles and optimize the actuation. Characterization: UV absorbance spectra, SEM imaging, and measuring the light respon-siveness of the structures.
Prerequisites: Materials (to develop the fabrication process and understand the behavior of the hydrogels with and without nanoparticles).

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Experimental and numerical investigation of structural adhesive behavior under multiple loading conditions

Description

Context of the master thesis

Adhesive joints are commonly used to bond components in composite structures. Adhesive bonding not only facilitates lightweight designs but also offers significant advantages over mechanical fastening, including excellent durability, fatigue resistance, and the ability to evenly distribute stress across the joint. Despite these benefits, adhesive joint failure often reduces the lifespan of composite structures [1]. Therefore, comprehensive experimental characterization of structural adhesives and the development of reliable numerical models are essential for understanding adhesive joint behavior in large-scale structures, such as wind turbine blades. Due to the cross-linking nature of epoxy adhesives, their tensile, shear, and compressive behaviors differ. These differences can be accounted for using a pressure-dependent material model [2]. The Drucker-Prager model, a commonly used pressure-dependent material model, has been applied by researchers to simulate epoxy-based adhesives, though most studies are limited to the linear form of the model [3]. In this master's thesis, structural adhesive specimens will be tested under tensile, shear, and compressive loading to characterize material behavior, including post-yield response, and to extract material constants for the Drucker-Prager exponential model. Each experiment will be simulated using ABAQUS finite element (FE) software to replicate the observed material behavior and damage propagation. Following complete characterization and modeling of the adhesive, fracture tests will be performed on Single Edge Notch Bending (SENB) specimens under various loading conditions. The developed advanced material model will then be used to numerically replicate these experiments, demonstrating the applicability of the exponential Drucker-Prager model in simulating the behavior of epoxy adhesives.

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Objectives of the master thesis

1. To perform advanced mechanical characterization of epoxy-based adhesives experimentally.
2. To develop a numerical model that replicates adhesive behavior under tensile, shear, and compressive loading.
3. To assess the model's capability to predict damage propagation in cracked specimens.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

On-line measurement and validation of thermal gradients during 3D metal printing through IR-camera measurements.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is an metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible.

Fig. 2 shows a 3D tower part that has been manufactured in a hybrid way with the MiCLAD machine. During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part.

In this context, two thermal cameras (FLIR and SWIR) have been integrated into the machine, and a dedicated tool has been developed to enable in-process thermal gradient monitoring. The use of both cameras allows for broader thermal range coverage, capturing the various temperature the part experiences during the process. The tool enables simultaneous recording from both cameras and provides real-time visualization of thermal gradients through a dedicated application, with the aim of enabling online thermal gradient control in the future. An example of a captured thermal field of the build plate during process is shown in Fig. 5.

This setup and tool now require further development and validation to assess the accuracy of the results. To this end, an experimental campaign will be conducted under varying

heat input boundary conditions, primarily focusing on laser power and build plate preheating settings. The resulting data will be analyzed to gain a deeper understanding of the thermal history of parts during the DED process and ultimately to reduce the thermal gradient and resulting residual stresses.

In parallel, the measured thermal gradients will be compared with numerical simulations using an existing DED process model. This comparison aims to validate the model as well as the associated material parameters (such as density, latent heat, and heat capacity) and boundary conditions against the experimental results. A specific parameter matrix will be defined for both the experimental and numerical campaigns. The thermal history simulations will be carried out using Morfeo (Manufacturing Oriented Finite Element tOol), an extended finite element (FEM) code developed by the Belgian research center Cenaero [3].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Investigation of Microstructural Evolution and Corrosion Resistance in Hybrid DED-Manufactured Parts

Description

3D printing is a widely used additive manufacturing process in which layers of material are successively deposited to create a three-dimensional part. Over the past decade, it has gained significant interest due to increased accessibility and technological advancements.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) technique that uses a focused laser beam to melt metallic powder, which is simultaneously delivered through a nozzle. The Additive Manufacturing Research Lab (AM-Lab) at the Vrije Universiteit Brussel (VUB) has developed an in-house hybrid DED machine called the MiCLAD, which is extensively presented in [2].

The MiCLAD system is equipped with a 5-axis CNC controller and allows for a rapid transition between additive deposition (DED) and subtractive machining (milling/drilling). This combination of processes is referred to as hybrid manufacturing. An in-situ image of the DED process is shown in Fig. 1, where the nozzle, powder particles, and melt pool (visible as a high-intensity spot) can be observed. Fig. 2 illustrates a hybrid 3D tower manufactured using the MiCLAD system, combining additive and subtractive operations to directly integrate functional features into the part. The milling operations are indicated by the red dashed lines.

The subtractive process is further illustrated in Fig. 3 (cogwheel) and Fig. 4 (research sample). During hybrid manufacturing, the process parameters and thermal history play a critical role in determining the final part quality, as they directly influence the microstructure, residual stresses, corrosion behaviour, and mechanical properties.

An Electron Backscatter Diffraction (EBSD) map is shown in Fig. 5, highlighting a clear effect of the milling operation on grain size and crystallographic orientation. These microstructural modifications are expected to significantly affect the corrosion behaviour of the material and therefore require detailed investigation.

It is therefore essential to understand the combined effect of additive and subtractive operations on the microstructure and to monitor the melt pool temperature during processing. The SURF [3] and MECH [4] departments at VUB are collaborating closely to investigate these effects.

To evaluate the influence of hybrid manufacturing on corrosion resistance, a dedicated experimental campaign will be carried out on the MiCLAD machine, and the melt-pool temperatures during manufacturing will be measured. Samples produced via hybrid DED (additive + milling) will be compared to purely additive-manufactured samples.

The corrosion behaviour will be assessed using standard electrochemical and surface analysis techniques, including potentiodynamic polarization and immersion tests to evaluate the electrochemical response of the samples, as well as XPS and SEM/EDS to analyze the impact of the processing condition on the microstructure and passive oxide layer of the material. These analyses will help establish correlations between process conditions, melt-pool temperature, resulting microstructures, and corrosion performance.

The final objective of this master thesis is to design and conduct a hybrid experimental campaign using the MiCLAD system to manufacture samples suitable for corrosion analysis, and to compare their corrosion resistance with that of conventionally additively manufactured samples.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-A
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Post-processor extension to 3D material allocation for metal 3D printing through Directed Energy Deposition manufacturing process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part/sprocket that has been manufactured with the MiCLAD machine.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

FGMs are used for example in injection molding molds, as shown in Fig. 3 [3], to optimize performance by combining high thermal conductivity near the mold surface for faster cooling with a tougher core for structural strength. This gradient in properties improves cycle times, reduces wear, and extends mold life. The production of such a part required a different material allocation in 3 dimensions (x, y, and z), see Fig. 4.

CAD/CAM software (Computer-Aided Design / Manufacturing) plays a crucial role in DED by converting CAD models into toolpaths that guide the deposition head and define process parameters. However, current commercial solutions lack the capability to handle FGMs by assigning specific materials and corresponding process settings to precise locations within a part. To address this, the AM-Lab developed the CamLink post-processor, which serves as a translator between the CAD/CAM software and the CNC machine, enabling advanced control over material deposition.

It allows the generation of machine compatible Gcode from any geometry, incorporating the desired material gradient at specified locations, via a standalone MATLAB application. However, at this stage, material allocation is limited to the -z and -x directions. An example of a composition transition from copper to 316L in the x-direction is shown in Fig. 6–7.

The aim of this master thesis is to further develop the existing CamLink post-processor to enable material allocation in all three spatial dimensions, thereby allowing complete design freedom in the manufacturing of FGMs. In the next phase, this extension will be validated through simple experiments using the DED machine. Subsequently, process parameters will be optimized, based on microstructural analysis, to ensure defect-free transitions between material compositions. Finally, the enhanced post-processor will be validated through the production of a demonstrator part featuring composition gradients in all three directions.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Development of the wedge test for thick adhesive joints to prevent crack deviation under mode I loading

Description

Context of the master thesis
Adhesive joints are widely used across various industries, including wind turbine manufacturing, shipbuilding, aerospace, and automotive applications. Compared with traditional joining methods, adhesive bonding offers several advantages, such as the ability to join similar and dissimilar materials, weight savings, improved stress distribution along the bond line, and enhanced corrosion and fatigue resistance. When considering thick adhesive joints, however, the definition varies across industries. For example, in the wind turbine and shipbuilding sectors, thick adhesive joints typically have an adhesive layer thickness of approximately 10 mm or greater [1]. The influence of adherend constraint, joint geometry, and residual stresses on crack kinking under mode I loading conditions is well documented in the literature [2], [3]. Nevertheless, to date, no experimental setup has been proposed that enables stable crack propagation within the mid-plane of the adhesive layer under pure mode I loading. To address this gap, the present master’s thesis will employ a combined numerical–experimental approach to develop a test method capable of promoting stable crack growth in thick joints. A series of numerical models will first be developed using ABAQUS finite element (FE) software to evaluate fracture parameters under mode I loading using conventional Double Cantilever Beam (DCB) specimens subjected to point loading. In the subsequent step, in addition to the opening load applied normal to the crack plane, an auxiliary load will be applied in a perpendicular direction. This auxiliary load is intended to reduce crack-tip constraint arising from joint geometry and residual stresses. Based on the numerical results, the appropriate load ratio between the parallel and perpendicular loading directions will be determined, and a wedge-based support system capable of delivering this load ratio will be designed. Experimental tests will then be conducted on pre-cracked thick adhesive joint specimens to assess the feasibility and effectiveness of the proposed method. Finally, the wedge test experiments will be replicated through FE simulations to provide a comprehensive understanding of the underlying fracture mechanisms and crack propagation behavior.

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[3] A. Sharma et al., “Combined computational-experimental investigation of residual stresses and pre-cracking in mode I behaviour of thick adhesively bonded GFRP composite joints,” Compos. Struct., vol. 351, p. 118549, Jan. 2025, doi: 10.1016/J.COMPSTRUCT.2024.118549.

Objectives of the master thesis
1. To determine the fracture parameters of thick adhesive joints under point-load conditions.
2. To identify fracture parameters that mitigate unstable crack propagation in adhesive joints and to design a wedge-based loading system accordingly.
3. To experimentally evaluate the proposed setup for facilitating stable crack propagation.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Integration of Internal Capillaries in Hybrid Directed Energy Deposition parts: Impact on Microstructure and Corrosion Behaviour

Description

3D printing is a widely used additive manufacturing process in which layers of material are successively deposited to create a three-dimensional part. Over the past decade, it has gained significant interest due to increased accessibility and technological advancements.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) technique that uses a focused laser beam to melt metallic powder, which is simultaneously delivered through a nozzle. The Additive Manufacturing Research Lab (AM-Lab) at the Vrije Universiteit Brussel (VUB) has developed an in-house hybrid DED machine called the MiCLAD, which is extensively presented in [2].

The MiCLAD system is equipped with a 5-axis CNC controller and allows for a rapid transition between additive deposition (DED) and subtractive machining (milling/drilling). This combination of processes is referred to as hybrid manufacturing. An in-situ image of the DED process is shown in Fig. 1, where the nozzle, powder particles, and melt pool (visible as a high-intensity spot) can be observed. Fig. 2 illustrates a hybrid 3D tower manufactured using the MiCLAD system, combining additive and subtractive operations to directly integrate functional features into the part, such as internal capillaries (see red vertical arrow). These capillaries can serve as cooling channels or for Structural Health Monitoring of the part. The milling operations are indicated by the red dashed lines.

The subtractive process is further illustrated in Fig. 3 (drilling) and Fig. 4 (milling). During hybrid manufacturing, the process parameters and thermal history play a critical role in determining the final part quality, as they directly influence the microstructure, residual stresses, corrosion behaviour, and mechanical properties.

An Electron Backscatter Diffraction (EBSD) map is shown in Fig. 5, highlighting a clear effect of the milling operation on grain size and crystallographic orientation. These microstructural modifications are expected to significantly affect the corrosion behaviour of the material and therefore require detailed investigation. In particular, the drilling operations required to integrate capillaries are also expected to alter the local microstructure and may influence corrosion performance.

It is therefore essential to fully understand the effect of subtractive drilling operations on the microstructure. The SURF [3] and MECH [4] departments at VUB are collaborating closely to investigate these effects.

To evaluate the influence of hybrid manufacturing with integrated capillaries on corrosion resistance, a dedicated experimental campaign will be carried out using the MiCLAD system. Melt pool temperatures will be monitored during fabrication. Samples with embedded capillaries produced via hybrid DED (additive + drilling) will be compared to purely additively manufactured samples.

The corrosion behaviour will be assessed using standard electrochemical and surface analysis techniques, including potentiodynamic polarization and immersion tests to evaluate the electrochemical response of the samples, as well as XPS and SEM/EDS to analyze the impact of the processing condition on the microstructure and passive oxide layer of the material. These analyses will help establish correlations between process conditions, melt-pool temperature, resulting microstructures, and corrosion performance.

The main objective of this master thesis is to design and conduct a hybrid experimental campaign using the MiCLAD system to manufacture samples with embedded capillaries suitable for corrosion analysis, and to compare their corrosion resistance with that of conventionally additively manufactured samples.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-A
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Processing and characterization of a 316L to CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will engage in the explorative research regarding the process-material-property relationship of this multi-material. Especially the effect of ultrasound excitation during the DED processing of such 316L/CuCr1Zr multi-material will be explored. Samples with varying/gradient compositions will be manufactured and mechanically/microstructurally characterized to further optimize the processing conditions. The effects on corrosion resistance will be evaluated as well. The student will suggest process parameter optimizations and machine modifications with the purpose of enhancing the quality of the produced multi-material samples.

Practically, coupons will be produced under varying processing conditions, amongst which the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. Additionally, corrosion testing will be conducted macroscopically, and at localized regions to carefully evaluate the performance along the build direction. The functional properties (thermal/mechanical/corrosion) will be compared to reference conditions without ultrasound excitation.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O

Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Unraveling the effect of geometry on crack kinking under mode I loading using biaxial testing

Description

Context of the master thesis

Fracture mechanics is a branch of solid mechanics that studies the behavior of structures in the presence of cracks. In real structures, crack initiation can occur in regions of high stress or due to material voids, among other causes. Understanding material and structural behavior in the presence of cracks is crucial for avoiding catastrophic failure and enabling fail-safe design methodologies. To achieve this, fracture behavior must be studied under different loading modes, i.e., mode I, mode II, and mode III [1]. Mode I, or opening mode, is the most common loading condition encountered in real structures [1]. Experimental studies on mode I have shown that cracks do not always propagate in a straight path; rather, they often kink due to geometric constraints. In other words, changing the specimen geometry under the same loading conditions can lead to different crack propagation behaviors [2], [3]. Despite extensive experimental work, the primary factors triggering crack kinking remain not fully understood. It is well recognized that altering the geometry from Single Edge Notch Tension (SENT) to Double Cantilever Beam (DCB) specimens under mode I loading can induce unstable crack propagation [2], [3]. In this master's thesis, PMMA (polymethyl methacrylate) DCB specimens will be modeled under the Linear Elastic Fracture Mechanics (LEFM) framework using ABAQUS finite element (FE) software to determine the stress field and fracture parameters at the crack tip. Subsequently, biaxial loading conditions will be applied to the specimens, and the corresponding fracture parameters will be evaluated. The main objective is to identify a biaxial loading condition that suppresses crack kinking in the DCB specimen. Once the appropriate loading conditions are determined, the specimens will be tested using a biaxial testing machine to validate the simulations. This research will provide high-quality insights into the influence of geometry and loading conditions on crack trajectory under mode I, enhancing our understanding of fracture behavior in engineering structures.

References

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Objectives of the master thesis
For the first time, the combined effects of specimen geometry and loading on mode I fracture will be investigated. This study aims to achieve the following objectives:
1. To understand the effect of geometry on crack trajectory under mode I loading.
2. To identify loading conditions that mitigate unstable crack propagation under mode I.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Numerical study for thermal gradient reduction during 3D printing Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses, see Fig. 3. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part. Next to the process parameters, as shown on Fig. 3, buildplate preheating involves heating the baseplate before material deposition begins, is also used to reduce the thermal gradients.

Preheating minimizes the temperature difference between the incoming molten material and the cooler buildplate. This helps controlling the thermal history of the part, and might lead to better overall quality of the printed part.

The aim of this master thesis is to investigate numerically the effect of temperature dependent material parameters (density, latent heat, heat capacity, ...) and build plate preheating settings on the thermal history of the part.

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol) an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of milling process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on
the MiCLAD machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build/cutting strategy on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [3].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of a post milling operation (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [5,6].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of ablation process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

Hybrid Additive Manufacturing is based on the combination of multiple processes improving the cost, quality, functionality, and efficiency of the

parts [3]. Possible examples of additive-subtractive combination are Hybrid-AM by Machining or hybrid-AM by Ablation [4]. The MiCLAD machine is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. The lab is also equipped with an external ablation stage that will be soon integrated in the machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [5].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [6] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of the ablation process (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [7].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Characterization of the liner/composite overwrap interface in type IV hydrogen storage vessels

Description

Context of the master thesis

Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation,Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation. Despite their advantages in weight reduction and performance, Type IV tanks present critical challenges at the interface between the polymer liner and the composite overwrap that directly affect safety and durability. During high-pressure filling, hydrogen can permeate into the polymer liner and subsequently accumulate at the liner–overwrap interface. Upon rapid depressurization, this trapped hydrogen may generate local pressure differentials, leading to binder cavitation, interfacial void growth, and, in severe cases, liner collapse [2]. Furthermore, repeated pressurization–depressurization cycles can induce fatigue damage and progressive interfacial degradation, increasing hydrogen permeation, reducing structural reliability, and ultimately shortening the service life of the storage vessel. This thesis will focus on the characterization of the liner–composite overwrap interface in a Type IV hydrogen storage vessel. Mechanical testing will include double cantilever beam and T-pull tests to quantify the interfacial adhesion between the polymer liner and the composite overwrap. The effects of temperature and hydrogen exposure on interfacial properties will also be investigated. In addition, fatigue testing will be conducted to evaluate the long-term durability of the storage vessel.

References
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[2] Y.T. Li, W.J. Huang, Y.M. Zhang, M. Fan, Z.M. Xiao, W.G. Li, Investigation of liner collapse behaviors in Type IV hydrogen storage vessels at different temperatures, J. Energy Storage 129 (2025) 1–18. https://doi.org/10.1016/j.est.2025.117307.
[3] J. Pépin, E. Lainé, J.C. Grandidier, G. Benoit, D. Mellier, M. Weber, C. Langlois, Replication of liner collapse phenomenon observed in hyperbaric type IV hydrogen storage vessel by explosive decompression experiments, Int. J. Hydrogen

Objectives of the master thesis
This thesis will aim to develop a comprehensive understanding of the interfacial behaviour between the polymer liner and the composite overwrap in Type IV hydrogen storage tanks under service-relevant conditions, including hydrogen exposure, cryogenic temperatures, and cyclic mechanical loading. The insights obtained from this work are expected to support the design, material selection, and optimization of hydrogen storage systems with improved durability and safety performance.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Ultrasonic welding of thermoplastics and thermoplastic composites- Parametric study and optimization

Description

Context of the master thesis

Thermoplastic materials are widely used in many industries, either as plain materials or in composites where they are reinforced with fibers, leading to lightweight and resistant structures, which at the same time offer sustainable solutions. The reason for this is that thermoplastics are processed at high temperatures in order to obtain their final shape and since they can be melted, solidified and re-heated, they offer great recyclability potential. This property however offers much more industrial interest, since thermoplastics can also be welded, providing therefore alternatives compared to traditional mechanical fastening using e.g. bolts or rivets. One of the most promising welding methods is ultrasonic welding. Ultrasonic plastic welding (USW) is the joining or reforming of thermoplastics through the use of heat generated from high-frequency mechanical motion. It is accomplished by converting high-frequency electrical energy into high-frequency mechanical motion. That mechanical motion, along with applied force, creates frictional heat at the plastic components’ mating surfaces (joint area) so the plastic material melts and forms a molecular bond between the parts. Ultrasonic welding can offer a very fast and energy-efficient way for joining materials and in particular thermoplastics. Despite its potential and the fact that ultrasonic welding is being used in some industries for joining thermoplastics together, there is still a lot of open research related to the understanding of the impact of the different parameters involved in the process on the quality of the obtained joints. Moreover, automation of the welding process and optimization of the different parameters is of great importance, towards its further and more well-established industrialization. During this thesis subject, the student will initially have to perform a dedicated literature review on ultrasonic welding. Then, an experimental campaign will be performed, during which joints of thermoplastic parts will be manufactured by altering the parameters related to the ultrasonic welding process, e.g. applied load, weld time and hold time. The quality of the manufactured joints will be controlled through ultrasonic measurements after their production, in order to be directly correlated to the combination of welding parameters used. Moreover, mechanical testing will be performed and the damage of the joints will be evaluated through non-destructive methods, i.e. acoustic emission and digital image correlation. Based on the data collection through the ultrasonic welding process and the performed tests, in the final step of the thesis, the student will use machine learning/AI tools in order to use the obtained data in the most optimal way for the optimization of the method through closed-loop automation controls.

Objectives of the master thesis
1. Parametric study on ultrasonic welding of thermoplastics.
2. Damage evaluation of ultrasonic welds using non-destructive methods.
3. Optimisation of ultrasonic welding parameters combining experiments with machine learning.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Metallurgical, mechanical & corrosion characterization of ultrasonic assisted additively manufactured 316L

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the processing of single 316L alloy, yet Functionally Graded, constituting of a microstructural gradient by grain refinement through ultrasonic assisted additive manufacturing. Without such ultrasound assistance, grains tend to grow to elongated and larger grains during the solidification step, typically resulting in undesired, anisotropic material properties. The ultrasound excitation perturbs the melt pool during the solidification step, causing an interrupted grow of these elongated grains, and leading to a more refined and more isotropic material properties. The student will engage in the explorative research regarding the process-material property relationship through the addition of ultrasound excitation.

Practically, the student will be involved in the practical integration and machine control implementation of an ultrasonic stack to harmonically work alongside the additive manufacturing process. Coupons will then be produced under varying processing conditions, including primarily the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. The anisotropy of the mechanical properties will be compared to reference conditions without ultrasound excitation. Besides, a systematic microstructural characterization will be conducted by SEM to evaluate, not only the grain structure, but also the sub-granular micro-segregation cell structure and inclusion formation along the build direction; since these aspects have a very important impact on the properties of the material.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Process parameter optimization for 3D printing of single alloy rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Rocket nozzles must be extremely resistant to withstand the intense thermal and mechanical loads experienced during launch, see Fig. 2-3. They are exposed to temperatures exceeding 3000 °C and high-pressure exhaust gases moving at supersonic speeds. In addition, they endure significant thermal gradients, vibrations, and mechanical stresses from the combustion chamber and external aerodynamic forces. As a result, nozzle materials and designs must ensure high thermal conductivity, oxidation resistance, mechanical strength, and structural integrity throughout the mission.

Producing the rocket nozzle using DED offers significant advantages. It allows for precise control over material deposition, enables the fabrication of complex geometries, function integration minimizes material waste, and supports rapid iteration.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October

2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and not with additive manufacturing techniques.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. The results of the manufacturing of the miniature rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping due to the printing on inclined surfaces, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

This master thesis will ai to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example remelting, controlled cooling to reduce cracking, regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

Instrumented glass gripper: Percipio Robotics’ Tulip gripper revisited (+ internship – to be confirmed by the company Percipio Robotics)

Description

Context: Percipio Robotics is a spin-off from the FEMTO-ST research institute, which has designed the Tulip gripper [1]. This compact, lightweight gripper, weighing less than 30g, is designed for micromanipulation and can grip objects from 50µm to 10mm. It solves the problems of large grippers and fragility frequently encountered in micro-robotics. Parallely, the TIPs department designs and manufactures compliant mechanisms in glass (FemtoPRINT technique), whose deformation is measured with optical/photonics techniques.
Objectives: This thesis aims to design and develop an instrumented version of the Percipio Robotics’ Tulip gripper. The master thesis can be preceded by a 3 months internship in the company (Besançon, France).
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and characterization of the flexure mechanism.
Prerequisites: mechanical design, good command of French

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRCNE, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IRPH
Nombre de sujets	2

Supervision

Supervisor : LAMBERT Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

The measurement of elastomers self-healing efficiency using Electrical Impedance Tomography sensing

Description

1) the objectives of the project

Self-healing materials are emerging as a promising technology for improving the durability and reliability of soft robotic systems, flexible electronics, and wearable devices. When damage occurs, such materials can autonomously recover their mechanical and electrical properties, extending the lifetime of components and reducing maintenance requirements. However, monitoring the healing process and evaluating the healing efficiency remain significant challenges, especially when the damage occurs inside soft materials and cannot be directly observed.

In our previous research, we developed a self-healing Electrical Impedance Tomography (EIT) sensor, which can reconstruct conductivity distributions inside soft materials and detect damage such as cuts or cracks. Based on this technology, we discovered that EIT sensing can also be used to monitor the recovery process of damaged materials, providing valuable insight into the healing status and efficiency over time.

This project aims to further investigate the use of EIT sensing as a non-invasive method to monitor the healing status of self-healing materials. The objective is to develop a sensing system capable of tracking damage and healing evolution inside soft materials, and to evaluate how effectively the material restores its functionality after damage. Such technology can be broadly useful for soft robotics, structural health monitoring, wearable devices, and smart materials.

2) the methodology

This project focuses on developing experimental methods to monitor self-healing processes using EIT sensing. The project will include:

(i) A literature study on self-healing materials and Electrical Impedance Tomography

sensing methods.
(ii) Fabrication of self-healing material samples integrated with electrode arrays for EIT measurement.
(iii) Implementation of damage and healing experiments, including controlled cutting and healing cycles.
(iv) Use our data acquisition and image reconstruction methods to visualize healing evolution inside the material.
(v) Quantitative evaluation of healing efficiency based on electrical and mechanical recovery.

To support this project, we already have experience with EIT-based sensing and self-healing materials, as demonstrated in our previous publications. The student will build upon existing experimental platforms and contribute to advancing smart sensing technologies for monitoring material health.

3) Prerequisites needed to succeed in this project

(i) Electronics and sensor systems
(ii) Programming and data processing
(iii) Interest in experimental testing and hands-on engineering
(iv) Interest in smart materials, sensing, or health monitoring systems

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE
Nombre de sujets	1

Supervision

Supervisor : Wang Zhanwei (Zhanwei.Wang@vub.be)

Master’s program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

Multi-robot localisation

Description

This thesis topic is a broad collection of subtasks that can be undertaken within multi-robot localisation research.
This includes topics such as:
- Multi-agent SLAM.
- UWB Anchored localisaiton
- Relative pose estimation
- Map sharing
- ODometry sensors: IMU, Camera, VIO, LiDAR, LIO.

And this on multiple different robots:
- AGVs
- Humanoids
- Drones.

In case you want to discuss possibilities in this research field please contact yuri.durodie@vub.be for more details.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	5

Supervision

Supervisor : Vanderborght Bram (Bram.Vanderborght@vub.be)

Mastering corrosion in molten chlorides

Program : Chemical & Materials engineering - M-IRMAE

Description

Molten Salt Reactors (MSRs) are among the most promising Generation IV nuclear reactor concepts to achieve key objectives such as inherent safety, improved fuel cycle closure (i.e. more efficient use of fissile materials), and a significant reduction in the volume and radiotoxicity of long-lived nuclear waste.
Among the various MSR concepts, molten chlorides are considered particularly suitable as both fuel carrier and coolant in fast-spectrum reactors.
One of the major challenges that remains to be addressed is the selection of materials (stainless steels and Ni-based alloys) capable of withstanding prolonged exposure to molten salts at temperatures between 500°C and 700 °C. Previous studies have demonstrated that strict control of impurities in the salts, particularly oxygen-containing species and moisture, is essential to maintain corrosion kinetics within acceptable limits compatible with industrial operation.
To meet the testing needs of nuclear technology developers and equipment manufacturers (pumps, seals, heat-exchangers..), several state-of-the-art experimental facilities are available at Laborelec. These include glove boxes capable of maintaining oxygen and moisture levels below a few ppm.
The objectives of this master's thesis are to:

- Develop and validate a procedure for purification of a NaCl/MgCl/KCl mixture
- Determine the O^{2-} concentration in molten chlorides using electrochemical techniques (Cyclic Voltammetry (CV) and Square Wave Voltammetry (SWV))
- Investigate the influence of impurities on the corrosion of 316 stainless steel and a nickel-based alloy. Which impurity level is required to keep corrosion rates within acceptable levels? Can this level be kept on large scale installations?

Most of the experimental activities will be carried out at the Laborelec laboratory, located in Linkebeek. The master's thesis may be combined with an internship/stage within the company.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Revilla REYNIER (rrevilla@vub.be)

Matrix Effects on Lipid Preservation and Extraction from Archaeological Ceramics

Program : Chemical & Materials engineering - M-IRMAE

Description

The analysis of organic residues, particularly lipids, extracted from archaeological ceramics provides valuable information on ancient subsistence practices, exchange networks, and ritual activities. While the influence of ceramic porosity on lipid preservation is recognized, the influence of the matrix composition, most notably calcium carbonate, has only recently become the focus of systematic investigation. The presence of calcium carbonate may affect lipid retention and extraction efficiency, potentially introducing biases that influence the interpretation of archaeological datasets.

The objective of the master thesis will be to systematically investigate the influence of calcium carbonate on lipid extraction from archaeological artefacts. Samples from Sicilian calcitic ceramic wares will be characterised in terms of porosity, elemental and mineral composition (XRF, XRD). Lipids will be extracted using two standard solvent extraction protocols. The extracted lipids will be analyzed and characterized by GC-MS. Extraction protocols will be optimized to take the nature of the ceramic matrix into consideration

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Kristin BARTIK (Kristin.bartik@ulb.be)

Co-supervisor : Alicia Van Ham-Meert (alicia.van.hammert@ulb.be)

Sustainable iron metal production by direct electroreduction of iron ore

Program : Chemical & Materials engineering - M-IRMAE

Description

Steel production accounts for more than 8% of global emissions and sustainable steel production is key to achieve a decarbonized economy. The direct electroreduction of iron oxide to produce metallic iron (ULCOS project) is truly a fascinating field of research and offers a breakthrough alternative to the existing status quo of blast furnace based iron production. The reaction happens in alkaline media and the mechanism of electroreduction -ie, solid state direct reduction is yet to explored in detail. Furthermore, a lot of other sources such as bauxite residue can be directly used to produce metallic iron via this method. The student will work on firstly understanding the fundamental reaction mechanism of direct electroreduction of iron from iron oxide in alkaline media.

Promotor: Prakash Venkatesan (Prakash.venkatesan@ulb.be)

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCBS, M-IRCNE
Number of topics	2

Supervision

Supervisor : Prakash Venkatesan (prakash.venkatesan@ulb.be)

Analysis of Heat and Mass Transport During Hydrogen Bubble Growth in Water Electrolysis

Program : Chemical & Materials engineering - M-IRMAE

Description

Hydrogen can be produced by splitting water through electrochemical reactions in electrolysis. Although the process is overall endothermic, additional heat can be generated locally, most notably through Joule heating at the electrode surface. This localized heating modifies the temperature field near the growing hydrogen bubble, creating temperature gradients that induce thermocapillary (Marangoni) flows along the bubble interface.
In addition to thermal effects, concentration gradients of surface active species such as ions or dissolved gases can also alter surface tension, resulting in solutal Marangoni convection. These interfacial flows strongly affect bubble growth, shape, and detachment dynamics. Understanding these coupled effects requires the ability to accurately resolve the local temperature and concentration fields around the bubble. However, measuring both fields at the same time remains a significant experimental challenge.
Previous studies have demonstrated that at high applied potentials, Joule heating dominates, and thermocapillary effects become the primary drivers of interfacial motion, while solutal effects can often be neglected. Various optical techniques such as Schlieren imaging, laser induced fluorescence, and interferometry have been used to study these fields.
Mach Zehnder interferometry stands out as a noninvasive and calibration free technique for resolving instantaneous temperature fields with high sensitivity.
This thesis will focus on hydrogen bubble dynamics on a microelectrode in acidic electrolysis, using two complementary experimental techniques:

• Mach Zehnder Interferometry, to quantify the temperature field near the electrode and at the base of the bubble, especially when concentration variations are negligible.
• High speed visualization, to qualitatively capture the bubble inception, growth, and detachment processes.
• Complementary Schlieren imaging may be used for qualitative validation as done in the previous study [1].

Methodology

1. Literature survey

The student will begin by familiarising themselves with the topic. A thorough review of recent literature, especially on interferometric and visualisation techniques applied to gas-evolving electrodes, will help define the research scope and objectives.

2. Experimental set-up

The student will work with the existing electrolysis cell, Mach Zehnder interferometer, and high-speed imaging system available at the TIPS laboratory. This phase will involve hands-on training with laser alignment, optical adjustments, electrode handling, and system calibration. The student will also participate in test runs to optimise measurement conditions and gain confidence in operating the setup independently.

3. Measurement campaign and data analysis

The student will conduct experiments to visualise hydrogen bubble growth on microelectrodes using high-speed imaging and Mach Zehnder interferometry. Interferometric data will be analysed to extract local temperature fields, while high-speed recordings will be used to characterise bubble shape, growth, and detachment dynamics. Post-processing and analysis will be carried out using MATLAB. If numerical simulation results are available, they will be compared with the experimental data. In parallel, the student will measure the refractive index, density, and viscosity of the electrolyte across different concentrations and temperatures, using the available facilities at the TIPs laboratory, ULB.

4. Reporting

- Weekly meetings with the supervisor(s) to define tasks and discuss outcomes and practicalities.
- Monthly meeting with the team to verify the progress and discuss follow-up
- Final presentation

References

[1]. A. Babich, A. Bashkatov, X. Yang, G. Mutschke, and K. Eckert, “In-situ measurements of temperature field and Marangoni convection at hydrogen bubbles using schlieren and PTV techniques,” Int. J. Heat Mass Transf., vol. 215, p. 124466, 2023.

[2]. J. Massing, G. Mutschke, D. Baczyzmalski, S. S. Hossain, X. Yang, K. Eckert, and C. Cierpka, “Thermocapillary convection during hydrogen evolution at microelectrodes,” Electrochimica Acta, vol. 297, pp. 929–940, 2019.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	2

Supervision

Supervisor : Pierre Colinet (pierre.colinet@ulb.be)

Co-supervisor : Senthil Kumar Parimalanathan (senthil.parimalanathan@ulb.be)

Unraveling the degradation of applied brocades in the Van Eyck's brothers' "Adoration of the Mystic Lamb" Altarpiece: synthesis and multi-analytical characterization of Sn(II) metal soaps

Program : Chemical & Materials engineering - M-IRMAE

Description

The iconic "Adoration of the Mystic Lamb" altarpiece, painted by the Van Eyck brothers in the XVth century, presents a severe alteration of its applied brocades, an ancient decorative technique involving a complex superposition of numerous materials. Previous analysis of samples taken from the altarpiece suggest the degradation of the brocades' tin foils occurs through the formation of metal soaps that have not been yet described in the scientific literature. Considering the as-obtained results as well as the materiality of the applied brocades' tin foils, Sn(II)-based soaps are suspected to be one of the main degradation products formed. Nonetheless, the lack of Sn-soap references hinders their identification as well as a refined understanding of the brocades' degradation mechanism. The project currently seeks to clearly identify such mechanisms to propose better conservation-restoration solutions that ensure their preservation.

The project aims to define a reproducible synthetic pathway allowing to obtain a Sn(II) metal soap which will have to be characterized using numerous (micro)analytical techniques (ATR-µFTIR, SEM-EDX, Raman, pXRPD, XPS, ToF-SIMS and NMR). Once obtained, a novel reflection µFTIR analytical methodology will be developed to identify and localize such soaps in mock-ups and samples taken from the altarpiece, thus improving our understanding of the applied brocade's degradation phenomena.

The work will be carried in collaboration with the Royal Institute for Cultural Heritage in Brussels (KIK-IRPA), more specifically in the Materials Science for Conservation Research (MatCoRe) unit which is dedicated to the study of the molecular phenomena involved in the degradation of historical oil paintings.The main techniques that will be used in this project are: ATR-FTIR, Raman, NMR, SEM-EDX, XPS, ToF-SIMS.

Prerequisites
- Spectroscopy
- Organic Chemistry

Link : https://www.kikirpa.be/fr/presse/restauration-agneau-mystique

For more information, please contact Dr. Francisco Mederos-Henry (francisco.mederos@kikirpa.be) or Kristin Bartik (Kristin.bartik@ulb.be).

Language	EN (english)

Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

Supervisor : Kristin BARTIK (kristin.bartik@ulb.be)

Co-supervisor : Francisco Mederos-Henry (Francisco.Mederos-Henry@ulb.be)

Topics offered to students by other master's programs

TARGET PROGRAM

Chemical engineering

Master's program offering the topic : Architectural engineering - M-IRARE

Incorporating Sustainability in the design process of products, processes and businesses.

Description

How to design products that have a better impact on environment, social and economy? This thesis starts with a state of art review of methods for 'Design for Sustainability'. What are methods to decision on sustainability and what are the remaining challenges and pitfalls? The aim of the thesis is to formulate a novel way to embed sustainability in the decision process of companies and link it to existing methods for corporate sustainability reporting.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Messagie Maarten (maarten.messagie@vub.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Redox-Active Hydrogel Scaffolds for Nanoparticle Encapsulation and Controlled Manganese Release in Postoperative Anticancer Applications

Description

Hydrogel-based biomaterials are increasingly explored as localized platforms for improving postoperative cancer treatment by enabling the encapsulation and sustained release of therapeutic nanomaterials. In this context, manganese dioxide (MnO_2) nanoparticles offer redox-responsive properties and the ability to release manganese ions, which can induce oxidative stress and contribute to cancer cell cytotoxicity. This thesis proposes the development of MnO_2 nanoparticle–embedded photocrosslinkable hydrogels as systems for nanoparticle encapsulation and controlled, sustained manganese release for in vitro anticancer evaluation.

Two hydrogel matrices, Gelatin Methacryloyl (GelMA) and Carboxymethyl Cellulose Methacrylate (CMCMA), will be investigated in a comparative study. GelMA provides a biomimetic and biocompatible environment, while CMCMA offers enhanced mechanical stability and potential printability. The study will focus on the fabrication and mechanical characterization of MnO_2-loaded hydrogels, evaluating key properties including rheological behavior, compressive strength, swelling ratio, degradation rate, gel fraction, and porosity. These parameters will be correlated with the hydrogel’s ability to encapsulate nanoparticles and regulate their sustained release.

The cumulative release of manganese species will be monitored using UV–Vis spectrophotometry and colorimetric manganese detection assays, enabling analysis of MnO_2 degradation and Mn^{2+} ion release kinetics. The biological effects of released manganese species will be assessed using in vitro cancer cell models, with cell viability evaluated via the CellTiter-Glo® 3D assay (Promega) and Live/Dead staining to visualize cell survival and membrane integrity.

By correlating hydrogel structure, nanoparticle encapsulation, release behavior, and cellular response, this work aims to establish MnO_2-loaded hydrogels as effective platforms for localized and controlled nanomaterial delivery in postoperative anticancer applications.

Langue	EN (english)

Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Dynamically Tunable Hydrogels for Vascular Stiffness Modulation

Description

Hydrogel-based matrices are widely used to model the physical microenvironment of cells in engineered tissues. However, most current systems rely on static materials with fixed mechanical properties, limiting the ability to study how cells respond to mechanical changes over time. In native tissues, extracellular matrix properties such as stiffness evolve dynamically, influencing cell behavior, barrier function, and mechanotransduction.
In this project, you will develop phenol-modified hydrogels with controllable crosslinking and stiffness. Phenol-functionalized polymers enable enzymatic crosslinking reactions that allow the degree of crosslinking, and therefore the mechanical properties of the hydrogel, to be adjusted over time. By tuning crosslinking conditions, the material can undergo controlled stiffening after gel formation, creating a dynamic matrix whose mechanical properties can be programmed during experiments.
Some tasks will involve:

- Tune enzymatic crosslinking conditions to control gelation and stiffness.
- Characterize hydrogel mechanical properties using rheology or mechanical testing.
- Develop protocols for inducing controlled stiffness changes over time.
- Test compatibility of the hydrogels with endothelial cell culture and perfused channel systems.

The resulting platform will enable dynamic control of the mechanical microenvironment, which can be used to study how vascular cells respond to changes in matrix stiffness. Such systems may also serve as in vitro models to investigate processes associated with arterial stiffening, which are difficult to capture using conventional static materials.

See - R. Schnellmann et al.,Stiffening Matrix Induces Age-Mediated Microvascular Phenotype Through Increased Cell Contractility and Destabilization of Adherens Junctions, Advanced Science, 2026
J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

Langue	EN (english)

Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Development of a realistic and easy-to-use mucus simulant

Description

Context: Over the last years, the respiratory drug delivery has drawn a strong interest due to the large surface area of the airway mucosa, providing an easy access to the blood. In particular, nasal sprays intending to treat non-local disorders, like migraine or hypoglycaemia, have appear. Compared to oral medicines, they are easier to use, act faster and can be given to unconscious patients [1]. However, the current characterisation techniques for spray are still lacking. Cutting-edge methods, such as experimental and digital models of the nose aims to bridge this gap but further development is still needed to reproduce adequately spray deposition in the nose. In particular, the interactions between the spray particles and the mucus lining the interior of the nose governs the final deposition site of the spray.
Objective: This thesis aims to develop a realistic and easy-to-use fluid replicating the nasal mucus. This simulant needs to reproduce the rheological characteristics of the biological mucus [2] and must be coated easily into nasal replicas. This mucus simulant will then be used to assess the influence of its properties (viscoelasticity, viscoplasticity, surface tension,...) on the trajectories of impacting particles. These results would strengthen the current understanding of the mucus-particles interactions and help to validate advanced simulation models.

Langue	EN (english)
Ouvert à d'autres masters	yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Light-Responsive Sacrificial Hydrogels for 3D Bioprinting Applications

Description

Three-dimensional (3D) bioprinting enables the fabrication of complex biological structures with spatial control over materials and cells. However, creating perfusable channel networks within these constructs remains a major challenge. Sacrificial hydrogels offer a promising solution by acting as temporary templates that can be removed after printing to form hollow structures.

This project focuses on the development of light-responsive sacrificial hydrogels that can be processed under mild conditions and selectively dissolved upon external stimulation. The material system can be tuned to function either as a support bath for embedded printing or as a printable sacrificial filament, enabling flexible fabrication strategies. The student will investigate how formulation and processing affect mechanical properties, printability, and removal behavior, and will demonstrate the fabrication of simple perfusable structures.

The objective of this project is to design and evaluate a tunable hydrogel system for use as a sacrificial material in 3D bioprinting. This includes understanding how material composition influences gel formation, mechanical behavior, and responsiveness to light-based triggering, as well as demonstrating its applicability in creating defined structures and channels.

Tasks

- Chemical preparation and modification of polymer-based hydrogels
- Formulation optimization to tune mechanical properties (soft vs. structured gels)
- Rheological characterization (viscosity, gel strength, recovery behavior)
- Development of support bath systems for embedded 3D printing
- Extrusion-based 3D printing experiments (filaments, simple structures)
- Evaluation of light-triggered material removal
- Fabrication of hollow channels and perfusion testing
- Basic biocompatibility assessment (cell viability assays)

Methods & Techniques

- Hydrogel synthesis and preparation
- Rheometry and mechanical testing
- 3D bioprinting (extrusion-based)

- Optical/light-based triggering experiments
- Microscopy and image analysis
- Cell culture and viability assays

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Food and house dust mite allergens

Description

Allergy represents an important public health problem. On the one hand, we are developing bioinformatics tools to predict whether a protein corresponds to a food allergen. Such tools are
very important for the development of new food products. On the other hand, we are studying
certain structural and dynamic properties of house dust mite allergens.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS
Nombre de sujets	1

Supervision

Supervisor : Gilis Dimitri (dimitri.gilis@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Improved adenoid hypertrophy treatment through nasal replicas

Description

Context: Adenoid hypertrophy is the pathologic enlargement of the tonsils at the back of the nose. It is one of the most common no-infectious ENT affection in children with a prevalence of about over 30%. Nowadays, the first-line treatment of adenoid hypertrophy is corticosteroid nasal sprays. While half of the patients shows improvement with this treatment, it is ineffective for the other half [1]. One issue may be that the current treatments aim for maximum coverage of the nasal cavity and not maximal penetration. Consequently, only a small part of the medicine reaches directly its site of action. New medication strategies, combining adapted devices, formulations and administration procedures [2], could increase the success of corticosteroid treatment and decrease the use of surgery in children.
Objective: This thesis aims to maximise the amount of drug reaching the pharyngeal tonsils. The fraction of drug reaching the site of action will be determined using a 3D-printed nasal replica of a child anatomy. The main goal is to combine the characteristics of the spray (viscosity, surface tension) and the administration procedure (instillation angle, inspiration) to increase the amount of drug reaching the back of the nasal cavity. Correlations between the characteristics of the sprays and the deposition in the nose should also be drawn to provide simple guidelines for future medicine development.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Modular Volumetric Bioprinted Vascular Models to Study Cell–Flow Interactions

Description

Understanding how geometry and flow conditions influence cellular behavior is crucial for studying vascular biology, disease development, and tissue engineering. Recent advances in volumetric bioprinting enable the rapid fabrication of complex hydrogel structures with precisely defined internal geometries. These structures can be used as model systems to investigate how physical cues affect cell responses in engineered microenvironments.
In this project, you will develop modular hydrogel building blocks containing internal channel geometries that can be linked together to form artificial vessel-like networks. Using volumetric printing, these building blocks will be fabricated with features such as constrictions, angles, and porous regions that create distinct flow regimes (e.g., altered shear stress, recirculation zones, or diffusion-dominated regions).
Some tasks will involve:

- Design and volumetrically print modular hydrogel blocks with embedded channels.
- Assemble these blocks into customizable artificial vascular systems.
- Introduce cells into the channels and apply controlled perfusion flow.
- Investigate how channel geometry, flow patterns, and shear stress influence cell behavior such as adhesion, morphology, migration, and proliferation.
- Analyze how porous or structured regions affect diffusion and cell–material interactions.

The project combines advanced biofabrication, microfluidics, and cell biology, providing a platform to systematically study how physical microenvironmental parameters regulate cellular responses. It will help to uncover fundamental principles governing cell behavior in vascular-like environments.

See - J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

Langue	EN (english)
Ouvert à d’autres masters	Yes

Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Master thesis in microfluidics

Description

Several research topics related to microfluidics and lab-on-a-chip: droplets, bubbles, capsules, antibubbles, double emulsions, flow crystallisation, cell encapsulation, cell sorting, giant unilamelar vesicles, confined Leidenfrost, coalescence, subretinal injection, blood testing by elastocapilarity, organoid encapsulation, …

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	2

Supervision

Supervisor : Scheid Benoit (Benoit.Scheid@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Construction of Bacterially in Situ Generated Cellulose-Based Tannic Acid Nanozyme and Investigation of Its Enzymatic Performance Study

Description

Nanozymes, as synthetic nanomaterials with enzyme-like catalytic activities, have attracted significant attention in biosensing, catalysis, and antibacterial applications. Among them, metal–polyphenol networks (MPNs), especially tannic acid (TA)-based nanozymes, exhibit excellent catalytic efficiency, biocompatibility, and drug-loading capacity due to the inherent antioxidant and anti-inflammatory properties of polyphenols. Bacterial cellulose (BC), biosynthesized by microorganisms such as Komagataeibacter xylinus, is a highly pure, mechanically robust, and biocompatible nanofibrous material, making it a promising candidate for tissue engineering and functional materials. Integrating nanozymes with BC can impart multifunctionality to the composite system. However, conventional approaches typically rely on in vitro incorporation of nanozymes into preformed BC, which often results in uneven distribution and weak interfacial interactions. To address these limitations, this study proposes an in-situ biosynthesis strategy, in which TA-based nanozymes are directly introduced into the bacterial fermentation system, enabling the simultaneous formation of BC and nanozymes. This approach is expected to achieve uniform distribution and strong interfacial integration. Furthermore, the interaction mechanisms between nanozymes, BC fibers, and bacterial behavior will be systematically investigated, providing fundamental insights into the bio-fabrication of engineered living materials (ELMs).

Research points:
A) Construction of in situ BC complexes by co-culturing bacteria with TA nanozymes
B) Investigation of the interaction mechanisms between nanozymes and BC fibers through comprehensive material characterization.
C) Evaluation of multi-enzyme activities in the composite system and investigation of the effects of BC matrix on catalytic activity stability, reaction kinetics, and pH adaptability.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH

Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic : Biomedical engineering - M-IRCBS

Development of a Bioactive HAMA/GelMA Hydrogel for Volumetric Printing of Biomimetic Structures

Description

Volumetric 3D printing is an emerging approach in biofabrication that enables the rapid production of complex three-dimensional structures. Unlike layer-by-layer printing techniques, this method allows an entire volume of photosensitive resin to be polymerized in a matter of seconds. However, its use in tissue engineering remains limited by the small number of compatible bioinks, which must both possess suitable optical properties for printing and maintain a biologically favorable environment for cells.

This project aims to develop and characterize a new bioactive hydrogel formulation based on a GelMA (gelatin methacryloyl) and HAMA (hyaluronic acid methacrylate) mixture for volumetric printing. The goal is to design a resin that enables both efficient polymerization during printing and a supportive environment for cell viability. The potential addition of PEGDA may also be explored to fine-tune mechanical properties and crosslinking kinetics.

The first work axis will focus on material formulation and characterization. HAMA will be synthesized, and different molecular weights may be investigated. Methacrylation will be analyzed (by NMR if possible, or by FTIR for qualitative estimation). These polymers will then be incorporated into GelMA/HAMA hydrogel formulations at various ratios, optionally complemented with polyethylene glycol diacrylate (PEGDA) to adjust mechanical properties and crosslinking. Simple UV photopolymerization tests will be conducted to assess the reactivity of the formulations, followed by mechanical characterization of the resulting hydrogels (Young's modulus and storage modulus).

The second project axis will address the compatibility of the formulations with volumetric printing. The optical properties of the resin (refractive index, absorbance) will be measured to verify their suitability for the printing technique. Volumetric printing polymerization tests and light-dose adjustments will be carried out to determine the conditions required to produce stable and well-defined hydrogel structures, with the ultimate goal of creating more complex structures, such as those containing microchannels.

Finally, in parallel, a third axis will focus on evaluating the biological activity of the hydrogels. Cell viability assays (MTT or Alamar Blue) will be performed using fibroblasts or endothelial cells. Cell morphology will also be studied using fluorescent labeling to assess the interactions between cells and the different formulations (HAMA molecular weight and

ratios). These tests can be conducted on hydrogel discs.
This project will thus explore the potential of HAMA/GelMA hydrogels as bioinks for volumetric printing and provide insights into how formulation affects the mechanical, optical, and biological properties of the material.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master’s program offering the topic : Biomedical engineering - M-IRCBS

Artificial intelligence methods to design ligands for olfactory receptors

Description

The olfactory system relies on protein receptors expressed by olfactory neurons. These olfactory
receptors belong to the family of G protein-coupled membrane receptors (GPCR). The relationships between odorant molecules, targeted olfactory receptors and odour perception are
complex and not yet well understood. In addition, it has been shown that some olfactory receptors are expressed in tissues other than the olfactory epithelium and may have a physiological or potentially therapeutic role.
This project consists in developing artificial intelligence approaches, allowing (1) to predict the
olfactory receptor(s) targeted by an odorant molecule, and (2) to design de novo a molecule able
to activate a given olfactory receptor. It is carried out in collaboration with the group of Prof. I.
Langer (Faculty of Medicine), which experimentally characterises these systems.
The master thesis topics related to this project can be entirely bioinformatics or include an experimental part.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS
Nombre de sujets	1

Supervision

Supervisor : Gilis Dimitri (dimitri.gilis@ulb.be)

Master’s program offering the topic : Chemical & Materials engineering - M-IRMAE

Process parameter optimization for 3D printing of Functionally Graded rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

Rocket nozzles need FGMs to withstand extreme thermal and mechanical stresses by gradually transitioning from heat-resistant materials at the throat to tougher structural metals, improving durability, reducing thermal mismatch, and preventing failure. This is why rocket nozzles are manufactured with a graded transition from 316L or Inconel to copper as shown on Fig. 2-3.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October 2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and doesn't rely yet on the FGM technology.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. When printing FGMs, these parameters increase in number and must be actively tuned during the build as the material transitions from one type to another. The results of the manufacturing of the miniature FGM rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping, crack formation, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

The aim of this master thesis will be to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores, cracks, or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : Chemical & Materials engineering - M-IRMAE

Plasmonic nanoparticles inside PNIPAM hydrogel for light-driven soft actuators using femtosecond laser writing

Description

Context: Soft matter can serve as an actuator in microrobotics by deforming under external stimuli (light, heat, or pH…) and producing mechanical outputs like force or displacement. At the microscale, these smart materials can be 3D printed without assembly. In our lab, we use two-photon polymerization (2PP) to fabricate soft actuators from a thermo-responsive pol-ymer, poly(N-isopropylacrylamide) (pNIPAM). This material swells below its lower critical solution temperature (LCST) by absorbing water and shrinks above the LCST by expelling it. Recently, we fabricated 50 µm × 50 µm × 50 µm active cubes capable of bending, contract-ing, twisting, or shearing in heated water [1]. To achieve precise, multidirectional motion control, multiple actuators could be combined and selectively triggered by different wave-lengths of light. This is possible by doping them with photothermal nanomaterials that lo-cally convert light into heat [2]. Metallic nanostructures like gold (Au) and silver (Ag) nano-particles or nanorods have been used to actuate PNIPAM-based hydrogels [3]. However, they are usually dispersed uniformly, preventing spatial control. An alternative approach uses a tightly focused femtosecond laser in a PNIPAM hydrogel swollen with silver nitrate, locally forming Ag nanoparticles by multiphoton reduction [4]. Applying this method to our actuators would enable spatially selective nanoparticle patterning, allowing localized, pre-cise activation.
Objective: The aim of this thesis is 3D print photosensitive nanoparticles inside PNIPAM hydrogels with the 2PP machine. After printing, light will be used to illuminate the actuators and will be converted into heat by the nanoparticles. The generated heat will trigger actuator mo-tion by shrinking the hydrogel.
Methods: Literature review. Hydrogel fabrication (with 2PP printing). Printing of Ag/Au nanoparti-cles i.e., tune the printing parameters to obtain nanoparticles and optimize the actuation. Characterization: UV absorbance spectra, SEM imaging, and measuring the light respon-siveness of the structures.
Prerequisites: Materials (to develop the fabrication process and understand the behavior of the hydrogels with and without nanoparticles).

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Experimental and numerical investigation of structural adhesive behavior under multiple loading conditions

Description

Context of the master thesis
Adhesive joints are commonly used to bond components in composite structures. Adhesive bonding not only facilitates lightweight designs but also offers significant advantages over mechanical fastening, including excellent durability, fatigue resistance, and the ability to evenly distribute stress across the joint. Despite these benefits, adhesive joint failure often reduces the lifespan of composite structures [1]. Therefore, comprehensive experimental characterization of structural adhesives and the development of reliable numerical models are essential for understanding adhesive joint behavior in large-scale structures, such as wind turbine blades. Due to the cross-linking nature of epoxy adhesives, their tensile, shear, and compressive behaviors differ. These differences can be accounted for using a pressure-dependent material model [2]. The Drucker-Prager model, a commonly used pressure-dependent material model, has been applied by researchers to simulate epoxy-based adhesives, though most studies are limited to the linear form of the model [3]. In this master’s thesis, structural adhesive specimens will be tested under tensile, shear, and compressive loading to characterize material behavior, including post-yield response, and to extract material constants for the Drucker-Prager exponential model. Each experiment will be simulated using ABAQUS finite element (FE) software to replicate the observed material behavior and damage propagation. Following complete characterization and modeling of the adhesive, fracture tests will be performed on Single Edge Notch Bending (SENB) specimens under various loading conditions. The developed advanced material model will then be used to numerically replicate these experiments, demonstrating the applicability of the exponential Drucker-Prager model in simulating the behavior of epoxy adhesives.

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Objectives of the master thesis
1. To perform advanced mechanical characterization of epoxy-based adhesives experimentally.
2. To develop a numerical model that replicates adhesive behavior under tensile, shear, and compressive loading.
3. To assess the model’s capability to predict damage propagation in cracked specimens.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

On-line measurement and validation of thermal gradients during 3D metal printing through IR-camera measurements.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is an metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible.

Fig. 2 shows a 3D tower part that has been manufactured in a hybrid way with the MiCLAD machine. During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part.

In this context, two thermal cameras (FLIR and SWIR) have been integrated into the machine, and a dedicated tool has been developed to enable in-process thermal gradient monitoring. The use of both cameras allows for broader thermal range coverage, capturing the various temperature the part experiences during the process. The tool enables simultaneous recording from both cameras and provides real-time visualization of thermal gradients through a dedicated application, with the aim of enabling online thermal gradient control in the future. An example of a captured thermal field of the build plate during process is shown in Fig. 5.

This setup and tool now require further development and validation to assess the accuracy of the results. To this end, an experimental campaign will be conducted under varying

heat input boundary conditions, primarily focusing on laser power and build plate preheating settings. The resulting data will be analyzed to gain a deeper understanding of the thermal history of parts during the DED process and ultimately to reduce the thermal gradient and resulting residual stresses.

In parallel, the measured thermal gradients will be compared with numerical simulations using an existing DED process model. This comparison aims to validate the model as well as the associated material parameters (such as density, latent heat, and heat capacity) and boundary conditions against the experimental results. A specific parameter matrix will be defined for both the experimental and numerical campaigns. The thermal history simulations will be carried out using Morfeo (Manufacturing Oriented Finite Element tOol), an extended finite element (FEM) code developed by the Belgian research center Cenaero [3].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic : EM - Aeronautics - M-IREMR-A

Investigation of Microstructural Evolution and Corrosion Resistance in Hybrid DED-Manufactured Parts

Description

3D printing is a widely used additive manufacturing process in which layers of material are successively deposited to create a three-dimensional part. Over the past decade, it has gained significant interest due to increased accessibility and technological advancements.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) technique that uses a focused laser beam to melt metallic powder, which is simultaneously delivered through a nozzle. The Additive Manufacturing Research Lab (AM-Lab) at the Vrije Universiteit Brussel (VUB) has developed an in-house hybrid DED machine called the MiCLAD, which is extensively presented in [2].

The MiCLAD system is equipped with a 5-axis CNC controller and allows for a rapid transition between additive deposition (DED) and subtractive machining (milling/drilling). This combination of processes is referred to as hybrid manufacturing. An in-situ image of the DED process is shown in Fig. 1, where the nozzle, powder particles, and melt pool (visible as a high-intensity spot) can be observed. Fig. 2 illustrates a hybrid 3D tower manufactured using the MiCLAD system, combining additive and subtractive operations to directly integrate functional features into the part. The milling operations are indicated by the red dashed lines.

The subtractive process is further illustrated in Fig. 3 (cogwheel) and Fig. 4 (research sample). During hybrid manufacturing, the process parameters and thermal history play a critical role in determining the final part quality, as they directly influence the microstructure, residual stresses, corrosion behaviour, and mechanical properties.

An Electron Backscatter Diffraction (EBSD) map is shown in Fig. 5, highlighting a clear effect of the milling operation on grain size and crystallographic orientation. These microstructural modifications are expected to significantly affect the corrosion behaviour of the material and therefore require detailed investigation.

It is therefore essential to understand the combined effect of additive and subtractive operations on the microstructure and to monitor the melt pool temperature during processing. The SURF [3] and MECH [4] departments at VUB are collaborating closely to investigate these effects.

To evaluate the influence of hybrid manufacturing on corrosion resistance, a dedicated experimental campaign will be carried out on the MiCLAD machine, and the melt-pool temperatures during manufacturing will be measured. Samples produced via hybrid DED (additive + milling) will be compared to purely additive-manufactured samples.

The corrosion behaviour will be assessed using standard electrochemical and surface analysis techniques, including potentiodynamic polarization and immersion tests to evaluate the electrochemical response of the samples, as well as XPS and SEM/EDS to analyze the impact of the processing condition on the microstructure and passive oxide layer of the material. These analyses will help establish correlations between process conditions, melt-pool temperature, resulting microstructures, and corrosion performance.

The final objective of this master thesis is to design and conduct a hybrid experimental campaign using the MiCLAD system to manufacture samples suitable for corrosion analysis, and to compare their corrosion resistance with that of conventionally additively manufactured samples.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-A
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Post-processor extension to 3D material allocation for metal 3D printing through Directed Energy Deposition manufacturing process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part/sprocket that has been manufactured with the MiCLAD machine.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

FGMs are used for example in injection molding molds, as shown in Fig. 3 [3], to optimize performance by combining high thermal conductivity near the mold surface for faster cooling with a tougher core for structural strength. This gradient in properties improves cycle times, reduces wear, and extends mold life. The production of such a part required a different material allocation in 3 dimensions (x, y, and z), see Fig. 4.

CAD/CAM software (Computer-Aided Design / Manufacturing) plays a crucial role in DED by converting CAD models into toolpaths that guide the deposition head and define process parameters. However, current commercial solutions lack the capability to handle FGMs by assigning specific materials and corresponding process settings to precise locations within a part. To address this, the AM-Lab developed the CamLink post-processor, which serves as a translator between the CAD/CAM software and the CNC machine, enabling advanced control over material deposition.

It allows the generation of machine compatible Gcode from any geometry, incorporating the desired material gradient at specified locations, via a standalone MATLAB application. However, at this stage, material allocation is limited to the -z and -x directions. An example of a composition transition from copper to 316L in the x-direction is shown in Fig. 6–7.

The aim of this master thesis is to further develop the existing CamLink post-processor to enable material allocation in all three spatial dimensions, thereby allowing complete design freedom in the manufacturing of FGMs. In the next phase, this extension will be validated through simple experiments using the DED machine. Subsequently, process parameters will be optimized, based on microstructural analysis, to ensure defect-free transitions between material compositions. Finally, the enhanced post-processor will be validated through the production of a demonstrator part featuring composition gradients in all three directions.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Development of the wedge test for thick adhesive joints to prevent crack deviation under mode I loading

Description

Context of the master thesis
Adhesive joints are widely used across various industries, including wind turbine manufacturing, shipbuilding, aerospace, and automotive applications. Compared with traditional joining methods, adhesive bonding offers several advantages, such as the ability to join similar and dissimilar materials, weight savings, improved stress distribution along the bond line, and enhanced corrosion and fatigue resistance. When considering thick adhesive joints, however, the definition varies across industries. For example, in the wind turbine and shipbuilding sectors, thick adhesive joints typically have an adhesive layer thickness of approximately 10 mm or greater [1]. The influence of adherend constraint, joint geometry, and residual stresses on crack kinking under mode I loading conditions is well documented in the literature [2], [3]. Nevertheless, to date, no experimental setup has been proposed that enables stable crack propagation within the mid-plane of the adhesive layer under pure mode I loading. To address this gap, the present master’s thesis will employ a combined numerical–experimental approach to develop a test method capable of promoting stable crack growth in thick joints. A series of numerical models will first be developed using ABAQUS finite element (FE) software to evaluate fracture parameters under mode I loading using conventional Double Cantilever Beam (DCB) specimens subjected to point loading. In the subsequent step, in addition to the opening load applied normal to the crack plane, an auxiliary load will be applied in a perpendicular direction. This auxiliary load is intended to reduce crack-tip constraint arising from joint geometry and residual stresses. Based on the numerical results, the appropriate load ratio between the parallel and perpendicular loading directions will be determined, and a wedge-based support system capable of delivering this load ratio will be designed. Experimental tests will then be conducted on pre-cracked thick adhesive joint specimens to assess the feasibility and effectiveness of the proposed method. Finally, the wedge test experiments will be replicated through FE simulations to provide a comprehensive understanding of the underlying fracture mechanisms and crack propagation behavior.

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[3] A. Sharma et al., “Combined computational-experimental investigation of residual stresses and pre-cracking in mode I behaviour of thick adhesively bonded GFRP composite joints,” Compos. Struct., vol. 351, p. 118549, Jan. 2025, doi: 10.1016/J.COMPSTRUCT.2024.118549.

Objectives of the master thesis
1. To determine the fracture parameters of thick adhesive joints under point-load conditions.
2. To identify fracture parameters that mitigate unstable crack propagation in adhesive joints and to design a wedge-based loading system accordingly.
3. To experimentally evaluate the proposed setup for facilitating stable crack propagation.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Integration of Internal Capillaries in Hybrid Directed Energy Deposition parts: Impact on Microstructure and Corrosion Behaviour

Description

3D printing is a widely used additive manufacturing process in which layers of material are successively deposited to create a three-dimensional part. Over the past decade, it has gained significant interest due to increased accessibility and technological advancements.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) technique that uses a focused laser beam to melt metallic powder, which is simultaneously delivered through a nozzle. The Additive Manufacturing Research Lab (AM-Lab) at the Vrije Universiteit Brussel (VUB) has developed an in-house hybrid DED machine called the MiCLAD, which is extensively presented in [2].

The MiCLAD system is equipped with a 5-axis CNC controller and allows for a rapid transition between additive deposition (DED) and subtractive machining (milling/drilling). This combination of processes is referred to as hybrid manufacturing. An in-situ image of the DED process is shown in Fig. 1, where the nozzle, powder particles, and melt pool (visible as a high-intensity spot) can be observed. Fig. 2 illustrates a hybrid 3D tower manufactured using the MiCLAD system, combining additive and subtractive operations to directly integrate functional features into the part, such as internal capillaries (see red vertical arrow). These capillaries can serve as cooling channels or for Structural Health Monitoring of the part. The milling operations are indicated by the red dashed lines.

The subtractive process is further illustrated in Fig. 3 (drilling) and Fig. 4 (milling). During hybrid manufacturing, the process parameters and thermal history play a critical role in determining the final part quality, as they directly influence the microstructure, residual stresses, corrosion behaviour, and mechanical properties.

An Electron Backscatter Diffraction (EBSD) map is shown in Fig. 5, highlighting a clear effect of the milling operation on grain size and crystallographic orientation. These microstructural modifications are expected to significantly affect the corrosion behaviour of the material and therefore require detailed investigation. In particular, the drilling operations required to integrate capillaries are also expected to alter the local microstructure and may influence corrosion performance.

It is therefore essential to fully understand the effect of subtractive drilling operations on the microstructure. The SURF [3] and MECH [4] departments at VUB are collaborating closely to investigate these effects.

To evaluate the influence of hybrid manufacturing with integrated capillaries on corrosion resistance, a dedicated experimental campaign will be carried out using the MiCLAD system. Melt pool temperatures will be monitored during fabrication. Samples with embedded capillaries produced via hybrid DED (additive + drilling) will be compared to purely additively manufactured samples.

The corrosion behaviour will be assessed using standard electrochemical and surface analysis techniques, including potentiodynamic polarization and immersion tests to evaluate the electrochemical response of the samples, as well as XPS and SEM/EDS to analyze the impact of the processing condition on the microstructure and passive oxide layer of the material. These analyses will help establish correlations between process conditions, melt-pool temperature, resulting microstructures, and corrosion performance.

The main objective of this master thesis is to design and conduct a hybrid experimental campaign using the MiCLAD system to manufacture samples with embedded capillaries suitable for corrosion analysis, and to compare their corrosion resistance with that of conventionally additively manufactured samples.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-A
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Processing and characterization of a 316L to CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will engage in the explorative research regarding the process-material-property relationship of this multi-material. Especially the effect of ultrasound excitation during the DED processing of such 316L/CuCr1Zr multi-material will be explored. Samples with varying/gradient compositions will be manufactured and mechanically/microstructurally characterized to further optimize the processing conditions. The effects on corrosion resistance will be evaluated as well. The student will suggest process parameter optimizations and machine modifications with the purpose of enhancing the quality of the produced multi-material samples.

Practically, coupons will be produced under varying processing conditions, amongst which the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. Additionally, corrosion testing will be conducted macroscopically, and at localized regions to carefully evaluate the performance along the build direction. The functional properties (thermal/mechanical/corrosion) will be compared to reference conditions without ultrasound excitation.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O

Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Unraveling the effect of geometry on crack kinking under mode I loading using biaxial testing

Description

Context of the master thesis

Fracture mechanics is a branch of solid mechanics that studies the behavior of structures in the presence of cracks. In real structures, crack initiation can occur in regions of high stress or due to material voids, among other causes. Understanding material and structural behavior in the presence of cracks is crucial for avoiding catastrophic failure and enabling fail-safe design methodologies. To achieve this, fracture behavior must be studied under different loading modes, i.e., mode I, mode II, and mode III [1]. Mode I, or opening mode, is the most common loading condition encountered in real structures [1]. Experimental studies on mode I have shown that cracks do not always propagate in a straight path; rather, they often kink due to geometric constraints. In other words, changing the specimen geometry under the same loading conditions can lead to different crack propagation behaviors [2], [3]. Despite extensive experimental work, the primary factors triggering crack kinking remain not fully understood. It is well recognized that altering the geometry from Single Edge Notch Tension (SENT) to Double Cantilever Beam (DCB) specimens under mode I loading can induce unstable crack propagation [2], [3]. In this master’s thesis, PMMA (polymethyl methacrylate) DCB specimens will be modeled under the Linear Elastic Fracture Mechanics (LEFM) framework using ABAQUS finite element (FE) software to determine the stress field and fracture parameters at the crack tip. Subsequently, biaxial loading conditions will be applied to the specimens, and the corresponding fracture parameters will be evaluated. The main objective is to identify a biaxial loading condition that suppresses crack kinking in the DCB specimen. Once the appropriate loading conditions are determined, the specimens will be tested using a biaxial testing machine to validate the simulations. This research will provide high-quality insights into the influence of geometry and loading conditions on crack trajectory under mode I, enhancing our understanding of fracture behavior in engineering structures.

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fracture," Eng. Fract. Mech., vol. 187, pp. 94–102, 2018, doi: 10.1016/j.engfracmech.2017.10.022.
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Objectives of the master thesis

For the first time, the combined effects of specimen geometry and loading on mode I fracture will be investigated. This study aims to achieve the following objectives:

1. To understand the effect of geometry on crack trajectory under mode I loading.
2. To identify loading conditions that mitigate unstable crack propagation under mode I.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Numerical study for thermal gradient reduction during 3D printing Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses, see Fig. 3. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part. Next to the process parameters, as shown on Fig. 3, buildplate preheating involves heating the baseplate before material deposition begins, is also used to reduce the thermal gradients.

Preheating minimizes the temperature difference between the incoming molten material and the cooler buildplate. This helps controlling the thermal history of the part, and might lead to better overall quality of the printed part.

The aim of this master thesis is to investigate numerically the effect of temperature dependent material parameters (density, latent heat, heat capacity, …) and build plate preheating settings on the thermal history of the part.

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol) an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of milling process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build/cutting strategy on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [3].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of a post milling operation (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [5,6].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of ablation process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

Hybrid Additive Manufacturing is based on the combination of multiple processes improving the cost, quality, functionality, and efficiency of the

parts [3]. Possible examples of additive-subtractive combination are Hybrid-AM by Machining or hybrid-AM by Ablation [4]. The MiCLAD machine is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. The lab is also equipped with an external ablation stage that will be soon integrated in the machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [5].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [6] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of the ablation process (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [7].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Characterization of the liner/composite overwrap interface in type IV hydrogen storage vessels

Description

Context of the master thesis

Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation,Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation. Despite their advantages in weight reduction and performance, Type IV tanks present critical challenges at the interface between the polymer liner and the composite overwrap that directly affect safety and durability. During high-pressure filling, hydrogen can permeate into the polymer liner and subsequently accumulate at the liner–overwrap interface. Upon rapid depressurization, this trapped hydrogen may generate local pressure differentials, leading to binder cavitation, interfacial void growth, and, in severe cases, liner collapse [2]. Furthermore, repeated pressurization–depressurization cycles can induce fatigue damage and progressive interfacial degradation, increasing hydrogen permeation, reducing structural reliability, and ultimately shortening the service life of the storage vessel. This thesis will focus on the characterization of the liner–composite overwrap interface in a Type IV hydrogen storage vessel. Mechanical testing will include double cantilever beam and T-pull tests to quantify the interfacial adhesion between the polymer liner and the composite overwrap. The effects of temperature and hydrogen exposure on interfacial properties will also be investigated. In addition, fatigue testing will be conducted to evaluate the long-term durability of the storage vessel.

References

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[2] Y.T. Li, W.J. Huang, Y.M. Zhang, M. Fan, Z.M. Xiao, W.G. Li, Investigation of liner collapse behaviors in Type IV hydrogen storage vessels at different temperatures, J. Energy Storage 129 (2025) 1–18. https://doi.org/10.1016/j.est.2025.117307.
[3] J. Pépin, E. Lainé, J.C. Grandidier, G. Benoit, D. Mellier, M. Weber, C. Langlois, Replication of liner collapse phenomenon observed in hyperbaric type IV hydrogen storage vessel by explosive decompression experiments, Int. J. Hydrogen

Objectives of the master thesis

This thesis will aim to develop a comprehensive understanding of the interfacial behaviour between the polymer liner and the composite overwrap in Type IV hydrogen storage tanks under service-relevant conditions, including hydrogen exposure, cryogenic temperatures, and cyclic mechanical loading. The insights obtained from this work are expected to support the design, material selection, and optimization of hydrogen storage systems with improved durability and safety performance.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Ultrasonic welding of thermoplastics and thermoplastic composites-Parametric study and optimization

Description

Context of the master thesis
Thermoplastic materials are widely used in many industries, either as plain materials or in composites where they are reinforced with fibers, leading to lightweight and resistant structures, which at the same time offer sustainable solutions. The reason for this is that thermoplastics are processed at high temperatures in order to obtain their final shape and since they can be melted, solidified and re-heated, they offer great recyclability potential. This property however offers much more industrial interest, since thermoplastics can also be welded, providing therefore alternatives compared to traditional mechanical fastening using e.g. bolts or rivets. One of the most promising welding methods is ultrasonic welding. Ultrasonic plastic welding (USW) is the joining or reforming of thermoplastics through the use of heat generated from high-frequency mechanical motion. It is accomplished by converting high-frequency electrical energy into high-frequency mechanical motion. That mechanical motion, along with applied force, creates frictional heat at the plastic components’ mating surfaces (joint area) so the plastic material melts and forms a molecular bond between the parts. Ultrasonic welding can offer a very fast and energy-efficient way for joining materials and in particular thermoplastics. Despite its potential and the fact that ultrasonic welding is being used in some industries for joining thermoplastics together, there is still a lot of open research related to the understanding of the impact of the different parameters involved in the process on the quality of the obtained joints. Moreover, automation of the welding process and optimization of the different parameters is of great importance, towards its further and more well-established industrialization. During this thesis subject, the student will initially have to perform a dedicated literature review on ultrasonic welding. Then, an experimental campaign will be performed, during which joints of thermoplastic parts will be manufactured by altering the parameters related to the ultrasonic welding process, e.g. applied load, weld time and hold time. The quality of the manufactured joints will be controlled through ultrasonic measurements after their production, in order to be directly correlated to the combination of welding parameters used. Moreover, mechanical testing will be performed and the damage of the joints will be evaluated through non-destructive methods, i.e. acoustic emission and digital image correlation. Based on the data collection through the ultrasonic

welding process and the performed tests, in the final step of the thesis, the student will use machine learning/AI tools in order to use the obtained data in the most optimal way for the optimization of the method through closed-loop automation controls.

Objectives of the master thesis

1. Parametric study on ultrasonic welding of thermoplastics.
2. Damage evaluation of ultrasonic welds using non-destructive methods.
3. Optimisation of ultrasonic welding parameters combining experiments with machine learning.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Metallurgical, mechanical & corrosion characterization of ultrasonic assisted additively manufactured 316L

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the processing of single 316L alloy, yet Functionally Graded, constituting of a microstructural gradient by grain refinement through ultrasonic assisted additive manufacturing. Without such ultrasound assistance, grains tend to grow to elongated and larger grains during the solidification step, typically resulting in undesired, anisotropic material properties. The ultrasound excitation perturbs the melt pool during the solidification step, causing an interrupted grow of these elongated grains, and leading to a more refined and more isotropic material properties. The student will engage in the explorative research regarding the process-material property relationship through the addition of ultrasound excitation.

Practically, the student will be involved in the practical integration and machine control implementation of an ultrasonic stack to harmonically work alongside the additive manufacturing process. Coupons will then be produced under varying processing conditions, including primarily the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. The anisotropy of the mechanical properties will be compared to reference conditions without ultrasound excitation. Besides, a systematic microstructural characterization will be conducted by SEM to evaluate, not only the grain structure, but also the sub-granular micro-segregation cell structure and inclusion formation along the build direction; since these aspects have a very important impact on the properties of the material.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic : EM - Aeronautics - M-IREMR-A

Process parameter optimization for 3D printing of single alloy rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Rocket nozzles must be extremely resistant to withstand the intense thermal and mechanical loads experienced during launch, see Fig. 2-3. They are exposed to temperatures exceeding 3000 °C and high-pressure exhaust gases moving at supersonic speeds. In addition, they endure significant thermal gradients, vibrations, and mechanical stresses from the combustion chamber and external aerodynamic forces. As a result, nozzle materials and designs must ensure high thermal conductivity, oxidation resistance, mechanical strength, and structural integrity throughout the mission.

Producing the rocket nozzle using DED offers significant advantages. It allows for precise control over material deposition, enables the fabrication of complex geometries, function integration minimizes material waste, and supports rapid iteration.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October

2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and not with additive manufacturing techniques.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. The results of the manufacturing of the miniature rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping due to the printing on inclined surfaces, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

This master thesis will ai to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example remelting, controlled cooling to reduce cracking, regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

Instrumented glass gripper: Percipio Robotics' Tulip gripper revisited (+ internship – to be confirmed by the company Percipio Robotics)

Description

Context: Percipio Robotics is a spin-off from the FEMTO-ST research institute, which has designed the Tulip gripper [1]. This compact, lightweight gripper, weighing less than 30g, is designed for micromanipulation and can grip objects from 50μm to 10mm. It solves the problems of large grippers and fragility frequently encountered in micro-robotics. Parallely, the TIPs department designs and manufactures compliant mechanisms in glass (FemtoPRINT technique), whose deformation is measured with optical/photonics techniques.
Objectives: This thesis aims to design and develop an instrumented version of the Percipio Robotics' Tulip gripper. The master thesis can be preceded by a 3 months internship in the company (Besançon, France).
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and characterization of the flexure mechanism.
Prerequisites: mechanical design, good command of French

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRCNE, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IRPH
Nombre de sujets	2

Supervision

Supervisor : LAMBERT Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

The measurement of elastomers self-healing efficiency using Electrical Impedance Tomography sensing

Description

1) the objectives of the project

Self-healing materials are emerging as a promising technology for improving the durability and reliability of soft robotic systems, flexible electronics, and wearable devices. When damage occurs, such materials can autonomously recover their mechanical and electrical properties, extending the lifetime of components and reducing maintenance requirements. However, monitoring the healing process and evaluating the healing efficiency remain significant challenges, especially when the damage occurs inside soft materials and cannot be directly observed.

In our previous research, we developed a self-healing Electrical Impedance Tomography (EIT) sensor, which can reconstruct conductivity distributions inside soft materials and detect damage such as cuts or cracks. Based on this technology, we discovered that EIT sensing can also be used to monitor the recovery process of damaged materials, providing valuable insight into the healing status and efficiency over time.

This project aims to further investigate the use of EIT sensing as a non-invasive method to monitor the healing status of self-healing materials. The objective is to develop a sensing system capable of tracking damage and healing evolution inside soft materials, and to evaluate how effectively the material restores its functionality after damage. Such technology can be broadly useful for soft robotics, structural health monitoring, wearable devices, and smart materials.

2) the methodology

This project focuses on developing experimental methods to monitor self-healing processes using EIT sensing. The project will include:

(i) A literature study on self-healing materials and Electrical Impedance Tomography

sensing methods.
(ii) Fabrication of self-healing material samples integrated with electrode arrays for EIT measurement.
(iii) Implementation of damage and healing experiments, including controlled cutting and healing cycles.
(iv) Use our data acquisition and image reconstruction methods to visualize healing evolution inside the material.
(v) Quantitative evaluation of healing efficiency based on electrical and mechanical recovery.

To support this project, we already have experience with EIT-based sensing and self-healing materials, as demonstrated in our previous publications. The student will build upon existing experimental platforms and contribute to advancing smart sensing technologies for monitoring material health.

3) Prerequisites needed to succeed in this project

(i) Electronics and sensor systems
(ii) Programming and data processing
(iii) Interest in experimental testing and hands-on engineering
(iv) Interest in smart materials, sensing, or health monitoring systems

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE
Nombre de sujets	1

Supervision

Supervisor : Wang Zhanwei (Zhanwei.Wang@vub.be)

Master's program offering the topic : EM - Robotics & mechatronics constructions - M-IREMR-M

Multi-robot localisation

Description

This thesis topic is a broad collection of subtasks that can be undertaken within multi-robot localisation research.
This includes topics such as:
- Multi-agent SLAM.
- UWB Anchored localisaiton
- Relative pose estimation
- Map sharing
- ODometry sensors: IMU, Camera, VIO, LiDAR, LIO.

And this on multiple different robots:
- AGVs
- Humanoids
- Drones.

In case you want to discuss possibilities in this research field please contact yuri.durodie@vub.be for more details.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	5

Supervision

Supervisor : Vanderborght Bram (Bram.Vanderborght@vub.be)

Chemical & Materials Engineering Master Thesis Topics (M-IRMAE)

Academic year 2026–2027

Effect of additives on optical properties and corrosion resistance of anodized recycled Al alloys

Program : Chemical & Materials engineering - M-IRMAE

Description

The use of recycled aluminum (Al) alloys is rapidly increasing in industrial applications due to their potential to reduce energy consumption and improve material sustainability. Moreover, industries demand high surface quality and durability, particularly for functional or decorative applications. One of the most applied surface treatments for Al alloys is anodizing, which produces a protective alumina (anodic) layer that enhances corrosion resistance, wear resistance, and aesthetic appearance. However, recycled Al alloys may differ from primary alloys in terms of microstructure, impurity levels, and alloying element composition (e.g., zinc). These differences can influence the formation, morphology, and properties of the oxide layer. As a result, anodized recycled alloys may show variations in optical appearance, corrosion resistance, and overall surface performance compared with anodized primary alloys. Understanding and controlling these differences is therefore essential for enabling the broader industrial adoption of recycled Al.

This project focuses on the role of additives in the anodizing electrolyte and their influence on the resulting oxide layer. The study will explore how these additives affect optical properties and corrosion resistance under different anodizing conditions. Experimental work will involve anodizing selected primary and recycled Al alloys under controlled conditions with different concentration of additives in anodizing electrolyte. The resulting oxide layers will be characterized using advanced surface analysis and electrochemical techniques, including SEM and EDS for morphology and chemical composition, XRD for crystalline structure analysis, and EIS to evaluate corrosion resistance. By correlating alloy composition, anodizing parameters, and electrolyte additives with the resulting surface properties, this research aims to provide insights into how anodizing processes can be performed to ensure high-performance coatings on recycled Al alloys.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRARE
Number of topics	1

Supervision

Supervisor : Iris De Graeve

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Co-supervisor: Roya Malekkhouyan

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AI-Accelerated Design of Anderson-type Polyoxometalate Clusters for Low-Temperature CO2 Hydrogenation to Methanol

Program : Chemical & Materials engineering - M-IRMAE

Description

This project is based on the recent work by Liu et. al., [1], and it deals with Anderson-type PtMo6O24 clusters for low-temperature CO2 hydrogenation, which focuses on the high-value conversion of carbon dioxide into methanol—a critical "circular economy" objective for the oil and gas industry. Current industrial processes for methanol synthesis require high temperatures (>250 °C) and pressures, leading to significant energy penalties and catalyst degradation; however,
molecular clusters encapsulated in Metal-Organic Frameworks (MOFs) offer a pathway to high selectivity and stability under much milder conditions. The hypothesis of this thesis is that the electronic synergy between the central noble metal (Pt) and the surrounding transition metal ring (Mo6) creates unique oxygen vacancies that facilitate a "non-classical" CO2 activation mechanism, which can be further optimized by tuning the metal composition to break traditional scaling relationships. By replacing Pt or Mo with earth-abundant alternatives (e.g., Ni, Fe, or W), we aim to identify the specific electronic descriptors—such as the d-band center and vacancy formation energy—that dictate whether the reaction follows the efficient Reverse Water-Gas Shift (RWGS+CO)2 pathway or the slower formate (HCOO*) route.
Computational Methodology
Based on the paper the methodology will be using standard DFT combined with ML or DNN techniques:
1. Electronic Structure Modeling (DFT): As a first step we can use DFT (e.g., vasp or CP2K) to model the Anderson cluster within the pores of the NU-1000 MOF and then compute the adsorption energies of critical intermediates (CO∗
2,CO∗,HCOO∗,OH∗)
and determine the activation barriers for the rate-limiting steps using the Nudged Elastic Band (NEB) method or some other methods methods that uses foundational model.
2. Machine Learning (AI/ML) Screening: To bypass the high computational cost of exploring all possible bimetallic combinations (M1M2,6O24), what we can do is to develop an ML regression model. Using a dataset generated from approximately 30–50 DFT calculations, the model will use "atomic descriptors" (e.g., d-band center, electronegativity, and vacancy formation energy) to predict the binding energies and catalytic activity of over 200 candidate clusters.
3. Mechanistic Insights: We will employ Crystal Orbital Hamilton Population (COHP) analysis to quantify the orbital interactions between the metal centers and CO2. Which is quite standard to understand how different metal substitutions influence the C − O bond activation and why specific clusters favor the RWGS pathway over the competitive formate route.
4. Microkinetic Modeling: Finally, if time permits, we can go to deeper and more complicated microkinetic modeling; the calculated energies will be integrated into a microkinetic model to predict the Turnover Frequency (TOF) and methanol selectivity under industrialrelevant
pressures (20–50 bar).

Bibliography

[1] Liu, Q., Rabbani, S.M.G., Hou, Z. et al. Isolated and H2-reduced Anderson clusters catalyse low-temperature hydrogenation of CO2 to methanol. Nat. Chem. (2026). https://doi.org/10.1038/s41557-026-02104-x

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Mesfin Haile Mamme

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Co-supervisor: Asif Iqbal Bhatti

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Tracing slow relaxation modes in polymer thin films

Program : Chemical & Materials engineering - M-IRMAE

Description

Relaxation of mechanical stresses is central to many technological applications as it controls a plethora of critical behaviors in polymer materials ranging from polymer dewetting to creep in organic electronics. Controlling and predicting stress relaxations is therefore crucial for material stability and remains an open question which limits our predictive power and force us to keep a trial and error approach in material synthesis. One of the main reasons beyond these limitations is the difficulty of tracking relaxation behavior in polymer films (<10 um) deep in the glassy state, where microscopic dynamics is extremely slow and responsible microscopic motions are unknown. During this thesis the student will tackle this problem by applying a novel method in dynamical mechanical analysis, namely, static square-wave mechanical spectroscopy (SSWMS), which allows accessing extremely slow relaxation modes in polymer materials in relatively short time.

Supported by the research team, the student will:

1) Implement the SSWMS procedure on different DMA instruments,

2) Develop a script (Python, Matlab,...) to analyse the experimental data,

3) Validate the protocol on standard polymer films and extract their ultra-slow mechanical properties.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

Supervisor : Guy Van Assche

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Co-supervisor: Federico Caporaletti

Contact : Federico.Caporaletti@vub.be

Lien : First introduction of static square-wave mechanical spectroscopy - https://www.cell.com/newton/fulltext/S2950-6360(26)00074-5

Electrochemical pathways towards sustainable copper recovery

Program : Chemical & Materials engineering - M-IRMAE

Description

More than 50 metric tons of E-waste are generated globally per year. Copper is one of the abundant metals present in E-Waste, especially in the important subsystems of PCBs. This project will deal with developing novel and scalable electrochemical pathways towards recovering copper. The student will work on developing regenerable reagents which can selectively leach copper from the bare boards and/or depopulated components. Redox regeneration of reagents will be combined with rational cathodic reactions to deliver value on both electrodes following the principles of paired electrolysis.

The topic will be a part of the SPRIND project framework of tech metal transformation challenge - https://www.sprind.org/en/actions/challenges/tech-metal wherein 4MAT/E-murgy are one of the 8 winners of stage 1. The student must have clear affinity towards applied research that has a potential for industrial application.

Language	EN (english)
Open to other master's programs	no
Eligible master's programs	
Number of topics	2

Supervision

Supervisor : Prakash Venkatesan

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Designing of solid-state electrolyte for high performance all-solid-state lithium-ion batteries

Program : Chemical & Materials engineering - M-IRMAE

Description

With rising gas prices due to war and the incredibly pressing need to rapidly transition away from fossil fuels, energy conversion and storage devices are getting a lot of attention. Over the last two decades, it has been confirmed that energy storage devices, more specifically, Lithium-ion batteries (LIBs), are a key enabling technology for many needs of our everyday life; for example, they have enabled the revolution of internet of things (how we share and communicate), and meanwhile inspired the development of full electrical cars. However, its applicability is currently limited by its use of liquid organic electrolytes, which are extremely flammable and hazardous, which pose a very serious safety risk and short lifetimes. As a result, in recent years there has been a considerable push toward the development of all-solid-state batteries and, specifically, new solid and/or semi-solid electrolyte materials. This project aims to design a new composite electrolyte (e.g., Polymer-Ionic-liquid electrolyte) with high lithium-ion conductivity and electro-chemo-mechanical stability for all-solid-state batteries. In this regard, understanding the role of different functional groups in the composite electrolyte is the key if the performance, lifetime and the safety of the electrolyte is to be improved. In this project, a hybrid multiscale computational approach alongside with experimental methods will be used to get new insights into mechanisms of lithium mobility with such a composite electrolyte.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Mesfin Haile Mamme

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Co-supervisor: Asif Bhatti

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Modeling and optimization of a brewing fermentation process

Program : Chemical & Materials engineering - M-IRMAE

Description

This thesis will begin by selecting a dynamic model published in the scientific literature that simulates the temporal profiles of concentrations of certain components, including yeast, sugars, ethanol, CO2, VDK (vicinal diketones), etc. The effects of temperature and pH will also be considered. Some models have already been pre-selected, but others could be considered within the scope of this thesis. The simulator based on the selected model will be implemented using Matlab software.
Secondly, based on the simulation model developed in the previous section, optimal fermentation conditions will be determined to minimize its duration while guaranteeing certain fixed characteristics, notably the final concentrations of ethanol and VDK. The initial concentrations of sugars and yeast, as well as the temperature temporal profile, will be optimization variables to be predicted in order to achieve the aforementioned optimization objective.
Determining these optimal conditions can later be used to develop a closed-loop controller that will allow for a robust implementation of these conditions with respect to model errors.
This project is part of the launch of the university brewery Beer in Mind, founded by Stéphane Bruyneels and Denys Van Elewyck.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Philippe Bogaerts

Contact : philippe.bogaerts@ulb.be

Tailored Hydrochar from Seafood Waste via Microwave-Assisted Hydrothermal Carbonization for Pollutant Removal from Water

Program : Chemical & Materials engineering - M-IRMAE

Description

Seafood-processing waste, particularly lobster shell residues, represents an abundant and underutilized biomass resource with strong potential for conversion into functional carbon-based materials. Hydrothermal carbonization (HTC), especially when assisted by microwave heating, enables efficient processing of wet biomass without the need for energy-intensive drying. This project aims to develop tailored hydrochar from seafood waste, such as lobster shell waste, via microwave-assisted hydrothermal carbonization (MHTC) and to evaluate its performance in removing pollutants (such as Rhodamine B/ methylene blue) from aqueous systems. Key process parameters, including temperature, residence time, and solid-to-water ratio, will be optimized using a design-of-experiments approach, with the response being pollutant removal under fixed conditions of pH, contact time, and dye concentration. The produced materials will be characterized using CHNS analysis, FTIR spectroscopy, and proximate analysis. Adsorption performance will be evaluated through batch experiments to assess the effects of pH, contact time, dye concentration, and other influential parameters. UV–visible spectroscopy will be used to quantify dye removal. The project will establish relationships between hydrochar production conditions, surface chemistry, and adsorption performance, demonstrating a sustainable approach for converting seafood waste into functional adsorbents.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

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Development of activable NIR contrast agents for photoacoustic imaging.

Program : Chemical & Materials engineering - M-IRMAE

Description

Photoacoustic Imaging (PAI), the fastest growing biomedical imaging modality in the last decade, has the potential to significantly impact the field of nanomedicine. It is non-ionizing, non-invasive and uses a nanosecond pulsed laser to generate pressure waves that can be detected by conventional ultrasound transducers. Because PAI uses a light-in-sound-out approach, it has the strengths of ultrasound, i.e. good tissue penetration, real-time monitoring, low cost and high spatial resolution, but also the high contrast, specificity and sensitivity of optical methods. Although endogenous contrast agents such as oxygenated or deoxygenated hemoglobin and melanin can be used, PAI still lacks exogenous contrast agents, which could increase sensitivity and allow targeting of specific cells (such as cancer cells). The EMNS laboratory is involved in the development of such functionalized nanomaterials based on gold nanorods, silver nanoplates and copper sulfide nanoparticles.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	2

Supervision

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Lien : https://emns.polytech.ulb.be/en/research/nanomaterials-1

Towards Low-Carbon Construction Materials: Linking Strength to Carbonation in CO_2-Cured Steel Slag

Program : Chemical & Materials engineering - M-IRMAE

Description

Cement production is one of the largest industrial sources of CO_2, responsible for roughly 8% of global emissions. Unlike most industries, more than half of these emissions come not from energy use but from the chemical process itself — the decomposition of limestone — meaning that switching to renewable energy alone cannot solve the problem.
A promising alternative lies in steel slag, a by-product of the steel industry that is currently underused. When mixed with water and exposed to CO_2, certain minerals in steel slag react to form stable carbonates that bind the material together and give it mechanical strength. This approach offers a double environmental benefit: it avoids the need for conventional cement, and it actively locks CO_2 into the final product, effectively turning a greenhouse gas into a building material.
However, making this process reliable remains a challenge. The carbonation reaction is sensitive to many interacting parameters — CO_2 concentration, humidity, temperature, and exposure time — and achieving more carbonation does not always lead to higher strength.
This master's thesis tackles these questions by combining complementary characterisation techniques. Impulse excitation — a non-destructive method that measures stiffness by analysing the natural vibration frequency of a specimen — offers a quick window into mechanical performance without breaking the sample, while conventional compression testing provides direct strength values. Together, they allow the investigation of the process parameters and sample handling affect mechanical outcomes. Thermogravimetric analysis (TGA), which tracks mass loss as carbonates decompose under controlled heating, is then used to determine the actual degree of carbonation and relate it to the measured strength. A key part of the work will be developing sampling and testing protocols that are not only accurate and reproducible, but that could ultimately help bring CO_2-cured construction materials from the laboratory to real-world application.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCNE
Number of topics	1

Supervision

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Development of a structured adsorbent for the separation of hydrogen from ammonia cracking gas.

Program : Chemical & Materials engineering - M-IRMAE

Description

An alternative to large-scale electricity transport is shipping chemical energy carriers (e.g. renewable
molecules). Ammonia is seen as the most promising hydrogen carrier, as it has clear advantages. Cracking of ammonia generates hydrogen, which can serve for energy production and which is important in many chemical processes. However, this requires separation and purification of H2 from the ammonia decomposition reactor effluent stream, which is challenging as the required purities of H2 for chemical processes and fuel cell applications are very high (98-99.995%). Membrane reactors at lab/pilot scale have been reported with in situ separation of H2 from N2; but require a downstream adsorption unit to keep the fuel cell H2 specification <0.1ppm NH3. State-of-the-art typically considers ammonia cracking, separation and effluent/product purification separately, without a priori integration and optimization of the individual units. In the SHERPA project, we aim to integrate the reactor, ammonia recovery and H2 separation and purification.
In particular, this master thesis focusses on the development of a monolithic, hybrid adsorbent for selective NH3 adsorption that allows electrified regeneration. To allow resistive heating and regeneration, an electrically conductive property will be incorporated based on a method we have developed very recently (patent application) to produce structured adsorbents with high electrical heating efficiencies using a minimal amount of conductive material. For screening purposes, small monoliths (5 cm length) will be extruded with stable, commercially viable adsorbents with large NH3 affinity and capacity: zeolites and supported metal halides. The main formulation variables (amounts of adsorbent, electrically conductive material, plasticizer and binder) will be tuned to achieve an optimal balance between capacity and heating performance. Materials will be characterized: textural properties via Ar and Hg porosimetry, mechanical strength, heat capacity, and SEM (homogeneity and channel/wall properties).

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Evaluating the Role of Electrolyte Deprotonation in the Degradation of Lithium-Ion Battery Interfaces via Modelling Approach

Program : Chemical & Materials engineering - M-IRMAE

Description

As the global transition toward renewable energy intensifies, Lithium-Ion Batteries (LIBs) have become a cornerstone of modern society, powering everything from portable electronics to electric vehicle fleets. To achieve long-term high performance, the stability of interface, i.e. electrolyte/electrode junction, is crucial. Degradation that can occur at interface, e.g. electrode dissolution or cracking, electrolyte decomposition leading to the cell drying out, can possibly lead to the growth of a decomposition layer and the consumption of active material. Consequently, the internal resistance increases while the battery capacity fades, which eventually lead to the the battery lifespan to be limited. While many pathways for capacity loss are well-documented, the role of electrolyte deprotonation at the battery interface has recently emerged as a critical, yet frequently overlooked, driver of performance decay.

This research aims to bridge a significant scientific gap by gaining a fundamental understanding of the deprotonation mechanism at the positive electrode / electrolyte interface. Investigating these processes experimentally presents a major challenge, as the "buried" nature of the interface and the presence of hydrogen—a very light element often found only in trace amounts — make it difficult to probe via standard laboratory procedures.

To overcome these limitations, this study will leverage a computational approach based on Density Functional Theory (DFT). By modeling the interface at the atomic scale, DFT provides the necessary resolution to expose the subtle hydrogen dynamics and electronic shifts that govern degradation. The goal of this work is twofold: (I) gaining insights in electrolyte deprotonation mechanism and proton co-intercalation in positive electrode matrix; (II) providing a predictive framework for electrolyte stability, ultimately contributing to the design of longer-lasting and more efficient energy storage systems.

References: · Science 2024, 385, 6714, 1230-1236. DOI: 10.1126/science.adg4687 · ACS Appl. Mater. Interfaces 2024, 16, 41, 55258–55266. DOI: 10.1021/acsami.4c10458 · ACS Appl. Energy Mater. 2020, 3, 4, 4078–4087. DOI: 10.1021/acsaem.0c00602

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Optimization of heat treatment for novel high-performance 3D-printed aluminum alloy dedicated to aerospace

Program : Chemical & Materials engineering - M-IRMAE

Description

Heat exchangers for aerospace engines are designed with thin walls shaped in a lattice structure, in order to maximize the heat transfer. Additive Manufacturing (AM) is particularly suitable to manufacture such complex geometry; however, the printable wall thickness is critical for the heat exchanger performances and thermal conductivity. Currently, heat exchangers are manufactured using conventional Al-Si-Mg alloys, although with great limits related to their poor performances in terms of mechanical strength (static or fatigue) and temperature stability. It is therefore necessary to transpose the knowledge acquired on conventional alloys to other, higher-performance aluminum alloys.

The Master's Thesis lies in the frame of a collaboration with Safran Aerobooster (SAB) based in Liège. ULB, UCL and SAB are collaborating over manufacturing aluminum thin to ultra-thin walls (below 600 microns) via the technology Laser Powder Bed Fusion (LPBF), towards developing innovative heat exchangers. One associated challenge is the optimization of the post-manufacturing heat treatments, in order to control the microstructure and maximize the mechanical properties of the material. Indeed, the heat treatment strategy of Aluminum alloys has a significant impact on hot cracking risks and on the microstructure, notably the formation of precipitates.

The Master's Thesis will focus on an innovative high-performance Aluminum alloy, prospected by SAB for the next generation of heat exchangers. The objective is twofold: (1) to start the characterization of such material, 3D-printed via LPBF, in terms of microstructure, hardness and tensile properties, and (2) to investigate the heat treatment strategy to optimize the final material microstructure and performance. This Master's Thesis will take a major path of experimental works. The lab work will consist in conducting mechanical tests (tensile, hardness, etc.) and microstructure investigation via optical microscopy, Scanning Electron Microscopy (SEM) and SEM-based techniques (EDX, EBSD).

Language	**FR (français)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Facilitating battery diagnosis through advanced EIS and AI methods

Program : Chemical & Materials engineering - M-IRMAE

Description

Although Li-ion batteries are used for many applications nowadays, determining the Remaining Useful Life (RUL) of these devices still proves challenging. One way of measuring the different processes happening inside batteries is through Electrical Impedance Spectroscopy (EIS). EIS is known to be a real-time, non-invasive technique, and contains rich information on all materials properties, interfacial phenomena, and electrochemical reactions by obtaining the impedance over a wide range of frequencies. However, deploying EIS to predictive battery diagnosis is hampered by the complex data interpretation. Although qualitative changes are apparent, it is challenging to pick out quantitative features correlated with degradation. Implementation of an AI-based approach on EIS data would allow us to identify battery parameters without pre-defined models for accurate State of Health (SoH) and RUL estimation, even without complete knowledge of past operating conditions of the battery.
In this master thesis project, we aim to develop a machine learning model capable of predicting the SoH and RUL of a battery, using information that can be obtained while the battery is charging. For this project, machine learning will be combined with advanced EIS measurements. Traditional EIS techniques cannot measure an impedance spectrum of a commercial Li-ion battery while charging, however, by using an in-house developed EIS technique, it is possible to overcome this barrier (operando EIS) [1]. This data can then be correlated through the measured SoH and RUL of the battery. Using this technique, an excellent dataset to use for machine learning can be obtained. The goal is to develop a model with some physical insights by leveraging the latest machine learning models and algorithms and advanced EIS measurement. The unique combination of operando EIS with machine learning can be very appealing in an industrial setting for both the end user and the battery manufacturer.

[1] X. Zhu et al., Journal of Power Sources 544 (2022) 231852

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Development of PEG/Hydrochar Composite Materials Derived from Seafood Waste for Sustainable Functional Applications

Program : Chemical & Materials engineering - M-IRMAE

Description

The integration of biomass-derived carbon materials into polymer matrices offers new opportunities for sustainable material development. Hydrochar derived from seafood waste serves as a low-cost, tunable carbon filler, while polyethylene glycol (PEG) provides a versatile, hydrophilic polymer matrix. This project aims to develop PEG/hydrochar composite materials using hydrochar derived from seafood waste, such as lobster shell waste, via microwave-assisted hydrothermal carbonization. Hydrochar will be incorporated into PEG at varying loadings to produce composite materials with tailored properties. The influence of hydrochar incorporation on rheological behavior, mechanical properties, and structural characteristics will be investigated. Rheological testing, mechanical analysis, FTIR spectroscopy, and microscopy will be used to assess material performance and interactions between hydrochar and PEG. The project will explore how hydrochar content and processing conditions affect composite functionality and will demonstrate the feasibility of using seafood-derived carbon materials in sustainable composite systems.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

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Process Design and Economic Analysis for Isobutyric Acid Production by Fermentation

Program : Chemical & Materials engineering - M-IRMAE

Description

This MSc thesis focuses on developing a comprehensive, computer-based model of an industrial plant that produces isobutyric acid (IBA) via a biological fermentation process using Clostridium luticellarii, which consumes carbon dioxide (CO_2) and hydrogen (H_2) gases as feedstocks, offering a sustainable alternative to traditional petrochemical synthesis. The work is divided into two main phases: first, process simulation in Aspen Plus/HYSYS, where a steady-state model of the entire plant is built, including the fermentation reactor where bacteria convert CO_2 and H_2 into IBA, and the downstream separation train which purifies IBA from the fermentation broth using methods such as adsorption and extractive distillation; second, a techno-economic analysis (TEA) , wherein simulation results (mass flows, energy consumption, equipment sizing) are used to calculate the capital expenditure (CAPEX), or total plant construction cost, and the operating expenditure (OPEX), which includes annual costs for feedstocks, utilities, labor, and maintenance.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	2

Supervision

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Exploring how fillers affect the strength and heat resistance of new cement mixes

Program : Chemical & Materials engineering - M-IRMAE

Description

The construction industry, a significant contributor to global carbon emissions, faces a pressing need to reduce its environmental footprint. Traditional cement production processes release an enormous amount of carbon dioxide, due to the conversion of calcium carbonate to calcium oxide which requires high temperature (fossil fuels burnt). Additionally, conventional cement-based mortars exhibit compromised mechanical performance at elevated temperatures, this is attributed to the decomposition of Calcium Silicate Hydrate (CSH) which starts at around 300 °C. Alkali activation is a promising alternative, using industrial waste materials from sectors like iron or copper industries as precursors; this allows to reduce cement consumption, so less CO2 is emitted, and enhance mechanical and thermal properties. However, the thermal resistance and mechanical strength of alkali-activated materials are influenced by various factors such as water/binder ratio, binder/filler ratio, and the type of filler used (e.g., sand, granite, limestone, chamotte). Moreover, the different chemical compositions of potential raw materials, such as metakaolin, fly ash, and blast furnace slags, can significantly impact thermal resistance. The choice of alkali cation could also play an important role in the thermal behaviour of the materials.

The main objective of this master's thesis is to investigate the influence of different fillers on the mechanical and thermal properties of alkali-activated mortars. Initially, a literature review will be conducted to provide a ground understanding of the topic. Then, an alkali activation system will be selected: precursors, activators, and different types of fillers. Formulation of the system will be started by assessing the reactivity through isothermal calorimetry. The mechanical characterization of the formulations will be done with flexural strength, compressive strength, and Young's modulus testing to evaluate mechanical properties. The residual mechanical properties of materials after exposure to high temperatures (up to 1000 °C) will be assessed, and the study of crack formation using acoustic emission analysis might be a test to be performed as well. Additionally, the evolution of Young's modulus during heating, from room temperature to high temperatures, will be monitored. Microstructural changes in the different compositions will be investigated to provide insights into the elemental mechanisms influencing the mechanical and thermal behaviour of the alkali-activated mortars.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCNE
Number of topics	1

Supervision

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Biorefining of Biowaste for Biobutanol Production: Simulation and Techno-Economic Analysis

Program : Chemical & Materials engineering - M-IRMAE

Description

The biorefining of household food waste (HFW) into biobutanol addresses two critical global challenges: waste management and renewable chemical production. HFW represents a significant environmental burden due to greenhouse gas emissions from landfilling and incineration. However, its high organic content, which is rich in carbohydrates, proteins, and lipids, makes it an ideal feedstock for biochemical conversion. Biobutanol is a valuable platform chemical serving as an advanced biofuel and a precursor for industrial chemicals such as butyl acrylate, butyl acetate, and butyl ethers. Current butanol production relies on petrochemical routes, which are fossil-dependent and carbon-intensive.

This MSc thesis will develop a sustainable alternative: an integrated biorefinery that converts HFW into biobutanol via sequential pretreatment, acetone-butanol-ethanol (ABE) fermentation, and adsorptive product recovery using zeolite. The process will be simulated using Aspen Plus and Aspen HYSYS to establish mass and energy balances, followed by a techno-economic analysis (TEA) to evaluate the economic feasibility and commercial potential of the proposed biorefinery.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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A multimodal approach, combining finite element modeling, machine learning and advanced surface characterization for corrosion sensor interpretation.

Program : Chemical & Materials engineering - M-IRMAE

Description

Atmospheric corrosion of steel infrastructure accounts for around 1 % of a country's GDP each year and a notable share of global CO_2 emissions. Because the process evolves over decades and is strongly influenced by microclimate, no reliable analytical model currently exists to predict its progression. The standard practice relies on exposure coupons that provide an average annual corrosion-induced mass-loss rate. Corrosion sensors can offer the missing temporal resolution; among them, electrical-resistance (ER) probes measure section loss at hourly intervals. The data from these sensors can subsequently be related to weather conditions to identify meaningful relationships.

This thesis uses data from different corrosion sensors, eventually coupled in-situ to a camera system. The first core objective is to relate the electrochemical corrosion and camera imaging analysis data with previously developed predictive models. A sensitivity analysis for different (coated) metal substrates will provide a better understanding of the developed atmospheric corrosion analysis set-up and generated datasets and models, allowing determination of the accuracy levels of the resulting machine learning models. The follow up objective is to conduct a post-exposure analyses (e.g. mass loss, optical microscopy, SEM, Raman spectroscopy) to assess discrepancies between ER probes and coupons, and evaluate how different environments influenced corrosion product formation.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Effect of microstructural changes in recycled aluminum alloys on the surface treatment processes

Program : Chemical & Materials engineering - M-IRMAE

Description

Through the use of aluminium with a high recycle metal content unusual alloying elements concentrations reach the market. These new levels of iron, copper, zinc, etc. can cause issues when the recycled alloys are treated together with non-recycled alloys. However, a separation of the processing of conventional and recycled alloys is not feasible. Because the microstructure has a not-to-be-underestimated effect on the mechanisms of the surface treatment processes, a better understanding of the influence of those microstructural changes has to be established.

In the beginning, this thesis will therefore focus on the analysis of recycled vs conventional alloys and the characterization of their microstructures. Secondly, one or two surface treatment processes will be chosen to be studied specifically how the mechanisms change between the two types of alloys and which microstructure has which effect. Finally, a proposal will be made on how the process(es) can be driven so that recycled and conventional alloys fulfill the industrial requirements.

The processes to be looked into are degreasing, (alkaline and/or acid) etching, conversion, (DC or AC) anodizing and sealing. The student needs a good understanding of chemistry, electrochemistry and surface analysis. Although obviously trainings in the chemical lab and on the characterisation techniques are scheduled, a certain independence of a diligent student is required. They will work with our potentiostats for global electrochemical analysis and potentially with local electrochemical techniques. Depending on the orientation of the thesis. SEM and EDX, AES, XPS, AFM and SKPFM are the surface techniques which are most probably the ones used within the thesis, more are optional.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Diffusion of hydrocarbons in adsorptive zeolites via chromatography

Program : Chemical & Materials engineering - M-IRMAE

Description

Zeolites are highly porous structures with forming channels, cages and windows in the nanometer sized regions, only slightly larger than small molecules.
Over the past decades, this type of adsorbent has gained significant interest in the CO2 utilization industry, particularly in CO2-to-olefins (C2O) processes. For this reason, fundamental research is indispensable. The focus of this research is to investigate the behaviour of various hydrocarbon chains though these channels, cages and windows by exploring diffusion dynamics using chromatographic techniques. For some types of zeolites unusual and fundamental trends have emerged as molecule and cage size become similar, going under the name 'cage/window effects'.
In this thesis we have access to some state-of-the-art new zeolites via our academic synthesis partner (KUL).

Hence, besides traditional pulse gas chromatography, we offer a new zero-length column chromatography set-up to explore these novel unusual diffusion behaviours.

We are looking for a motivated hands-on candidate, interested in gas chromatography, and fundamental behaviour of molecules in zeolite structures.
The work involves using existing set-ups, validating new (ZLC) set-up, performing chromatographic analysis, and some modelling work (Matlab/Phyton) related to kinetic analysis.
Please don't hesitate to contact us if you have any interest and want to find out if this topic matches your interest.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Designing sustainable covalent adaptable networks from cardanol

Program : Chemical & Materials engineering - M-IRMAE

Description

The transition to a sustainable chemical industry demands bio-based alternatives to traditional petroleum-based resins. Conventional phenolic resins, widely used in for example adhesives, suffer from poor recyclability due to their permanently crosslinked structure, contributing to plastic waste accumulation. Covalent Adaptable Networks (CANs) present a promising solution by introducing reversible covalent crosslinks that can rearrange in response to an externally applied stimulus. These networks enable improved recyclability, processability, and self-repair, making them an ideal replacement for conventional resins.
The sustainability of such CANs can be further enhanced by investigating new bio-based building blocks such as cardanol, a low-cost agricultural byproduct obtained from cashew nut shell liquid (CNSL). Cardanol is a promising candidate as a starting material for the development of CANs. This thesis work focuses on the use of functionalized CNSL in Diels-Alder polymer networks for adhesive applications. The synthesized CAN materials will be thoroughly characterized to evaluate their thermal, rheological, and mechanical properties. The most promising formulations will be further assessed for their performance in adhesive applications.
Objective:
The goal of this thesis is to develop innovative adhesive formulations based on cashew nut oil-derived building blocks. Material properties will be systematically characterized and optimized to meet the requirements of targeted adhesive applications.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision

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Influence of the Chemical Environment on the Curing Kinetics of Amine Cured Epoxy Resins

Program : Chemical & Materials engineering - M-IRMAE

Description

Context

Epoxy resins are widely used in lightweight structural applications such as wind turbines and aerospace composites. Predicting their polymerization kinetics is crucial for assessing the feasibility of processing routes like resin transfer molding. Existing models, however, often fail to capture how the chemical environment, such as polarity, hydrogen bonding or reactive diluents, modifies the reaction rate, leading either to oversimplified or overly complex kinetic descriptions.

Objective

This thesis aims to quantify how controlled changes in chemical environment influence epoxy-amine curing kinetics, and to integrate these effects into a compact and predictive kinetic model.

Expected work

- Experimentally measure curing kinetics under different chemical environments using advanced thermal analysis.
- Track reaction progress and mobility effects with selected spectroscopic or rheological techniques.
- Compare experimental trends to relevant literature to evaluate how strongly environmental factors shift reactivity.
- Develop a simplified kinetic model that incorporates chemical environment effects, assisted by existing MATLAB tools.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Understanding interfacial degradation of positive electrode materials in lithium metal batteries using a combined modelling-experimental approach

Program : Chemical & Materials engineering - M-IRMAE

Description

Next-generation battery systems are playing a major role in the global shift towards a society based on renewable energy. Lithium metal batteries are leading this domain with a high power and energy density. However, challenges such as dendrite formation and solid-electrolyte interphase (SEI) formation due to the high reactivity of lithium metal highlight the need for a better understanding of interactions directly at the electrolyte-electrode interfaces. The goal of this project is to study the degradational behaviour of a electrolyte on a wide variety of positive/negative electrode materials such as LMNO, LMO, NMC, LCO, Li-, Na-metals and variations in their surface facets. The researcher will be gain experience in computational chemical modelling using ab-initio molecular dynamics and density functional theory methods and will verify with experiments using surface analysis techniques (SEM, XPS, Raman,...) to identify decomposition products. This project offers a unique opportunity to collaborate in interdisciplinary research between chemistry and material science in this state-of-the-art research area.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Design and investigation of Reorientation Induced Plasticity in titanium alloys for aerospace applications

Program : Chemical & Materials engineering - M-IRMAE

Description

Summary :

The aerospace sector is currently in significant expansion with the main goal of reducing weight and energy consumption. Increasing amounts of research are focusing on enhancing the damage resistance of the materials used, whilst also opting for materials with a very high strength-to-density ratio. Titanium alloys are known to response to this latter condition, having a low density while maintaining a high strength. To this day, the most widely used titanium alloy for aeronautics applications is the well-known TA6V (Ti-6Al-4V). However, this alloy exhibits low damage resistance and work hardening capacity. In recent years, a new deformation mechanism has been discovered in some α+β alloys : Reorientation Induced Plasticity (RIP). Once a martensitic phase has been formed by quenching, this mechanism can be activated by applying stress to the material. It results in a considerable increase in work hardening through the reorientation of specific martensitic variants. To this end, novel alloys, optimized for RIP, have to be designed to achieve a controlled and effective RIP effect at the microscopic level.

Novel alloy development is one of the core research axes of 4MAT laboratory, investigated using a "high-throughput" strategy : maximizing the number of tested new alloys compositions whilst minimizing the number of tests and associated samples. To this end, the use of additive manufacturing techniques, notably Laser Metal Deposition (LMD) is favored, as being rapid and enabling the production of samples with a composition gradient using various metal powders. Within this framework, it is possible to investigate the activation of RIP and its effects on the mechanical properties of a large panel of compositions in one sample.

This Master's thesis follows two main lines of inquiry :

1. Suitable compositions enabling RIP activation will be identified, using predictive tools, among which the CALPHAD (CALculation of Phase Diagrams) method plays a keyrole.
2. The various compositions will then be tested on gradient samples, produced by LMD, and will be studied using different characterization techniques, notably microhardness testing and scanning electron microscopy (SEM) with different scanning techniques (EDX and EBSD).

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Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Investigating the applicability of green solvents in Liquid chromatography (LC)

Program : Chemical & Materials engineering - M-IRMAE

Description

Liquid chromatography (LC) is a vital analytical technique widely used in various fields, including biotechnology, for separating, identifying, and quantifying components in complex mixtures. Its ability to handle a diverse range of samples—from small molecules to large biomolecules—makes it indispensable for quality control, drug development, and protein analysis. In biotechnology, LC plays a crucial role in monitoring the purity of biologics, identifying impurities, and ensuring product consistency, thereby supporting research and development and regulatory compliance.

The most commonly used LC separation technique, i.e. reversed phase LC (RPLC), uses water as the main component of the mobile phase, but requires an organic co-solvent to tune retention and selectivity. This reliance on organic solvents results in a substantial environmental impact, with an estimated annual global solvent consumption of approximately 150,000 metric tons for RPLC alone. The most frequently used co-solvent in RPLC is acetonitrile, which poses significant environmental and health concerns.

To reduce the environmental impact of HPLC, several strategies have been proposed, such as the use of narrow-bore or capillary columns and the replacement of conventional organic modifiers with greener alternatives. In recent years, ethanol was the primary choice of green co-solvent due to its low toxicity, biodegradability, and potential for production from renewable resources. However, its relatively high viscosity leads to reduced separation performance, increased back pressures, and consequently limits the achievable analysis speed.

Recently, dimethyl carbonate (DMC) has emerged as a potential alternative co-solvent due to its relatively low viscosity, green character, and high elution strength [2]. Nevertheless, its limited miscibility with water restricts its direct application in LC. A possible solution to this is the use of mixtures of DMC with organic solvents to improve water miscibility while enabling fast and greener separation methods. Therefore, this study investigates the possibilities and limitations of using DMC-mixtures as a greener co-solvent for LC by examining all relevant chromatographic parameters and their effects on separation performance. In addition, elution strength is evaluated to quantify the potential reduction in solvent consumption, to quantify the overall improvement in method greenness, and its possibility to obtain unique separation selectivities compared to the traditional co-solvents.

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Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision

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Separation of ethane/ethene and propane/propene mixtures

Program : Chemical & Materials engineering - M-IRMAE

Description

Olefins such as ethene and propene as massively produced and used for the production of plastics. Before their use in the polymerisation reactor, olefins have to be separated from the paraffins which are also obtained in the production process. This separation between light olefins and paraffins of the same carbon number is industrially done via cryogenic distillation, which is extremely energy intensive given the small difference in boiling points. Olefin purification accounts for 0,3% of the global energy use. Any improvement in efficiency will have a large impact on energy consumption and global CO2-emissions. In this thesis, we will focus on the adsorptive separation of light olefins and paraffins. We recently discovered a Metallic Organic Framework (MOF) with exceptional separation capabilities, showing inverse selectivities for ethane/ethene and propane/propene mixtures. For ethane/ethene, the separation is driven by differences in thermodynamic affinity, while the separation of propane and propene is driven by diffusion effects in the ultra-narrow pores of the material.
In this thesis, the molecular transport of the molecules in the porous network of the MOF will be studied, which is crucial for the design of

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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AI-Driven Compuational Design Of Hetroatom-Doped Naps4-Yxy Electrolytes For Next-Generation Sodium Metal Batteries

Program : Chemical & Materials engineering - M-IRMAE

Description

As the global shift toward renewable energy accelerates, the development of sustainable, costeffective, and ultrahighperformance rechargeable batteries has become essential for enabling reliable largescale energy storage. Building on the moleculardynamics insights gained for heteroatomsubstituted $Na_3PS_3X_1$ solid electrolytes [1,2], the next phase of the modelling work will focus on expanding and deepening the exploration of heteroatom doping strategies that enhance electrolyte–sodium interfacial stability. Future efforts will employ higherfidelity neuralnetwork potentials trained on expanded abinitio datasets to accurately capture complex bonding environments and a broader chemical space. Systematic screening of single and codoped analogues will quantify how variations in dopant electronegativity, valence, and atomic radius influence decomposition pathways, defect formation mechanisms, and Na^+ transport. Advanced totaltrajectory analysis will be used to identify mechanistic descriptors linking dopant chemistry to interfacial reactivity. In parallel, simulations will investigate dopant clustering, site preference, and concentration effects on both bulk stability and electronic structure. These activities aim to establish predictive design rules for stabilizing the Sodium–electrolyte interface and to generate a ranked set of promising doped compositions for experimental validation, thereby accelerating the discovery of chemically robust solid electrolytes for nextgeneration solidstate sodium batteries.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	
Number of topics	2

Supervision

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Lien : https://doi.org/10.1021/acs.jpcc.3c02379; https://doi.org/10.1002/cssc.202300676

AI-Accelerated Design of Anderson-type Polyoxometalate Clusters for Low-Temperature CO$_2$ Hydrogenation to Methanol

Program : Chemical & Materials engineering - M-IRMAE

Description

This project is based on the recent work by Liu et. al., [1], and it deals with Anderson-type \ce{PtMo6O24} clusters for low-temperature \ce{CO2} hydrogenation, which focuses on the high-value conversion of carbon dioxide into methanol—a critical ``circular economy" objective for the oil and gas industry. Current industrial processes for methanol synthesis require high temperatures (>250\,°C) and pressures, leading to significant energy penalties and catalyst degradation; however, molecular clusters encapsulated in Metal-Organic Frameworks (MOFs) offer a pathway to high selectivity and stability under much milder conditions. The hypothesis of this thesis is that the electronic synergy between the central noble metal (Pt) and the surrounding transition metal ring (\ce{Mo6}) creates unique oxygen vacancies that facilitate a ``non-classical'' \ce{CO2} activation mechanism, which can be further optimized by tuning the metal composition to break traditional scaling relationships. By replacing Pt or Mo with earth-abundant alternatives (e.g., Ni, Fe, or W), we aim to identify the specific electronic descriptors—such as the d-band center and vacancy formation energy—that dictate whether the reaction follows the efficient Reverse Water-Gas Shift (RWGS+CO) pathway or the slower formate (HCOO*) route.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

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Mitigating Irreversible Side Reactions in Furan-Maleimide Thermoreversible Polymers Using Natural Antioxidants and Various Maleimide Linker Structures

Program : Chemical & Materials engineering - M-IRMAE

Description

Furan-maleimide networks utilize reversible Diels-Alder reactions for self-healing and reprocessability. However, irreversible maleimide homopolymerization and oxidation cause brittleness and loss of reversibility. Unlike fossil-fuel-derived industrial inhibitors, natural antioxidants—such as catechin and gallic acid—offer sustainable, biocompatible alternatives to scavenge radicals and preserve network reversibility. Alternatively, incorporating electron-withdrawing substituents into the maleimide linker can suppress radical polymerization, offering a structural strategy to enhance network reversibility.

The objective is to evaluate natural inhibitors and varied maleimide linker structures in suppressing irreversible side reactions, validating the most effective combinations through comprehensive recyclability testing. The experimental workflow below will be followed to achieve this objective.

1. Thermal & Kinetic Analysis: Assessment of individual maleimide linkers and inhibitor mixtures via TGA, isothermal/non-isothermal DSC (for kinetic modeling), and molecular characterization (NMR, FTIR, UV/vis).
2. Polymer Synthesis: The most stable linkers and effective inhibitors will be implemented into self-synthesized furan-maleimide model networks, followed by molecular and thermal analysis.
3. Recyclability Testing: The reprocessing performance is evaluated through rheometry and thermomechanical testing over repeated heat cycles, benchmarking against uninhibited or commonly used industrial inhibitors (Irganox) or standard-linker controls.
4. Optional Novel Linkers: If resources permit, new N-acylmaleimide or N-phenylmaleimide linkers will be synthesized and implemented in the optimized experimental workflow above (steps 1–3).

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

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Development of suitable composite adsorbents for direct air capture and investigation of different regeneration strategies

Program : Chemical & Materials engineering - M-IRMAE

Description

Capturing carbon dioxide directly from the atmosphere, also known as direct air capture (DAC), holds immense promise in mitigating climate change by reducing CO2 levels in the atmosphere. However, the process of separating CO2 from ambient air presents significant challenges. Separating CO2 from air requires energy-intensive methods due to the relatively low concentration of CO2 in the atmosphere (400 ppm). Traditional DAC systems often rely on sorbents that demand substantial amounts of energy, contributing to high operational costs and limited scalability. In this thesis, we aim to address these challenges by exploring innovative approaches for improving the efficiency of DAC systems, particularly focusing on material development and regeneration methods using steam or electrified processes.
We will investigate the transformation of microporous adsorbent powders into more complex structured configurations. Through innovative shaping techniques such as extrusion, we aim to engineer tailored geometries (monoliths or laminates) that further enhance CO2 capture efficiency (improved heat and mass transfer). Furthermore, we will explore the integration of steam or electrified regeneration methods into DAC systems to enhance their energy efficiency and reduce overall carbon emissions. Steam regeneration, for instance, involves using heat from steam to release captured CO2 from sorbents, while electrified methods transform electrical energy into thermal energy to drive the desorption process. Through experimental studies and possibly modelling simulations, we will evaluate the performance and scalability of these regeneration approaches in DAC systems. In our lab, there is a dedicated experimental setup specifically designed for DAC studies, enabling precise measurement of low concentrations of CO2. Moreover, this setup facilitates investigation into the impact of humidity on CO2 adsorption, as higher levels of humidity are anticipated to enhance CO2 uptake efficiency.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	2

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Enhancing Hydrochar Quality Derived from Seafood Waste via Co-Carbonization with Glucose and Fruit Waste: A Comparative Study

Program : Chemical & Materials engineering - M-IRMAE

Description

Improving the carbon content and surface functionality of hydrochar remains a key challenge in hydrothermal carbonization, particularly when using mineral-rich marine biomass such as lobster shell waste. Co-carbonization with additional carbon-rich precursors offers a promising strategy to enhance hydrochar properties. This project aims to investigate the effect of adding glucose and fruit waste as co-precursors during microwave-assisted hydrothermal carbonization of lobster shell biomass. The study will compare the influence of pure glucose addition versus natural fruit waste (e.g., citrus or apple residues) on hydrochar yield, carbon content, and surface chemistry. A design-of-experiments approach will be used to optimize process parameters, including temperature, residence time, and additive concentration. The resulting hydrochars will be characterized using CHNS analysis, FTIR spectroscopy, and proximate analysis to assess elemental composition and functional groups. The study will evaluate how different co-carbonization strategies influence hydrochar quality, particularly in terms of carbon enrichment and functionalization. The findings will provide insights into sustainable strategies for upgrading hydrochar properties using low-cost organic additives.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

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A new way to think Oxide Dispersion Strengthened alloys through in-situ precipitation : application to titanium.

Program : Chemical & Materials engineering - M-IRMAE

Description

Nowadays, titanium alloys designed for aeronautic, aerospace or nuclear applications are constantly evolving. Thanks to their attractive compromise between mechanical properties and density, such materials represent a great hope for replacing heavier tungsten or nickel-based alloys in aircraft reactor conception. However, mechanical properties of titanium alloys such as yield strength or creep resistance tend to sharply decrease at higher temperature. Thus, for applications in extreme conditions (above 500 °C), a strengthening method must be developed.

Dispersing oxide nanoparticles into titanium alloys microstructure has tremendous potential. Primarily developed in the ferritic steel industry for nuclear application, ODS (Oxide Dispersion Strengthening) methods have demonstrated noteworthy durability improvements compared to conventional ones. Indeed, interactions between dislocations and particles grant to the resulting material outstanding helium swelling and creep resistances. The latter property is the reason for which transposition from ferritic steels to titanium alloys is of interest.

Historically, the synthesis of ODS materials is done by mechanical alloying : powders of oxide precursors (Y2O3, TiO2) are ball milled along with atomized metallic matrix. After numerous shocks, oxides are incorporated into the matrix and form Y-Ti-O nanoclusters. The powder as produced then undergoes a shaping step (hot extrusion or hot isostatic pressing) to obtain an industrially viable material. Although such materials show irrefutable creep resistance improvements, lacks of chemical or size homogeneity between nanoparticles remain a crucial concern, often leading to early fracture.

Better control on nanoparticles formation can be acquired by making them precipitate directly within the microstructure. This phenomenon occurs during the solidification step in the production process of the Ti-4.5Zr-0.6O-0.6Y alloy. Indeed, after adding a fine powder (~500 µm ⌀) of metallic yttrium to a Ti-Zr-O melt, numerous micrometric Y-Zr-O complex oxides appear throughout the titanium matrix.

This Master's Thesis focuses on determining how to disperse yttrium-based complex oxide particles efficiently in a Ti-Zr-O matrix through classical metallurgy thermomechanical treatments (hot/cold rolling, annealing ...). Microstructural and chemical analysis will be carried out by SEM/EDXS. Tensile tests and microhardness measurements will provide the first insights into the mechanical properties. The understanding of precipitation mechanisms will be completed by a CALPHAD (CALculation of PHAse Diagrams) simulation step using the Thermo-Calc software.

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Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

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Development of corrosion protective coatings on additively manufactured aluminium alloy

Program : Chemical & Materials engineering - M-IRMAE

Description

Over the last decade, the quick evolution of Metal additive manufacturing (MAM), or metallic 3D printing, has become a fact. This technology enables the production of complex-shaped metallic components with minimal material waste and superior energy efficiency compared to conventional processing methods. Among the materials processed by MAM, Aluminium alloys are particularly interesting due to their low density and suitable mechanical properties, making them highly attractive in the transport industry. Nevertheless, the microstructural properties and corrosion behaviour of this group of alloys processed by MAM remain unknown.

To this end, this project will focus on (i) the microstructural and electrochemical analysis of an Al alloy processed by MAM and (ii) the investigation of electrochemical surface treatments to enhance its corrosion protection. By achieving these goals, the student will gain a deep understanding of the corrosion phenomena in this alloy and identify the most suitable electrochemical surface treatments, drawing on both literature and experimental research.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

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Delivery of anticancer peptides combined to mild-photothermal therapy for improved cancer treatment.

Program : Chemical & Materials engineering - M-IRMAE

Description

Today, cancer is one of the leading causes of death. Current treatments involve mostly chimio- and radiotherapies but they lack specificity and cause damages to healthy tissues. Anticancer peptides (ACPs) are short polycationic peptide sequences, typically produced by microorganisms, that have anticancer properties via membrane disruption, pore formation or metabolisms disfunction. The efficiency of ACPs can be enhanced when combined to mild photothermal therapy (PTT) using plasmonic nanomaterials. Mild PTT (<45°C) is safer for healthy tissues than traditional PTT (>60°C). Combining ACPs delivery and mild PTT could thus be a promising strategy for specific and safe cancer treatments. Cancer cells overexpress various biomolecules such as enzymes. This dysfunction in their metabolism can be used for targeted therapy.

The goal of this project is to use plasmonic nanomaterials (gold nanorods and/or silver nanoplates) decorated with ACPs for cancer treatments. Gold nanorods and silver nanoplates have absorption in the near-infrared region (700 nm-950 nm) and can thus be used as thermal transducer in vivo. We have developed specific surface modifications of these nanomaterials that allow precise control over the conjugation with peptides. Also, we want to use ACPs that are enzyme-responsive to increase the specificity of the peptide release.

Functionalized gold nanorods and silver nanoplates will be synthesized and then conjugated to ACPs. Various ACPs will be investigated as well as the modification of the nanomaterials with targeting peptides to enhance their selectivity. For every combination of ACPs and targeting peptides, the materials will be characterized using a wide variety of techniques such as UV-Vis, IR, TEM, DLS, … The capacity to release the ACPs form the material surface in the presence of enzyme will be systematically investigated. Promising materials in term of thermal conversion, peptide delivery and colloidal stability will be used in the cytotoxicity study on colorectal cancer and glioblastoma cell lines.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	2

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Leveraging artificial intelligence and evolution to design new biocatalysts

Program : Chemical & Materials engineering - M-IRMAE

Description

In this project, we leverage recent advances in artificial intelligence to redesign enzymes with improved activity and stability for polymer degradation. In particular, we focus on different enzyme subclasses, such as PETases and PLAases, involved in the breakdown of plastic polymers.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Tuning the rheological behaviour of reversible polymer networks for extrusion-based (additive) manufacturing

Program : Chemical & Materials engineering - M-IRMAE

Description

Thermoreversible polymer networks combine the best properties of chemically crosslinked networks with the reprocessability of thermoplastics. This thesis tests the hypothesis that thermosets, elastomers and their composites can be recycled, while having nearly the same mechanical properties as the conventional irreversibly crosslinked networks. The thermally reversible polymer networks generally dissociate into small molecules at elevated temperatures, resulting in a very low viscosity for processing. This is a great advantage for certain moulding processes. However, for extrusion-based processing a higher melt viscosity is desired. The solution consists of designing the prepolymers and polymer network architectures to achieve the rheological behaviour required for extrusion-based manufacturing, including 3D printing. The novel reversible polymer networks developed during this master thesis in the FYSC lab will be processed at the CPMT lab of UGent and are prospected to solve multiple challenges in the collaboration with the BruBotics research center for advanced processing and manufacturing of self-healing (soft) robotic actuators and flexible electronics.

Objective:
Monomers and prepolymers will be developed with different architectures, molecular weights and functionalities. The relations between their structures and the polymer network structures and resulting properties will be unravelled and these relations will be used to optimize the extrudability of reversible polymer networks for 3D printing applications. The work is an extension of and will leverage the already existing knowledge of Diels-Alder-based reversible polymer networks at the FYSC lab.

Methods:
Higher molecular weight monomers and prepolymers will be developed and characterized:
* Monomers will be prepolymerized into linear polymers with target molecular weights, functionalities
* The synthesized monomers will be crosslinked with different crosslinkers and crosslinker contents to obtain a variety of mechanical and thermal properties
* The thermal, rheological and mechanical properties of the polymer networks will be determined
* The reversible polymer networks with the best rheological behaviour will be extruded at CPMT (UGent) and eventually be evaluated for 3D printing at Brubotics (VUB).

Prerequisite:
The student will be trained for spectroscopic and thermal analysis and modelling of the reaction kinetics and the assessment of mechanical properties and healing performance.
* Basic knowledge about polymer chemistry is a must
* Basic knowledge about reaction kinetics and thermodynamics is appreciated

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	2

Supervision

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Towards the next generation of bone replacement – Characterization of Additively-Manufactured Ti-Cu gradients

Program : Chemical & Materials engineering - M-IRMAE

Description

In the medical sector, Titanium (Ti) alloys have been the optimal choice for bone replacements, due to their high strength, low density, excellent corrosion and biocompatibility. Currently, most titanium implants are either commercially pure Titanium (grade 2), or the ubiquitous Ti-6Al-4V for applications where mechanical properties are critical. Whilst both are considered biocompatible for use in bone replacing implants, neither offer any specific biological benefits, and Ti implants still face a high risk of bacterial infections during clinical surgery. Thus, the addition of new alloying elements to the Ti grade is currently investigated, to enhance the implants biological and antibacterial performances. Notably, studies have demonstrated that Copper (Cu) integration with Titanium, in relatively small quantities, can limit or eliminate bacterial colonisation on the surface. The alloy design to balance the Ti-Cu quantities is thus critical to optimise the microstructural, mechanical and antimicrobial properties of Ti-Cu implants [Rabbitt 2025]. In this regard, Additive Manufacturing via Laser Powder-Bed Fusion (PBF-LB) is a simple and rapid method to produce test alloy samples for alloy design. Moreover, recent novel deposition techniques have unlocked the potential to produce compositional gradients within a single PBF-LB specimen. By seeding bacteria along a compositionally graded Ti-Cu specimen, it is then possible to determine critical biological behaviour thresholds in a single experiment, rather than the more time-consuming and labour-intensive efforts to produce individual compositions.

This Master's Thesis lies in the frame of a starting collaboration between ULB-4MAT and the Centre for Custom Medical Devices from the University of Birmingham, exploring binary Ti-Cu gradients printed via PBF-LB. As a first approach, this Master's Thesis aims at characterizing the microstructure and mechanical properties of Ti-Cu gradients to understand the impact of Cu-addition and study the Ti-Cu interactions.

This Master's Thesis takes a major path of experimental works. The lab work will consist in conducting microstructure investigation via Scanning Electron Microscopy (SEM) and related SEM techniques (EDX, EBSD), as well as Transmission Electron Microscopy (TEM) for nano-scale investigation of potential intermetallics and second phases. Micro-hardness testing will also bring preliminary information on the mechanical behaviour of the Ti-Cu gradients.

Language	FR (français)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Process parameter optimization for 3D printing of Functionally Graded rocket nozzle through Directed Energy Deposition process.

Program : Chemical & Materials engineering - M-IRMAE

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

Rocket nozzles need FGMs to withstand extreme thermal and mechanical stresses by gradually transitioning from heat-resistant materials at the throat to tougher structural metals, improving durability, reducing thermal mismatch, and preventing failure. This is why rocket nozzles are manufactured with a graded transition from 316L or Inconel to copper as shown on Fig. 2-3.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October 2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and doesn't rely yet on the FGM technology.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. When printing FGMs, these parameters increase in number and must be actively tuned during the build as the material transitions from one type to another. The results of the manufacturing of the miniature FGM rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping, crack formation, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

The aim of this master thesis will be to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores, cracks, or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

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Mechanistic Study and Morphological Control of Electropolymerized PEDOT and PPy for High-Stability Quasi-Reference Electrodes

Program : Chemical & Materials engineering - M-IRMAE

Description

Conducting polymers, such as Polypyrrole (PPy) and Poly(3,4-ethylenedioxythiophene) (PEDOT), are highly promising candidates for solid-state Quasi-Reference Electrodes (QREs) due to their mixed ionic-electronic conductivity and chemical stability. However, the potentiometric stability of these electrodes is fundamentally linked to the morphology, adhesion, and oxidation state of the polymer film.

Currently, there is a significant gap in the literature regarding the controlled deposition of smooth, highly adherent PEDOT films on metallic substrates for reference electrode applications. Traditional Cyclic Voltammetry (CV) often results in rough, nodular ("cauliflower-like") morphologies that suffer from poor mechanical integrity and unpredictable voltage drift.

This project aims to systematically investigate the electro-polymerization kinetics of EDOT and Pyrrole monomers to understand and control their nucleation and growth mechanisms. The core objective is to transition from empirical "trial-and-error" deposition to a deterministic protocol that yields smooth, homogeneous, and electrochemically stable polymer films.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Versatile corrosion predictive models as the basis for digital twin and surrogate model development

Program : Chemical & Materials engineering - M-IRMAE

Description

Corrosion control of metals and alloys is of high importance to prolongate their service life across diverse applications. Eventually, a complex coating system consisting of several (organic) coating layers is added to provide barrier corrosion protection. Additional corrosion inhibitors contribute to active corrosion protection. Dedicated evaluation of corrosion protective properties of these (active) corrosion protective layers is strictly necessary. While laboratory trial procedures and outdoor test programs are personnel and time intensive and accelerated corrosion tests can lead to limited service performance information, predictive modelling of the durability and lifetime of (coated) metal alloys under (long-term) environmental corrosion can provide a promising alternative. These predictive models constitute an important first step towards more complex and accurate predictive deterministic and/or hybrid models, allowing the development of surrogate models and digital twins to aid material and coating design.
This thesis aims to build on previously developed finite element corrosion models, by implementation of extra, relevant corrosion features as well as by varying the underlying corrosion system (for example change of alloy or coating variation), as a starting point for the development of versatile digital twins and surrogate models, ready to be used in industrial applications at higher TRL. The development of these models and applications will be coupled to experimental data generation for model parametrization and validation.

[1] Meeusen, M. et al., Progress in Organic Coatings 182, 107710 (2023).
[2] Abdelrahman, N. et al., Corrosion Science 250, 112861 (2025).

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

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Modeling and simulation of a brewing fermentation process

Program : Chemical & Materials engineering - M-IRMAE

Description

This thesis will focus on developing a beer fermentation process simulator using Matlab software. This simulator will use a library of several dynamic models published in the scientific literature. The models will be selected to reproduce the temporal profiles of concentrations of the following key components: yeast, sugars, ethanol, CO2, VDK (vicinal diketones), etc. The effects of temperature and pH will also be considered. Several models have already been pre-selected, and others may be added.

The state variables will differ from one model to another, depending on its level of complexity (for example, the distinction between sugars as glucose, maltose, and maltotriose, or the distinction between yeast in the lag phase, active, and dead).

Some generic models, i.e., not specifically developed for a brewing fermentation process but easily adaptable to this type of process, will also be considered. Depending on the availability of experimental results (obtained at ULB and/or in collaboration with UMONS), an estimation of the parameters of certain models in the library will be performed to reproduce the available data rather than those published in the corresponding article.

Such a simulator could later be used to develop and test optimization, control, or state observation tools.

This project is part of the launch of the university brewery Beer in Mind, founded by Stéphane Bruyneels and Denys Van Elewyck.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Mitigation of chromium release in high-temperature heat exchangers via alumina-forming Ni-Based Alloys

Program : Chemical & Materials engineering - M-IRMAE

Description

Stainless steels are widely used in high-temperature heat exchanger (HT-HEX) systems due to their excellent properties. However, under operating conditions (T > 600 °C, moisture and oxygen), they release toxic Cr(VI) species. This release leads to corrosion issues, electrochemical degradation of fuel cell and electrolyzer stacks, and potential pre-contamination during the initial HT-HEX welding. To develop Cr-free HT-HEXs, this project will focus on the microstructural analysis of different materials and surface treatments. Also, the project will be developed between Bosal Group and Vrije Universiteit Brussel (VUB).

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Plasmonic nanoparticles inside PNIPAM hydrogel for light-driven soft actuators using femtosecond laser writing

Program : Chemical & Materials engineering - M-IRMAE

Description

Context: Soft matter can serve as an actuator in microrobotics by deforming under external stimuli (light, heat, or pH…) and producing mechanical outputs like force or displacement. At the microscale, these smart materials can be 3D printed without assembly. In our lab, we use two-photon polymerization (2PP) to fabricate soft actuators from a thermo-responsive pol-ymer, poly(N-isopropylacrylamide) (pNIPAM). This material swells below its lower critical solution temperature (LCST) by absorbing water and shrinks above the LCST by expelling it. Recently, we fabricated 50 µm × 50 µm × 50 µm active cubes capable of bending, contract-ing, twisting, or shearing in heated water [1]. To achieve precise, multidirectional motion control, multiple actuators could be combined and selectively triggered by different wave-lengths of light. This is possible by doping them with photothermal nanomaterials that lo-cally convert light into heat [2]. Metallic nanostructures like gold (Au) and silver (Ag) nano-particles or nanorods have been used to actuate PNIPAM-based hydrogels [3]. However, they are usually dispersed uniformly, preventing spatial control. An alternative approach uses a tightly focused femtosecond laser in a PNIPAM hydrogel swollen with silver nitrate, locally forming Ag nanoparticles by multiphoton reduction [4]. Applying this method to our actuators would enable spatially selective nanoparticle patterning, allowing localized, pre-cise activation.

Objective: The aim of this thesis is 3D print photosensitive nanoparticles inside PNIPAM hydrogels with the 2PP machine. After printing, light will be used to illuminate the actuators and will be converted into heat by the nanoparticles. The generated heat will trigger actuator mo-tion by shrinking the hydrogel.

Methods: Literature review. Hydrogel fabrication (with 2PP printing). Printing of Ag/Au nanoparti-cles i.e., tune the printing parameters to obtain nanoparticles and optimize the actuation. Characterization: UV absorbance spectra, SEM imaging, and measuring the light respon-siveness of the structures.

Prerequisites: Materials (to develop the fabrication process and understand the behavior of the hydrogels with and without nanoparticles).

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

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Lien : https://plambert.ulb.be/wp-content/uploads/2026/03/2026-03-31_LAMBERT.pdf

Representation Learning for Polymer Cure: Building a Low Dimensional Embedding of Network Evolution

Program : Chemical & Materials engineering - M-IRMAE

Description

Context

The behaviour of a curing polymer network is governed by a combination of monomer chemistry, reaction progression, and the evolving topology of the macromolecular structure. Today, no compact set of descriptors exists that can capture this evolution across different chemistries and curing paths, which limits both prediction and design of thermoset materials. Recent advances in data driven modelling provide a new opportunity: instead of imposing predefined descriptors, one can learn a reduced "state" directly from physically consistent simulations of network formation.

Objective

This master thesis aims to develop and analyse a low dimensional embedding (feature vector) that captures the essential features of curing polymer networks. The embedding will be learned from large, synthetic datasets generated by simplified, physically consistent polymerization models. The emphasis is on discovering interpretable patterns and identifying the conditions under which different curing histories converge to similar states.

Expected work

- Generate a synthetic dataset of curing trajectories using provided tools (conversion histories + evolving structural descriptors).
- Construct descriptors of monomer chemistry using group contribution theory and cohesive interaction parameters.
- Train a self supervised model to learn a compact embedding that jointly represents chemistry, conversion and network topology.
- Analyse the embedding for physical meaning, robustness and invariance across stoichiometry, functionality and cure paths.
- Identify when different curing trajectories collapse onto similar states, and where the limits of state reduction appear.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS
Number of topics	1

Supervision

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Engineering Nitrogen-Enriched Hydrochar from Seafood Waste Using Microwave-Assisted Hydrothermal Carbonization

Program : Chemical & Materials engineering - M-IRMAE

Description

The valorization of seafood-processing waste into functional materials presents a valuable chance to advance circular bioeconomy initiatives. Waste such as lobster shells, which contain abundant organic carbon, proteins, and minerals, functions effectively as feedstock for hydrothermal carbonization (HTC). HTC is a thermochemical method that converts moist biomass directly into carbon-rich hydrochar without requiring drying beforehand. This project aims to systematically investigate the production of hydrochar from seafood waste using microwave-assisted hydrothermal carbonization (MHTC) and to establish relationships between processing conditions and material properties. The study will employ a design-of-experiments approach to evaluate the influence of key parameters, including temperature, residence time, and solid-to-water ratio, on hydrochar yield, composition, and physicochemical characteristics. In addition to process optimization, the project will explore the impact of targeted modification strategies, including nitrogen doping via urea and acid treatment for mineral removal. These modifications are expected to influence the elemental composition and surface functionality of the hydrochar, thereby affecting its potential applications. The produced materials will be characterized using CHNS elemental analysis, FTIR spectroscopy, and proximate analysis to determine ash composition. Measurements of pH and electrical conductivity will provide further insight into surface chemistry. The project will focus on understanding how process parameters and modification strategies influence hydrochar structure and composition. The results will provide fundamental knowledge on tailoring hydrochar properties from marine biomass and will contribute to the development of optimized production strategies for sustainable carbon materials.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

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Evaluation of the electrochemical behavior and surface evolution of stainless steels for alkaline electrolysis bipolar plates

Program : Chemical & Materials engineering - M-IRMAE

Description

Alkaline Water electrolysis (AWE) is a mature and cost-effective technology for producing green hydrogen in large scale. The AWE electrolyzer is composed of a series of electrolysis cells stacked together. Each cell is composed by two bipolar plates and two electrodes (anode and cathode), which are in direct contact with a concentrated aqueous KOH solution. Upon the application of a constant current, the electrolyte is split into H_2 and O_2 in the cathode and anode, respectively. Currently, the AWE technology is of great interest to the stainless steel industry, since it could replace nickel based materials for the bipolar plates. In this project, four different stainless steel grades will be investigated to assess their electrochemical behavior and surface evolution when in contact with highly alkaline environments, aiming to correlate the stainless steel composition to its corrosion mechanisms and passivation behavior. Electrochemical tests (open circuit potential and cyclic voltammetry) will be conducted during different immersion periods. Surface characterization will be performed prior and after electrochemical tests using techniques available at the Core Facility "Materials Characterization" of VUB, including Scanning Electron Microscopy (SEM) X-ray Photoelectron Spectroscopy (XPS) and Auger electron spectroscopy (AES). The results of this study will be included in a report for a collaborative project between VUB and APERAM S.A. and will contribute to a scientific publication. Candidates are expected to have a background in electrochemical methods, corrosion, and surface analysis techniques.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Lien :
https://www.aperam.com/sites/default/files/documents/Aperam_Hydrogen_Brochure_en.pdf

Carbon capture for waste incineration in Flanders

Program : Chemical & Materials engineering - M-IRMAE

Description

Waste incinerators are crucial components in waste handling. State-of-the-art installations have advanced energy recuperation (electricity generation, district heating network) and flue gas treatment (deNOx, filters, VOC removal, washing,...). Climate change has pushed forward a need for carbon capture and storage/utilization (CCS/CCU), and waste incinerators provide an interesting opportunity to deploy CCS/CCU technology. In collaboration with an industrial partner the goal is to study the feasibility and operation of an amine solvent carbon capture unit, via modelling and a techno-economic analysis (TEA). You will be supervised on the modelling (CHIS) and TEA (Brussels school of Governance) by a multidisciplinary team. A first model is available from a previous master thesis.

We are looking for a motivated candidate with process modelling affinity.
Don't hesitate to contact us to see if you want more information this topic matches your interests.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Nucleotide-peptide complex for the specific delivery of miRNA

Program : Chemical & Materials engineering - M-IRMAE

Description

MicroRNA have emerged has promising candidates for targeted therapy. They can interact with the cell metabolism and restore (or inhibits) the normal (or abnormal) function at the cellular level. The main challenge to deliver miRNA is the specificity of the distribution and the protection of the nucleotide from degradation by endogenous enzymes. Various strategies have been investigated to carry the nucleotide to the cells such as noble metal nanoparticles or lipidic vesicles, but they have either a poor body clearance or a high toxicity, respectively. Developing new strategies are thus highly necessary.
We have recently developed self-assembled peptide-nucleotide complexes. By using specific peptide sequence, we could produce stable RNA-peptide assembly with interesting optical properties. We want now to demonstrate its potential for miRNA delivery associated to optical imaging modalities. We want to engineer the peptide sequences to ensure appropriate targeting of the RNA delivery, and two applications are currently under investigation: cancer and Alzheimer's disease.
Students will investigate the assembly between peptides and nucleotides with various methods such as UV-Vis, emission, DLS, TEM, … Various sequences will be studied to understand the mechanism controlling the assembly. Particularly, isothermal calorimetry, that is an original technique for which the EMNS has a top-notch expertise, will be used to determine the affinity constants and the stoichiometry of the RNA-peptide assembly. When the optimal peptide sequence will be determined, studies on cells and animals will be carried out. The student will use an RNA carrying an infrared fluorophore for the tracking of the RNA delivery. The cell internalization will be investigated with confocal microscopy on cell cultures and the biodistribution will be studied by fluorescence imaging on murine model.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	2

Supervision

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Lien : https://emns.polytech.ulb.be/en/research/nanomaterials-1

Cationic Frontal Polymerization

Program : Chemical & Materials engineering - M-IRMAE

Description

Frontal polymerization (FP) is a process where an initial input of heat or UV-light at one area initiates a localized polymerization reaction zone that spontaneously propagates as a wave. The front is sustained by heat generated by the reaction, coupled with acceleration of the polymerization reaction at increased temperature. Since the reaction requires only one brief energy stimulus to propagate through the entirety of the resin, the process is much more energy efficient for curing materials compared to oven-cure methods. So far, FP has been investigated for use in composites manufacturing, coatings and adhesives, and 3D printing. This thesis will use radical-induced cationic FP, a growing subset of FP.
The factors which significantly affect FP are resin composition and boundary conditions. Considering this, the thesis includes the design of test setups to investigate the effects of surroundings, and investigation of different chemistries in cationic FP. The process will be monitored using thermocouples and visible/IR cameras to track the front position. Analysis of the materials after FP will be done using thermal, mechanical, and spectroscopic techniques. At the completion of the thesis, the student is expected to discuss how different variables affect cationic FP and the final material properties. If the student is interested in process modelling, the experimental findings can be used to improve an existing COMSOL model.
An example of the cationic FP process is seen in the attached video link, where the front is initiated from the left and travels to the right through a rectangular mold.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Mechanistic Study of Conversion Layer Formation on Galvanized Steel

Program : Chemical & Materials engineering - M-IRMAE

Description

Galvanized steel is extensively used in construction, automotive, and industrial applications due to its excellent corrosion resistance, mechanical strength, and cost-effectiveness, making it a critical material in modern engineering. To further extend its service life and functional performance, additional surface treatments are commonly applied to galvanized steel. Conversion treatment in zirconium-based solutions is an important surface modification technique for galvanized steel, as it enhances corrosion resistance and improves coating adhesion while offering an environmentally friendly alternative to traditional chromate systems [1, 2].

Understanding the mechanism of conversion layer formation, as well as the impact of solution additives such as organic and inorganic compounds on this mechanism, is crucial for optimizing the structure and performance of the resulting conversion film.

Studying the mechanism of conversion layer formation using conventional post-treatment (ex situ) characterization techniques is challenging, as these methods do not capture the dynamic processes occurring at the solid–liquid interface during film growth.

In this proposal, state-of-the-art operando odd random phase electrochemical impedance spectroscopy (ORP–EIS) will be applied during the conversion treatment to monitor the process in real time and to elucidate the formation mechanism and its dynamic evolution [2]. Moreover, complementary ex situ techniques, such as SEM, EDX, and XPS, will be employed to further elucidate the mechanism of conversion-layer formation.

M.Nabizadeh et al, Surface & Coatings Technology 441 (2022) 128567.
M.Dabiri Havigh et al, Corrosion Science 223 (2023) 111469.

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Low-environmental impact materials for articial coral reefs

Program : Chemical & Materials engineering - M-IRMAE

Description

Coral reefs are among world's most biodiverse ecosystems. Yet they are degrading due to several reasons like climate change. Artifical coral reefs can be constructed but the material the supports are made off is important for the success of the coral reef to survive over long term. The surface of the artificial coral reef for instance needs to have the right roughness for good adhesion. On the other hand, the production of artifical coral reefs (or at least their support) should have a very low environmental impact. Among others, non-traditional cements like alkali activated materials or carbonated materials are possible for making coral reef supports on large scale. In this thesis, an overview of possible materials for artifical coral reefs needs to be made. The possibilities of alkali activated materials or carbonated materials (like carbstone) will be investigated. This is a first project in this are for the research group and collaboration with other (international research groups in this area will be necessary)

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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Influence of the surface finishing on the pitting corrosion of low carbon steel in the context of the Belgian nuclear waste management program

Program : Chemical & Materials engineering - M-IRMAE

Description

Belgium's strategy for the disposal of high-level nuclear waste includes the development of an underground supercontainer designed to store waste canisters and safely isolate the radioactive material. The supercontainer is a multi-layered structure where the inner structure is a cylindrical carbon steel shell surrounded by a concrete layer. The temperature of the structure is expected to reach 100 °C upon insertion of the nuclear waste, and then gradually decrease over the course of the first thousand years. Simultaneously, the oxygen within the system is expected to become depleted over time, resulting in an anoxic environment. It is critically important to evaluate the corrosion behavior of carbon steel under conditions that mimic those within the supercontainer, in order to ensure the long-term safety of the structure. The objective of this project is to assess how different surface finishings influence the corrosion behavior of carbon steel in such conditions. Surface characterization of the samples will be carried out before and after corrosion tests using techniques available at the Core Facility "Materials Characterization" of VUB, including Scanning Electron Microscopy (SEM) and Auger electron spectroscopy (AES). Corrosion testing will be performed via linear sweep voltammetry, from which the pitting potential will be extracted and compared to a theoretical model describing the growth and breakdown of passive films on metal surfaces in oxidizing environments. The results of this study will be included in a report for a collaborative project between VUB and the Belgian National Agency for Radioactive Waste and will contribute to a scientific publication. Candidates are expected to have a background in electrochemical methods, corrosion, and surface analysis techniques.

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

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