IRT SAINT EXUPÉRY



Materials & Processes Platforms Offer

Our vision

Our strategy explained by our skills managers: a shared ambition to develop our skills and testing resources



Julien Munoz, Head of Composites and Coatings

The Organic Composites and Coatings team at IRT Saint Exupery develops, tests, validates and characterizes new lightweight and multifunctional materials from lab to pre-manufacturing. Our offer combines semi product elaboration (pellets, powder, 3D printing wire, Prepreg), process development (3D printing, AFP, Injection) and set up specific testing (characterization of the microstructure and properties of materials) with the development of new digital tools and methodologies to reduce design and qualification phases. To meet the challenges of weight and energy saving and support a composite value chain with lowest environmental impact, our research activities focus on the implementation of high-performance materials, the design of new composite architecture and the development of new materials and processes such as vitrimers or 3D printing/AFP hybridization. Thanks to our network of partners, we are working, for example, on the development of acoustic and vibration damping solutions using bio-sourced fillers in particular, or on the implementation of organic composites capable of withstanding temperatures of around 300°C. Finally, we work on multiphysics and multiscale modeling with the use of a specific approach based on the study of the relationship between materials properties and processes



Laurent Ferres, Head of Surface & Assembly and ceramic materials

At IRT Saint Exupéry site in Bordeaux, we systematically work in pairs with engineers and technicians to provide the best possible response to industrial needs. Thanks to our test center, we are able to add benefit across the entire value chain. We can anticipate future industrial needs by developing skills and technology roadmaps. We are working on high-temperature composites as part of our research projects, with materials that are even hotter and more resistant. Our surface treatment team in Bordeaux uses the needs of high-power and high-speed markets to back up future resources such as lasers and atmospheric plasma technologies with potential industrial transfer. Thanks to our unique resources and the strategic vision of our test center, we can assert our differentiation and continue to develop research, which is the heart of the engine.



Simon Perusin, Head of Metallic Materials and Processes

IRT Saint Exupéry focuses on the development and maturation of hot transformation processes for alloys used in aerospace and space industry, as well as in other industrial sectors. Additive manufacturing using wires and powders, as well as forging/forming processes, are at the heart of our research work.

This development involves ongoing research into the links between the parameters of the processes studied, the macro and microstructures inherited from these processes and the final properties obtained. All the staff at the IRT Saint Exupéry test center are involved, whether in defining experimental programs, operating manufacturing and heat treatment facilities, instrumenting these facilities and analyzing the resulting data, or characterizing the products manufactured. The team's strength lies in its ability to deal with research topics requiring multiple skills in design (choice of alloys and geometries), physical metallurgy, mechanics of materials and structures, forming processes, non-destructive and destructive testing, and digital tools for developing and monitoring processes.

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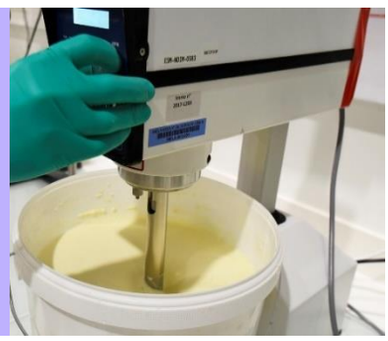
High Performance Organic Composite Elaboration

Develop on-demand your raw materials and prepregs

We develop and characterize customized raw materials and prepregs to improve organic composite performances and answer your needs.

Elaboration of aqueous polymer dispersion

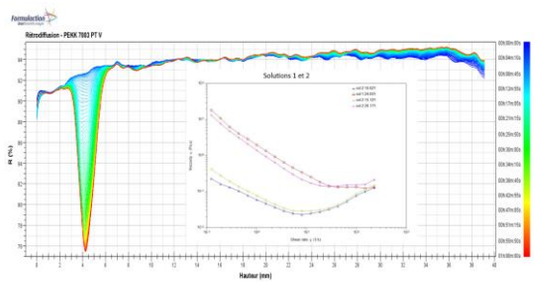
- Mechanical blender
- High speed mixer
- Characterization laboratory including:
  - Multiple Light Scattering (MLS) to analyse time stability of aqueous dispersion
  - Viscosimeter, pHmeter



“ We adapt the properties of the materials according to your requirements”

We prepare and characterize specific aqueous polymer dispersions and functionalized matrix from commercial or specific resins/fillers.

Then, we evaluate their processability for different application (prepregs, RTM, etc.).



Stability analysis of a PAEK dispersion



Twin-screw co-rotating extruder

- Co-rotating twin screws
- Heating temperature until 450°C
- Mass Flow rate: from 0.5 to 10 kg/h
- Volumetric feeders for powders and pellets
- Air cooling stand conveyor (1 m length)
- 3 feeding positions along the barrel

“ We functionalize resins by extrusion”

We produce it under different shapes (powder or pellets), with different kind of matrix, up to high performance matrix, melting at 400°C, such as PEAK matrix family.

Different fillers can be introduced in the chosen matrix like ceramic, organic fillers or short fibres according to the required expected performances.

Characterization means for raw materials:
Matrix characterization (DSC, TGA, rheology), fibre/matrix interfacial characterization (Pull Out).

High Performance Organic Composite Elaboration

Develop on-demand your raw materials and prepregs

Laboratory pilot: fibre sizing & tow impregnation

- Sizing or impregnation of technical fibres (HR/IM/HM, glass, aramid, natural fibre, …)
- Using thermoplastic and thermoset resins (PAEK, PA, bio-based resin, vitrimer and high temperature resin, …)
- Line speed up to 10 m/min
- Yarn tension control
- Modular units for impregnation and sizing
- Impregnation capability from 1 to 3 spools (sized or unsized)
- IR heating capacity
- Parallel and cross winding technologies



“Thanks to this versatile manufacturing pilot, we develop prepregs from any fibre/matrix couple with optimized key manufacturing process parameters”

The modular conception of the laboratory pilot allows to use both thermoplastics or reactive resins like thermoset. The small size of this pilot is a real advantage to support R&D programs as it allows to work with the minimum amount of material involved**.**



Example of a thermoset prepreg material



Semi-industrial pilot: impregnation line for thermoplastic prepregs

- Production of thermoplastic prepregs
- 20 spools (extensible to 80)
- Line speed up to 10 m/min
- Prepreg width up to 300 mm
- Different technologies of impregnation : slurry, dry powder, etc.
- IR heating capacity
- Compaction unit

This semi industrial scale pilot (around 20 m length) is dedicated to the production of thermoplastic prepreg materials.

“ We can manufacture unidirectional prepregs, but also specific reinforcement, like fabric or thin ply, thanks to a specific unwinding system”

The line is endowed with **different impregnation technologies** (slurry, dry, spray, etc.) which can be combined to produce prepregs on demand with tailored material architecture, enabling to optimize its processability for manufacturing process (AFP, Out of Autoclave consolidation, welding processes, etc.).

Full equipped laboratory to characterize prepregs and composites:
C-scan analysis, Differential Scanning Calorimetry, mechanical tests.

Composite Implementation

Develop and optimize manufacturing processes by a material approach

We invested on out of autoclave consolidation equipment to produce laminate materials from semi-products developed in our projects. Besides, we can support you in composite implementation process developments.

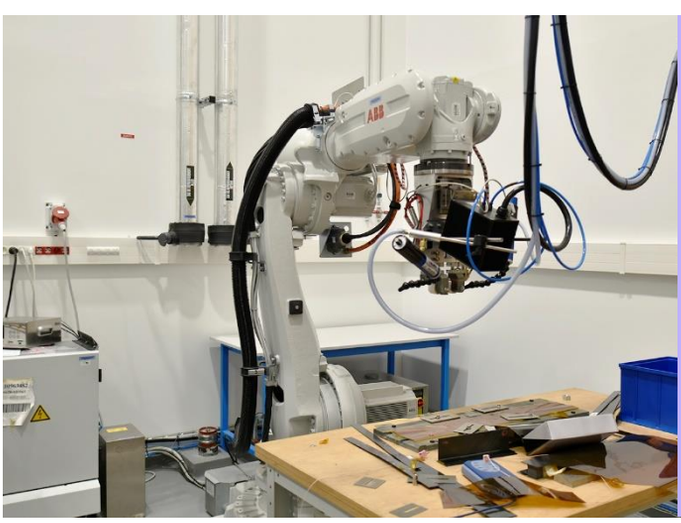
Organic composites consolidation

- Out off autoclave Consolidation
  - 2 high temperature ovens (1 m^3 & 0,4 m^3)
  - Tmax = 410°C
- Laboratory Press
  - 400°C /40 bars
  - 130x130 mm



“ We produce composite specimens and demonstrators with representative methods of industrial consolidation processes and then we characterise the performances of obtained laminate materials”

One of our added value is to **integrate in situ process monitoring and specific instrumentation** to give understanding and a capability to improve production processes, composite properties and reduce manufacturing cycle time.



Automated Thermoplastic induction welding

- 6-Axes robot
- CEIA 12 kW induction generator; working frequency 200 Hz
- Induction head designed in IRT Project including : induction coil, surface temperature pyrometer, compacting rolls (540 N load each), vortex type cooling nozzles

“ We study continuous and dynamic direct welding processes using strong multi-physical coupling such as magnetic, electrical, thermal, physical, and mechanical aspects”

With our expertise in composite functionalization, we can integrate tailored properties to adapt the material's behaviour during the process, which is a major enabler for optimizing composite welding processes.

Composite Implementation

Discover the future of High Performance Thermoplastic Processes

This joined platform with University Toulouse 3 (UT3) & Institute Clément Ader (ICA) is an automated multi-processing cell for thermoplastic composites, enabling the hybridization of several manufacturing technologies

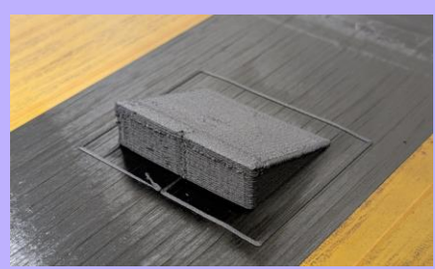
Coriolis CPico multi-processes platform :

- 6-axis robotic arm



- 3 interchangeable heads:
  - AFP (Automated Fibre Placement) process enables the production of high-performance composite parts using unidirectional prepregs reinforced with continuous, specifically oriented carbon fibres.





Hybridized AFP + Fab Add sample

  - FGF (pellet extrusion) for additive manufacturing process enables parts to be functionalized.



  - Renishaw (mould probing).



- Filament winding process using the rotating mandrel



“These processes and their hybridization enable us to meet the growing needs of cutting-edge industries to address high value-added applications and designs, while benefiting from the advantages of thermoplastic materials in terms of implementation and eco-design.”

Special features of this cell:

- Continuous reinforcement micro-wicking to achieve smaller material bending radii;
- Process hybridization/coupling;
- Part functionalization; for high-performance thermoplastic materials (PAEK, PEEK, PEKK, PEI, etc.).

Components:

- Robot Comao NJ130-2, 6 Axes
- Comao positioner (max 1000kg) infinite rotation
- HMI (Human Machine Interface)
- Coriolis CADFiber® & AM Software programming software
- 2 high temperature ovens (1 m3 & 0,4 m3)

3D printing:

- Printing nozzle diameter: 0.6 mm to 1.2 mm
- Heat source: air flashlight and cartridge heater (max. 500°C)

AFP process:

- Material: single-tap (width: 1 mm and 6.35 mm)
- Cutting and feed repeatability: ± 2.5 mm at 300 m/s
- Maximum speed: 300 mm/s
- Compaction force: 120 N
- Inter-ribbon deposit tolerance: +2.5/-0 mm
- Distance between cutting device and guide roller: 10 mm
- Minimum cutting distance: 37 mm
- Dynamic head compliance: ±5 mm
- Coil in creel with dry air overpressure
- Heating system: 300W laser
- Fiber tension up to 36N

Metallic Material Platforms

Assess Metallic Additive Manufacturing Technologies

Our platform provides timely and effective solutions aligned with customer needs to support the development of high quality & value-added structural components (e.g. tailored process monitoring with thermal or speed camera, identification of optimal process parameters for new alloys or specific composition, etc.)

Laser Metal Deposition – Powder (LMD-p)

- Nd:YAG 2kW LASER CW source
- **Unique powder mixing system (BeAMix®)**
- 2 vibrating and 3 rotating powder feeders
- High-performing argon purification
- 5-axis system (build vol. h600 x 400 x 400 mm)



“Thanks to highly versatile Directed Energy Deposition (DED) technologies, we can produce entire parts from powder and/or wire in inert atmosphere, operate localized repairs on damaged parts (for MRO market) with minimum impact on substrate’s mechanical properties”

IRT’s Additive Manufacturing platform is equipped with a unique powder mixing system (BeAMix®) in order to operate Functionally Graded Materials by LMD-p. We also offer full LASER beam analysis with a PM48/FM+ PRIMES power & focus monitor system.



Laser Metal Deposition – Wire (LMD-w)

- Nd:YAG 2kW LASER CW source
- **High accessibility COAXwire deposition head**
- Wire Ø from 0,8 to 1,2mm
- High-performing argon purification
- 5-axis system (build vol. h600*400*400 mm)

Through our R&D projects, we have developed partnerships that enable us to call on other additive manufacturing technologies to answer your needs

Metallic Material Platforms

Improve Closed-die forging/ hot forging

This joint platform with Aubert&Duval is a strategic tool for supporting the French forging industry faced with strong international competition.

- Development of disruptive forging and closed-die-forging ranges for the manufacture of primary aeronautical parts in TA6V titanium alloy.
- Hot-forging and closed-die-forging of raw materials from various sources (standard, PAM billets, pre-blanks from additive manufacturing, pre-blanks from hybrid processes).
- Forging and closed die-forging operations on a pre-industrial scale, enabling rapid technology transfer of the results.

Semi automatic handling system

- Capability to sustain temperature up to 1260°C
- Transfer of metallic parts from furnace to press in less than 10s
- Handling part up to 500mm length and 150 kg

Forging press

- Max load 1000t for metallic parts of 30kg f300mm and height 50mm
- Speed:
  - ✓ Max 20mm/s up to 300t +/-10%
  - ✓ Max 10mm/s between [300t-1000t] +/-10%
  - ✓ Min 0,01mm/s between [0-300t] +/- 10%
- Capability to maintain static load without displacement at +/-5% of the target value
- Automatic moden driving by load or displacement





Current developments are severely limited by the lack of flexibility of the facilities available to manufacturers, which are essentially devoted to production activities and have very high capacity (high operating costs per hour).

- Development of very high added-value hot metal alloy transformation routes that break with current standards.
- Development of transformation routes for alloys under development using limited volumes of material compared with a production tool
- Support to validate more predictive modelling of the hot behaviour of alloys (rheology, phase transformations, recrystallization, etc.), thanks to accurate monitoring of the process
- Exploration of processes hybridisation to manufacture aeronautical parts such as forging preforms produced by additive manufacturing

Ceramic Matrix Composite

Elaborate & Functionalize Ceramic matrix / Produce Composite Semi-product

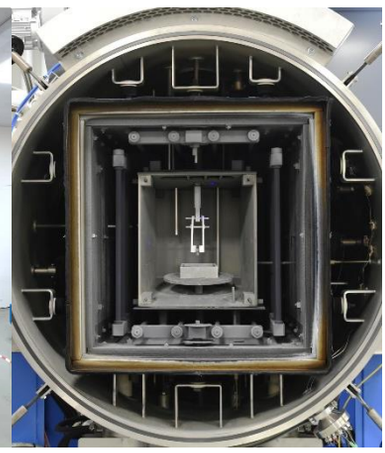
Our aim is to develop upscalable processes at market cost and demonstrate feasibility of disruptive technologies – Technological challenges tackled are linked to:

- Design of parts assisted by models
- Raw materials control
- Process control and KPI identification
- Industrialization with efficiency optimization at same costs, conception and set-up of industrial equipment and associated process control means

Slurry Cast & Melt infiltration for Non-Oxides

- Automated preparation of functionalized suspensions
- Multi objects/molds injection in press under up to 10 bars @ 1,500 cc/min
- Melt infiltration of Fibrous preforms at up to 1,600°C in our 90L furnace, controlled atmosphere with real time, In situ visualization of treated parts





Several collaborative projects led with key industrials players in France are targeted at developing Oxide/Oxide Ceramic Matrix Composites (CMC) or SiC/SiC CMC.

Key tools and process lines were designed and set-up in our lab as:

- dedicated moulds for engine parts for aeronautics,
- injection moulding press and Melt Infiltration Furnace,
- an impregnation line for tow-preg is also being developed, dedicated at Oxide/Oxide CMC for Automated Fibre Placement (AFP).



Impregnation Platform for Oxides

- Design, Preparation and Control of adapted slurries for tow-preg impregnation
- Impregnation speed 0.1-10 m/min
- Tension 5-50 N
- Thermal desizing up to 580°C
- Bath or kiss roll
- Up to **6 roving assembly** for a 50mm band width

Lines fully instrumented for process control and instrumentation continuously developed – Automation of data processing in progress.

Composite and Sandwiches POC

Elaborate Composite and/or sandwiches
Develop complex characterization means

Our aim is to develop upscalable processes at market cost and demonstrate feasibility of disruptive technologies – Technological challenges tackled are linked to:

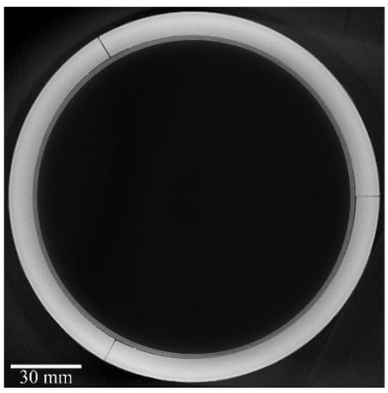
- Design of parts assisted by models
- Raw materials control
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Large scale manufacturing processes

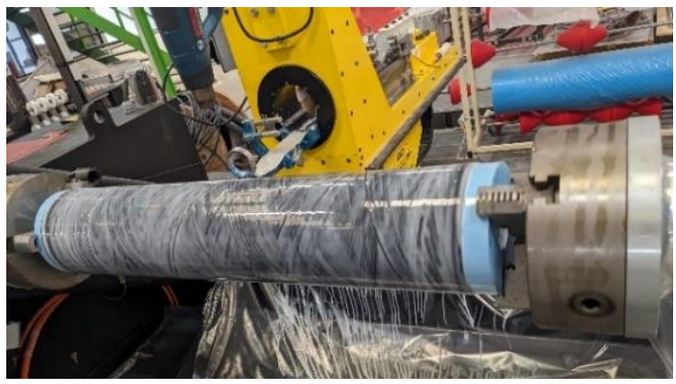
2D parts manufacturing through autoclave curing
- up to 10 bars @ 430°C (suitable for PEEK and Polyimide composites)

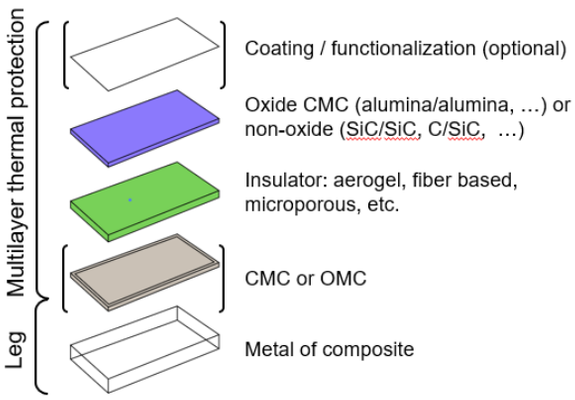
1D parts manufacturing
- Through Automated fiber placement
- Through Filament winding (coming soon, for the moment: subcontracting with our partners!)











Manufacturing of your proof of concept

- From design and manufacturing to Non Destructive Testing (NDT)
- Sandwiches manufacturing:

➔ Skin can range form OMC to CMC
➔ Core materials from ceramics to honeycomb and insulators

Surface & Assembly Platforms

Functionalize Surfaces, develop high performances coatings & Assembly

We can master the entire process chain to optimize coatings and functionalize surfaces to answer your needs and applications

To maximize the results of our studies, our developments tackle the following steps:

Surface Preparation

- Atmospheric pressure plasma
- Laser
- Sandblasting
- Sanding

Elaboration – Formulation

- Sol-gel
- Adhesives
- Paints, varnishes, inks
- Micro-Arc Oxidation

Application:

- Manual Application (labscale)
- Automated Application with a 6-axis robot (industrial level) and Paint Booth
- Automated Assembly & Bonding

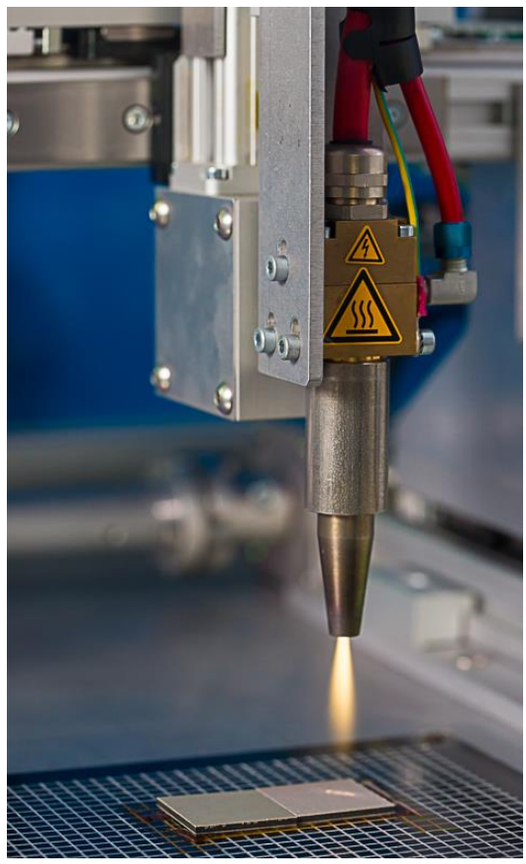
Drying – Sintering

- Oven – up to 300°C
- Furnace – up to 1300°C
- UV and IR radiation

Characterisations from lab tests to in service conditions tests

Thanks to our facilities and expertise, we address a wide range of surface properties:

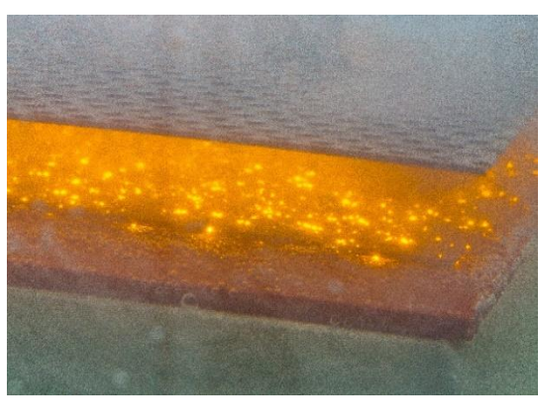
- **Anticorrosion**
- **Anti-erosion**
- **Anti- / de-icing**
- **Fire / thermal protection**
- **Printed electrics**
- **Bonding / Assembly**



Plasma activation



Automated paint application



Micro-Arc oxidation

“Dry” Surface Preparation

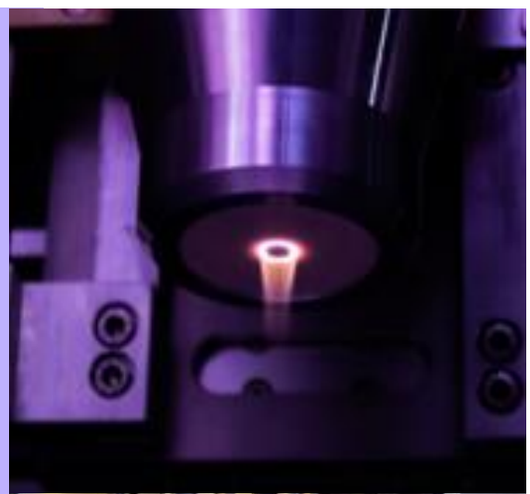
Functionalize surfaces to enhance wettability, bonding or durability

Laser and plasma technologies enables the surface preparation of any kind of materials, without HSE hazard and high cost processes

Plasma Treatment:

2 machines to adress large panel of materials:

- AcXys: High power plasma activation, for surface tension activation, perfectly suitable for OMC and polymers. ➔ **Robotisable!**
- Molecular Plasma Group: Deposition of precursor, suitable for any kind of materials, from elastomers to metals.



Nano-second Laser Treatment:

2 kind of lasers:

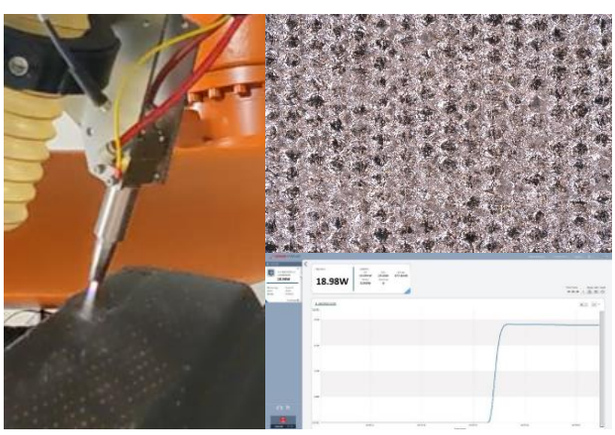
- Ultraviolet (UV) laser: for surface preparation of OMC, polymers and elastomers
- Infrared (IR) laser: for surface preparation of metals, ceramics and ceramic matrix composites (CMC)

2 machines:

- A cabin, suitable for 2.5D treatement: laser head move on X,Y axis, Z axis is monitored through a Varioscan (up to XXmm)
- A 6 axis Kuka robot for complex shape parts, perfectly suitable for high TRL demonstration (only 100W IR laser)



Thanks to our facilities and expertise, we manage the whole process, from optimum parameter definition, to proof of concept manufacturing!



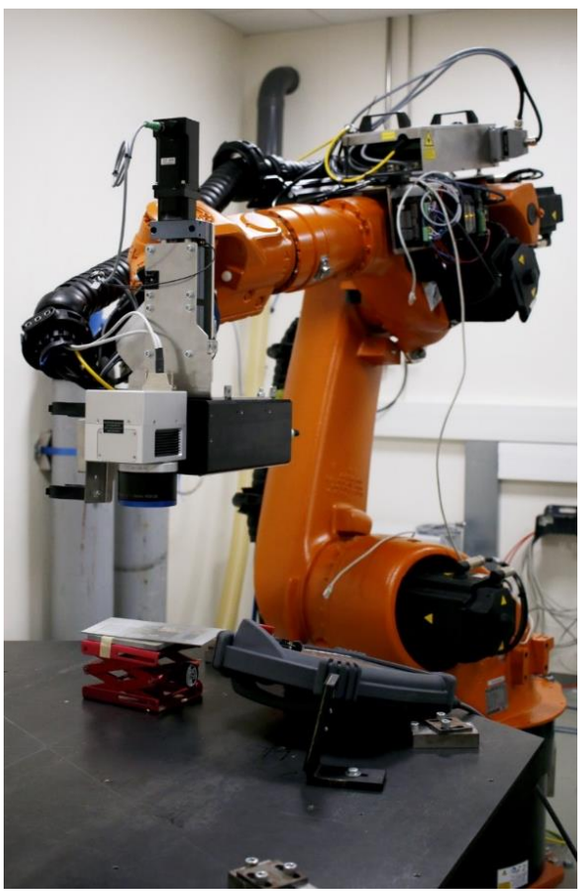
Our skills to achieve these challenges:

- Mechanical characterization
- Physical and chemical analysis
- Multi-physical numerical simulation
- Online NDT: from AI based picture analysis to spectroscopy and plasma characterization

Automated Assembly Platform

Bring innovating surface treatments from « 2D » to high Technological Readiness Level for industrial complex parts

We develop our own skills on programming poly-articulated 6 axis robot. Through this platform, we can address large scale technological limitation for our pre-bonding surface treatment processes. After addressing process technological limitation on simple parts, industrial pilot is set up according to industrial environment and constraints.



Multiple treatments for a multi-instrumented device

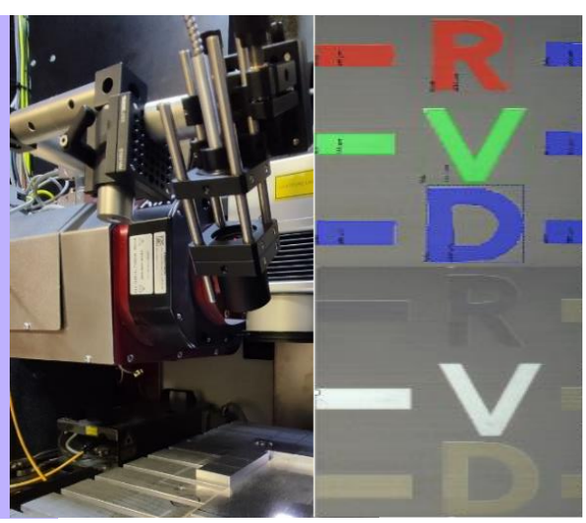
- Laser treatment – 100 W IR source
- Atmospheric plasma treatment
- Automated paste dispensing
- 2 axis support plate to work on large parts
- 3D scanner for automated part location identification

With ten years of development of dry processed surface treatment, we acquired strong skills in identifying and defining optimum parameters depending on the substrate and paste. We monitor process through AI assisted experimental plan, conducting single lap shear experiments for each significant parameter.

“ We are working on sensitivity of the process to deviation from optima and to different contaminants”

On-line monitoring

- Artificial Intelligence assisted image processing to identify poor treatment.
- **Proprietary** apparatus to **automatically**:
  - Identify contaminants on the substrate
  - Adjust lens position to remain in a **+/- 0.5 mm** distance from the surface even in presence of defects and/or part deformation during the process (**patented**)
  - Detect defocus
- Fully automated defect correction (on target areas)



Bonding Processes Platform

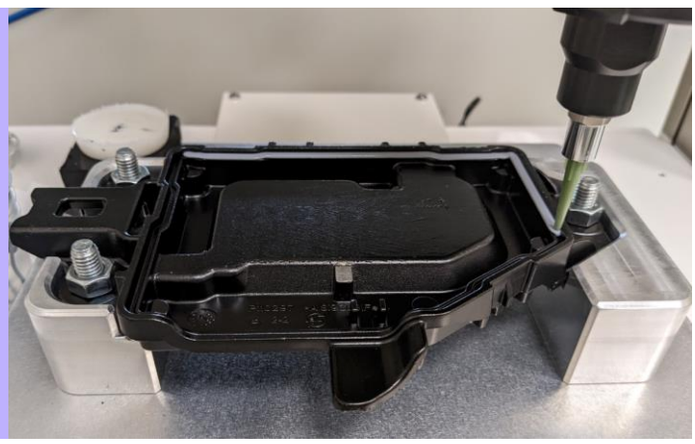
Since 2014, we are working on the development of robust bonding processes
So the question is not: “how to do it?” but “what we do next?”!

Tooling definition and design

➔ Development of specific tools for our partners use case

Process optimization

➔ Bonding process: mixing, deposition, …



Adhesive Characterization

- Differential Scanning Calorimetry
- Viscosity Monitoring
- Thermal Conductivity (LFA)

Bonding Characterization

- Mechanical characterization
- Optical Analysis (through Keyence, MEB, …)
- Thermal Aging
- Surface energy measurement (Goniometer)

How to recycle bonded materials? What to do if the assembly process went wrong and the parts have to be saved?
➔ Simply debond them!



Through different types of triggers

Thermal: Dismantling occurs when exposed to heat.
Electrical: Dismantling occurs when exposed to a current.

- Additive added to our partners adhesives
- Dedicated dismantling platforms IRT SE

Printed Electronics Platform

Add electrical and electronic functions on 3D complex surfaces

We develop the full process from 2D rapid prototyping (concept) to complex 3D implementation (demonstrator) for printing electronics or electrical functions on high added value parts. We propose different technologies enabling to cover a wide range of print resolution and performances.

3-axis robots for 2D prototyping

- High precision 3-axis Cartesian table:
  - X*Y*Z: 1,000*1,000*300 mm
  - Max speed : 250 mm/s
- CNC Router for rapid prototyping
  - X*Y*Z: 420*690*200 mm
  - Repeatability: 0.01mm / Max speed: 100 mm/s



After the first step of 2D prototyping necessary to define optimized printing parameters (speed, frequency, distance to substrate, etc.) to achieve the right performance in terms of pattern resolution and conductive or dielectric properties, the technology can be scaled-up to the real 3D part following these **4 main steps:**





6-axis robot

- Repeatability: 0.01mm / Load: 7 kg / Radius: 911mm
- Options : DCS (Dual Safety Check), DPM (Dynamic Path modification)
- Vision : HD Camera 8mm / 3D Scan / Profilometer
- Embedded Sintering and Polymerization equipment : N-IR focused lamp, UV lamp

Available printing heads are multimaterials: depending on rheological properties, **conductive inks**, **polymers** and other **functional materials** can be printed to build on-demand multilayer functional architectures.

	Spray	Inkjet	Aerosol	Aerojet (jetting)	Micro-extrusion
Drop size	10-200µm	3-5µm	10-50 µm	50-200 µm	-
Min accuracy	>mm	Dot/line ~ 10µm Pitch < 20µm (Substrate dependent)	Down to 20µm	Dot/line: 100-150µm Pitch: 100µm	Line: 150µm Pitch < 50µm (Substrate dependent)
Metal particle content	< 5%vol	< 50% vol	< 50% vol	Up to 85% vol	Up to 85% vol
Pattern	Surfaces	Surfaces / lines	Lines /dots	Lines /dots	Lines/dots

Surface Characterisation Platforms

We are equipped with all the characterization means to be able to down selects best surface technologies regarding customer specific requirements, up to the pre-qualification by performing standard tests.

Our added value is to design and perform representative tests to estimate in addition the reliability of developed solutions

Screening laboratory tests

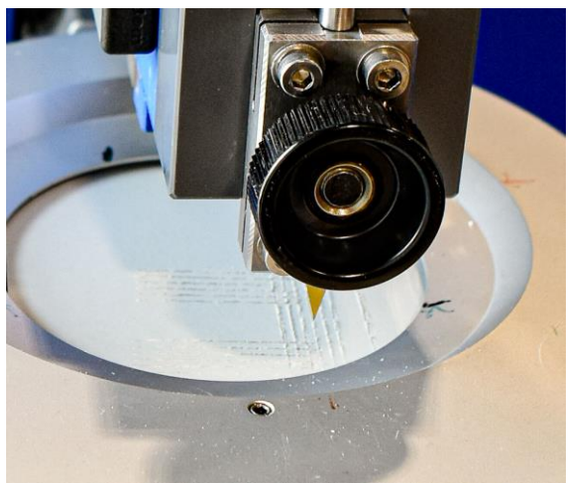
Thickness: Eddy current, microscopy
- Adhesion: Cross-cut, scratch test, pull-off test
- Impact
- Roughness
- Goniometer
- Fluid susceptibility
- Salt Spray according to EN ISO 9227

In service conditions tests

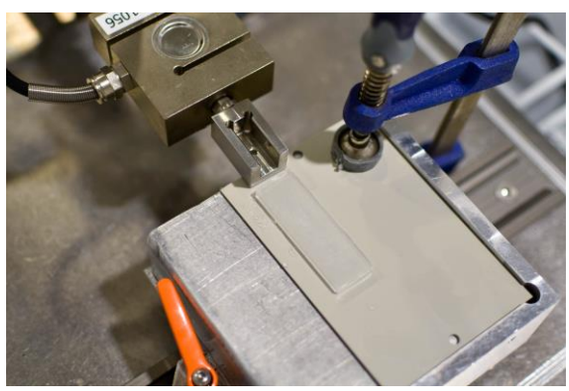
- Sand erosion ASTM D968
- Taber test
- Humid abrasimeter
- Pusher test – ice adhesion measurement
- Dynamic ice accretion – Cold chamber

In service conditions tests: focus on STORM (rotating arm tests)

- Accelerated aging test to preform coating screening:
  - Coating durability vs Rain erosion
  - Centrifuge ice adhesion test
- Speed up to 230 m/s
- Highly representative to in flight conditions

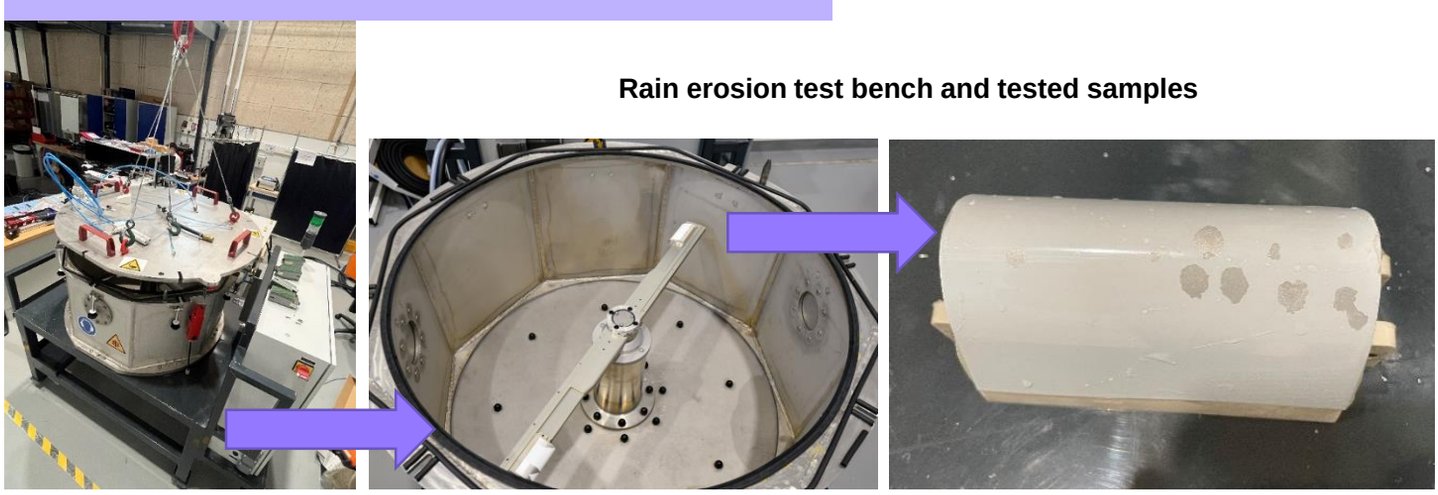


Crosscut test



Ice adhesion measurement

Rain erosion test bench and tested samples



Material Analysis

Investigate the microstructure of your samples in high resolution

We are equipped with a microscopy laboratory addressing the characterisation of multi-materials within the field of metal additive manufacturing, composites materials and electronic devices.

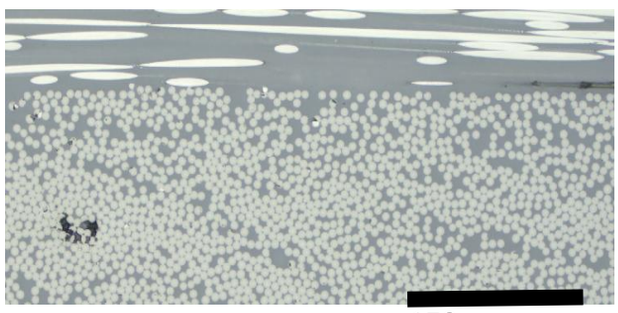
Scanning Electron Microscopy

- Accelerating Voltage: 500 V – 20 kV
- Secondary electron and Backscattered modes
- Motorized X-Y stage
- Resolution down to 4 nm at 20 kV
- Energy Dispersive X-ray Spectroscopy (EDS-X)
- Magnification from x8 to x100.000

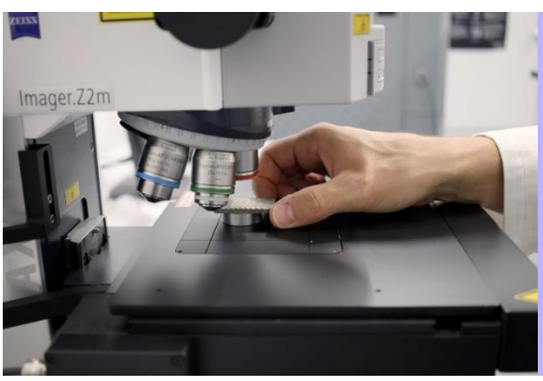


Microscopy imaging techniques are powerful tools to precisely explore the main features of your specimen's microstructures. **From classical optical microscopy to very accurate surface analysis using confocal microscopes**, we provide a complete scope of characterisations. If higher resolutions are required, our **Scanning Electron Microscope** provides detailed images in **the submicron range, as well as chemical maps** of the different material phases using EDS-X measurements.

The quality of your materials regarding mechanical resistance can also be tested using micro hardness tester.



150 µm



Optical characterizations

- Inverted Optical Microscope (Zeiss Axio Oberver)
- Confocal Microscope (Zeiss LSM 800)
- Automated Digital Microscope (Keyence VHX 7000)

In addition to our microscopy services the complete sample preparation phase is operated in our lab: polishing machines and precise micro-cutting devices are available on demand.

Non Destructive Testing

Evaluate the integrity of your materials

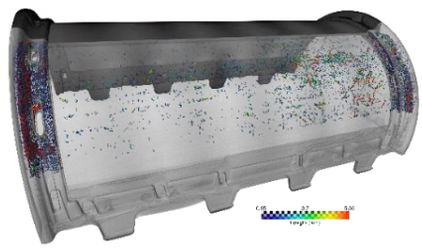
The Non Destructive Test (NDT) department provides a full control of the internal defects of your specimens without destroying them. Our laboratory is equipped with two main techniques able to cover a wide range of materials and geometries. X-ray tomography is used to precisely inspect in 3D the locations and geometries of defects such as pores, cracks or inclusions in very complex parts. Immersion Ultrasonic Testing allows a direct access to large defects (0.5 mm– 1 mm range) for flat specimens such as carbon fibre prepreg composites.

X-ray Microtomography (XRM)

- X-ray tube voltage: 20 - 230 kV
- Spatial resolution down to 2 µm
- Ability to scan complete parts of a maximum size of 300 mm (Ø) x 600 mm (H)
- Up to 20 kg on the rotation stage
- Image Processing using Avizo for Industrial Inspection
- *In situ* tests (tensile and compression up to 8 kN, thermomechanical tests in the range of 25 – 900 °C)



In the field of non-destructive tests, the interest of XRM for the inspection of parts is largely growing in the Industry. The method can be used at different steps during the manufacturing process, helping to **identify critical defects and understand their impact** on the final properties of the material. XRM is particularly **suited for complex inspections of materials** by providing a complete 3D map of local density variations.



“ In situ testing on dedicated samples can also be performed by applying a specific constrain (mechanical, thermal or both) during the scan.”



Immersion Ultrasonic testing

- Olympus Omniscan SX with A-Scan / C-scan mode
- Multi-elements probe 5 MHz
- Immersion tank: 980 mm x 980 mm x 300 mm
- Maximum sample size: 900 mm x 900 mm

We are conducting projects combining NDT methods and characterization techniques such as mechanical testing or microscopy imaging to provide a full map of the material properties.

Mechanical Testing

Characterize and understand the mechanical behavior of materials under stress

We perform and develop mechanical tests following the technical standards recommendations. The methods are selected according to the specificity of the materials and customers need.

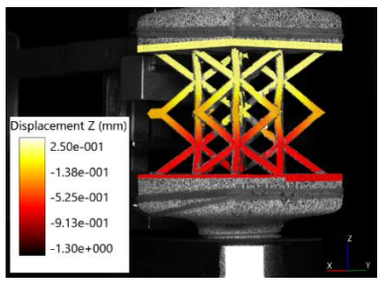
Dynamic Materials Test Machine

- Maximum load capacity: 100 kN
- Frequency up to 50 Hz
- Thermomechanical tests in the range of 0°C - 950°C
- 5 kN and 100 kN load cells



Our laboratory dedicated to mechanical testing provides data information **helping to understand the mechanical behaviour of materials** during the test. The high versatility of the control software allows to **create non standard method** depending on the requirements in terms of acquisition data, specific closed loop control or monitoring during the test. Iterations between tomography, microscopy observations and mechanical testing can be performed all along the campaign, allowing a better understanding of the final results.

Furthermore, contact or contact-less measurements such as **fast imaging** or **stereocorrelation** are regularly performed on multi-materials, as well as multi-physics tests (thermal testing, multi-scale testing, etc.).



Displacement measurement via image correlation



Static Materials Test Machine

- Maximum load capacity: 100 kN
- 5 kN and 100 kN load cells

	Tensile	HCF/LCF	Bending (3-4 point)	K1c / FCGT	ILSS	Compression
Test type	Static	Dynamic	Static / Dynamic	Static / Dynamic	Static	Static
Specimens geometrie	Flat / Cylindrical	Flat / Cylindrical / Lattice	Flat	CT	Flat	Pawn / Lattice
Specimens material	Metal / Composite	Metal / Composite	Metal / Composite	Metal	Composite	Metal / Composite
Test control	Displacement / Strain / Load	Load / Strain	Displacement / Load / Strain	Load / Stress intensity	Displacement	Displacement
Test signal	Ramp	Sinus / Dwell / Triangle	Sinus / Dwell / Triangle	Sinus / Dwell	Ramp	Ramp
Additional equipement	Extensometer / DIC / Temperature	Extensometer / DIC / Temperature	LVDT/ DIC	Extensometer / DCPD / DIC / Temperature	DIC	DIC
Equivalent standards	NF EN 2002-001 / ASTM E8	ASTM E466 / E606	NF EN ISO 14125	ASTM E399 / E647	ISO 14130	ASTM E9
High temperature	✓	✓				

Physico-Chemical & Thermal Analysis

Characterize and understand the key properties of your materials for process optimization

We are equipped with the required thermal analysis and physico-chemical characterization equipment to determine the characteristics of the resins and fibres to be implemented. It allows also to fine-tune the key manufacturing process parameters and the final material properties (prepregs, laminates)

Differential Scanning Calorimetry (DSC)

- Temperature range: from -90°C to 600 °C
- Modulated Differential Scanning Calorimetry (MDSC)
- Reaction kinetics
- Cp measurement
- Enthalpy accuracy: 0.1 %
- Temperature accuracy: 0.1°C



The ATG provides information on the degradation temperatures of resins (thermoplastics, thermosets or vitrimers). It is associated with DSC to determine the crystallinity rate, the cross-linking percentage or the Tg∞. **Carbon fibre composites as well as bio-based materials are analysed in our laboratory.**



Thermogravimetric Analysis (ATG)

- Room temperature at 1200°C
- Heating rate of 500°C/min
- High Resolution ATG
- Modulated ATG
- Volatile analysis possible with optional crucible piercing prior to analysis
- 25-position sample changer

"Our different equipment associated with thermal analysis tests enable to determine the optimised manufacturing process parameters of the composites."

Laser Flash Analyzer (LFA)

- Temperature range: from -100°C to 500 °C
- Target temperature controlled to +/- 2°C
- Thermal diffusivity analysis leading to thermal conductivity with Cp and density
- Non-conductive sample (e.g. polymer resin) to conductive sample (e.g. aluminum)
- 25.4mm diameter round sample or 20x20mm square sample



Additional instrumentation: Fourier Transform Infrared spectroscopy (FTIR), Diffusivimeter, etc.

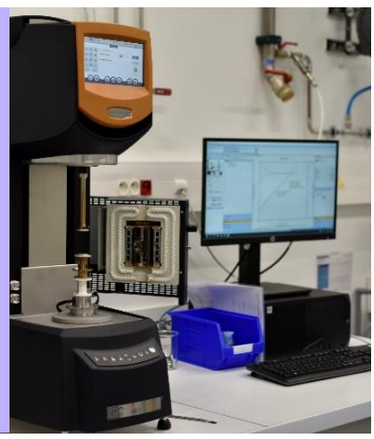
Physico-Chemical & Thermal Analysis

Characterize and understand the key properties of your materials for process optimization



DMA / Rheometer

- Temperature range: -85°C to 600°C
- Frequency range: 10^{-7} Hz to 100 Hz
- Axial force 50 N and displacement of 100 µm
- Flexural, tensile, compressive geometries



The rheometer is used to **measure the viscosity of resins, their processing window, and their characteristics** (Young's modulus, Coulomb modulus) under different mechanical stresses (bending, torsion, traction) and temperatures in order to better **understand their behavior** during their processing phase.



Pull-out

- Semi automatic testing
- Fiber traction
- 400°C oven
- Thermoplastic and Thermoset resins
- Adjustable setting speed and depth
- Controlled heating and cooling speed

The pull-out is a complementary device to characterisation tests on composite materials.

“ We can characterize single fibres linked in a resin drop to study the interaction of fibre/matrix couples”

The pull-out analysis is done in 3 steps:

- characterisation of the fibre (tensile test, measure of fibre diameter, etc.)
- creation of the sample (automatic system to chain the fibre into the drop)
- characterisation of the fibre/matrix interactions in order to obtain the decohesive stress.

Studies and implementation of analysis methods adapted to all types of materials: PEKK, PEEK, Thermosets, vitrimers, bio-based materials.

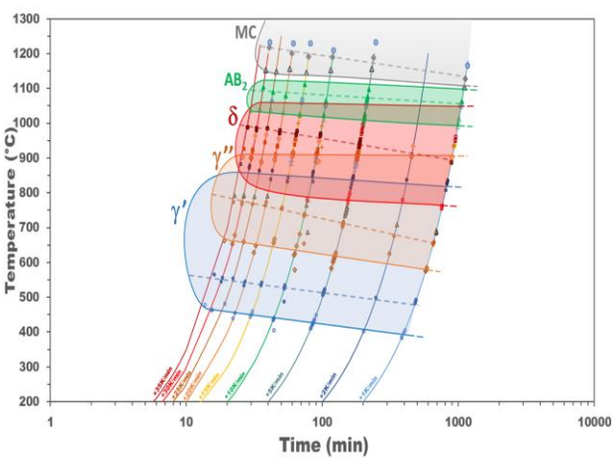
Physico-Chemical & Thermal Analysis

Characterize and understand the key properties of your materials for process optimization

DTA (Differential thermal analysis)

- Ambiant temperature to 1,600 °C
- Reaction kinetics
- Atmosphere: vacuum, Ar
- Usual heating rates: 0 to 30°C/min
- Measured signal: µV or mW





"Thermal analyzes results can provide understanding on materials transformation according to the temperature. By knowing such physical characteristics, it can be anticipated to develop specific treatments and learn on limitation and fields of use of final parts."



DILATOMETERS

Left: Horizontal, sample up to 52 mm length x 12 mm diam. (8 mm if dual channels) and 1,600 °C
Measuring range +/-10mm

Right: Vertical, differential, sample up to 25 mm length x 5 mm diam. and 1,500°C
Measuring range +/-5 mm

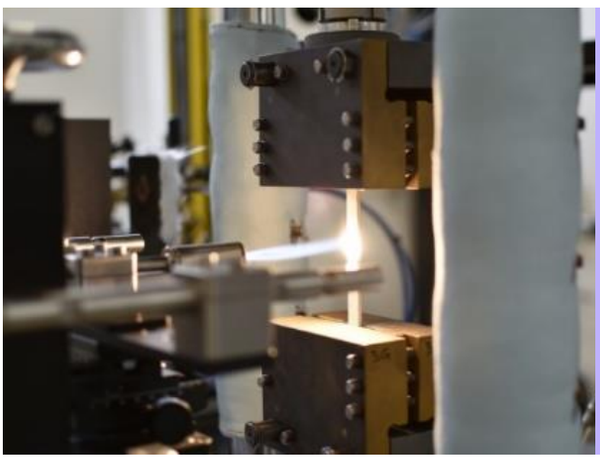
Common: Atmosphere: vacuum, Ar, N, air
DL resolution 1 nm



Additional instrumentation: Fourier Transform Infrared spectroscopy (FTIR), Diffusivimeter…

Thermomechanical Bench & Fire protection

Versatile device for very fast and accurate multi-material screening

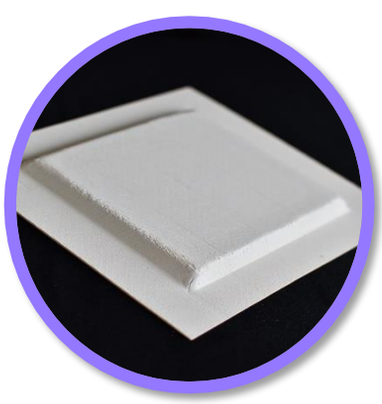


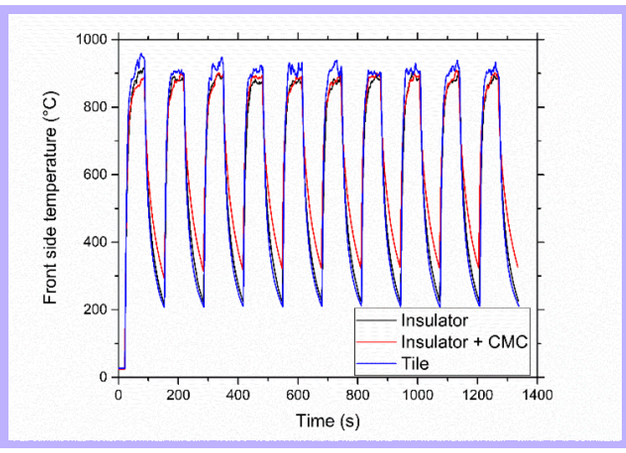
A unique thermo-mechanical characterization bench

- Exposure to controlled flame up to 1,800°C
- Traction/Compression up to 25 kN – cycled up to 5 Hz
- Thermal gradient management along sample thickness
- Controlled cooling
- Multi-instruments: FLIR Cameras, Pyrometers, thermocouples + multiple developments in progress
- Multiple tests can be achieved in one day

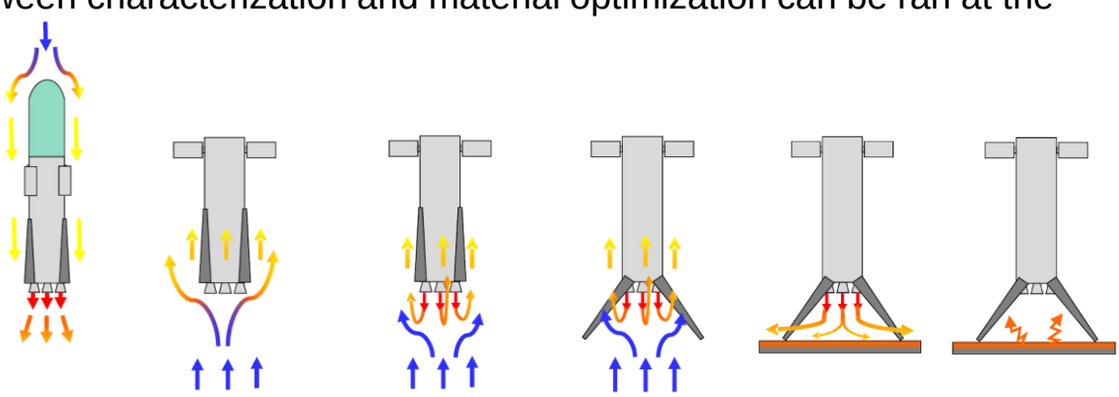
Flame and heat resistance are know key parameter to fulfil tomorrow aerospace challenges. On our platforms, we:

- Proceed to material screenings, under various solicitation, from H2 representative flame to near engine environment – to be ready to pass certification at affordable costs!
- Propose and set up solutions to protect materials, from fire resistant coatings to ceramic composite sandwich insulators





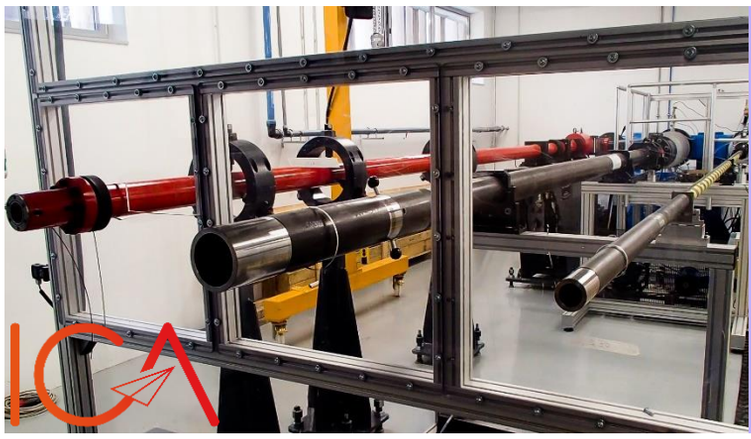
Iteration between characterization and material optimization can be ran at the same time.



Non-Standard Test Benches

Innovative and unconventional platforms adapted to your requirements

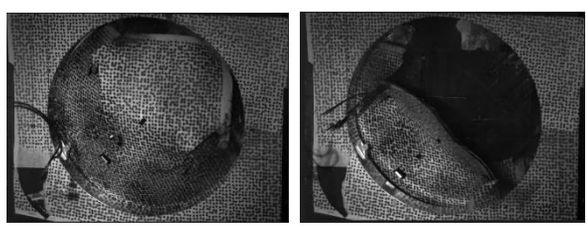
From BirdStrike high speed impact to acoustic performances evaluations, we offer several ways to push the limits of material characterizations.



STIMPACT Platform

- 3 gas launchers
- Impact velocity: from 50 to 800 m/s
- Projectile mass: from 10 g to 1.8 kg
- Target size : from 0.1 to 1 m
- High speed cameras for Digital Image Correlation and impact monitoring

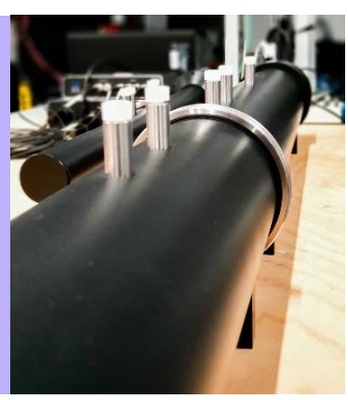
This equipment developed in collaboration with Institut Clément Ader (ICA) is fully dedicated to impact testing. We are able to address most of the impact load cases encountered in the aeronautics and transport fields. High strain rate response of structural materials can be studied helping in the development of new technological solutions.

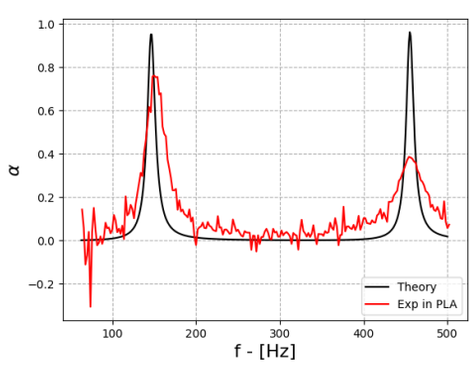


Impact monitoring of gelatine composite

Kundt's Tube

- Measurement following ISO 10534 standard
- Frequency band: 63 - 6300 Hz
- Absorption and insulation with the 2 & 4 microphones method
- Samples size: 30 and 100 mm diameter
- Materials: wools, foams, polymers, meta materials





The Kundt's tube is used to evaluate the acoustic performance of materials and structures by using small samples (between 30 mm and 100 mm). Insulation (Sound Transmission Loss) and absorption coefficient (Alpha) can be extracted, allowing to confirm the acoustic models with a fast iteration between theory and experimental results in the 63 to 6300 Hz frequency band.

Thermal Treatment & Aging Platforms

Thermal treatment & Aging

Heat treatments and aging platform offers solutions for the execution of a large set of thermal cycles specifications, often required for high quality & value-added materials.

All these processes applied on composite, metallic parts and surface coating allow us to ensure the continuity, control and improvement of post treatments chains between the advanced manufacturing products already developed at IRT Saint Exupéry and their analyzes.

Hot Isostatic Press

- Post-treatment consolidation
- Up to 2,000 bars and 1,400°C
- Rapid cooling with URQ™ technology (Uniform Rapid Quenching)
- **Gas analyzer**



Our Hot Isostatic Compaction has been updated with a gas analyzer, developed as part of the HIPPOME project. This gas analyzer can measure concentrations of impurities such as oxygen, hydrogen, nitrogen, water vapor and methane, up to levels of hundreds of ppb (parts per billion).

These precise measurements of the treatment atmosphere will help to improve the surface condition of parts after an HIP cycle.
« We are the only research institute to use this direct gas analysis technique on this type of equipment. »





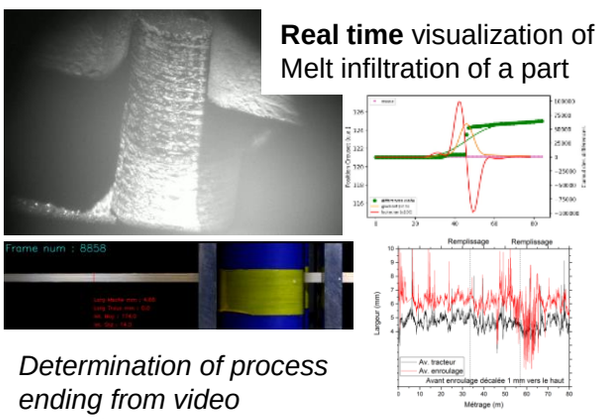
Aging and Heat treatments of composite, metallic and surface application samples

- Ovens, muffle furnaces and forced convection furnace
- Up to 1,600°C
- Temperature acquisition by thermocouples positioned within the load
- Treatment under inert atmosphere by gaz flowing up to 650°C

Multidisciplinary and digital platforms

Artificial Intelligence for Material processing

From Online Non Destructive Testing to tomorrow standalone manufacturing lines, we bring Data Science to (y)our platforms!



Real time visualization of Melt infiltration of a part

Determination of process ending from video recordings

Non-destructive controls & AI

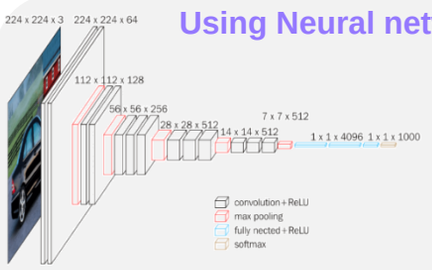
- Real time– automated image analysis using **Artificial Intelligence** Algorithms
- **Process monitoring** for associated composites production lines
- High level analysis techniques such as X-ray tomography could lead to consistent inputs for **digital twin** elaboration / **health diagnosis** tools for manufacturing processes

Thanks to our **multi-disciplinary teams**, we are able to develop algorithms for the **monitoring** of both our testing devices and our **manufacturing lines**.
➔ No equivalent in France and Europe!

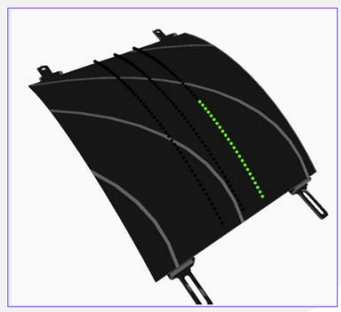
The aim is to get tools for process **optimization** and industrialization of time-consuming **Non destructive controls** means.

➔ We are working on turning industrial machines to **fully standalone** devices, it could be set up on yours!

Using Neural network training



GPU training
SoW establishment
for HMI upgrade



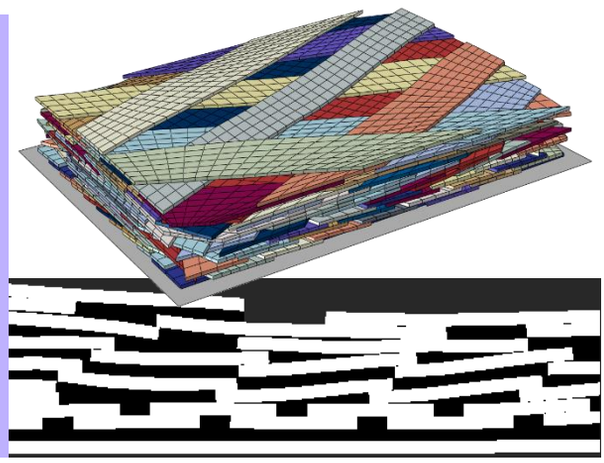
- Developments in line with the industrial tolerances
- Custom developments to address a **wide range of use cases** and **technologies**
- Designed for easy **transfer in industrial environment** (low cost hardware + user friendly software)
- Designed to integrate into a **data-driven autonomous process**

Multidisciplinary and digital platforms

Digital solutions to support materials & processes development

We are leveraging digital tools to:

- Reduce development lead-times
- Support the design of innovative structures
- Combination of modelling based on data and physics with methods and soft to:
- Provide a numerical toolchain,
- Increase technology maturity
- Facilitate the transfer into an industrial environment.

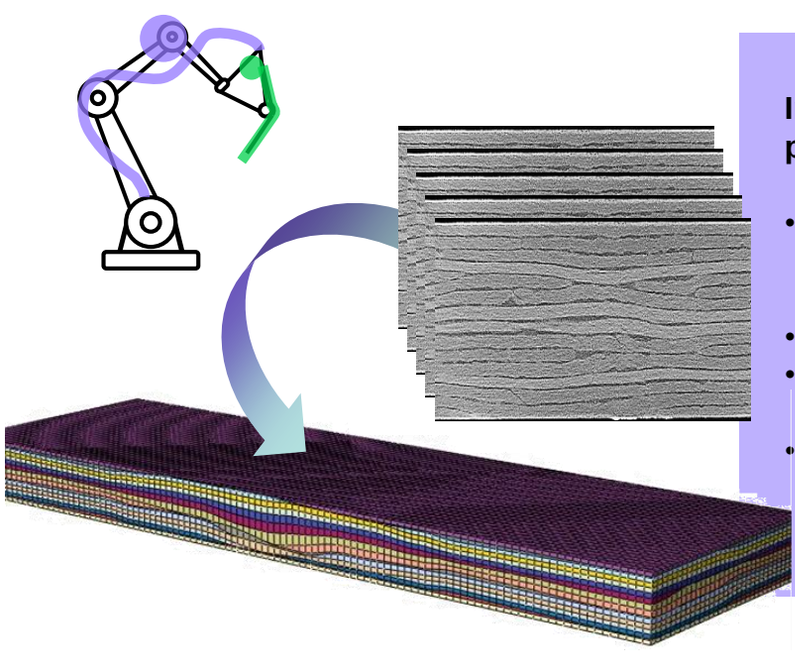


Process modelling

- Key process parameters identification
- Development of representative models at multiple scales, including composite tow, ply or part levels
- Simulate processes to predict material microstructure, final part shape, residual stresses and potentials defects such as porosity

“We are working on developing and optimising processes to control part performance, integrate new functionalities and reduce production time”

Combining smart testing, in-situ data acquisition, modelling and simulation for improved understanding and performance of processes and materials



Impact of defects on structural performance:

- Implement quality control, capture defect morphologies and create geometrical models
- Integrate defects into simulations
- Predict knockdown factors due to defects
- Optimise structure to mitigate defects impact on performance

Contacts

Always open to new challenges!
If you have one contact us

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Maxime BOX

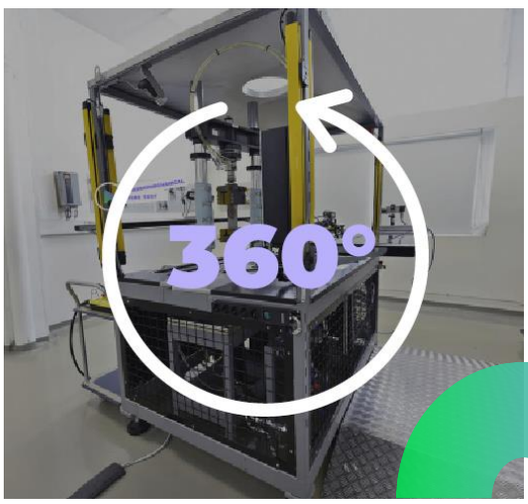
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