irCer

institute of research
for ceramics

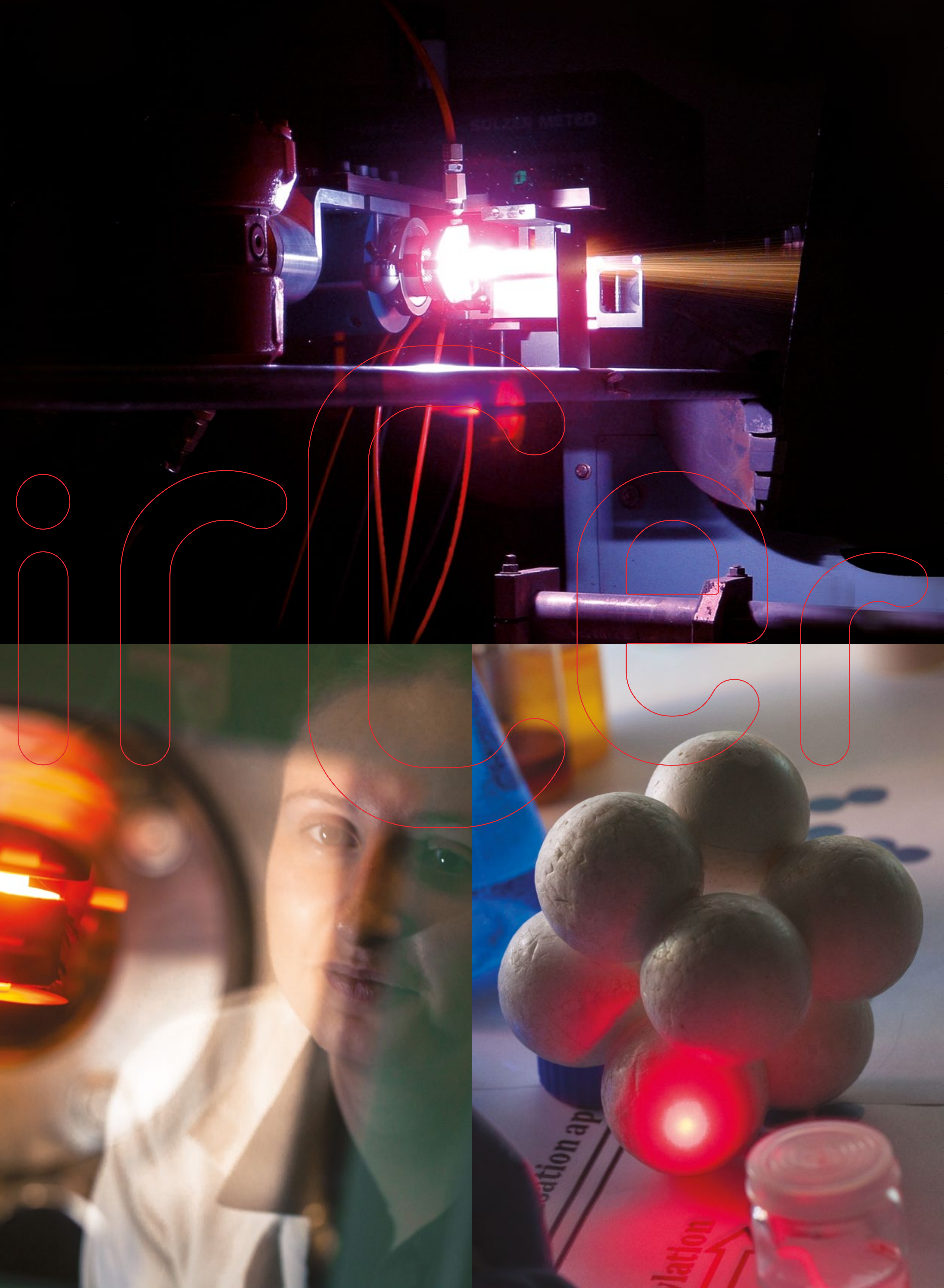
UMR CNRS 7315

Research and innovation in ceramics

WORK AT THE INSTITUTE OF RESEARCH FOR CERAMICS – IRCER – is devoted to the transformations of matter involved in processing of bulk ceramics and processing used in surface treatment. The laboratory activities are situating at the intersection of materials science – mostly ceramics – and process engineering.

IMPLANTED IN THE NEW AQUITAINE REGION AT LIMOGES, the birthplace of the ceramic industry in France, the IRCER makes the link between tradition and modernity with its pursuit of innovation in the development of highly technical ceramics which answer the new challenges of industry and society (energy, information and communication technologies, health, ecomaterials...). The IRCER houses in a single building of 8500 m2, called the "Centre Européen de la Céramique", all 200 members of the laboratory as well as the scientific equipment.

INTERNATIONALLY RECOGNIZED, the institute brings together teams of CNRS scientists, academics of the University of Limoges specialized in chemistry, physics and mechanics of ceramic based materials, physics of plasma processing as well as engineers, technicians and administrative staff. The latter provide essential support services to the laboratory activities and in particular running of the characterization center CARMALIM (CARactérisation des MAtériaux de LIMoges) and the platform SAFIR (Surface Advanced Functionalization for Industry and Research).



From the atomic scale to processing

The IRCER is structured on its strengths related to ceramic materials and their processing which have made its reputation. An interdisciplinary approach between materials science and process engineering based on both basic and applied research is adopted to understand, characterize, master and model the different processes which are employed to make a ceramic object or coating with tailored properties for a specific application. As well as the ability of the IRCER to innovate, transfer of the scientific results for exploitation by the socio-economic world is also part of the know-how of the IRCER.

THE INTERDISCIPLINARY APPROACH brings together, in 4 complementary research divisions, teams of CNRS scientists and University academics originating from different scientific backgrounds (chemistry, physics, mechanical engineering).

THE DEVELOPMENT OF MODERN INNOVATIVE CERAMICS means having to control the arrangement of entities at the atomic scale right up to the scale of the macroscopic object in order to generate new or improved properties. This is the case for both crystalline and non-crystalline solids. Characterization of the material organization at different scales requires analytical tools with very high resolution. In most cases we use these tools in combination with numerical simulation and synthesis of model (nano) materials in order to establish the relations between structure, microstructure and properties.

THE DEVELOPMENT OF INNOVATIVE PROCESSING, a priority aim of the IRCER, requires understanding of the basic mechanisms involved in forming bulk ceramics or coatings as well as their consolidation. Thus improved properties for specific applications can be achieved. The panoply of processing methods under study is very wide and all of them are potential candidates for hybrid processing routes: physical deposition by plasma or laser, sol-gel synthesis route, digital printing in 2D/3D, non conventional sintering methods…

THE LOGICAL COMBINATION "MATERIAL + PROCESSING => PRODUCTS" implies, for structural ceramics just as well as for functional ceramics, numerous collaborations with industrial actors concerned by the production of parts or components. Other collaborations involve developers of technologies using these materials (energy, information and communication technologies, health, mechanical engineering, transport, transformation of raw materials).

A BROAD RANGE OF EQUIPMENT is available to make and characterize the materials at different scales in order to study the chemistry and physical properties relevant to the specific application in view. This is a key point in the strategy of the basic research themes of the IRCER. Other projects involving national and international partnerships, stimulated by the perspectives of industrial exploitation, also benefit by this highly performant and dedicated technical support.

Innovative applications

The IRCER makes and tailors the properties of ceramic-based objects and coatings for innovative applications in many sectors where advanced technology is strategic.

FOR INFORMATION AND COMMUNICATION TECHNOLOGIES

- → Component miniaturization: deposit of thin films by laser ablation, PVD (Physical Vapor Deposition) or PECVD (Plasma Enhanced Chemical Vapor Deposition) for components and micro-electromechanical systems
- → Design and development of processing methods for nanocomposite functional materials
- → New component architectures: fabrication by additive manufacturing (stereography, ink jet printing, 3D micro-extrusion ...) of microwave dielectric components, 3D electronic circuit chips and multifunctional sensors
- → New telluride based glass materials presenting 2nd and 3rd order optical nonlinearity
- → Fabrication of optical fibers and/or waveguides from these telluride based materials
- → Transparent polycrystalline ceramic materials with large dimensions for light amplification in high power lasers
- → New lead free piezoelectric / ferroelectric compositions

FOR ECOMATERIALS

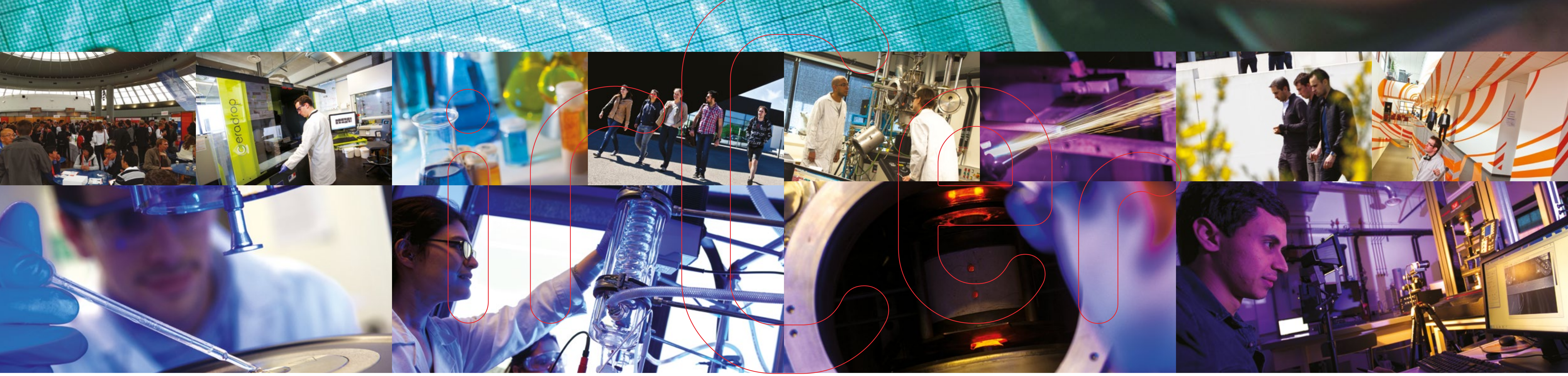
- → Conception of non-toxic ceramic materials (respecting the REACH standard)
- → Substitution of petrochemical additives by bio-sourced additives
- → Starting from ceramics, development of new sustainable materials which can be recycled including exploitation of waste materials.
- → Development of water based fabrication processing without firing in order to minimize environmental impact

FOR THE ENVIRONMENT AND ENERGY

- → High temperature materials in aggressive environments (*e.g.* new generations of nuclear reactors, combustion chambers in aircraft engines or rockets, steam methane reforming)
- → New generations of thermal barriers (*e.g.* turbine blades in aircraft engines)
- → Multi-material coatings for wear applications
- → Catalytic systems for the production of synthetic gas or hydrogen from natural gas (Air Liquide joint laboratory)
- → New electrolyte materials for solid oxide fuel cells (SOFC at 700°C). Fabrication of battery cores and EHT units (high temperature electrolysis)
- → New materials for energy harvesting (*e.g.* photovoltaic effect) and storing energy (*e.g.* battery / supercapacitor hybrid systems)

FOR HEALTH

- → Synthesis of different calcium phosphates. Adapted surfaces for grafting
- → Functionalization of bioceramics by active molecules to stimulate bone regeneration processes (peptide grafting) and / or therapeutic treatments (inclusion and liberation of antibiotics, antiviral drugs, anticancer drugs)
- → Preparation of implants with specific microstructure and architecture for applications in bone tissue engineering
- → Bio-sensors for diagnostics and treatment of early stage cancers



An open laboratory

The quality and diversity of the IRCER research activities reach out to a varied public. The aspect of technological innovation leads to close collaboration with industry (large companies, SMEs, start-ups). Its programmes draw doctoral students and scientists from the entire world. The relevance of the research places the IRCER in the heart of an international network which gives the opportunities to embark on major scientific projects.

TEACHING PROGRAMMES AT IRCER

In the context of the harmonized Bachelor – Master – Doctor cursus of European University education, the IRCER's mission is to contribute to the training of students for research in ceramics by participating in the different teaching programmes of the University of Limoges.

B.Sc. level

INSPE courses in the Faculty of Science and Technology:
Bachelor's degree in Chemistry, Materials Science course
Professional Bachelor's Degree in Physical and Chemical Methods for Characterizing Ceramic Materials
University Institute of Technology:
Mechanical and Production Engineering (GMP):
Digital Simulation and Virtual Reality course
Innovation for Industry course
BUT Physical Measurements (MP):
Materials and Physical-Chemical Controls specialization

M.Sc. level

Engineering School ENSIL-ENSCI
Master in Materials Science and Engineering

Ph.D. level

Doctoral School in Science and Engineering (SI) - n°653
Doctoral College for the University of Limoges

University research school (EUR) "Ceramics & ICT" – TACTIC

Formation continue

Centre d'Actualisation Scientifique et Technique – ENSIL-ENSCI (CAST)
Direction de la Formation Continue de l'Université

INTERACTIONS WITH INDUSTRY

The research work of the IRCER often opens up interesting perspectives for the industrial world. The institute develops close and fruitful collaborations with both multinational companies as well as start-ups where ceramics are the driving force for innovation.

→ **Support laboratory for the CEA le Ripault**
The ELECTRA support laboratory is dedicated to the development of technical ceramics and coatings for temperature applications.

→ **Joint laboratory with SAFRAN and OERLIKON**
The PROTHEÏS joint laboratory operates in the field of surface treatments for aeronautical applications.

→ **Joint laboratory with IMERYS**
The LIRYS joint laboratory is dedicated to the development of innovative, sustainable solutions for the production of thin-film ceramic coatings for leading-edge industries.

→ **A large number of industrial collaborations**
Adisseo, Air Liquide, Alantum, Bernardaud, Balzers, CEA, Ceradrop, CILAS, 3DCERAM, Dior, EDF, GDF, Imerys, Lafarge, Oerlikon, PSA, Renault, Rio Tinto Alcan, Saint-Gobain, Safran, Thalès, Total, Usinor, Volvo, Sulzer, EADS/Astrium...

→ **Examples of start-ups created from the laboratory research activities**
- 3DCeram (Stereolithography)
- Ceradrop (Inkjet printing)
- DYAMEO (In vivo medical diagnostics)
- GAT (Geopolymers)

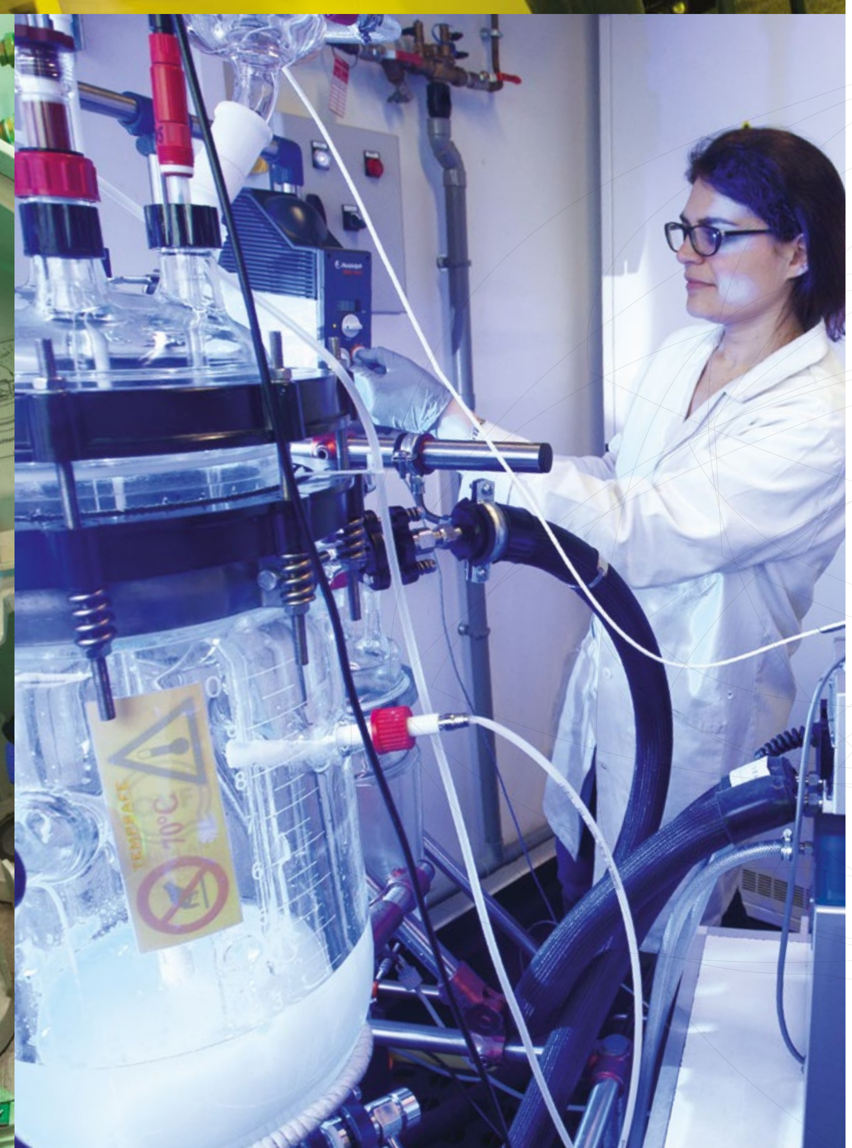
TECHNOLOGY TRANSFER

The institute is a privileged scientific partner of two technology research centers implanted in Limoges, the center for ceramic technology transfer (CTTC) and the center for engineering in advanced treatments and coatings of surfaces(CITRA), as well as a technical center for natural building materials (CTMNC). IRCER is also involved in two competitiveness clusters: the european cluster of ceramics and the ALPHA-RLH cluster.

INTERNATIONAL COLLABORATION

Recognized as a major laboratory devoted to ceramic research on the international scene, the IRCER participates in many international projects and networks such as in the last few years:

- **International Research Project (IRP-CNRS) FRESH (Functional inoRganic matErials for global Societal cHallenges)** with the Nagoya Institute of Technology (NITECH – Japan) (coordinator)
- **International Research Project (IRP-CNRS) B3Lab (Biointerfaces, Biominerals, Biomaterials)** with the Mulhouse Institute of Materials Science and the Department of Condensed Matter, Applied Physics and Nanoscience (CBPF, Brazil)
- The network of European academics involved in ceramic additive technologies: **Europe Makes Ceramics** (co-founder)
- The **global FIRE network** (Refractories)
- European programme **Research and Innovation Staff Exchange (RISE): AMITIE** (Additive Manufacturing Initiative for Transnational Innovation in Europe (coordinator)
- European programme **Concerted European action on Sustainable Applications of REFractories (CESAREF)** (coordinator)
- European programme **InVeCOF** focused on fiber-reinforced ceramics and O-CMC components
- European programme **ASTRABAT** for sustainable electric mobility
- The joint European H2020 programme **EURAD 2** for radioactive waste management
- M-ERA.NET programme **NewILUMIS (versatile platform for light and detection)**
- European Defence Fund (EDF) programme: **LAser CEramics (LACE)**



A scientific environment

The IRCER is a major actor in research on ceramics. The expertise, the activities and ability to innovate have been recognized for many years by the national research organizations, the industrial ceramics sector, scientists and Ph.D. students.

SCIENTISTS AND PERSONNEL WITH DIFFERENT BACKGROUNDS

The originality of the IRCER lies in the multidisciplinary and cross-sectorial approaches, which naturally can be found in the teams with different origins.

From several components of the University of Limoges:

- Science and Technical Faculty
- The engineering school ENSIL- ENSCI
- Faculty of Pharmacy
- University Institute of Technology of the Limousin (IUT)
- College of teaching and education (INSPE)

From the « Centre National de la Recherche Scientifique » (CNRS) / National Research Council:

- CNRS Chemistry
- CNRS Engineering

PARTNER OF LABEX Σ-LIM

The IRCER is associated with XLIM UMR 7252, another CNRS labelled institute, in the development of specific innovative materials for integrated secure and intelligent communication systems in the framework of the joint laboratory LABEX Σ-LIM. The activities are focused on four major themes: «Going beyond 5G», «Promoting health with advanced diagnostics and therapies», «Bringing a new light on photonics» and «Doing more with less energy». This LABEX (laboratory of Excellence) is based on an increase of exchanges with other laboratories, industrial companies, research organizations and technical centers… The policy has proved to be very efficient for the exploitation of scientific results and promotes mobility of CNRS scientists, University academics and Ph.D. students.

AN INDISPENSABLE ACTOR OF THE CERAMICS SECTOR

The IRCER is one of the principal actors of the European Cluster of Ceramics (PEC), an agency of business competitivity whose mission is to make the ceramics sector dynamic. The institute also contributes to the cluster ALPHA-RLH (Road of Lasers and Microwaves) and is involved in three research federations: FR3469 « Matériaux Val de Loire – Limousin » (MatV2L), FR2050 « Fédération de Recherche Spectroscopies de Photoémission » and FR2044 (FRH2) « Fédération de Recherche Hydrogène du CNRS »

IRCER in numbers

HUMAN MEANS
More than 200 people, including 105 permanent staff
More than 60 Professors and Associate Professors
About fifteen CNRS researchers
More than 100 PhD students, post-doctoral fellows, contract engineers
About twenty engineers, technicians and administrative support staff

FACILITIES
8500 m^2 of building next to Limoges

Some Major Scientific Results

ADDITIVE MANUFACTURING OF CERAMICS
as one of the pioneers of this technology for over 20 years, the laboratory is a world leader in the domain.

PLASMA PROCESSING METHOD
involving a self sustaining pulsed arc yielding pulsed liquid spray. The synchronization of injection of an ink jet type with the plasma oscillations is a significant advance for controlling plasma / material transfer.

DETERMINATION OF AN EXPLICIT AND EXACT EXPRESSION
of the total atomic pair distribution function (PDF) obtained by X-ray scattering as a function of partial PDFs.

PRE-CERAMIC NON OXIDE PRECURSORS
development of new synthetic organo-metallic polymer precursors containing group IV metal cations.

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Ceramics in 4 research axes and 2 cross-disciplinary themes

The institute is structured into 4 key thematic axes. This structure is enriched through transverse actions which derive benefit of the pluridisciplinary skills of the human ressources..

AXIS 1
INNOVATIVE CERAMIC PROCESSES

AXIS 2
PLASMA AND LASER PROCESSES

AXIS 3
MULTISCALE STRUCTURAL ORGANIZATION OF MATERIALS

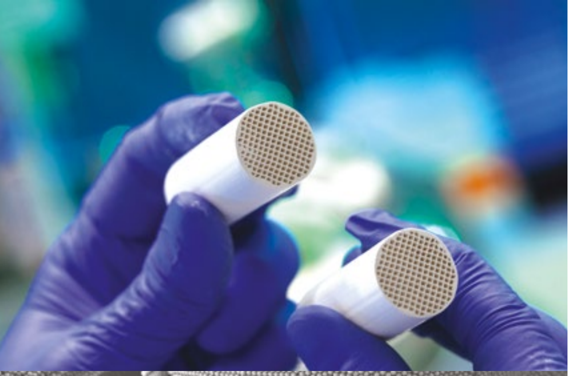
AXIS 4
CERAMICS UNDER ENVIRONMENTAL STRESSES

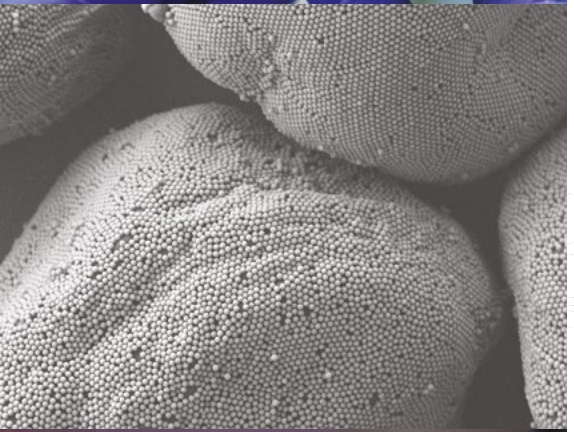
ARTIFICIAL INTELLIGENCE FOR MATERIALS SCIENCE AND CERAMIC PROCESSES

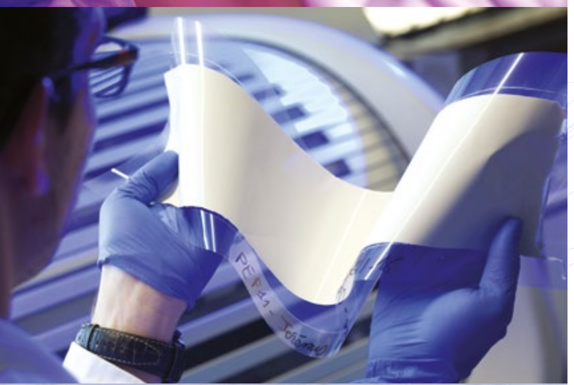
Development and application of AI methods for the study and exploration of new materials, control and improvement of ceramic processes

SUSTAINABLE DEVELOPMENT AND RECYCLABILITY

Conducting research in the field of ceramic materials and processes using a sustainable development approach aimed at reducing CO_2 emissions and energy consumption and preserving natural resources







1_ Extruded honeycomb structures
2_ Pickering emulsions
3_ Biosourced additives
4_ Tape casting

AXIS 1

INNOVATIVE CERAMIC PROCESSES

Development of innovative processes suited for the fabrication of ceramic objects with controlled architectures and nano-micro-structures.

Additive manufacturing, hybridization of processes, digitization of processes.

Upstream, **synthesis of structuring elements** (i.e. individual grains of a powder, aggregates, agglomerates, granules, etc.) and **study of their interactions**: synthesis of powders and nanopowders, functionalization and modification of their surface chemistry, development of new formulations. The aim is to **optimize multi-scale assembly strategies**, or provide texturing, taking into account environmental issues (eco-fabrication, energy savings, green chemistry).

Downstream, **understanding consolidation mechanisms** (drying, debinding), improving material properties through better control of microstructure via optimization of forming processes.

3 main themes:
- Raw materials
- Shaping
- Consolidation / properties

This is an integrated, multidisciplinary approach to the problem of shaping. In each of these areas, the common scientific approach aims to limit empirical approaches by combining model materials, numerical simulations and characterization tools at scales representative of the assembly's structural elements (i.e. local scale).

INTEGRATED APPROACH FROM POWDERS TO COMPONENTS

EXPERIMENTAL ASPECTS
MATERIALS AND PROCESSES

NUMERICAL ASPECTS
MODELING AND SIMULATIONS

Architectures/microstructures controlled at all scales
Industrial valorization 1 ≤ TRL ≤ 4

MULTISCALE PHYSICO-CHEMICAL CHARACTERIZATION METHODS

MULTISCALE AND MULTIPHYSICS NUMERICAL SIMULATIONS

RAW MATERIALS

Raw materials for eco-fabrication

Powder synthesis (models)

Functionalization, interaction control, texturing

Formulation, bio-based additives

SHAPING

Behavior of ceramic systems under stress (texturing)

Process development, optimization and hybridization

Additive/subtractive manufacturing

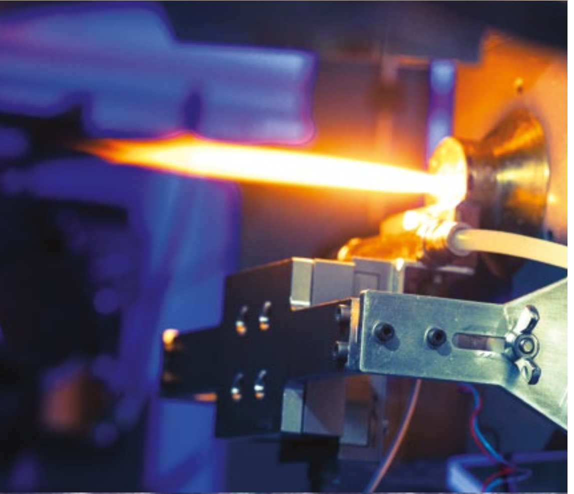
Digital chain

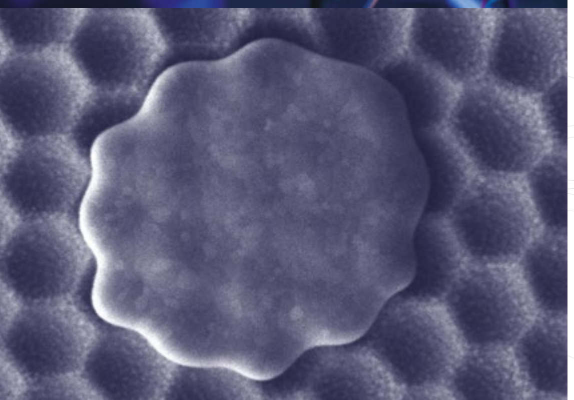
CONSOLIDATION / PROPERTIES

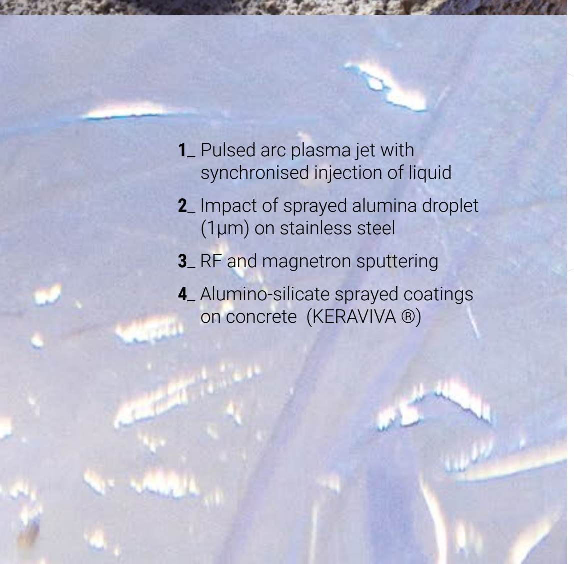
Physico-chemical transformations, drying, heat treatment

Electrochemical, mechanical and thermal properties

Process/microstructure/ properties relationships for process monitoring







1_ Pulsed arc plasma jet with synchronised injection of liquid

2_ Impact of sprayed alumina droplet (1μm) on stainless steel

3_ RF and magnetron sputtering

4_ Alumino-silicate sprayed coatings on concrete (KERAVIVA ®)

AXIS 2

PLASMA AND LASER PROCESSES

Development of plasma and laser processing including fundamental and applied approaches. At the interface of plasma process physics and condensed matter physics, our scientific approach leads to the synthesis of deposits with specific properties and the creation of functional objects.

Scientific approach
- Understanding of the elementary processes in plasmas using physical and numerical modeling and plasma diagnostics
- Definition of the growth mechanisms for better knowledge and control of the deposited materials
- Introduction of innovative materials in functional devices, systems and objects for improved performances
- Deposit preparation, characterization and process/property relationships

Three research themes
- Process design and optimization
- Elementary plasma-phase and surface processes
- Functional films and deposits and intelligent materials

The research themes are supported by two groups of skills related to the processes used.

Two expertise groups
- Thermal spraying: Plasma spraying of powders, suspensions and solutions, Plasma Spray PVD, flame spraying, cold spraying
- Thin films and nanostructures: Laser ablation, Sputtering, Low-pressure and atmospheric pressure PECVD, Extended microwave plasma.

Two joint laboratories
- **PROTHEIS with SAFRAN and OERLIKON**
- **LIRYS with IMERYS**

Process design and optimization
Coupling, hybridization, digitization

FROM PROCESS... TO MATERIAL AND FUNCTIONAL OBJECT

Elementary plasma phase and surface processes

Functional films and coatings
Smart materials

THERMAL SPRAYING

Thermal spraying processes

Modeling/Simulation of plasma arc torches and plasma spraying processes
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Plasma and particle diagnostics

Aeronautical coatings (thermal and environmental barriers, anti-CMAS), antibacterial and virucidal coatings

THIN FILMS AND NANOSTRUCTURES

Laser processes and out-of-equilibrium plasmas, characterization
-----
Generation of nanoparticles in gas phase

Micro and nanostructured thin films

Smart materials for electronics and photonics / Integration into micrometric components
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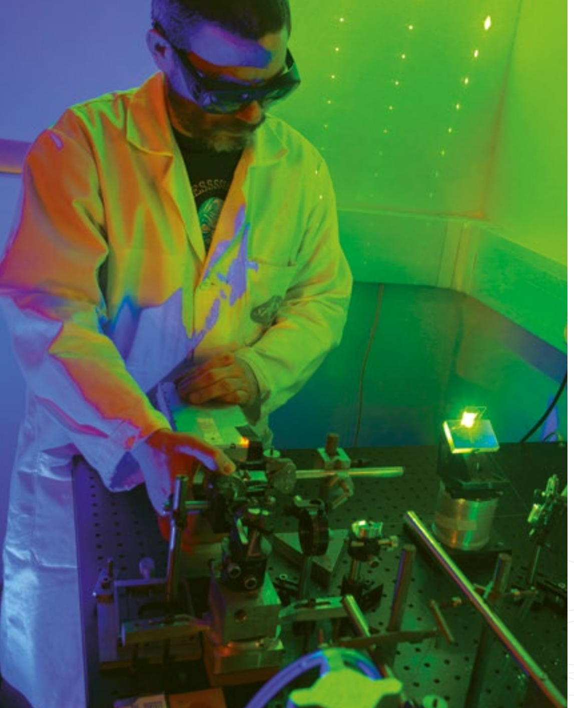
Multilayer coatings for precision mechanical components (aerospace)




1_ Non-linear optics characterization set-up
2_ Synthesis of geomaterials
3_ High-resolution X-ray diffractometer
4_ Synthesis of metal-oxide nanoparticles

AXIS 3

MULTISCALE STRUCTURAL ORGANIZATION OF MATERIALS

Discover new materials with improved/optimized properties, using a scientific approach based on the "synthesis/structure/properties" triptych.

Synthesize new materials and **elaborate** new micro- and nanostructures using a variety of synthesis routes (including solid-state and precursor routes such as sol-gel, hydro/solvothermal, co-precipitation, polymer, etc.). Promote low-energy syntheses involving low-carbon materials, in a spirit of **sustainable development.**

Determine/characterize these structures and nanostructures by combining experimental techniques and simulation methods. This is done using medium-heavy equipment (transmission electron microscopy, X-ray diffraction and scattering, vibrational and optical spectroscopy, etc.) and Very Large Research Infrastructures including SOLEIL, ILL and ESRF.

Analyze massive data using unconventional approaches (AI) and **develop predictive tools.**

Measure and calculate optical (light emission/conversion, nonlinearity), electrical (piezo/ferroelectricity, dielectrics, conductivity), vibrational and catalytic properties to establish links between structure, microstructure and material properties.

Meet societal needs in the fields of energy, electronics, optics, housing and natural resources. **Promote innovative work** and **scale-up.**

Measurement and calculation of properties on various scales (atomic, nanometric and macroscopic)

STRUCTURE PROPERTIES

Synthesis method development

Structural and microstructural characterization

ATOMIC-SCALE MODELING AND CRYSTALLO-CHEMISTRY

Crystallochemistry, medium and local structure refinements, DFT, molecular dynamics, machine learning
-----
Oxides, nanoparticles, clusters, disordered systems, surfaces and interfaces
-----
Structure-property relationships, nonlinear optics, ion scattering, electronic structure
-----
Code development

PRECURSORS AND INORGANIC MATERIALS

Geopolymers and preceramic polymers

Hybrids, PDCs and silicon-based materials

Synthesis, shaping and ceramization of precursors: coatings, fibers, matrices & composites, porous materials
-----
Reactivity of inorganic and organometallic precursors

FUNCTIONAL MATERIALS

Electroceramics: lead-free oxide materials

Glass, glass-ceramics and transparent ceramics for optics and energy
-----
Synthesis methods, including soft chemistry, and forming technologies (SPS, hybrid 3D printing, ADM, etc.)

Hyperspectral data processing (chemometrics, machine learning, etc.)

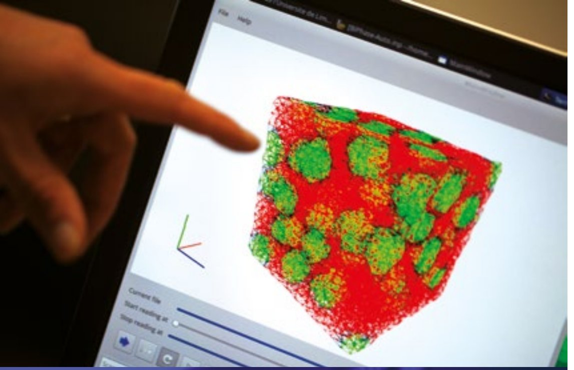
CRYSTALLO-GRAPHY AND MICROSTRUCTURE

Phase transitions, nanostructures and defects

X-ray diffraction/ scattering and synchrotron instrumentation
-----
Electron microscopy and near fields

Open source software development, massive data and deep learning

AXIS 3



1_ Thermomechanical modeling using discrete element methods
2_ Microscopic observation of cell adhesion
3_ Set-up for powders and hydroxyapatite syntheses
4_ Mechanical characterizations

AXIS 4

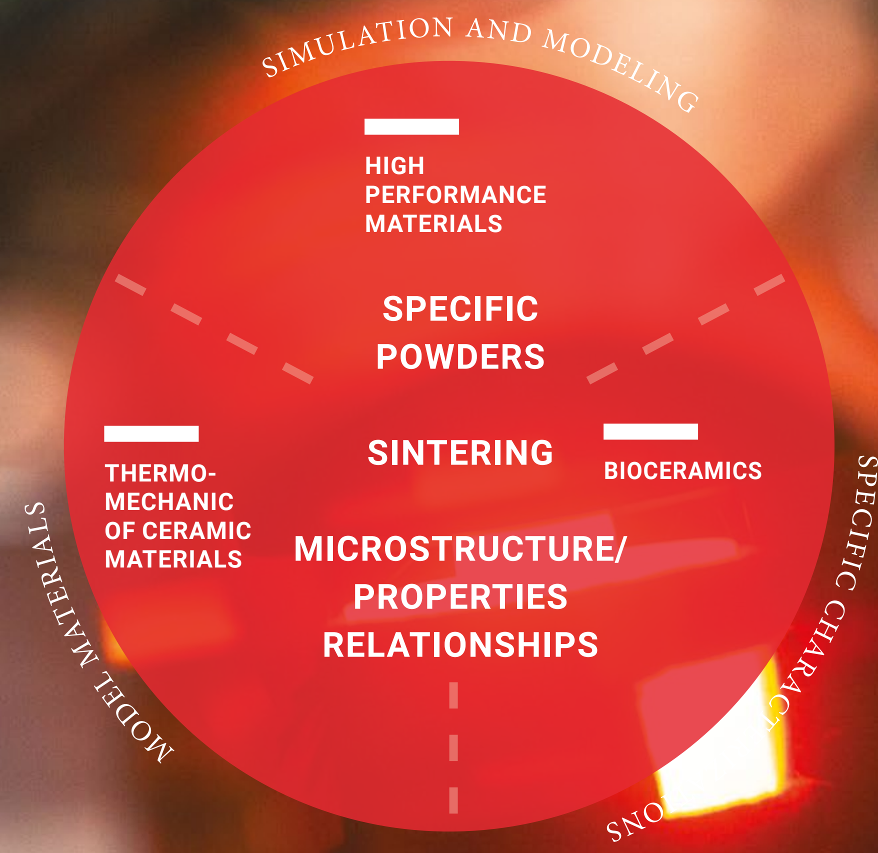
CERAMICS UNDER ENVIRONMENTAL STRESSES

Design textured ceramic materials with original properties answering to targeted conditions of use.

Establish and master the links between both, the nano- and/or microstructures issued from the synthesized material and the sintering, and the final properties of the materials (mechanical, thermomechanical, resistance to oxidation and corrosion, optical or biological).

3 thematic groups ("Bioceramics", "High Performance Materials" and "Thermo-mechanic of Ceramic Materials") with activities that are mainly based on the deployment of three shared fields of competence: synthesis of specific powders/physicochemical and multiscale approach of sintering/relationships microstructure-properties of use. The global scientific process builds on three major strategic pillars: the fabrication of model materials, the modeling and simulation of sintering and of the properties of materials in conditions of use, and the development of specific characterizations of materials during their production and in operating.

Application fields: energy, optics and electronics, implantable medical devices, bone tissue engineering, transport, (aerospace).



HIGH PERFORMANCE MATERIALS

Synthesis of nanostructured/ functionalized non-oxide systems
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Ceramics with complex architectures

Numerical multiscale and multiphysics modeling of sintering

THERMO-MECHANIC OF CERAMIC MATERIALS

Development of characterizations of high temperature behaviors
-----
Integration of an increasing complexity in the study of model materials
-----
Multiscale thermomechanical modeling effects associated to the sintering microstructure

BIOCERAMICS

Development of a new generation of bioceramics for bone tissue engineering
-----
Strengthening of the capacity of understanding the phenomena at the material/ living tissue interface

Equipment

IRCER operates mainly with the equipment and skills of two platforms, **CARMALIM** and **SAFIR**, and a **mechanical workshop**.

CARMALIM is specially dedicated to the physico-chemical characterization of materials and is directly involved in its work. It benefits from the know-how and experience of technicians and engineers, as well as the scientific support of researchers and lecturers. The performance of the equipment and the skills of the staff associated with this platform, which is unique in Europe, attract many external users, whether from technology transfer centers or industry. The platform brings together 15 engineers and technicians and 6 expert researchers around more than 60 pieces of equipment. It is organized into 6 divisions:

MICROSCOPY

Electron scanning
Electron transmission
Near field
Double beam (FIB/SEM)

THERMAL, CHEMICAL AND MORPHOLOGICAL ANALYSES

Dilatometry - Diffusivity
ATG-ATD-DSC
Morphology - Chemistry

SPECTROSCOPY AND OPTICS

Fluorimeters
Photometer
Raman
FTIR
XPS
Ellipsometer

THERMAL TREATMENTS – MECHANICAL PROPERTIES

Thermal treatments
Thermomechanical properties

SUSPENSIONS

Rheology
Suspensions

X-RAY DIFFRACTION

Diffractometers
Specific set-up

SAFIR, founded in partnership with Safran, Oerlikon, CNRS and the University of Limoges, is dedicated to the field of dry process surface treatment. It meets the needs of the aeronautical, marine, automotive, energy and electronics industries, and addresses maturity levels from TRL 1 to TRL 6, with the possibility of bringing together high-level multidisciplinary skills. This platform implements the scientific work of the PROTHEÏS joint laboratory and is open to other businesses. SAFIR is organized around two technology divisions:

THERMAL SPRAYING AND PVD DEPOSITION

PVD deposition machine
Robotic sandblaster
Atmospheric thermal spraying

CHARACTERIZATION

Non-destructive testing using Impulse Excitation Technique (IET)
Versatile tribometer
Microscope
Thermal cycling electric furnace

IRCER benefits from a 250 m² **mechanical workshop** with 2 staff dedicated to 4 areas of expertise:

- Design office / computer-aided manufacturing
- NC machining and grinding
- Welding
- Cutting

Ceramics
Shaping processes
Additive manufacturing
Plasma and laser processes
Plasma diagnostics and simulations
Coatings and surface treatments
Powder synthesis
Functionalization
Materials chemistry
Solid chemistry
Colloids / Suspensions
Condensed matter
Sintering
Modeling
Numerical simulation
Rheology
Thermal, mechanical, magnetic, electric, optical properties
Controlled microstructures and architectures
Nanostructured materials
Bioceramics
ICTs
Energy
Ecomaterials
High temperatures
High performance
Innovation and industrial valorization
Artificial intelligence

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