nanoMECommons

Harmonisation of EU-wide nanomechanics protocols and relevant data exchange procedures, across representative cases; standardisation, interoperability, data workflow

PARTNERS SERVICES BOOKLET

www.nanoMECommons.eu

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Introduction

NanoMECommons will establish a transnational and multidisciplinary research and innovation network to tackle the problem of nanomechanical materials characterisation in multiple industries. The focus of **nanoMECommons** is to employ innovative nano-scale mechanical testing procedures in real industrial environments, by developing harmonised and widely accepted characterisation methods, with reduced measurement discrepancy, and improved interoperability and traceability of data. To achieve this goal, **nanoMECommons** will offer protocols for multi-technique, multi-scale characterisations of mechanical properties in a range of industrially relevant sectors, together with novel tools for data sharing and wider applicability across NMBP domain: reference materials, specific ontologies and standardised data documentation.

Contact

Project Management	Dissemination and Exploitation Management
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National Technical University of Athens, RNanoLab – Greece

The "**Research Lab of Advanced, Composite, Nano Materials & Nanotechnology" (R-Nano**) is situated at the School of Chemical Engineering, **National Technical University of Athens (NTUA**) in Greece. The **R-Nano Lab**'s research group has extensive experience in Design, Production and Characterization of Advanced-, Composite- and Nano- Materials. The core expertise involves the development of carbon based novel advanced nanocomposite materials for aerospace, naval, civil engineering, and energy applications. The laboratory has been actively involved in research for more than a decade, enhancing its infrastructure and producing a large volume of peer reviewed scientific publications. It is committed to provide knowledge, services and expertise to both private enterprises and public organizations in material developing, manufacturing and testing. R-NanoLab has a strong presence in European Research Activities in Materials Science, through participation in numerous EU and national funded projects. As part of the European Technological Community, R-NanoLab is an active member of several Clusters: European Materials Characterisation Council (EMCC), European Pilot Production Network (EPPN), European NanoSafety Cluster (NSC) taking part in establishment of new standard methodologies, provide suitable background for regulation and nanosafety, and support EC policy development

Our products & services:

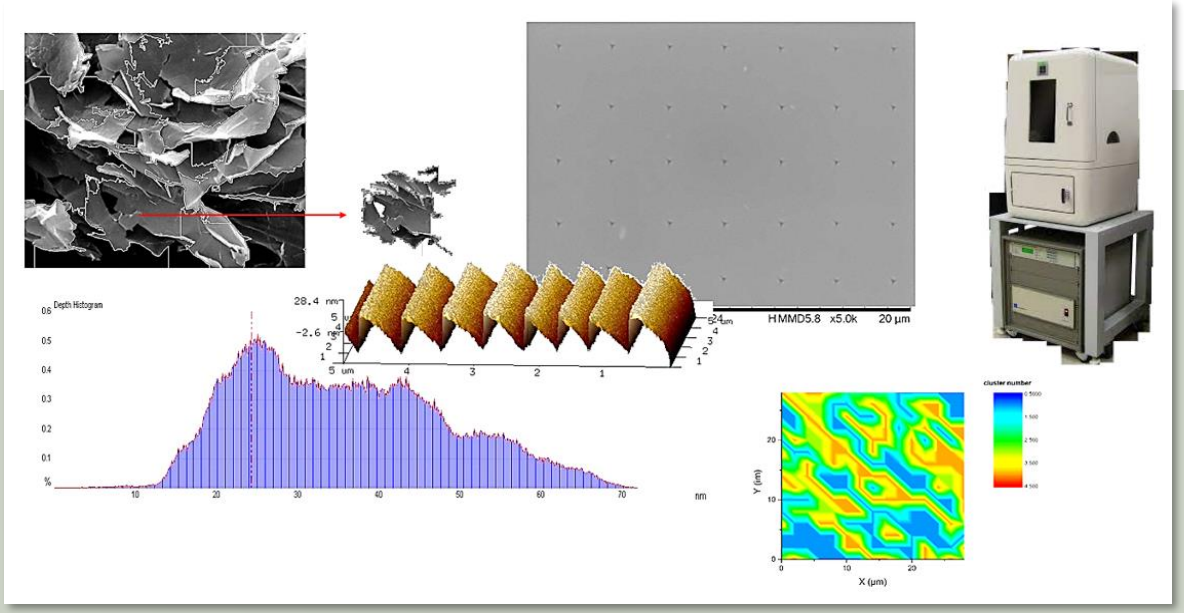
R-NanoLab, with a team of more than 35 Researchers with complementary and multidisciplinary expertise, and facilities at **NTUA** (Athens) and Lavrion Technological and Cultural Park - LTCP (Lavrion) can provide the following services:

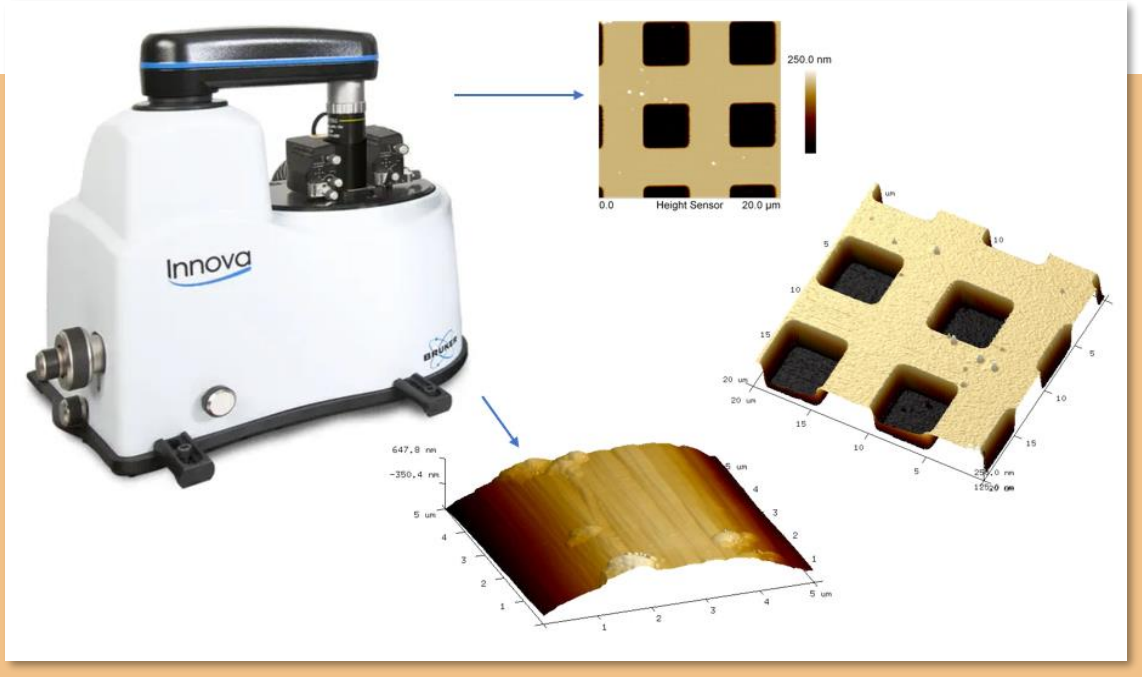
- Development of multi-functional materials and nanocomposites
- Development of characterization protocols and for nanometrology.
- Up-scaling production of carbon structures, composites/nanocomposites and integration of nanotechnology in existing products
- Access to pilot lines for testing upscaled production of specific polymers/composites/fibres and production of limited batches
- Access to tools for structural, chemical, thermal characterization for various materials (including multiphase) and composites
- Implementation of R&D projects for Automotive, Aerospace, Construction Industry and Companies
- Support in exploitation of technological assets and identification of industrial partners for the development of the technology
- Modelling & Design (including Machine Learning) for applications on smart materials and smart tools for the analysis of characterization data.

Continius stabilization **Polymer Blending** **Melt Spinning**

Role in the nanoMECommons Project:

NTUA is one of the key partners in the project, responsible for the coordination and management of the project. Furthermore, regarding material research, **NTUA** will develop nanoindentation protocols used for the characterization of materials produced in five industries. The goal is to develop and exploit a standard practice for high-speed nanoindentation technique for the precise characterization in industrial relevant environment and harmonized amongst different instruments (WP2). Moreover, Machine Learning will assist the process to correlate nanoindentation data with the structure of the tested materials, and take the maximum information about the tested specimen by nanoindentation. Interaction with WP4 will enable to harmonize multi-technique testing in different scale from nano, micro and intermediate characterization. Moreover, interaction with WP6 will enable to exploit the developed protocols by testing the industrial demonstrators Finally, interaction with EMCC, advisory and standardization bodies will be implemented during the project in order to validate the developed protocols and widen the impact of NanoMECommons achievements.





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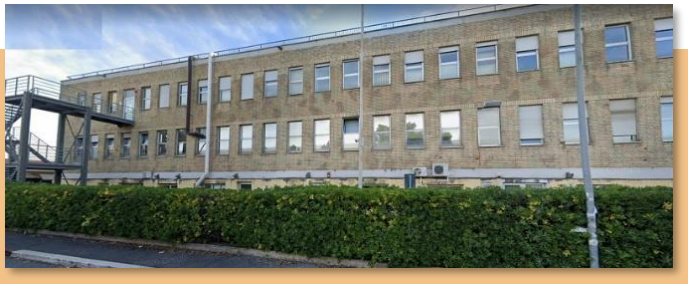
Universita Degli Studi Roma TRE – Italy

The "**Università degli Studi Roma Tre**" (Roma Tre University) has been established in 1991 and represents a central point of reference in the academic scenario at both local and national level hosting nearly 40000 students. The University has 12 Departments, 10 Libraries and 10 Centres and totals of about 970 teachers (553 professors I and II levels, 353 research assistant professors and 36 language experts). Since its foundation, Roma Tre has paid great importance to international cooperation, and it has been an active participant in the European Union exchange programmes. Particularly, **Roma Tre** has taken part in the Erasmus program since 1993/1994. In the academic year 2002/2003, **Roma Tre** was awarded the Erasmus University Charter (EUC), thus obtaining the right to participate in the Erasmus Program. Roma Tre is involved, either as coordinator or partner, in about 78 International Research projects.



Our products & services:

The materials science & technology group in "**Roma Tre**" has a consolidated experience in the field of advanced characterization of bulk materials and thin films, using high-resolution microscopy, (TEM, FIB/SEM and AFM), nanoindentation (four different heads available, including the novel high-speed heads), nano-scratch testing and micro-tribological facilities, composite materials design, and characterization.

Role in the nanoMECommons Project:

In this project, **Uniroma3** is the coordinator of WP3 (Nano-scale residual stress analysis by Focused Ion Beam). The partner also participates as a core partner to the activities related to the High-Speed in-line nanomechanics, given its recognised expertise in this field and the availability of several nanoindenters in the team. Finally, Uniroma3 is one of the main contributors to activities regarding the development of the ICHADA metadata structure. In addition, Uniroma3 is one of the main responsible partners for the connection of the project with existing European cluster, e.g. EMCC and EMMC.

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SINTEF - Norway

SINTEF (www.sintef.no) is one of the largest independent, multidisciplinary, project-based, research organizations in Europe, creating value through knowledge generation, research, innovation, and development of technological solutions. **SINTEF** participates in NanoMECommons via its group Material Physics-Oslo. The group belongs to the Department of Sustainable Energy Technology (Sustainable Energy-SINTEF) which is part of **SINTEF**s largest Institute, SINTEF Industry. The group operates state-of-the-art, characterization facilities (see examples in figure 1) and has access to testing, processing and manufacturing laboratories. It is also a key partner in the national infrastructures, the Norwegian Centre for Transmission Electron Microscopy-NORTEM (https://nortem.no) and the National Surface and Interface Characterisation Laboratory-NICE (https://www.nicesurface.no).

Examples of characterization infrastructure operated by Material Physics Oslo

The **group's vision** is creation of material and process innovation via world-class understanding of processes and materials properties, from the atomic to the macro scale, using electron microscopy, spectroscopy, surface analysis, atomic scale modelling, data processing, and solid-state physics competence within **SINTEF**'s prioritised socio-economic markets.

Our strategy is based on developing and combining various experimental and modelling methods to understand fundamental physical material properties which are necessary to solve problems associated with current industrial applications and address future materials challenges. We work with a wide range of materials including metals, ceramics, composite, hybrid materials and electronic components in bulk, particulate or thin film form.

Our expertise:

- Surface topography with white light interferometry (WLI) and atomic force microscopy (AFM).
- Surface compositional and chemical analysis with x-ray photoelecton spectroscopy (XPS). secondary ion mass spectrometry (SIMS) and glow discharge mass spectrometry (GDMS).
- Light microscopy, electron microscopy in scanning (SEM) and transmission (TEM) mode, focused ion beam (FIB), electron backscattered diffraction (EBSD), energy dispersive (EDS) and electron energy loss (EELS) spectroscopies.
- Powder X-ray Diffraction (PXD) and in situ measurements.
- Electronic structure calculations at atomistic level.
- Mechanical properties.
- Diffusion effects.
- Measurements and modelling of electrical, magnetic and thermal properties.
- Structural features and properties.
- Thermodynamic properties.
- Solid State Physics, Physical Metallurgy, Materials Science.
- Data Processing, Machine Learning.

Market focus

The whole range from basic research to industrial development and problem solving. We work in partnership with universities, other research institutes and industry in large and small projects targeting to: competence building-innovation-troubleshooting.

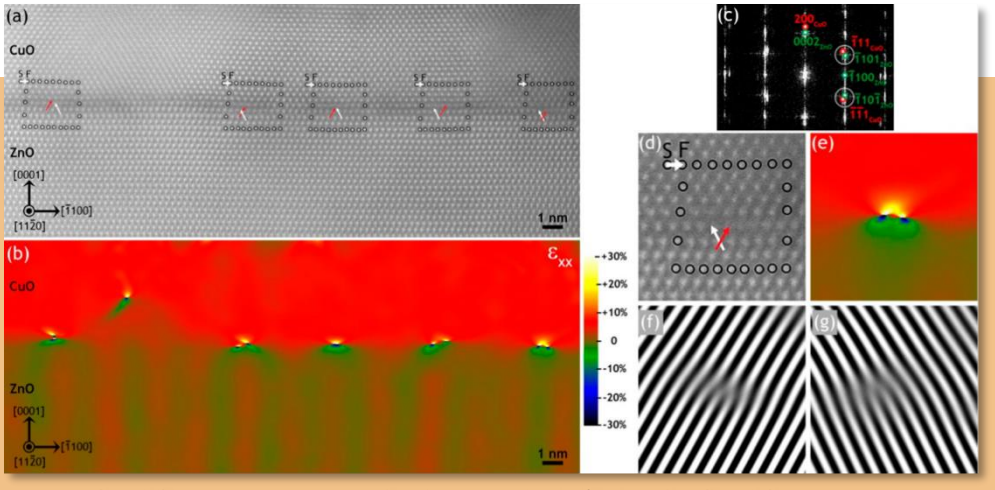
Examples of application fields

- Hydrogen in metals
- Corrosion and oxidation of metals
- Steel and light weight metals
- High Entropy Materials
- Thermoelectric, magnetic, magnetocaloric, elastocaloric materials
- Photovoltaics, optoelectronics and high temperature electronics
- Fuel Cells
- Batteries
- Minerals
- Catalysts
- Medical technology, dental materials and biomaterials
- Thin films and coatings
- Gas separation membranes
- Nanomaterials
- Additively manufactured materials

Role in the nanoMECommons Project:

Experimental activities as follows:

- we will perform Geometrical Phase Analysis to map residual strain at interfacial regions (see figure below).
- performance of multi-technique analysis based on microscopy, spectroscopy and in-situ mechanical properties assessment.



(a and d) burgers circuits around misfit dislocations at the CuO/ZnO interface, **(b and e)** εxx maps
(c) FFT of a indicating the spots used, **(f and g)** (1̄10̄1) and (1̄01) ZnO Bragg filtered images

Epitaxial Strain-Induced Growth of CuO at Cu2O/ZnO Interfaces (ref: Gunnaes et al, J. Phys. Chem. C 2016, 120, 41, 23552-23558)

Via our participation in the Operational Management Board of the European Materials Characterisation Council (OMB-EMCC), we will contribute to connecting NanoMECommons with the existing European cluster EMCC.

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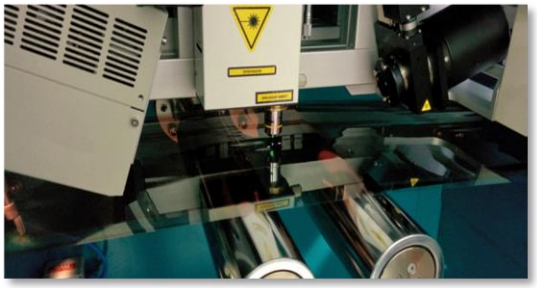
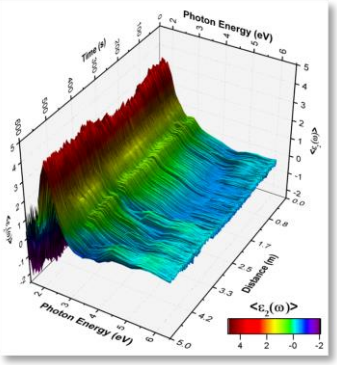
SINTEF
www.sintef.no/en/

Nanotechnology Lab LTFN, Aristotle University of Thessaloniki, Greece (LTFN/AUTh)– Greece

The **Nanotechnology Lab LTFN** (www.ltfn.gr), established in 1991, at the **Aristotle University of Thessaloniki (AUTh),** is an internationally acknowledged for R&D&I in Organic Electronics (OPVs, OLEDs, OTFTs, biosensors, etc), Plasmonics, Nanomedicine & Nanobiotechnology, Thin Film Technology & Nanoengineering, Advanced Nanomaterials & Nanoparticles, Real-time/In-line Optical Technology and Nanometrology, Real-time/In-line precision Metrology, Computational & Modelling at nano to microscale, Automation and Digital Manufacturing.



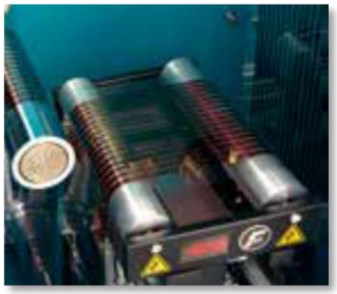


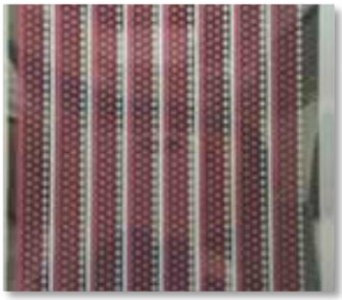
In-line metrology systems in the R2R pilot & production line: Raman Spectroscopy & Vis-UV real-time Spectroscopic Ellipsometry,

LTFN has established the Center of Organic & Printed Electronics - Hellas (COPE-H), for cutting-edge Research and Manufacturing of OE Devices for applications in Energy, Displays, Lighting, Electronics, Automotive, NanoBiomedicine, Smart Textiles and Wearables, IoT, Smart Food Packaging, Greenhouses.

LTFN has strong interaction and links with Academia, Research Institutes, SMEs and Industry. Equipped with 10 Pilot Lines and several TestBed facilities. LTFN is a Digital Innovation Hub and acts as a One-Stop-Shop offering Open Access facilities to interested entities (Academia, Research, Start-Ups, SMEs, Industries) and provides companies with Technology testing and Expertise, Incubation, Ecosystem building, Skills development and Access to Funding services. Moreover, it creates highly specialized and educated graduates, researchers and entrepreneurs for the society.

LTFN coordinates many EU/National R&D Projects, has founded the Hellenic Organic & Printed Electronics Association HOPE-A, the R&I Network





Flexible Printed Organic Photovoltaics fabricated in the Printed Electronics pilot to Production lines of the Nanotechnology Lab LTFN/AUTh

Nano|Net, the Post Graduate Program on Nanosciences & Nanotechnologies - NN, and organizes annually the internationally established NANOTEXNOLOGY multi-event which comprises International Conferences, Summer Schools and Exhibitions on Nanotechnology, Organic Electronics, 3D Printing, 3D Bioprinting & Digital Manufacturing and Nanomedicine

Main research activities and services

LTFN Services for Organic and Printed Electronics, Thin Films, Nanomaterials, Nanoengineering, Optical Technology and Nanometrology

- R2R Pilot &Production line: large area R2R manufacturing of OE devices, equipped with Ultra-fast Laser scribing and in-line metrology systems. Main technologies used: Printing (Slot-die, Inkjet, Screen printing), Ultrafast Laser Patterning, Encapsulation module, Raman Spectroscopy & In-line Spectroscopic Ellipsometry.
- Sheet2Sheet Pilot line: Hybrid Printing and Vacuum Technologies for OE devices with Encapsulation technologies and Solar Simulator system.

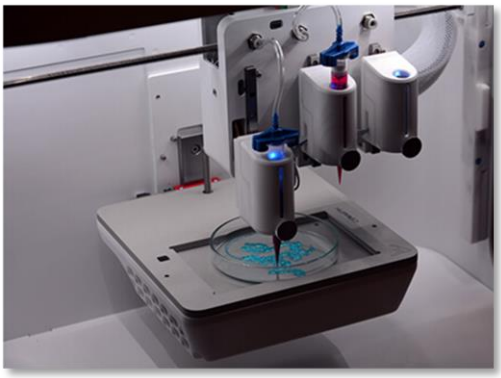
R2R Pilot &Production line of the Nanotechnology Lab LTFN/AUTh.

- OVPD Cluster-Gas Transport Pilot line: Scalable OVPD Pilot line equipped with in-situ optical metrology systems (Raman Spectroscopy, Spectroscopic Ellipsometry) for high precision fabrication of OE devices.
- Lab scale Printing: Printing techniques (S2S Gravure, Slot-die, Inkjet) for Digital fabrication of OEs & Bioelectronics nanomaterials, devices and systems.
- Short & Ultrashort Pulsed Lasers systems: High energy laser systems for ultrafast processes (laser ablation, laser annealing, patterning) for fabrication and functionalization of novel nanomaterials and nanoparticles.
- CVD Pilot line: Thermal and Plasma CVD Pilot line for Graphene and 2Dnanomaterials growth in 6” wafers. The system is equipped with real-time optical monitoring techniques (Vis-UV SE and Raman) for in situ characterization and process optimization.
- 2 Ultra High & 1 High Vacuum Pilot lines: equipped with state-

S2S Pilot Line for OE device manufacture with encapsulation technologies and solar system

of-the-art PVD techniques (DC & RF Magnetron Sputtering, HiPIMS, Thermal & e-beam Evaporation) for thin film growth on 2D/3D subs

- Surface and Nanomechanical characterization facilities: Variety of systems (SPM platforms, SNOM and Nanoindentation systems) that enable the surface and nanomechanical characterization of nanomaterials and devices.
- Fully equipped Labs for chemical synthesis, laser-based fabrication and solution processing of inorganic and organic nanoparticles.

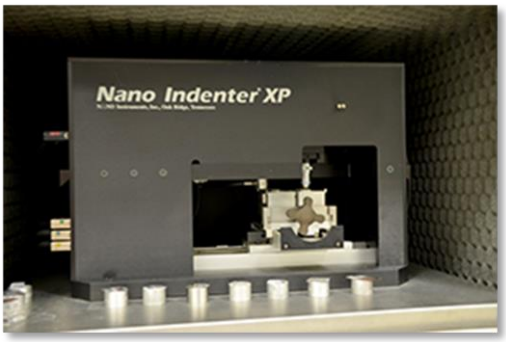


3D Scaffold manufacturing technologies for the production of complex structures

Role in the nanoMECommons Project:

LTFN/AUTh is the Leader of the WP4 and its role in the nanoMECommons includes:

- The definition of specifications and requirements for OE nanomaterials and devices.
- The selection of specific nanomaterials and device architectures (OPVs, OLEDs) that will be fabricated by R2R printing processes.
- Fabrication of OE nanomaterials in the form of blends combining novel organic semiconductors and luminescent nanolayers for OPVs and OLEDs, respectively.
- R2R printing Pilot to Production Line and integration/adaptation of metrology tools.
- The development of characterization protocols for printed nanomaterials and device architectures by non-destructive, ex-situ and in-line optical metrology tools (Spectroscopic Ellipsometry, Raman Spectroscopy, Photoluminescence) as well as by nanomechanical characterization tools (High Speed Nanoindentation for hardness and elasticity measurements, mechanical testing of flexible OE devices, including stretching, bending and nano-scratching)



The Nano Indenter XP of the Nanotechnology Lab LTFN/AUTh.

- The development of multi-technique characterization protocols combining nanomechanical testing and optical spectroscopy for flexible printed OE devices in order to assess the impact of the mechanical testing on the opto-electronic properties of the printed nanolayer, the structural stability of the printed OE devices and the final OE device performance (e.g. efficiency, life-time).
- Dissemination and exploitation activities. Organization of Special Workshops, Sessions and Summer Schools on the NanoMECommons activities within the world–class multi-event "NANOTEXNOLOGY International Conferences & Exhibition on Nanotechnologies, Organic

Electronics & Nanomedicine" (www.nanotexnology.com) that LTFN annually organizes since 2003 in Thessaloniki, Greece.

- Contribution to the connection of the NanoMECommons project with the academic, research and industrial communities, through its huge ecosystems. One of the main networks to be contacted will be the Research & Innovation Network "NanoNet" "(www.nanonet.gr) coordinated by **AUTh.**
- Communication and interaction with other EU Projects, such as in FoF, OIE, OITB.
- Links and communication with EU clusters/Platforms/Networks as EFFRA, EMCC, EMMC (AUTh member) and EPPN (AUTh member), OE-A, EUPVClusters, Nanosafety.

Photo from the Plenary Session of the "NANOTEXNOLOGY International Conferences & Exhibition on Nanotechnologies, Organic Electronics & Nanomedicine".

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ltfn nanotechnology lab

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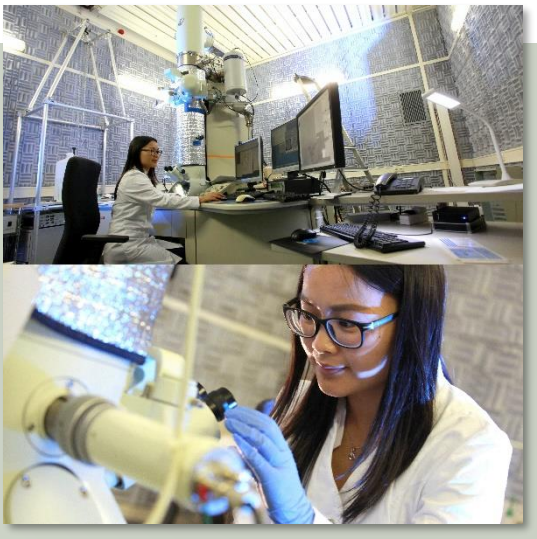
Montanuniversität Leoben (MUL), Department of Materials Science - Austria

Department of Materials Science (DMS) of the **MUL** is a world-wide recognized scientific institution in the field of synthesis and characterization of advanced functional nanostructured materials with more than 25 years of experience in the field and 150+ researchers (including technicians and administration staff). At the DMS, 100+ projects were funded within the last 5 years including Christian Doppler Laboratories, EU FP7 projects and national grants. Additionally, several Horizon 2020 projects including ERC starting, consolidator and advanced grants are running at the DMS.

Mission

Within the **Department of Materials Science**, research is done at the highest international level, to achieve a detailed understanding of the structure and the properties of materials and materials systems. In teaching, students are integrated as early as possible in research activities, to gain new insights by joint research of supervisors and students. The obtained findings are transferred to the society via publications, to establish a solid knowledge basis for future applications. International visibility of the Materials Science area at **Montanuniversität Leoben** stems from a supercritical size, which necessitates the completeness in methods available to us and in the materials classes covered.



Key Areas

- Basic research on topics of industrial relevance
- High-level education
- Graduates for industry and science

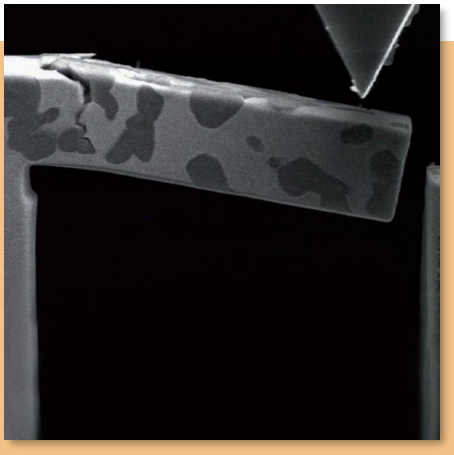
DMS provides with a high-level infrastructure for characterization of structurally complex nanostructured materials including facilities for material synthesis. The unique combination of advanced synthesis and characterization methods in one place allows for development of nanostructured thin films with highly defined microstructure and properties, which are based on established fundamental processing-structure-property relations and thus suitable as reference samples for a variety of applications.

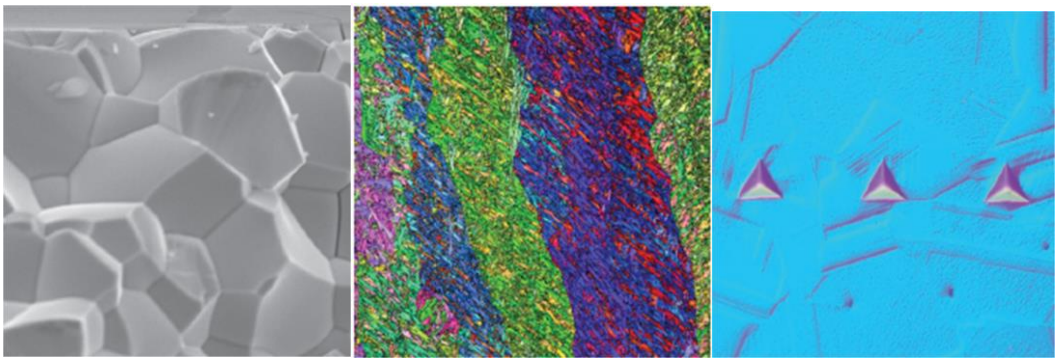
Methods

DMS operates a unique portfolio of facilities and methods for the design, synthesis, characterization and testing of advanced materials and materials systems, with strong emphasis on bridging length scales from atomistic to macroscopic. This includes top-down und bottom-up routes to synthesize nanostructured materials, a multitude of high-resolution methods for nanoscale characterization of microstructure and chemical composition, in-situ structural and functional characterization, also in harsh environments, and testing under near in-service conditions.

Role in the nanoMECommons Project:

The main responsibility of **MUL** in the frame of the project is the synthesis and characterization of thin films with specific profiles of composition, microstructure and stresses, which will be used as reference samples for the development of the FIB-DIC method for nanoscale residual stress depth profiling and cross-validation of the method with synchrotron X-ray diffraction within WP3 (Nano-scale residual stress analysis by Focused Ion Beam). **MUL** will also be a core partner for the research activities of WP2 (High-speed in-line nanomechanics), for which specifically designed reference samples with given architecture, mechanical properties and stress state will be synthesized and characterized. With the progress of the development of the FIB-DIC method and multi technique protocols, reference thin film samples will be developed to evaluate and enhance capability of the methods. Besides the state-of-the-art characterization methods including basic microstructural, morphology and stress studies (XRD, EM), characterization of interfaces (EM) and mechanical properties (nanoindentation), MUL will also actively participate to validation of the FIB-DIC method by spatially-resolved stress profile measurements based on transmission electron microscopy and cross-sectional synchrotron X-ray nanodiffraction.





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Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC) – Spain

CSIC (Spanish National Research Council) is the largest public research institution in Spain, with 123 institutes that cover basic and applied research in three global areas: Life, Society and Materia, and Interdisciplinary Thematic Platforms oriented to the coordinated resolution of great global challenges. 2 CSIC's institutes participate in NanoMECommons.

Role in the nanoMECommons Project:

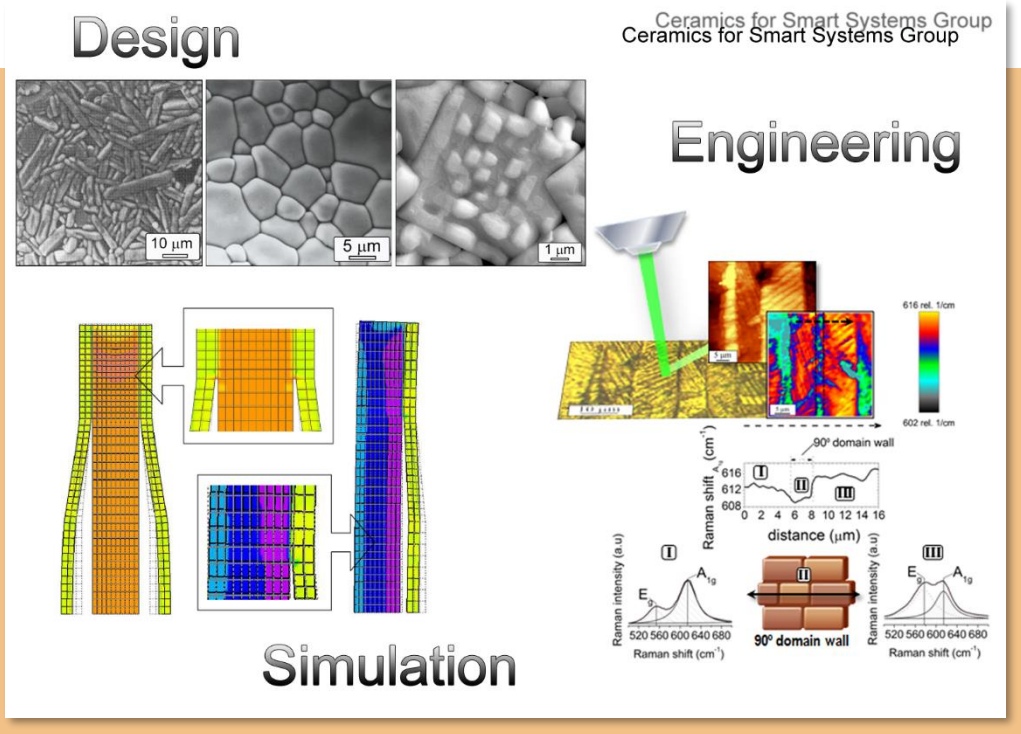
CSIC participates in NanoMECommons project as a research centre devoted to:

Spectroscopy & Industrial Catalysis group (Institute for Catalysis and Petroleum Chemistry, ICP)

- Elaborate ontologies as a basis for standardised documentation for methods and protocols for mechanical materials characterisation at microscale and nanoscale.
- Collaboration with existing NMBP characterisation projects, with 2 interaction workshops with relevant NMBP projects and the EMCC.
- Implementation of materials and process information management system (WP8).
- Submit data and reports during the project.
- Participate in the implementation of the nanoMECommons database system, alpha version.
- Project management to ensure that the planned activities will be carried out effectively pursuing the project objectives.

Ceramics for Smart Systems group (Institute of Ceramics and Glass, ICV).

- Elaborate ontologies as a basis for standardized documentation for methods and protocols for mechanical materials characterization at microscale and nanoscale.
- Lead the task 4.3 of the WP4 - Protocols for in-situ mechanical testing coupled with Microscopy & Spectroscopic methods (Raman spectroscopy and Scanning Electron Microscopy - Energy Dispersive X-ray spectroscopy, SEM-EDX, MOP, DPFM).
- Obtain true 3D optical images and topographies and measure mechanical properties by nanoindentation tests to correlate structural images of the mechanically tested surfaces.
- Collaboration with existing NMBP characterization projects, with 2 interaction workshops with relevant NMBP projects and the EMCC.
- Implementation of materials and process information management system.
- End-user requirements for the nanoMECommons database system.
- Submit data and reports during the project.
- Participate in the implementation of the nanoMECommons database system, alpha version.
- Project management to ensure that the planned activities will be carried out effectively pursuing the project objectives



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At ICP:
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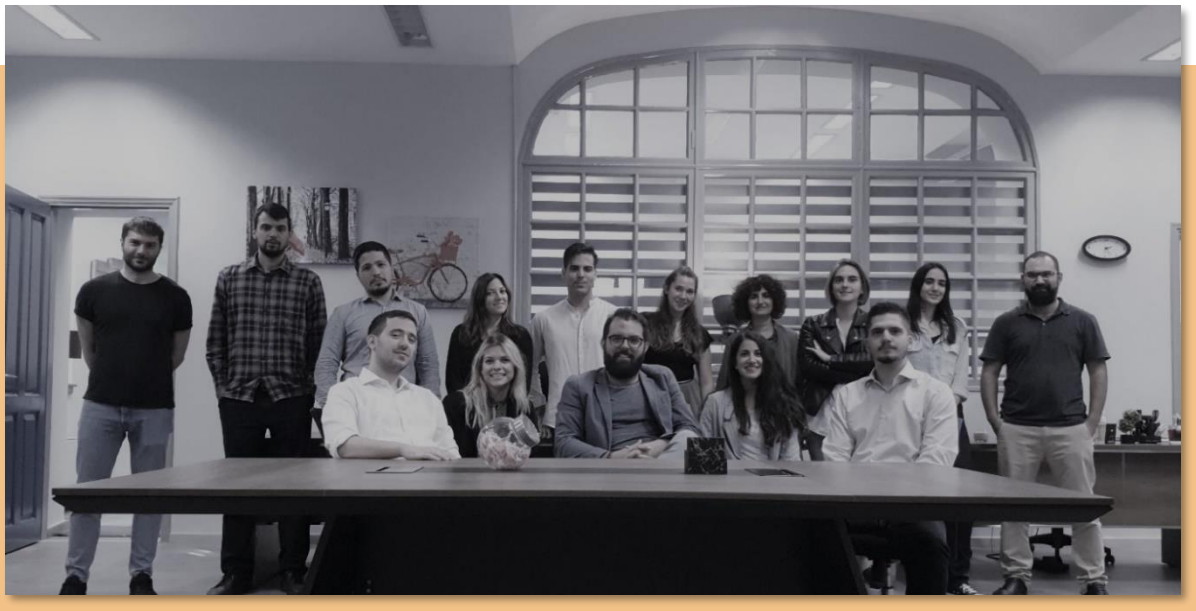
Research Full Professor
Dr Raquel Portela
Tenured Scientist.

CSIC

www.csic.es

Innovation in Research and Engineering Solutions – IRES - Belgium

IRES, founded in 2015, is devoted to provide decision making tools and methodologies for environmental, safety and risk assessment, materials characterization/digitization and process optimization. We are a team of chemical engineers, physicists, materials and data scientists with a mission is to deliver world-class innovative solutions. Customized and tailored solutions on demand, often in tool form, successfully identify possible business risks and provide sustainable directions. For this, the whole lifecycle of products is considered, through a holistic evaluation of social, environmental and economic aspects based on EU standards and regulations. In collaboration with external bodies and related initiatives, **IRES** is part of, build upon and push the frontiers at new technological events, arising innovative technologies and strategic research trends.



Our products & services:

IRES offers innovative nanotechnology solutions regarding the developing (nano)technologies focusing on the Life Cycle Sustainable Assessment (LCSA), Environmental & Carbon footprint and Circular economy, in line with the application of portable airborne nano(particle) concentration measurement instruments in specially designed exposure assessment experiments. Detailed analysis of data generated, and consultation on potential safety issues are also provided. All the above are merged with data driven solutions such as Machine Learning for Material Science, Computer Vision and Data management and generate extra value to the produced scientific data beyond their initial purpose. Also provides its expertise and services to the latest cutting-edge technologies, like Nearly Zero Emission Buildings (NZEBs), Renewable Energy Systems (i.e. photovoltaics, wind and tidal turbine

rotor blades), Additive Manu- facturing, (nanoenabled) Composites, Water Pollution and Wastewater Recycling.

Role in the nanoMECommons Project:

IRES will be mainly involved in the creation of i-CHADA that will be developed as a web platform and the creation of Nanoindentation data analysis tools, including machine learning and protocols. Also, **IRES** will assist in the development of Industrial case-specific application ontologies and metadata schema, in close collaboration with the other respective tasks. Finally, **IRES** will create Harmonized protocol for phase-separated compositional and nanomechanical characterisation data.

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Fraunhofer (IWM) – Germany

The **Fraunhofer-Gesellschaft**, headquartered in Germany, is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. As a pioneer and catalyst for ground-breaking developments and scientific excellence, Fraunhofer helps shape society now and in the future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions throughout Germany. The majority of the organization's 29,000 employees are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research.

The **Fraunhofer Institute for Mechanics of Materials IWM** (located in Freiburg; www.iwm.fraunhofer.de) is a leading research centre in the modelling, experimental and theoretical characterization of material properties. The objective of Fraunhofer IWM is to develop solutions that improve the safety, reliability, durability, and functionality of materials, technical components, and systems, thus making them more cost-effective and energy-efficient. The combination of experimental characterization, computational simulation, and multiscale modelling is a primary focus of the institute. Lately, the Fraunhofer IWM took a leading role in the digitization of materials, i. e. making data and models available and interoperable for advanced analytics and sustainable long-term accessibility. Fraunhofer IWM seeks for a common agreement on community-based ontologies for materials modelling and characterization and is heavily engaged in the European Materials Modelling Council (EMMC), in the European Materials Characterization Council (EMCC) and in the platform MaterialDigital.

Our products & services:

Fraunhofer IWM offers the following services:

- Solutions to prevent and control defects, crack formation, deformation, fracture, failure, wear, and fatigue in materials and components when taxed with mechanical, thermal, chemical or electrical loads
- Material characterization, component testing, failure analyses, defect diagnosis, and microstructural analysis
- Materials modelling, process and component simulation on the atomic, microscopic, mesoscopic and/or macroscopic scale
- Evaluation of surface layers, coatings, tribology, functionalization, bio-surface, and interface analysis
- Process and material development

Especially in the area of digitalization of materials, the Fraunhofer IWM offers:

- Conception and implementation of workshops for digitalization of material-intensive production chains (determination of requirements, analysis, obstacles, possible solutions)
- Support for the elaboration of process and material ontologies
- Hierarchical description of materials by data achieved from experiments and simulations alongside processes
- Generation of digital data sets and representations of materials
- Design and development of materials data spaces
- Integration of material data in a digital twin for materials, processes, and components including multiscale modelling techniques like virtual testing (Virtual Lab)
- Finding and attaining structure-property-relationships of new material systems
- Using material information as a means of control within the production process
- Digital imaging for more detailed analyses of the material
- Linking material histories including e.g. general information, experimental observations and the predicted behaviour in order to improve your material, process and component by analysing the material histories
- Automatic material data creation (e.g. 3D structure capturing, microstructure analysis, tribofarming)
- Top-down/bottom-up informed modelling of material properties ranging from the atomistic to the component scale (multiscale information exchange)
- Data analysis for the development of structure-process-property relationships (deep learning and statistics)
- Automatic generation of material card
- Semantic technologies via ontologies for the Open Innovation Environment (OIE) of the OYSTER and the MarketPlace Horizon2020 funded EU-projects
- Know-how in the European Materials & Modelling Ontology (EMMO)

Role in the nanoMECommons Project:

Fraunhofer IWM will be involved in the activities related to elaborate ontologies as a basis for standardised documentation for micro- and nanomechanical materials characterisation (methods and protocols) and multi-technique protocols

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Fraunhofer IWM

www.iwm.fraunhofer.de

Goldbeck Consulting Ltd. (GCL) - UK

Over the course of a 25-year career in academia and the software industry, **Gerhard Goldbeck** saw how materials modelling and informatics grew and developed on the one hand, and fell short of its full potential on the other. Founded in 2011, **Goldbeck Consulting** aims to identify and bridge the gaps holding the materials modelling ecosystem back.

While the term 'materials modelling' suggests a well-defined field, the reality is that it is an agglomeration of traditionally quite separate science and engineering sub-disciplines, in terms of models, methods and applications. The result is often very confusing for new-comers and stands in the way of the full discovery, development, and use of new materials in response to society's many challenges. **Goldbeck Consulting** helps you navigate this ecosystem successfully, by: connecting communities; supporting the validation and technology transfer of academic developments to industry; translating industrial needs into impactful materials modelling projects; and researching the pathways and barriers to economic and societal impact.

Goldbeck Consulting has a proven track record of delivering results working with more than 20 clients from the academic, software and materials sectors and more than 10 European Horizon projects.

Our services:

Insights

Obtain insights into the complex landscape of materials modelling, informatics, and digitalisation.

Translation:

Get independent translation advice on materials modelling and digitalisation solutions for industrial R&D.

Impact

Track the maturity and improve the impact of materials modelling in your organisation.

Commercialisation

Plan the commercialisation of your software developments.

Ontology

Make sense of ontology-based data modelling in the complex materials science domain.

Funding

Increase EU grant funding and project impact.

Role in the nanoMECommons Project:

GCL will support NanoMECommons contributions to ontologies data structures and standardised documentation, leading WP1. GCL will also support cooperation towards standardisation and an Industry Commons of characterisation data and protocols. **GCL** will contribute its experience and expertise in EMMO as well as standardisation to support the development of standardised documentation of characterisation protocols based on widely agreed EMMO compliant ontologies. It will include materials characterisation terminology and metadata standardisation and establishing reliable and standardised connections between characterisation metadata and performance descriptors. **GCL** will contribute fostering a close collaboration on metadata and ontologies between the European Materials Characterisation Council (EMCC) and the European Materials Modelling Council (EMMC). Further, GCL will support EMCC and EMMC efforts to establish a wider manufacturing/modelling/characterisation network linked with stakeholder platforms such as EPPN and OIE/OITB Projects (CORNET, MMAMA, OYSTER, TEESMAT, etc.)

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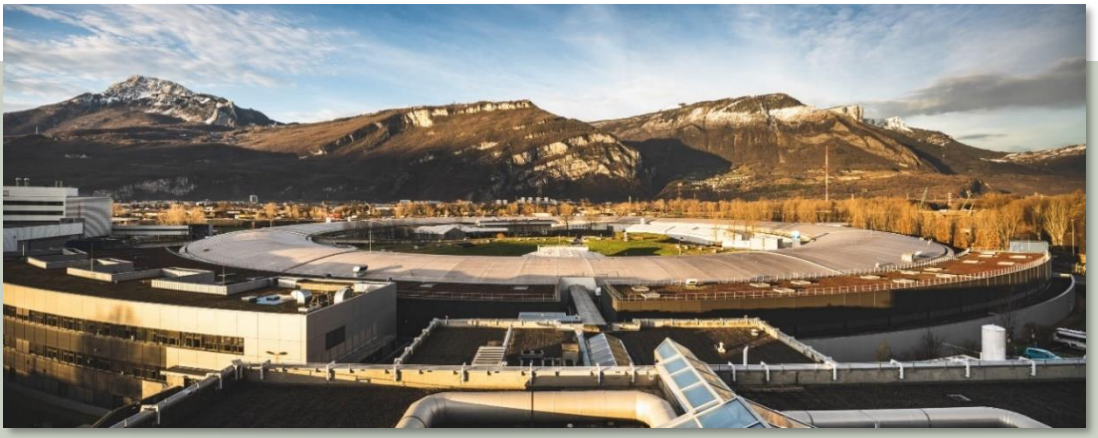
European Synchrotron Radiation Facility (ESRF) - France

The **ESRF i**s the most intense and brilliant hard X-ray sources existing today worldwide. An extremely bright source that produces X-rays 10 trillion times brighter than the X-rays used in hospitals or laboratories. Using these X-rays, the ESRF functions like a “super-microscope”, which "films" the position and motion of atoms in condensed and living matter, and reveals the structure of matter in all its complexity allowing:

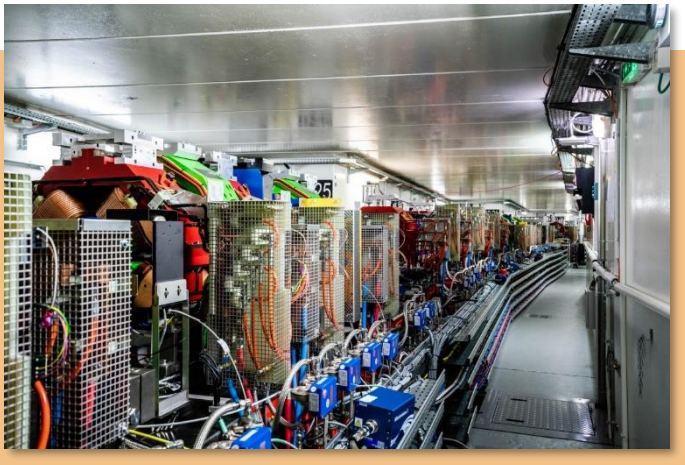
- NON-DESTRUCTIVE probing of material structure;
- HIGH SPATIAL RESOLUTION from millimetres to nanometres and even to atomic resolution;
- FAST-TO-FOLLOW processes in real time with less than a microsecond time resolution;
- IN SITU ANALYSIS under real manufacturing and operating conditions (extreme temperatures, pressure, mechanical stress, chemical environments, etc.);
- WIDE RANGE OF SAMPLE ENVIRONMENTS: furnaces, cryostats, diamond anvil cells, large volume press, on-line mixing, microfluidics, gas atmospheres...

The **ESRF** offers industry privileged and practical access to its 44 highly specialised experimental stations, called “beamlines", in a completely confidential manner (through the Non-Disclosure Agreement). Each beamline is equipped with state-of-the-art instrumentation, which support a wide range of experimental techniques. More about our techniques.



Because of its properties, synchrotron radiation is used increasingly as a response to industrial challenges related to the life cycle of materials: development, manufacturing, operation, ageing, wear-and-tear, preservation, restoration, recycling, evaluation, and more. Observing, characterising and understanding the structure of matter are at the heart of these challenges for industry. Our applications cover many fields, including pharmaceuticals and biotechnology, chemistry and catalysis, cosmetics, food products, construction and transport engineering, nanotechnologies, semi-conductors, energy, environment, metallurgy, and advanced materials.

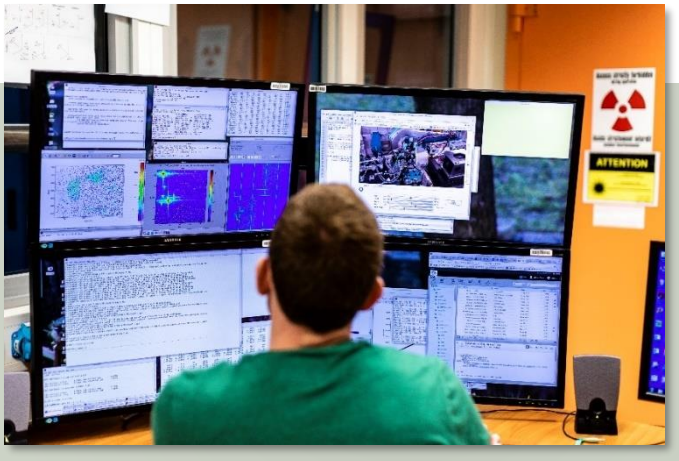
Welcoming thousands of scientists from around the world, the ESRF is an international centre of excellence for fundamental and innovation-driven research in condensed and living matter science. The ESRF plays a key role in stimulating innovation and enhancing competitiveness and it is accessible for companies of all sizes from all sectors of industry. 30% of the ESRF's public research involves industrial participation and over 150 clients ranging from start-ups to major brands have used the ESRF's facilities for confidential research over the last 5 years.



Our services:

Below we report the main techniques available at the **ESRF** for material and device characterisation.

Powder diffraction makes it possible to analyse the structures of materials under a wide range of conditions, e.g. while heating or cooling, or under different atmospheric conditions. The positions, intensities and shapes of the peaks in the powder diffraction pattern reveal information about the microscopic structure and strain state of a sample, and can also be used to identify which substances are present in a (possibly complex) mixture. Such information is crucial for understanding the properties and behaviour of materials.



Surface diffraction is a technique dedicated to surfaces and interfaces structural characterizations. It can be used for performing static surface crystallography studies or for studying processes at surfaces in real time. Even if several other techniques allow a structural determination of surfaces, X-ray diffraction offers unique possibilities. Surface X-ray diffraction is not limited to free surfaces under UHV conditions but it can be applied with success to study solid interfaces. Solid/liquid interfaces and high-pressure gas/solid interfaces are well adapted to the technique. This is of particular importance in the case of heterogeneous catalytic reaction where the role of the catalyser can be studied under real working conditions. In addition to crystallographic studies, surface diffraction is also suited to dynamical studies such as epitaxial growth, ion patterning, surface kinetics and phase transitions.

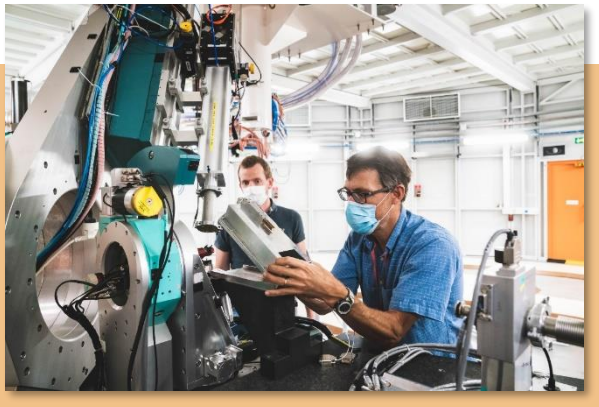
X-ray nano and microtomography extends the capacities of X-ray imaging to produce pictures of ultra-high resolution and contrast. Using synchrotron radiation enabled phase-contrast imaging, scientists can produce 2D and 3D representations with micrometre resolution. Often, samples can be studied where classical techniques do not provide any useful image at all. The ESRF provides a sample environment, with temperature ranges from -60° to 1600°C, as well as tension, compression and fatigue stress devices.

X-ray fluorescence microscopy and nano-spectroscopy use very fine high-quality beams, focused on extremely small areas within heterogeneous materials. For example, trace elements within hard or soft substances can be identified. This enables new investigations, of major interest in the biological and material sciences, with very little preparation needed for the materials being used.

Small- and wide-angle X-ray scattering (SAXS and WAXS) use the high brilliance to study condensed matter samples in liquid or solid form. It offers sub-micrometre spatial resolution and deep penetration into materials, such as colloids, polymers, surfactant membranes and proteins, even when these are opaque or turbid. SAXS and WAXS can be combined with other techniques, such as rheology and light scattering, to provide better understanding of sample behaviour on short time scales (sub-milliseconds).

X-ray absorption spectroscopy provides information on the atomic organisation and chemical bonding around an absorbing atom in whatever medium it is embedded, i.e. solids and liquids. There are essentially two types of absorption spectroscopy: X-ray Absorption Fine Structure (EXAFS) and X-ray Absorption Near Edge Structure (XANES). Both techniques are element-selective, which means that scientists and researchers can study and characterise elements in their “working state” within compounds.

Role in the nanoMECommons Project:



The main contribution of the **ESRF** to the NanoMECommons project is the implementation of a multi-material multi-modal strain microscope. This is based on a prototype developed by the ESRF in research partnership with Nelumbo Digital. It allows the homogeneous straining of thin films and membranes of metals, oxides, semiconductors (organic/ inorganic) and their observation by microscopy, Raman or UV/VIS spectroscopy or X-ray diffraction. The tool allows the dynamic imposition of homogeneous tensile strain over macroscopic areas up to the elastic limit of the material while limiting the impact of local defects and cracks on the strain. The operando investigation by optical means and high energy X-ray diffraction

allows for a precise characterisation of the strain itself but also its impact on electronic properties. It has been successfully tested with Si-membranes where strain levels of 1.9 % have been reached. The dynamic application of tensile strain with this apparatus allows the experimental determination of a materials Young's modulus. The deployment of this tool will provide a new extremely user friendly, economic and quantitative strain analysis tool supplying insight in fields ranging from metallurgy over flexible/organic electronics to batteries.

Beside the strain microscope, the **ESRF** contribute also to the validation of the high-speed 4D nano-indentation mapping methodology and of the nanoscale residual stress depth profiling. The validation is operated by characterising reference samples with non-destructive spatially-resolved synchrotron X-ray diffraction, to couple the resulting mechanical properties provided by the nanoindentation testing with the phase and structure analysis.

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ESRF
The European Synchrotron

www.esrf.eu/

Cambridge Nanomaterials Technology Ltd - UK

Cambridge Nanomaterials Technology Ltd (CNT Ltd) is an innovation management and nanotechnology consulting company based in Cambridge, UK.

The CNT Ltd helps companies, academic and government institutions to develop world-class innovative solutions for nanomaterials related R&D and IPR strategy, partnership, products, technologies, funding and markets. CNT Ltd is specialised in carbon nanomaterials R&D consulting and collaborative R&D project management, including exploitation and dissemination management, consortium and supply chain building. CNT has done a number of patent landscaping and market research analysis studies regarding production and use of various nanomaterials helping to link inventors and technology developers with end-users and investors. The CNT Ltd is a leader of two private consortiums: **Nano-Carbon Enhanced Materials** (**NCEM**) and the **Advanced Materials for Additive Manufacturing** (**AMAM**) with members coming from leading multinational companies and research institutions. Through both private consortiums NCEM and AMAM, as well as private and public contracts, **CNT Ltd** has established strong relations to the aerospace, automotive, construction, electronics, materials development, biomedical and chemical industry.

In March 2019 CNT Ltd opened a sister company **CNT Innovation** based in Brussels, Belgium, with the aim to support and complement their work, especially in European related activities.

Our products & services:

- Consulting and an expert advice related to nanomaterials regarding their production, composites, applications, key players, funding and market. Experts with more than 20 years of experience in commercialisation of carbon nanomaterials (graphene, carbon nanotubes, carbon nanofibres, etc.).
- Innovation management and technology transfer support related to R&D of novel nanomateials & composites.
- Advice and support related to development of Intellectual Property (IP) Strategy – patent landscaping reports, due diligence, invention and protection.
- Market Research and Strategy - market research reports, consulting and advice about innovation, new product strategy and development, proof-of-concept, market and funding.
- Organisation of nanomaterials and nanotechnology application related conferences, workshops and customised training, seminars and support multinational companies and research institutions.

- Management in collaborative R&D projects, such as EU Horizon 2020 projects: EPPN project (www.eppn.eu); n-TRACK (www.n-track.eu); Oyster (www.oyster-project.eu); M3DLoC (www.m3dloc.eu); Genesis (www.genesis-h2020.eu); Repair3D (www.repair3d.eu); Carbo4Power (www.carbo4power.eu), APOLO (https://project-apolo.eu/), DOME (https://dome40.eu/), TRIAnkle (https://triankle.eu/); and, nanoMECommons (www.nanomecommons.eu) as well as Innovate UK projects: UltraMAT (www.ultramat.co.uk) and GRAPHOSITE (www.graphosite.co.uk). Consortium set-up, grant proposal writing support; exploitation and dissemination management; liaising with EU officials.

Role in the nanoMECommons Project:

Cambridge Nanomaterials Technology Ltd. is leading the exploitation and dissemination activities of the nanoMECommons project. **CNT** is in charge of the project website (www.nanoMECommons.eu) leaflets, organisation of the Open Day workshops, Intellectual Property (IP) strategy, and preparation of patent landscaping reports. We are also involved in market research, business development and exploitation strategy of the project.

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CAMBRIDGE NANOMATERIALS TECHNOLOGY LTD

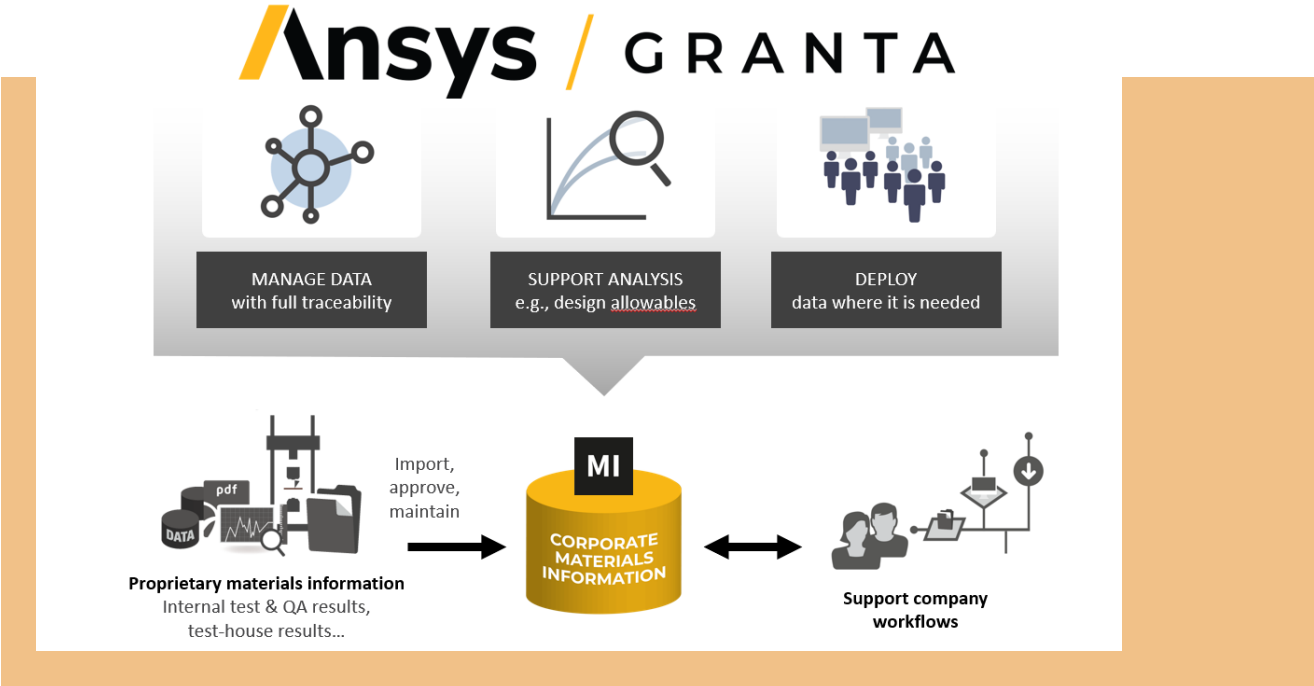
www.cnt-ltd.co.uk

Granta Design Ltd - UK

Ansys is the world leader for CAD/CAM and multiphysics engineering simulation software for product design, testing and operation and offers its software products and services to customers worldwide. The Ansys Materials Business Unit (**Ansys Granta**) has a core business for design and development of software products related to materials information management, data, and tools (eco-design, restricted substances, critical materials assessment, materials selection and substitution), several of which integrate with CAD/CAE/PLM. Ansys Materials contributes to networks and standardization bodies and supports a number of industry standard commercial databases for materials such as metals, composites, polymers, and medical devices. Ansys also produces and maintains several leading data products including Materials Universe (a database of over 4,000 commercially available engineering materials including technical, ecological and cost attributes for each material and its associated processes) and the Product Risk database which incorporates one of the leading resources on restricted substances as well as critical and conflict minerals risks and data needed for streamlined life cycle analysis. Ansys supports numerous collaborative projects by providing a centralized materials information management system for the project to enable the pooling and consolidation of project knowledge which would otherwise be dispersed amongst the partners, this approach enables standardization and capitalizes on the value in the project by avoiding duplication of effort and maximizing results visibility to partners and external stakeholders. Ansys also has reach to over 1000 educational institutes world-wide via its education software, GRANTA EduPack, which translates materials research into data, information and teaching resources. Being part of Ansus., our materials and process data, software tools, and learning resources can reach an even greater audience for higher impact of collaborative project outcomes, and we can leverage an unmatched experience in engineering simulations.

Our products & services:

Ansys Granta has a core business for design and development of software products related to: 1. Materials Information Management (GRANTA MI) 2. High quality materials and process data for selection in Concept to Details design phases to support trade-off and 'what-if' analysis (technical, environmental, sustainability, risk, cost data) 3. Tools for selection on topics of eco-design, restricted substances, critical materials assessment, circular economy, materials selection and substitution (GRANTA Selector, EduPack, and MI) 4. Integrations with business and engineering workflows such as CAD/CAE/PLM and other modelling software (GRANTA MI) Our main areas of R&D related to materials includes ICME including machine learning and modelling, biomaterials, biomedical materials, risk and sustainability, circular economy, eco-design, additive manufacturing, electronics and electrification, built environment, composites, advanced metallurgy, multi-scale modelling and characterisation, coatings, functional and smart materials, etc. We support numerous collaborative projects as a partner by providing a centralized materials information management system for the project to enable the pooling and consolidation of project knowledge which would otherwise be dispersed amongst the partners. We underpin active H2020 projects under the headings of Open Innovation Environments (Cornet), Open Innovation Test Beds for various material and process topics from metals to organic electronics (FormPlanet, iTRIBOMAT, nanoMECommons, iCLIMABUILT, MusiCode) which support the roadmaps for materials and process modelling (EMMC ASBL, MarketPlace), and materials and process characterization (EMCC), Pilot Lines (RealNano, FlexPol, AMAZE), raw materials and circularity (TripleLink, EcoBulk, Life+), Eco-Design (RESCOM, PLEIADES), antimicrobial products (FlexPol), additive manufacturing (AMAZE, SAM), among others. We have also worked on national projects for batteries and electrification (Mat2Bat, IDMBAT, EV-JOIN) and additive manufacturing (DRAMA).



Role in the nanoMECommons Project:

The main role of **Ansys Granta** in the nanoMECommons project is to establish a central materials and process information management platform for capturing characterisation data/information, digitizing of protocols, searching across multiple datasets and IP protection. This includes the design of appropriate schema and identification of metadata for specific materials and processing domains for the project for full traceability, from material batch to protocols for characterization protocols (experimental and virtual). The database system implementation will also incorporate the experience of other NMBP OITB's in these domains as represented by the project, and industry best practices as established by Granta and its partners over the past 25 years. The materials information system will be linked to other platform (e.g. OITBs and MarketPlaces) using or informing the latest interoperability standards derived from NMBP related activities for materials and processes (EMMC, EMCC, Pilot Plants, ….). The development will ensure the data and information generated within the project will follow FAIR principles. In addition, Ansys Granta will establish collaborative tools for early product design stages (ecological, cost, risk, REACh, health and safety, material & process selection, circular economy), tailored to the life cycle analysis of nanomaterials and related processes (up to 80% of life cycle cost and environmental impact is lock-in at the early product design stages). Finally, Ansys Granta will support development of a sustainable, scalable business model for Open Access to the materials, processes and characterization information and protocols digitized in the project for all relevant stakeholders (industries, SME's, equipment manufacturers, technology developers, RTOs, academia).

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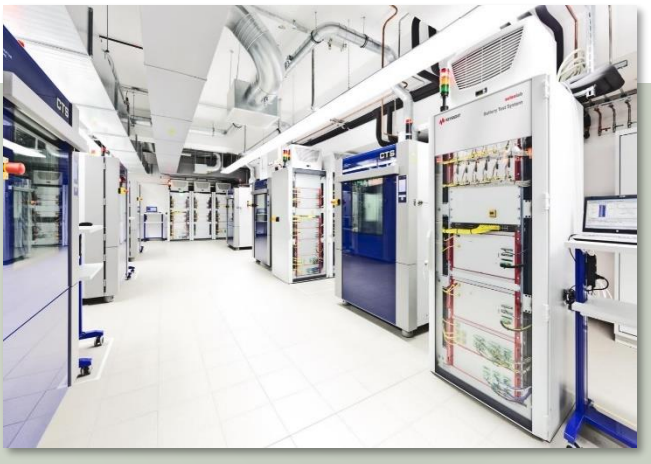
Keysight Technologies GMBH - Austria

Keysight Technologies (Keysight) is one of the world's premier electronic measurement companies with 14.000+ employees (spin-off from Agilent Technologies in 2014) and was added in 2018 to the famous USA S&P500 stock index. Keysight offers a portfolio of different electronic measurement equipment, calibration devices, software packages, and data analytics, including high speed oscilloscopes and performance network analysers that are in many aspects leading the edge on performance, speed, and sensitivity in the broad frequency spectrum. Recently, Keysight extended the automotive and battery division by adding automotive battery test systems on top of power supplies and source measurement units. Also, it provides GHz measurement technology including 3D electromagnetic modelling suites EMPro and electrical/thermal modelling ADS. Keysight Technologies GmbH Austria has one of the leading industrial research labs on the microwave GHz measurement including high frequency PNA technology, GHz calibration algorithms, and tomographic imaging reconstruction. Several Keysight scientists work in this lab on technology with a strong footprint in basic science, as shown by 100+ peer reviewed publications in the last 10 years.

Our products & services:



- Oscilloscopes + Analyzers
- Meters
- Generators, Sources + Power
- Wireless
- Modular Instruments
- Software
- Network Test
- Network Security + Visibility
- Battery Test Systems

Additional Products

- In-circuit Test Systems
- Application-Specific Test Systems and Components
- Parametric Test Solutions
- Photonic Test & Measurement Products
- Laser Interferometers and Calibration Systems
- Monolithic Laser Combiners & Precision Optics
- MMIC Millimeter-Wave and Microwave Devices

Services:

- KeysightCare Service and Support
- KeysightAccess Service
- Calibration Services
- Repair Services

- Technology Refresh Services
- Test as a Service (TaaS)
- Test Asset Management and Optimization
- Network/Security Services
- Consulting Services
- Financial Services
- Education Services
- Keysight Support Portal
- Used Equipment

Role in the nanoMECommons Project:

KEYS will develop and harmonize a protocol for the combined testing of batteries, including metrological data evaluation and standardization of the various instruments that are used in the data acquisition. New battery models are being developed including metrological data acquisition hardware and software.

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Thales Research & Technology - France

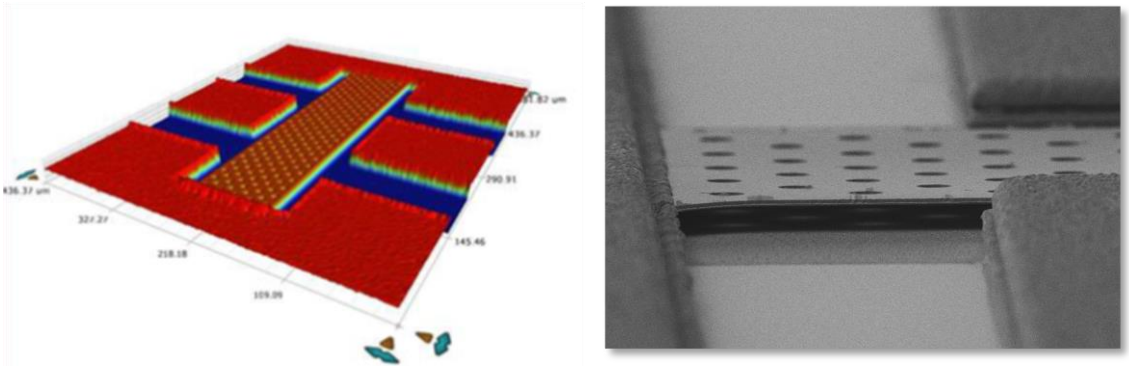
Thales Group is a French multinational company that designs and builds electrical systems and provides services for the aerospace, defence, transportation and security markets.
It is partially state-owned by the French government and has operations in more than 56 countries. It has 80,000 employees and generated €18.4 billion in revenues in 2019. As of 2017, it is also the 8th largest defence contractor in the world and 55% of its total sales are military sales.
Thales R&T's mission is to provide short-term and long-term competitive advantage to the THALES Group by transferring leading edge knowledge by injecting innovation. THALES Research & Technology-France, located in Palaiseau near Paris, is the main multidisciplinary research unit of the **THALES Group**, one of the major world players in aerospace, space, defence, and security. Through its internal activities and scientific links with industries and universities, either in France or internationally, **THALES** is participating in the preparation of THALES industrial future in strategic R&D fields.

Services:

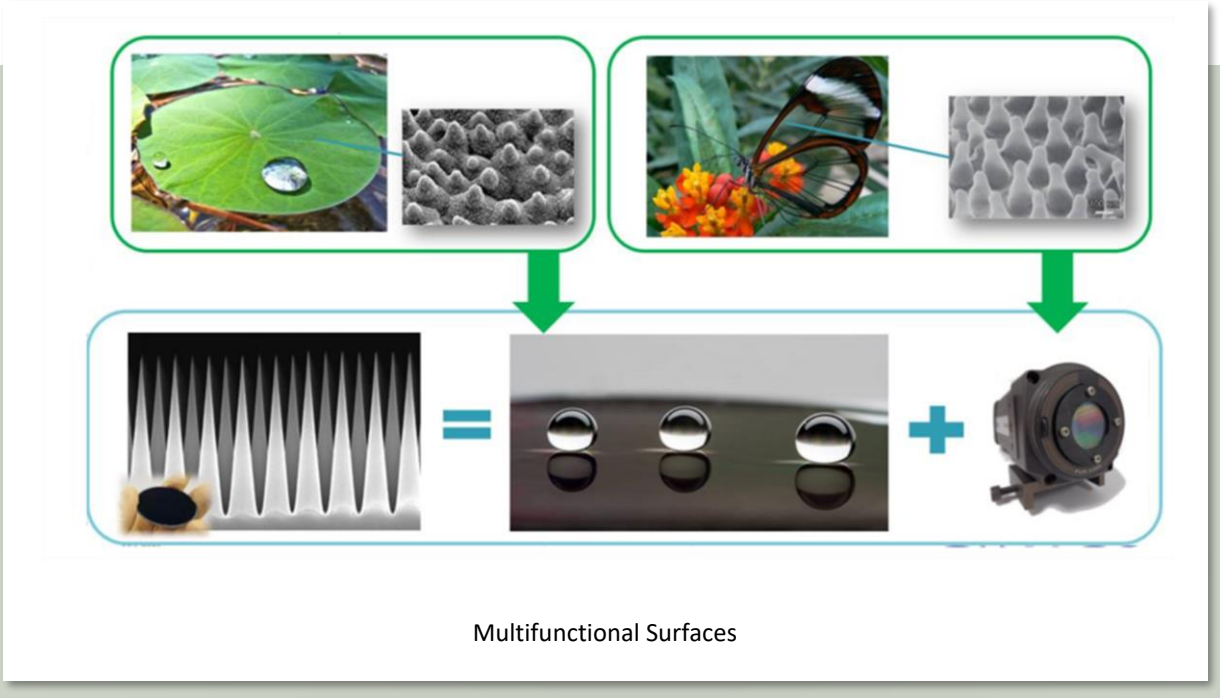
THALES is well equipped for this research with state-of-the-art 1700 m2 clean-room facilities and 13000 m2 laboratory space. Over 300 highly skilled staff have access at TRT to all necessary processing equipment, specific test benches and are supported by in-house analysis laboratories.

Role in the nanoMECommons Project:

Thales R&T is industrial case-studies provider in the nanoMECommons project. Its activities based on multifunctional surfaces, exhibiting both superhydrophobic and antireflecting behaviours, and NEMS/MEMS for RF-applications, need fast, reliable and non-destructive characterization methods to get higher TRL and accelerate the technological transfer to Thales entities.



MEMS/NEMS devices



Multifunctional Surfaces

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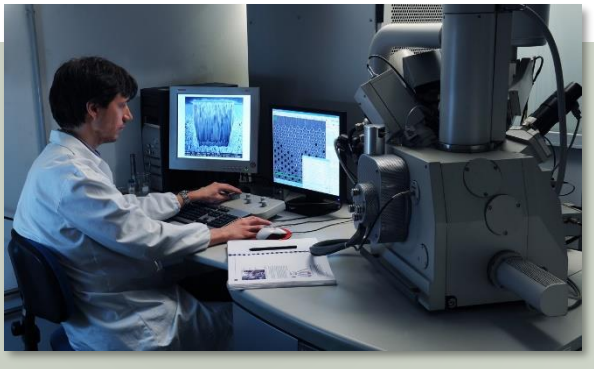
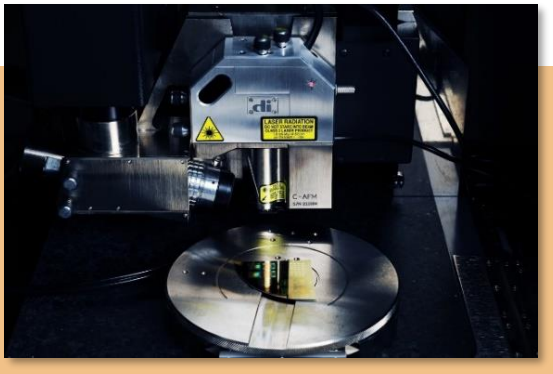
Centro Ricerche FIAT S.C.p.A. – Italy

Centro Ricerche FIAT (CRF) is an industrial organization having the mission to promote, develop and transfer innovation for providing competitiveness to the Stellantis Group. With a full-time workforce of more than 600 highly trained professionals, CRF fulfills its task by focusing on the development of innovative products & materials, implementation of innovative processes, development of new methodologies and training of human resources. To properly cover a very wide technological spectrum, CRF developed a global network with national and international institutes, private and public research organizations, universities and companies, through the promotion of common research activities, associations, conferences and seminars and researchers' mobility. This network further strengthens the center's global innovation strategies, the implementation of specific activities locally, creation of expertise and continuous monitoring to enhance competitiveness and further development in areas such as transportation vehicles and components, innovative materials and application technologies, as well as the work on innovative alternative propulsion systems and transmissions. CRF is organized in four technical divisions: Process Research, Vehicle and Body, Powertrain and Materials Engineering Methods and Tools. The division Materials Engineering Methods and Tools guarantees to Stellantis the knowledge and applications of the materials from innovation to ensuring the quality of the materials in all phases of product development. MEMT is a part of the material laboratories for the whole Stellantis group. This division is directly involved in the project.



Our products & services:



CRF Materials Engineering Methods and Tools is a part of materials engineering of Stellantis Group. MEMT has in charge the definition and maintaining of ex FCA company standards on materials and components and target performances for automotive applications, performing materials characterization and part and component validation.

Role in the nanoMECommons Project:

CRF Materials Engineering Methods and Tools (MEMT) acts as end user of the automotive supply chain. The expected activities within Nanomecommons project focus on the evaluation of mechanical and residual stresses of bulk materials subjected to surface heat treatment, via the correlation between retained austenite levels and hardnesses levels in real application cases, as gear tooth.

The main tasks attributed in the project are:

- Setting specifications and standards for automotive applications in vehicles: standards for in-line and off-line metrology and characterization
- Quality control and assessment of the process for automotive compliance following FCA standards
- Characterization of demonstrators and their applications: metals bulk assessment and coating characterization
- Follow-up manufacturing trials and characterization procedures
- Transferring of developed technical approaches in working automotive standards
- Validation process on demonstrator of automotive applications. Reliability assessment, non-destructive testing and prevalidation.
- Evaluation of metrology and assessment processes for the automotive sectors and exploitation within the automotive market and transfer to Tier1, Tier2 and SI.
-

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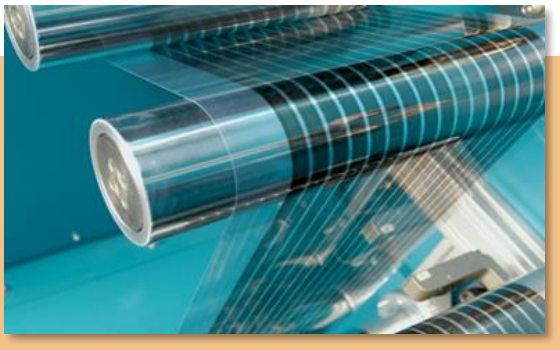
Organic Electronic Technologies (OET) - Greece

OET is a high-tech SME, founded in Thessaloniki in 2012 with an expertise in R2R manufacturing and technologies for flexible Organic Electronics (OE), holding more than 30 years of experience in thin film technologies and printed OEs. OET develops and optimizes unique, patented R2R manufacturing pro¬cesses and equipment (R2R printing, Laser patterning and Quality con¬trol tools) for Organic Printed Photovoltaics, Organic LED (OLED) and other OE products and applications. OET develops and optimizes the material formulations, thin films and process technologies for OE devices. Its expertise and know-how in¬cludes research and technology for design, manufacturing and applica¬tion of OPV and OLED products.

Our vision is "sustainable energy from every surface and everywhere" through the application of flexible, innovative Organic Printed Photovoltaics in buildings, facades, automotive and transport applications, tourism, greenhouses and wearable products. Our unique competencies include:

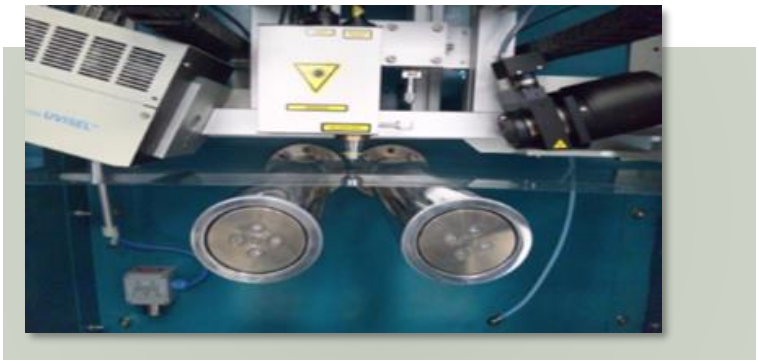
- R2R manufacturing and mass production of fully printed OPVs
- Process technologies and manufacturing automations for flexible OPVs and OLEDs
- In-line optical metrologies and methodologies and quality control tools for process reliability and manufacturability
- In-line Pulsed Laser patterning tools for minimal losses and high quality and performance devices at low T
- Turn-key Solutions for design and development of highly performing OPV and OLED applications.

ROLL TO ROLL (R2R) PRINTING



OET designs and develops R2R printing, pulsed laser processing and quality control technologies, aiming at cost-effective, high-throughput manufacturing of OPVs on flexible plastic surfaces. Its achievement in scalable production and nanoscale precision in R2R printing machines, optical engineering, reduction of manufacturing waste and costs, and increasing efficiency of OPVs is based on a huge R&D investment that took place during the last decade in developing R2R production line, unique in-line optical precision metrologies and quality control and pulsed laser scribing tools.

OPTICAL METROLOGY AND QUALITY CONTROL



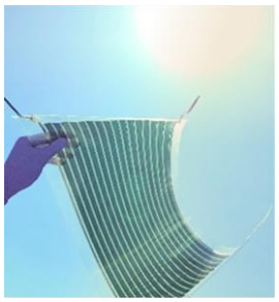
OET devices consist of multilayer stacks, with a thickness ranging from a few to hundred nanometers, deposited by various printing processes onto flexible substrates of only 100µm thick. The major factors that affect the functionality of the deposited films, which are directly related to the OPV device performance, are their optical properties, uniformity, composition, morphology, nano-separation, surface roughness and thickness. Thus, **in-line** and **real-time** precision optical metrology and quality control of film deposition down to sub-nanometer scale is crucial for the process repeatability, reduction of waste and cost-effective manufacturing production. OET holds vast experience in developing and deploying patented In-line and In-situ Spectroscopic Ellipsometry (SE) in thin films precision metrology and OPV production. SE is a powerful and robust, non-destructive optical metrology tool for the real-time monitoring of the key layer properties that affect device quality, performance and process reliability. In-line metrology tools aid the real-time automated decision-making process based on digital closed loop feedback control that can lead to **higher production yield, zero-defect manufacturing and product quality** that meets the highest standards.

PULSED LASER PATTERNING

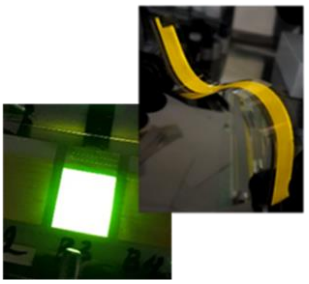
Ultra-Short, Pulsed Laser scribing is considered ideal for selective thin film (organic and inorganic) material removal and electrical isolation cuts, on rigid and flexible substrates, due to low temperature removal mechanism (Cold Ablation). OET provides the process technology platform for the optimization of in-line, micro-precision, pulsed laser scribing in production of OPVs to increase the active area and performance and by avoiding dangerous and toxic chemicals.

Our products & services:

OET products include mainly OPV panels, OLEDs and then RFID antennas and sensors that are integrated in various applications related with high-growth markets. OET has demonstrated OPVs and OLEDs in various applications including automotive, building integrated PVs, agriculture, wearables and tourism. OET is highly expert in R2R manufacturing of OEs and develops automated R2R printing systems combined with real-time feedback process control by in-line metrology tools that can be used as turn-key solutions in Organic Electronics industry and other industries.



OPVs



OLEDs

RFIDs and sensors

Next images show some of OET recent demonstrators.

Some of OET's demonstrators on OPVs.

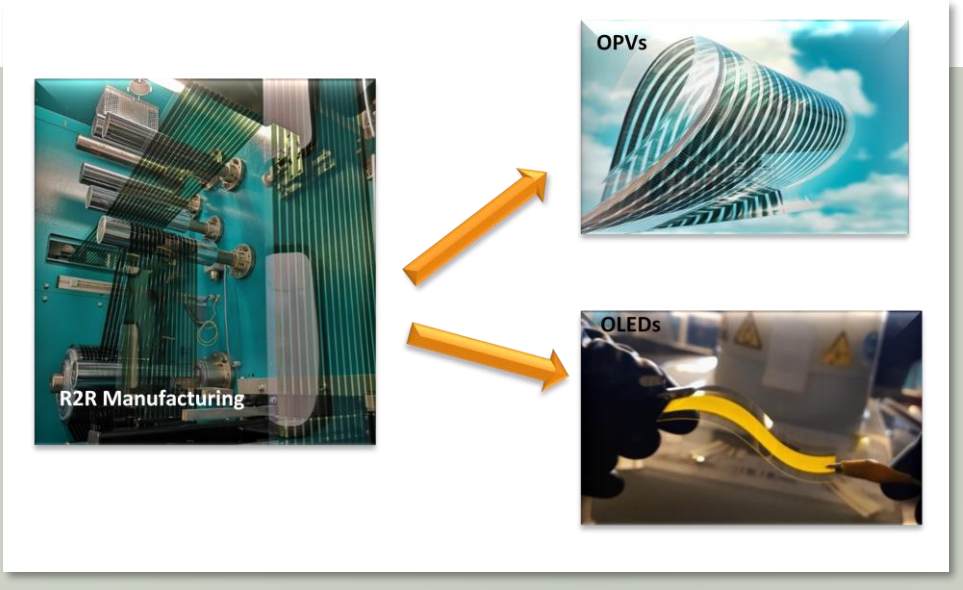
Role in the nanoMECommons Project:

The main role of OET in the project includes:

- Multi-technique characterization protocols (optical, electrical, nanomechanical) for Organic Electronic applications
- R2R manufacturing of OPV and OLED devices and in-situ & ex-situ electrical, in-situ optical, structural and mechanical characterization
- Fabrication of high-efficient OPV and OLED devices with improved mechanical performance and stability

More specifically OET, is one of the industrial partners and leads the use case of Organic Electronics, where multi-technique characterization protocols will be implemented and applied. OET and AUTh will focus the activity on Flexible Organic & Printed Electronic devices and will demonstrate and exploit the R2R in-line and non-destructive optical characterization methodologies and data analysis approaches developed for the manufacturing of printed flexible OE devices. Specific focus will be given

to the high-speed characterization data analysis for the automation of printing processes and manufacturing of high efficiency/stability/lifetime OE devices with improved mechanical performance and stability based on the implementation of nanomechanical characterization protocols from NTUA, SINTEF and Uniroma3. OET will fabricate printed nanolayers for OPV and OLED devices with R2R printing processes, including slot-die coating and rotary screen printing. Printed nanolayers will be characterized real-time by in-line optical metrology tools in terms of their optical properties (refractive index, optical transparency), electronic properties (electronic transitions, optical band gap), structure (surface/interface quality, blend morphology) and their thickness with nanometer scale precision. Moreover, AUTh and OET will employ their in-line metrology tools adapted on the R2R printing pilot line at AUTh to extract information on the electrical properties and device performance. Ex-situ nanoindentation measurements will be also performed for the extraction of elastic modulus and hardness of the printed nanolayers and OPV and OLED devices on plastic substrates. The nanolayer properties (structural, optical, electrical, mechanical) will be used to optimize the mechanical stability of the printed OE devices and their operation and lifetime under certain mechanical deformation (bending, stretching). OPV modules and OLEDs devices of high performance (PCE%, luminance) and mechanical stability will be fabricated and encapsulated based on the optimization of fabrication parameters.



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oet ORGANIC ELECTRONIC TECHNOLOGIES

www.oe-technologies.com

BASF - Germany

At **BASF,** we create chemistry for a sustainable future. We combine economic success with environmental protection and social responsibility. More than 110,000 employees in the BASF Group work on contributing to the success of our customers in nearly all sectors and almost every country in the world. Our portfolio is organized into six segments: Chemicals, Materials, Industrial Solutions, Surface Technologies, Nutrition & Care and Agricultural Solutions. BASF generated sales of around €59 billion in 2020.

The **BASF** team is part of the Material Physics & Analytics department, which has unique capabilities for the industry (including high throughput testing and data treatment using AI, data mining, etc.), a very broad chemical and physical characterization method portfolio (including morphology, mechanical, optical and electrical).

Role in the nanoMECommons Project:

As industrial member of the consortium, **BASF** contributes in verifying that the proposed protocols and data workflow is applicable in industrial environment to speed up development processes and increase product reliability. **BASF** will propose two industrial case demonstrators (Additive Manufacturing and Coating) for validation of the methods and characterisation protocols in relevant industrial environments.

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CONIFY Powder – Greece

CONIFY's main activities involve the revitalization, upcycling and recycling of unfused/low-cost powders, not meant for Additive Manufacturing (AM) towards high-quality AM-compatible powders. In such a way CONIFY tries to link production chain from 3D printing and post-processing wastes back to design and printing. The company gathers required expertise to provide a high-quality environment for the development and demonstration of new alloy compositions based on novel metal alloy design approaches.

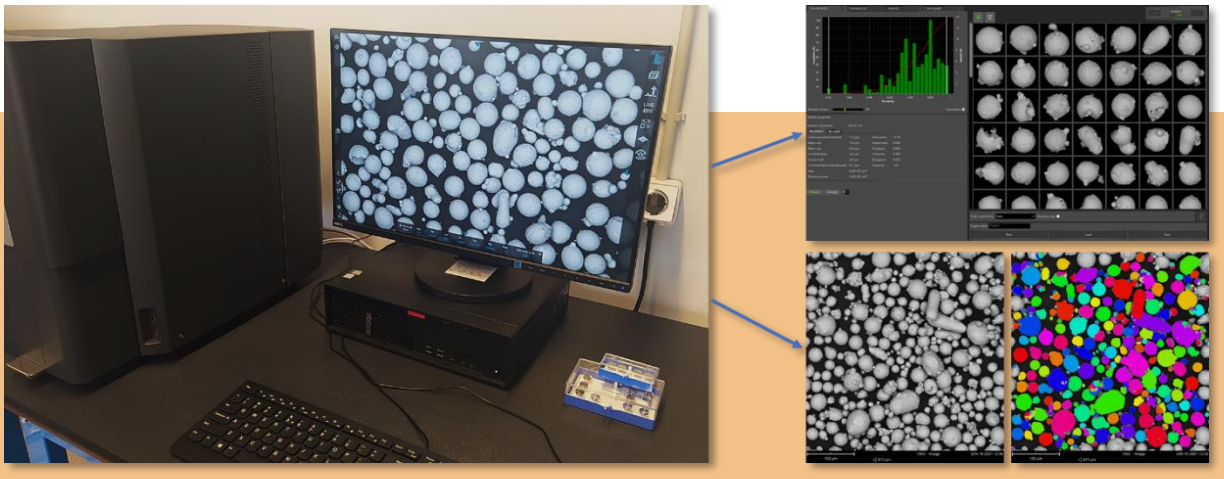
CONIFY brings into the current project its AM toolbox comprising of;

- raw material procurement and assessment tools, ranging from low-cost powders not intended for AM, unfused AM powders, and machining waste or recovered metals from industrial waste to commercially available AM powder feedstock
- in-house testing and precise physico-chemical material characterization according to ISO and ASTM methods, for quality-controlled AM-powders,
- dedicated, case-by-case adapted post-processing procedures and metal alloy design approaches are developed towards AM powders of high-quality standards and
- 3D printing activities and parametric studies to design and optimize our manufacturing processes in order to achieve print-tested, validated powdered materials, combined with microstructural and mechanical characteristics of the final parts. The team specializes in Laser-Powder Bed Fusion (LPBF) applications and Direct Energy Deposition (DED) processing while continuously pushing the frontier of AM manufacturing for more demanding applications (e.g., aerospace).

Our products & services:

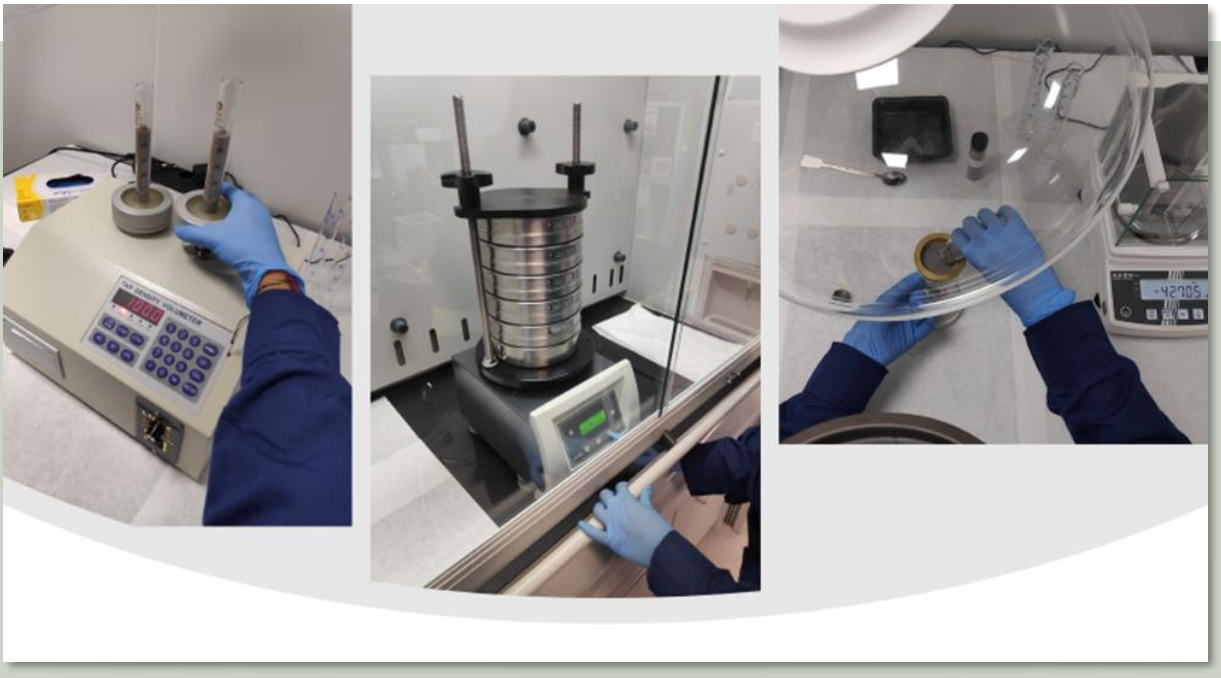
CUSTOM POWDER PROTOTYPING

- High purity custom alloy formulations
- Chemical profile
- Morphology
- Particle sizing
- Flowability measurements
- Development of the best material-process pairs



PRODUCT DESIGN

Performance testing of powders and finished parts



REPAIR AND REFURBISHMENT OF DAMAGED COMPONENTS

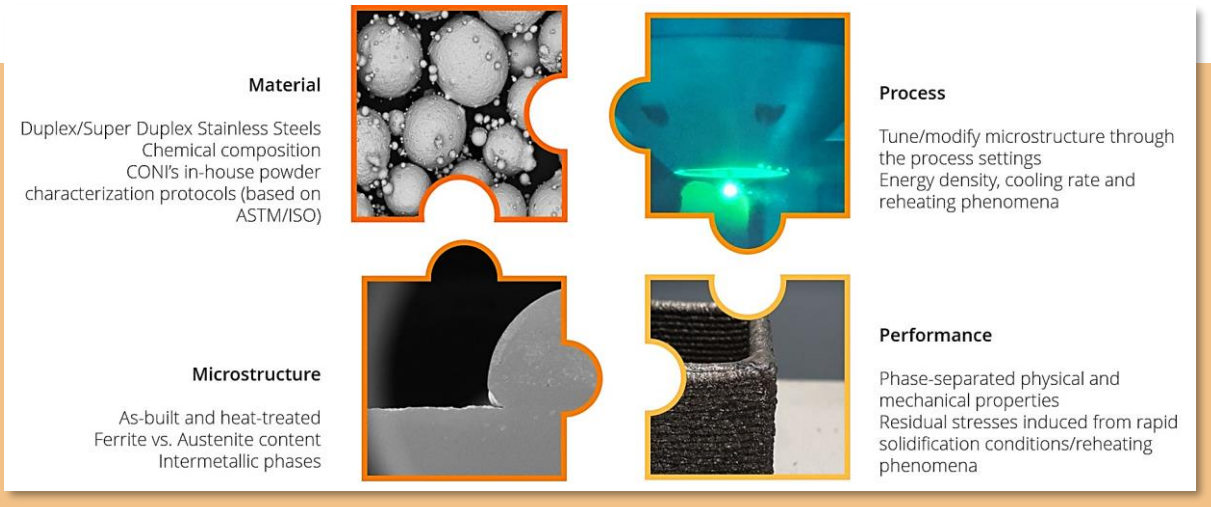
"on-site" and "on-time" repair and maintenance solutions for reduced costs and lead time

INTERNAL AM R&D

Continuous innovation to proactively develop solutions for urgent metal powder-based AM

Role in the nanoMECommons Project:

In nanoMECommons project (Grant Agreement No. 952869), **CONIFY** is involved as end-user for additively manufactured metallic components based on dual phase stainless steels (duplex), where a controlled set of samples will be processed with intentional variations in the feedstock quality. These variations will be selected based on the known plausible scenarios in the related to the AM feedstock. This will be realized through processing of relevant advanced alloys by LPBF and DED AM technologies that require understanding of the physical and mechanical behavior down to the nano length-scale. The powders are screened down to ppm level due to different feedstock quality, in terms of purity and oxygen content as well as morphology and shape characteristics. The intention is to identify the phase-separated properties towards correlating the quality of the feedstock with the evolved phases towards the establishment of harmonised interoperable characterisation protocols, data exchange and standardisation procedures for AM products, using DED and LPBF as process models and with special focus on various duplex stainless-steel classes as materials model. CONIFY envisions that within the project, by performing metadata correlation analysis, the ensemble of the generated data will lead into higher comprehension of targeting optimised material purity and effect of feedstock, will contribute to the AM production, pilot lines and processing conditions by converging the focus on the challenges that are proved to have substantial effect on the final product.



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MESA Consult – Luxemburg

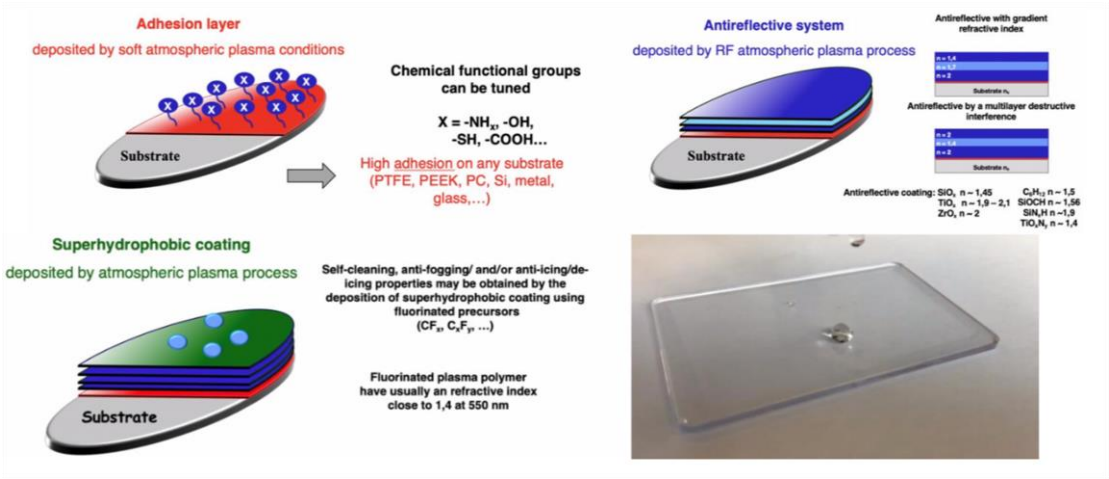
MESA CONSULT is a Material Science & Engineering Consulting company, providing solutions to your new R&D challenges or product development. As a complement to your in-house resources MESA CONSULT can assist your company in Advanced Materials manufacturing and characterization developed for a wide field of applications.

Our services:

The main activity offered by **MESA** is consultancy services in the fields of Research and Development (R&D), Chemistry, Surface Chemistry, Materials Science, and Nanocomposites and Nanoparticles. With a broad experience in innovative solutions, MESA addresses clients' needs related to a variety of materials such as polymers, metals and metal alloys, ceramics, composites from nano to micro level in a wide range of sectors including aeronautic, automotive, building, microelectronic, biomedical and packaging. MESA proposes a scientific assistance to industrial partners to place their innovative products on the market by reducing technical and operational risks. MESA provides support for R&D projects management, grant advice, writing proposal and project implementation.

Role in the nanoMECommons Project:

The role of **MESA** in this project is to develop and optimize anti-reflective systems combined with superhydrophobic properties based on multilayer architecture by using innovative plasma methods. **MESA** will manage the development and the implementation of anti-reflective coatings, which will be performed by using vacuum and atmospheric plasma deposition methods. **MESA** will manage the development and the achievement of such systems by using plasma equipment's and deposition methods available in different **MESA** partners laboratories such as University of Strasbourg and Molecular Plasma Group.



Examples of antireflective hydrophobic coatings produced by MESA

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