

SUSTAINABLE MATERIALS

The Division carries out research, development and qualification of materials, components, devices and related manufacturing and integration processes in complex systems, promoting process and product innovation. The division is present on the Italian territory in 6 of ENEA's research centers with a staff of 115 units and recently launched further activities in the new ENEA Laboratory at "Kilometro Rosso" Innovation District in Bergamo.

Strategic areas:

- **ADDITIVE MANUFACTURING AND 3D PRINTING.** Development of polymeric, ceramic, composite, metallic materials and biomaterials and related 3D direct deposition techniques, also through the recovery of processing waste (powders and scraps). Preparation of powders and filaments for wire printing. Densification by hot isostatic pressing. Application of research products to transport, health, space and energy..
- **COMPOSITE MATERIALS.** Development of: lightweight materials for transportation with reduced environmental impact based on virgin and recycled carbon fibres and ceramic materials for braking systems; heat-resistant composite materials based on basalt fibres; integration with intermediate products from spinning techniques (non-woven fabric made with carbon fibres).
- **DEVELOPMENT OF POLYMERIC DEVICES AND DIGITAL PRINTING TECHNOLOGIES.** Realization of photoactive and electroactive organic devices for domestic lighting, smart windows and solar energy, based on organic materials that can be processed at low temperatures and with limited use of raw materials. Integration of these materials with digital printing techniques (inkjet, offset, gravure, etc.).
- **ELEMENTARY MATERIALS AND DEVICES FOR ENERGY.** Demonstrator materials and devices for converting heat into electricity (according to the thermoelectric and pyroelectric effect); turbine and burner components made for AM; ionic liquids, electrolytes and other thin film materials, composite battery cases, organic solar cells.
- **CHEMICAL AND PHYSICAL ANALYSES AND TESTS ON MATERIALS AND COMPONENTS.** Development of complete and innovative test methodologies, for materials and components. Equipments for specific analyses: XPS, optical and electron microscopy, visible and NIR spectroscopy, mechanical and thermo-mechanical tests, ultrasounds, thermography, X-ray tomography, tribology, elemental analyses. Development of ad-hoc characterization methods based on the integration of optical components.
- **AEROSPACE.** Devices and related diagnostic technologies for monitoring aircraft engines air quality and emissions; 3D fabrication techniques and components welding for aerospace and related 3D ultrasonic testing methods; application of 3D printing to aerospace components manufacture.

Facilities and platforms:

Surface Analysis, Functional Characterization of Advanced Sensors, Optical, Electrical, Thermal and Mechanical Characterization, Physical Deposition of Thin Layers and Functional Treatments, X-Ray Diffractometry, Electron Microscopy, Chemical Synthesis of Polymeric Materials and Composites, Microstructural Characterization, Mechanochemistry, Synthesis and Chemical Characterization, High Energy density heat treatments, Materials and devices characterization, Digital printing of materials in solution, Additive manufacturing, Chemical-physical characterization for materials and process development, Materials characterization and component qualification, Mechanical processing and Rapid prototyping, Composite materials development, Powder development, advanced ceramics and coatings, Development of manufacturing processes for ceramic components.

The most important technology platforms: Open Infrastructure for 3D printing of advanced materials for aerospace and health (MAIA), Clean room for photolithography and realization of electronic devices and light sources, Distributed network of AM equipment (13 machines), Integrated carbon fibres spinning system; Equipment for the realization of industrial demonstrators in composite material.



ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES,
ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

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DEPARTMENT FOR SUSTAINABILITY

- Efficient use of resources and closure of cycles
- **Sustainable Materials**
- Models and technologies for risks reduction
- Protection and enhancement of the territory and natural capital
- Biotechnologies and Agroindustry
- Technologies and methodologies for health protection

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SUSTAINABLE MATERIALS



DEPARTMENT FOR SUSTAINABILITY



NANOMATERIALS AND DEVICES

The Laboratory, develops and applies preparation techniques for organic, polymer and hybrid based materials, devices and systems (light sources, solar cells, electronic, thermoelectric and pyroelectric devices, chemical and physical sensors for food packaging and health) as well as production techniques for 3D printing (powders and filaments). The methodological goal is the development of sustainable manufacturing processes based on a reduced use of raw materials, targeting low raw materials consumption, low cost and low environmental impact.

Namely, the Laboratory:

- Explores the use of materials and devices along the entire “organic electronics” knowledge chain, including: simulation and design of material and device properties; synthesis and processing of materials and substrates, also for the replacement or reduction of the use of critical, rare and/or expensive materials in devices; processing and refinement of process technologies for devices and systems, including printing techniques on con-

tinuous flexible substrate (roll-to-roll).

- Performs structural, microstructural, functional characterizations; analysis of ageing and operational stress of materials and components.
- Develops innovative analysis methodologies based on optical principles.
- Develops technologies for the recovery of raw materials and components from end-of-life products, in synergy with other units of the Agency.
- Promotes the use of materials and devices made even in highly interdisciplinary areas, such as the production of powders using “thermal plasma” technology and filaments to be applied in additive manufacturing processes.

The peculiarity of the laboratory lies in the integration of thin films and solution materials in complex devices, emphasising the sustainability of manufacturing processes also with the resource savings allowed by direct digital printing of the materials themselves, a subject of strategic projects and large laboratories managed in the past and related to “organic electronics”.

FUNCTIONAL MATERIALS AND TECHNOLOGIES FOR SUSTAINABLE APPLICATIONS

The Laboratory develops processes for the synthesis and fabrication of functional and structural materials based on composites, polymers, nanostructured, porous, thin and massive materials, for applications in energy, transport with the goal of environmental sustainability.

Namely, the Laboratory:

- Develops deposition, coating, treatment and surface functionalisation technologies for the combined optimisation of all functional properties required of materials and components for the integration of devices, sensors, systems for industrial applications, and sustainable development.
- Develops synthesis, fabrication, characterisation and diagnostic methodologies for the qualification of materials and devices for energy applications, the preservation and development of natural resources (environmental monitoring, intelligent use of resources) and the reduction of the use of critical materials used in the transport, mechanical engineering and energy sectors.
- Develops advanced morphological, structural and analytical study methodologies based on electron microscopy, stylus microscopy,

X-ray tomography and diffractometry, optical, electron and mass spectroscopy.

- Develops methodologies for mechanical, thermomechanical, thermo-analytical testing and nondestructive study.
- Develops optical and electronic devices, sensors and complex sensory systems, including at low cost, with a focus on energy-environmental aspects.
- Participates in the Public Research Laboratories of the Apulia region in the fields of functional and structural materials, energy and aeronautics.
- Coordinates the activities of the Regional Centre South Italy of the European raw materials innovation knowledge community.
- Develops research for the recovery of carbon fibres and their reuse in industrial products, also making use of fibre-based spinning equipment and the preparation of non-woven fabrics used in composite material artefacts.

The Laboratory’s specialities lie in its solid expertise in the characterisation of materials and components, in the application of materials to gas sensors and thermoelectric devices, and in the integration of nanotechnology in manufacturing processes.

MATERIAL TECHNOLOGIES FAENZA

The Laboratory carries out research and development in the field of structural and functional materials and related technologies to increase the sustainability of industrial processes and products, in close cooperation with domestic and foreign companies.

Namely, the Laboratory:

- Synthesizes powders and ceramics precursors, develops and sets up processes and technologies for manufacturing components from monolithic and composite ceramic materials.
- Develops manufacturing processes for longfibre reinforced ceramic composites using vapour-phase infiltration techniques and preceramic polymer precursors.
- Develops moulding, sintering and additive manufacturing processes and methodologies for chemical-physical, microstructural, thermomechanical characterisation and reliability verification of prototype products and components aimed at their engineering.

- Develops qualification methodologies for materials, components and devices for various sectors including transport, construction (traditional ceramics and bricks), energy production and recovery.
- Develops processes for the recovery and promotion of industrial and agro-industrial by-products and waste, for the development of innovative materials and applications, in a circular economy perspective.
- Provides qualified advice and services to the business and public administration system.

The Laboratory’s peculiarities are represented by the continuous collaboration with industry, the development of technical ceramic materials with infiltration and additive manufacturing techniques, the manufacturing technologies of composite materials, brought up to the level of “upscaling” in the projects of the European Knowledge and Innovation Community on Raw Materials.

CHEMICAL AND PHYSICAL TECHNOLOGIES

The Laboratory carries out research and development activities in the field of structural and functional materials, with the aim of increasing the energy and environmental sustainability of chemical-physical synthesis processes and production technologies.

Namely, the Laboratory:

- Develops physical, chemical, mechano-chemical methods for the synthesis of materials for various application areas pursuing the reduction or substitution of critical raw materials.
- Develops efficient and robust welding, surface treatment and additive manufacturing technologies for the fabrication of structural components and the functionalisation of surfaces using laser, electron beam and hybrid technologies.
- Materials synthesis and process development are supported by the development of advanced qualification and diagnostic methodologies including: non-destructive testing, micro-analytical techniques, macro-, micro- and

nano-structural characterisation, chemical, spectroscopic and surface analysis, micro- and macro-mechanical characterisation as well as the analysis of thermodynamic characteristics and their correlation with behavioural/functional aspects.

These activities are also provided to support the production ecosystem by providing advanced services to industries and public administration.

- Through the use of materials and process and diagnostic technologies developed, studies, designs and implements test methods, prototypes for the energy, transport and biomedical.
- Manages an important open infrastructure devoted to additive manufacturing technologies for the aerospace, energy, transport and biomedical sectors (MAIA).
- Performs non-destructive methods investigations on ancient paintings and other artepieces belonging to the cultural heritage.



Photolithographic processing of thin films in clean room



Thermomechanical tests on high temperature resistant materials (up to 1500 °C)



Microanalytical characterization of surfaces

Demonstrator produced by additive manufacturing in Titanium Grade 23 through EBM

