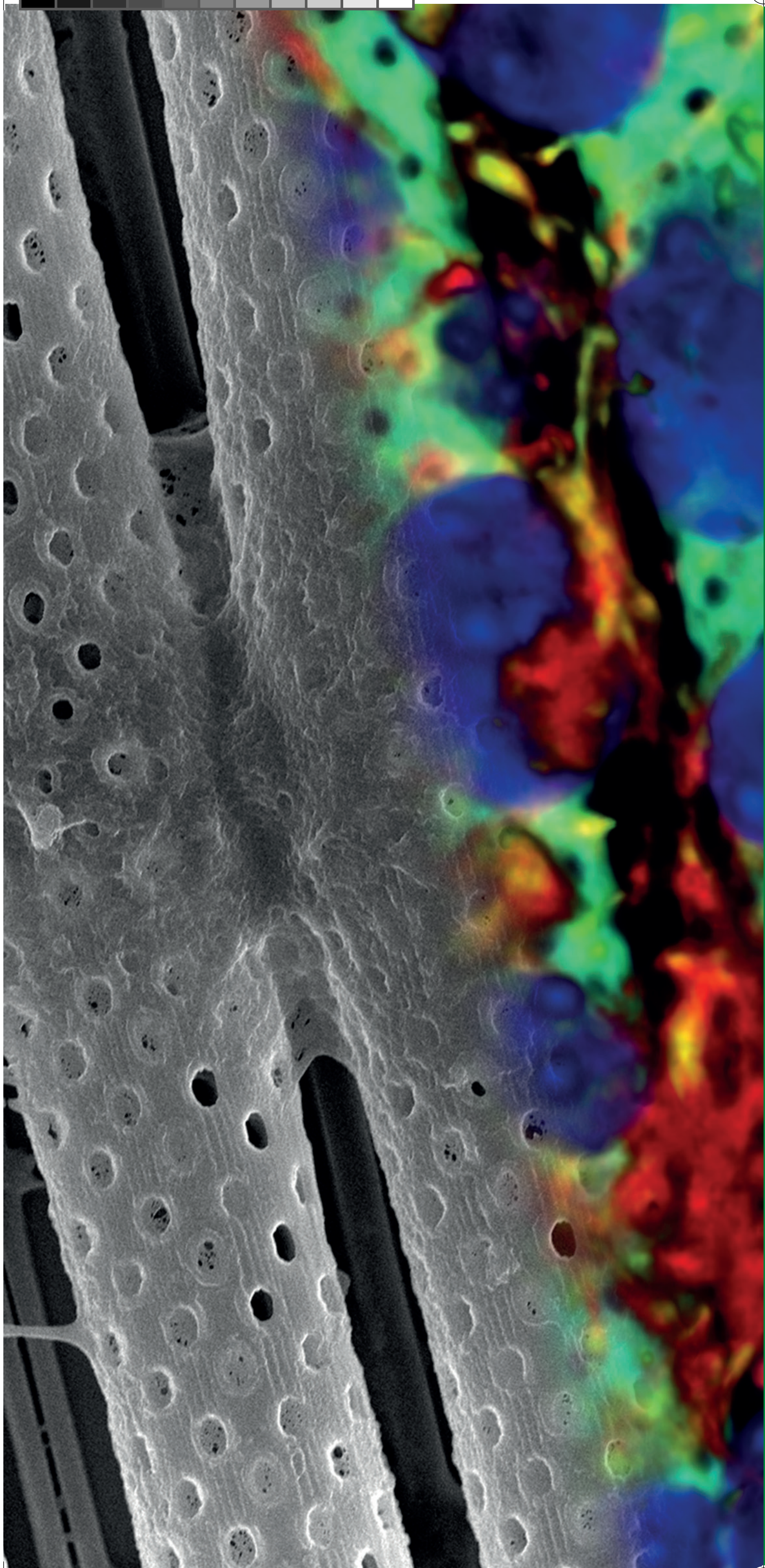

ISTITUTO ITALIANO DI TECNOLOGIA

Center for Materials Interfaces

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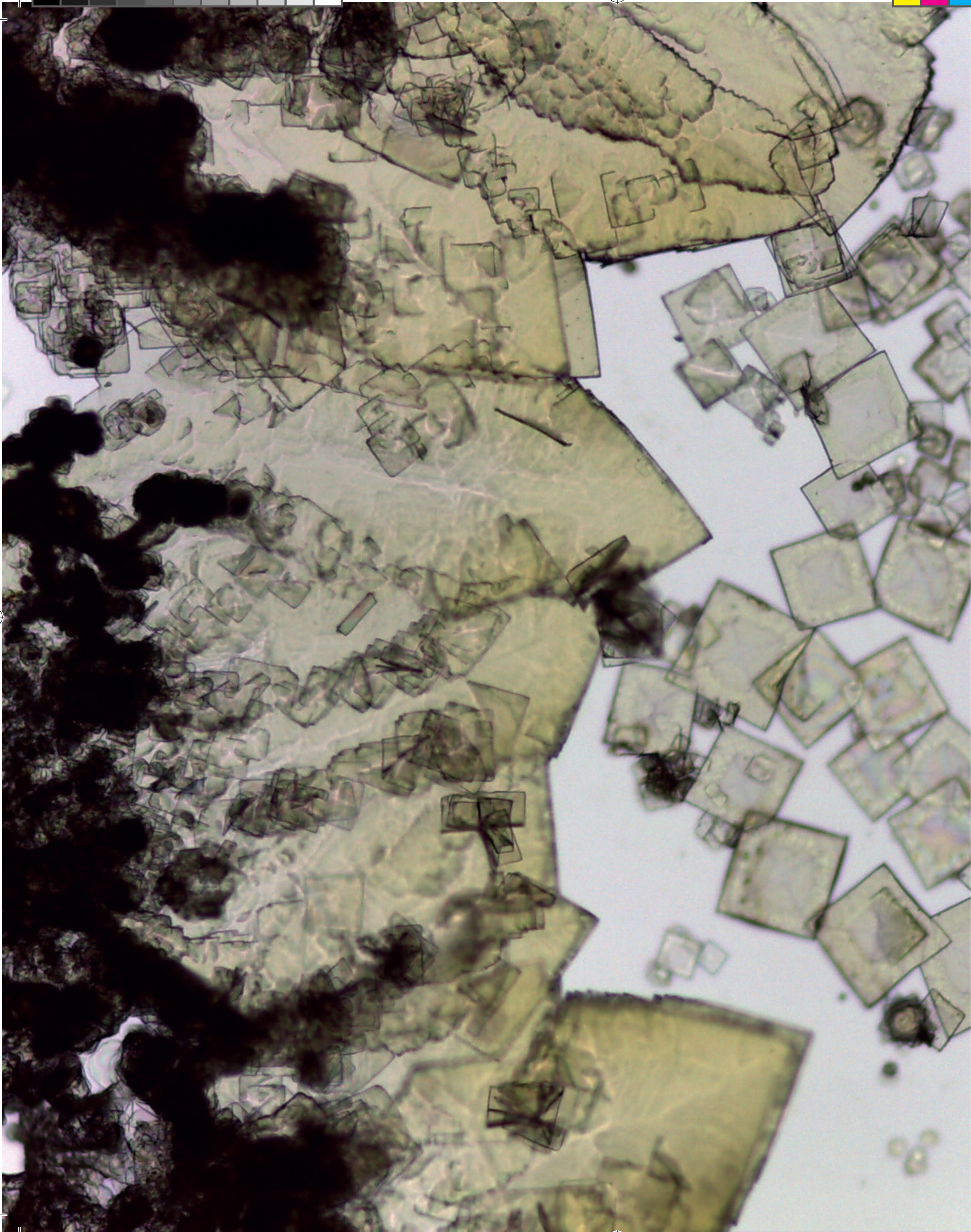
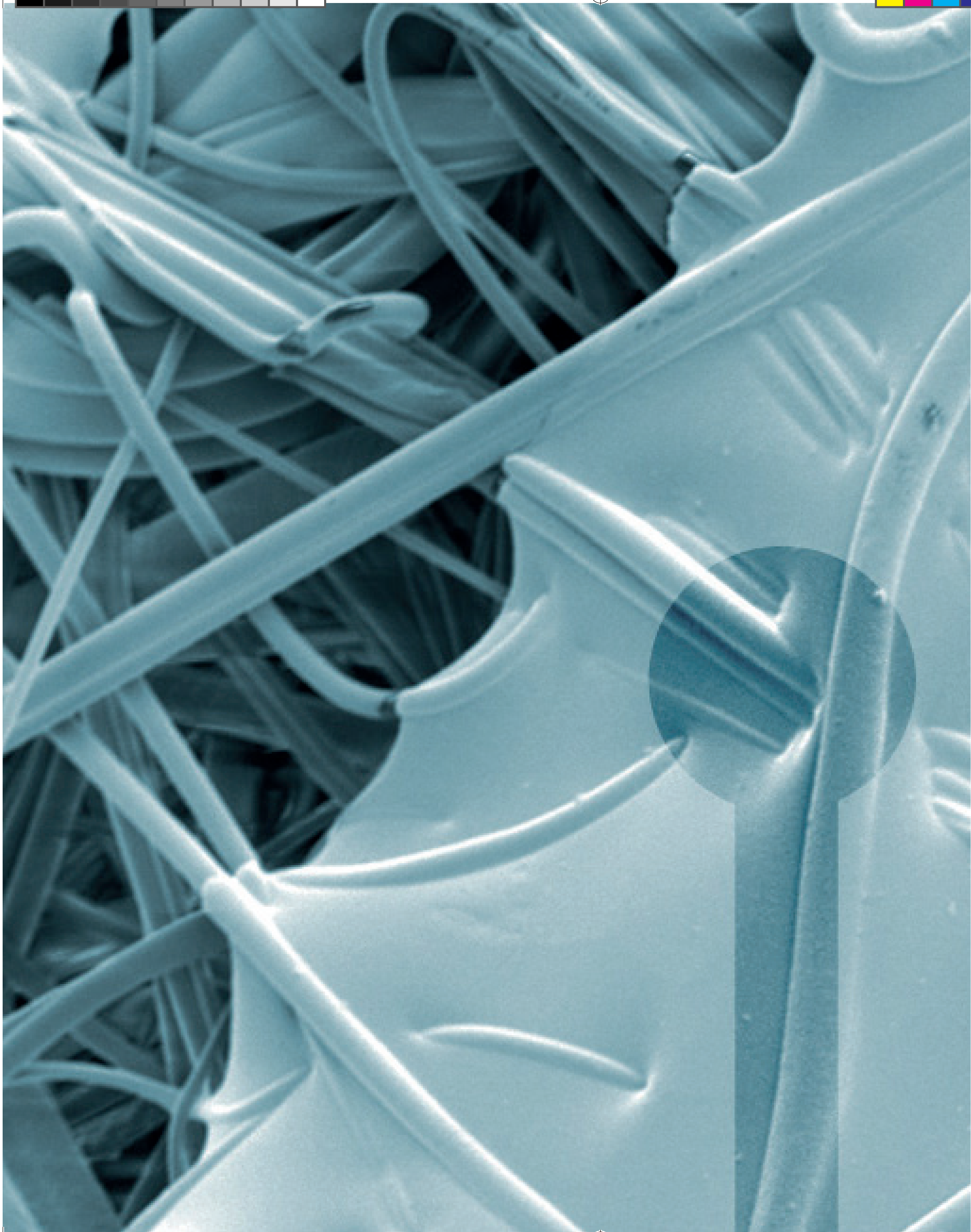
INTRODUCTION



Center for Materials Interfaces

The Center for Materials Interfaces – CMI@SSSA is an interdisciplinary R&D center dedicated to the investigation, development, characterization, and exploitation of materials at the nanoscale, with particular attention to the biomedical and technological sectors, and with a special focus on interface effects. The Center is highly multidisciplinary, and materials science, physics, chemistry, life science, and engineering merge to find how innovative materials and interfacial processes can be developed and exploited for specific applications.
The activities are organized into three main research areas, corresponding to two Research Lines and one Research Group:

- Bio-Interfaces, focused on the development and exploitation of physically-active nanoparticles and nanostructured materials, able to provide appropriate instructive cues to cells and tissues. Smart nanomaterials are investigated as both intracellular "nanotransducers" and as innovative platforms for theranostics.
- Functional Material Interfaces, investigating materials science and technologies to create smart and/or bio-inspired surfaces and interfaces, with advanced functionalities for a broad range of applications. Two approaches are considered: creation of functional surface via micro-nano-structuring of polymeric active materials, and exploitation of ultra-thin conformable functional systems to be coupled with arbitrary surfaces; functionalization of biological surfaces and related interfaces are also matter of study.
- Structures and Interface Characterization, investigating the structure of nanocrystalline materials (inorganic, organic, and of biological origin) with 3D electron diffraction



RESEARCH HIGHLIGHTS

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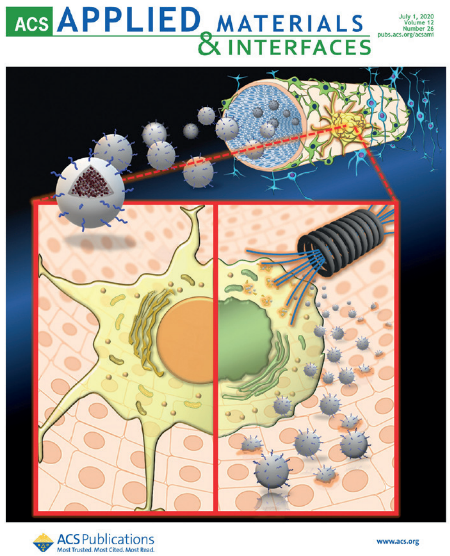
Smart Nanovectors for Brain Cancer

Glioblastoma multiforme (GBM) is the most lethal brain tumor, with a very poor prognosis. This is due to GBM highly aggressive and infiltrative nature, the limited delivery of drugs across the blood-brain-barrier (BBB), and their poor specificity towards cancer cells. To tackle these therapeutic hurdles, we are studying nanotechnology-based solutions, combining a pharmaceutical approach with magnetic hyperthermia. Our lipid-based nanovectors are made of biocompatible and biodegradable lipids and can encapsulate several kinds of drugs as well as superparamagnetic iron oxide nanoparticles that can generate heat in the tumor site, if properly stimulated with alternated magnetic fields; they can be moreover functionalized to promote BBB crossing and patient-specific cell targeting.

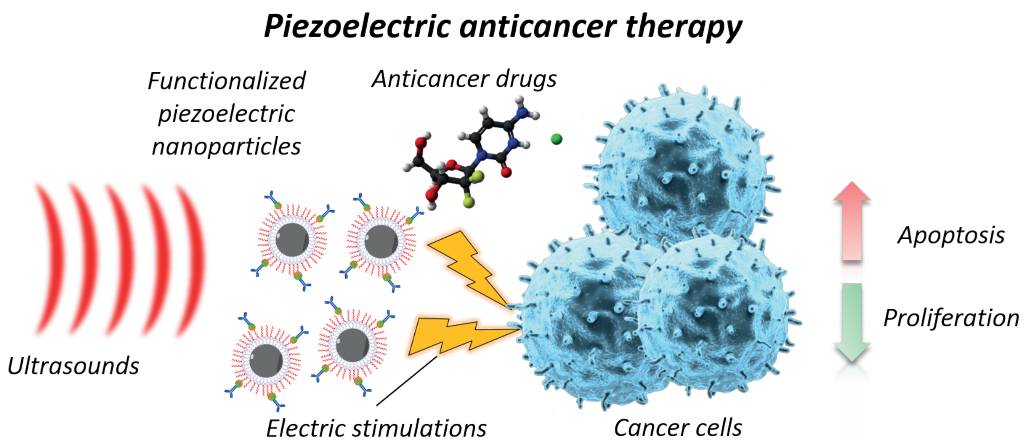
- Beola L., Iturrioz-Rodríguez N., Pucci C., Bertorelli R., Ciofani G. Drug-loaded lipid magnetic nanoparticles for combined local hyperthermia and chemotherapy against glioblastoma multiforme. ACS Nano, 17: 18441-18455 (2023)
- De Pasquale D., Pucci C., Desii A., Marino A., Debellis D., Leoncino L., Prato M., Moscato S., Amadio A., Fiaschi P., Prior A., Ciofani G. A novel patient-personalized nanovector based on homotypic recognition and magnetic hyperthermia for an efficient treatment of glioblastoma multiforme. Advanced Healthcare Materials, 12: 2203120 (2023)
- Pucci C., De Pasquale D., Marino A., Martinelli C., Lauciello S., Ciofani G. Hybrid magnetic nanovectors promote selective glioblastoma cell death through a combined effect of lysosomal membrane permeabilization and chemotherapy. ACS Applied Materials and Interfaces, 12(26): 29037-29055 (2020)



Piezoelectric Bio-Nanotransducers

Electric stimulation of cells and tissues is an extremely powerful tool to both activate electrically excitable cells (e.g., neurons and muscle cells) and to control fundamental cell behaviors, such as proliferation, differentiation, and apoptosis of different cell types (e.g., malignant tumor and stem cells). The remote delivery of electric stimuli without the use of implantable electrodes represents a huge technological challenge in biomedicine. In our laboratories, piezoelectric nanoparticles have been developed and exploited for the first time to convert mechanical into biologically-relevant electrical cues. The piezoelectric stimulation has been demonstrated to be successful acutely, to increase neuronal activity and, chronically, to inhibit the proliferation of tumors through drug-loaded piezoelectric nanoparticles.

- Montorsi M., Pucci C., De Pasquale D., Marino A., Ceccarelli M.C., Mazzuferi M., Bartolucci M., Petretto A., Prato M., Debellis D., De Simoni G., Pugliese G., Labardi M., Ciofani G. Ultrasound-activated piezoelectric nanoparticles trigger microglia activity against glioblastoma cells. Advanced Healthcare Materials, 13: 2304331 (2024)
- Pucci C., Marino A., Sen O., De Pasquale D., Bartolucci M., Iturrioz-Rodríguez N., di Leo N., de Vito G., Debellis D., Petretto A., Ciofani G. Ultrasound-responsive nutlin-loaded nanoparticles for combined chemotherapy and piezoelectric treatment of glioblastoma cells. Acta Biomaterialia, 139: 218-236 (2022)
- Sen O., Marino A., Pucci C., Ciofani G. Modulation of anti-angiogenic activity using ultrasound-activated nutlin-loaded piezoelectric nanovectors. Materials Today Bio, 13: 100196 (2022)



Nanotechnological Antioxidants

Reactive oxygen species (ROS) are at the basis of pivotal physiological functions. In physiological conditions, ROS levels are kept under control by the activity of antioxidant enzymes and molecules present in the body; however, when these mechanisms are overwhelmed by ROS, a condition of oxidative stress can arise causing oxidative damages to cellular components, and even leading to the development of severe pathological conditions. Despite some interesting results, the use of traditional antioxidant molecules has faced several obstacles including a limited antioxidant activity. The use of antioxidant nanoparticles promises to overcome the current limitations of traditional antioxidant molecules owing to their high antioxidant capacities, their tunability, and their capacity to be easily functionalized with targeting moieties. In our center, we are investigating the use of several antioxidant nanovectors including cerium oxide nanoparticles, polydopamine nanoparticles, and tannic acid iron oxide nanostructures.

- Battaglini M., Emanet M., Carmignani A., Ciofani G. Polydopamine-based nanostructures: A new generation of versatile, multi-tasking, and smart theranostic tools. Nano Today, 55: 102151 (2024)
- Carmignani A., Battaglini M., Bartolucci M., Petretto A., Prato M., Ciofani G. Polydopamine nanoparticles as a non-pharmaceutical tool in the treatment of fatty liver disease. Materials and Design, 239: 112825 (2024)
- Pucci C., Martinelli C., De Pasquale D., Battaglini M., di Leo N., Degl'Innocenti A., Belenli Gumus M., Drago F., Ciofani G. Tannic acid–iron complex-based nanoparticles as a novel tool against oxidative stress. ACS Applied Materials and Interfaces, 14: 15927-15941 (2022)

Nanotechnology & Space Biology

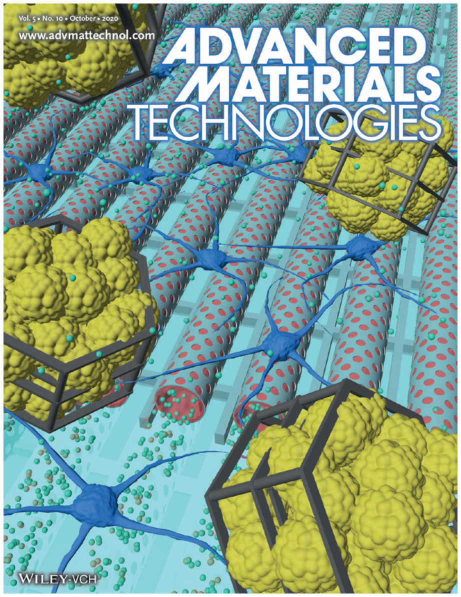
Human space exploration is expanding its frontiers from the low Earth orbit to the Solar System; by featuring mechanical unloading and gravitational transitions, as well as highly energetic cosmic radiation, space travels can pose significant health risks, and strongly demand for the elaboration of innovative technologies enabling progressively longer permanence in space. Far from the Earth, degenerative processes typically associated with aging and with exposure to several biotic and abiotic stressors are indeed significantly promoted, and they may concur with trauma to potentially life-threatening circumstances affecting astronauts. In our laboratories, multidisciplinary research is conducted to develop nanotechnology tools to support life in a hostile environment like space. Biological responses of cellular and animal models administered with nanomaterials and exposed to hypergravity, to simulated microgravity, or to real microgravity conditions (i.e., aboard the International Space Station) are studied to verify nanomaterial potentiality in mitigating adverse effects of altered gravity, in the hope of bringing benefit also to the aging terrestrial populations.

- Degl'Innocenti A., Braccia C., Genchi G.G., di Leo N., Leoncino L., Catalano F., Armirotti A., Ciofani G. Proteome alterations and nucleosome activation in rat myoblasts treated with cerium oxide nanoparticles. ACS Omega, 9: 29226-29233 (2024)
- Genchi G.G., Mollo V., Battaglini M., Belenli Gumus M., Marino A., Prato M., Marras S., Drago F., Pugliese G., Santoro F., Ciofani G. Effects of simulated microgravity on the internalization of cerium oxide nanoparticles by proliferating human skeletal myoblasts. ACS Applied Nano Materials, 6: 10853-10862 (2023)
- Genchi G.G., Degl'Innocenti A., Martinelli C., Battaglini M., De Pasquale D., Prato M., Marras S., Pugliese G., Drago F., Mariani A., Balsamo M., Zolesi V., Ciofani G. Cerium oxide nanoparticle administration to skeletal muscle cells under different gravity and radiation conditions. ACS Applied Materials and Interfaces, 13: 40200-40213 (2021)

Advanced in Vitro Models

The physiological complexity of cellular interactions is often neglected in in vitro studies: these interactions can however affect the behavior of the cells, and diversify the outcome of nanomedicine treatments. In vitro investigations on complex biomimetic systems allows obtaining results that are more predictive before moving towards pre-clinical testing. For this reason, in recent years, in vitro research focused its attention on more complex experimental set-ups with respect to the standard static 2D cultures. In our Center, we design, develop and test innovative multi-cellular fluidic bioreactors, with particular attention to the brain microenvironment. As an example, it is worth mentioning our pioneering 1:1 scale blood-brain barrier model, highlighted among the most disruptive results in the 2018 Annual Report on the ERC Activities and Achievements. Other examples involve fluidic systems able to provide physical stimulation to cells, owing to the coupling of piezoelectric materials with ultrasound stimulators.

- De Pasquale D., Marino A., Pucci C., Tricinci O., Filippeschi C., Fiaschi P., Sinibaldi E., Ciofani G. Remotely controlled 3D-engineered scaffolds for biomimetic in vitro investigations on brain cell co-cultures. Advanced Intelligent Systems, 6: 2400261 (2024)
- Tricinci O., De Pasquale D., Marino A., Battaglini M., Pucci C., Ciofani G. A 3D biohybrid real-scale model of the brain cancer microenvironment for advanced in vitro testing. Advanced Materials Technologies, 5: 2000540 (2020)
- Marino A., Tricinci O., Battaglini M., Filippeschi C., Mattoli V., Sinibaldi E., Ciofani G. A 3D real-scale, biomimetic and biohybrid model of the blood-brain barrier fabricated through two-photon lithography. Small, 14: 1702959 (2018)



Simple Worms to Validate Hypotheses: Planarians

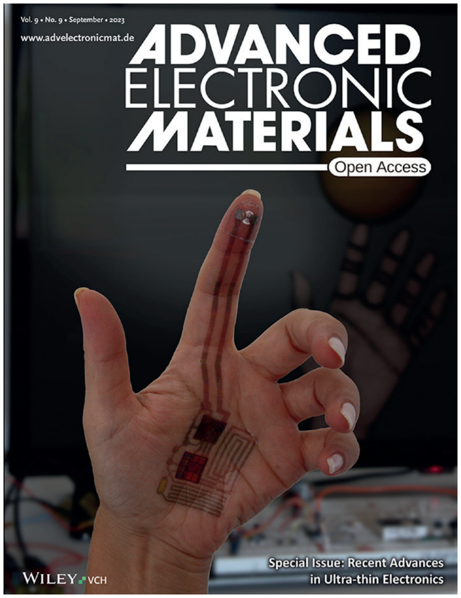
In addition to culturing cells, the center can count on planarian worms to validate bio-nanotechnologies in vivo. Planarians are simple organisms, popular in stem-cell research due to their exceptional regeneration capabilities and ease of maintenance. Toxicological screenings, behavioral experiments, and genetic assays are all standardized procedures for planarians, which makes them precious allies in biomedical testing.
At our Center, areas of research with a significant involvement of planarian worms include the characterization of antioxidant nanoparticles against space-elicited oxidative stress, as well as the impact of chlorophyll derivatives on animal vision.

- Salvetti, A., Degl'Innocenti, A., Gambino, G., van Loon, J. J., Ippolito, C., Ghelardoni, S., Ghigo, E., Leoncino, L., Prato, M., Rossi, L., Ciofani, G. Artificially altered gravity elicits cell homeostasis imbalance in planarian worms, and cerium oxide nanoparticles counteract this effect. Journal of Biomedical Materials Research Part A, 109: 2322-2333 (2021)
- Salvetti, A., Gambino, G., Rossi, L., De Pasquale, D., Pucci, C., Linsalata, S., Degl'Innocenti, A., Nitti, S., Prato, M., Ippolito, C., Ciofani, G. Stem cell and tissue regeneration analysis in low-dose irradiated planarians treated with cerium oxide nanoparticles. Materials Science and Engineering: C, 115: 111113 (2020)
- Degl'Innocenti, A., Rossi, L., Salvetti, A., Marino, A., Meloni, G., Mazzolai, B., Ciofani, G. Chlorophyll derivatives enhance invertebrate red-light and ultraviolet phototaxis. Scientific reports, 7: 1-8 (2017)

Ultra-thin Soft Electronics

The term "epidermal electronics" refers to those electronic devices that can conformably adhere to the skin, providing a versatile mean to acquire information about the body through the monitoring of biologically relevant chemical and physical variables for health monitoring, for feedback/control in prosthetic applications, and for human/computer interfaces. Our approach to epidermal electronics is based on organic electronics technologies through the development of free-standing conformable circuits made of ultra-thin films of conjugated polymers, directly transferrable on skin ("tattoo electronics") or to other complex surfaces. Possible future applications include: personal unperceivable healthcare monitoring devices, active tattoos (e.g., for sport, UV skin monitoring, etc.), as well as electrically controllable drug delivery systems.

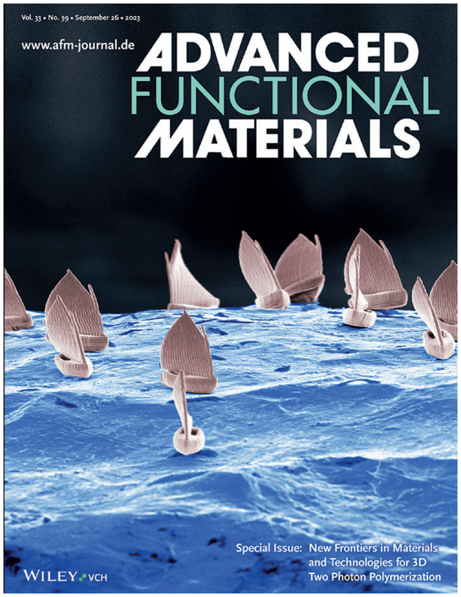
- Mazzotta A., Mattoli V. Ultra-thin conformable electronic tattoo for providing tactile sensations. Advanced Electronics Materials, 9: 2201327 (2023)
- Barsotti J., Rapidis A. G., Hirata I., Greco F., Cacialli F., Mattoli V. Ultrathin, ultra-conformable and free-standing tattoo-like organic light emitting diode. Advanced Electronics Materials, 7: 2001145 (2021)
- Ferrari L., Sudha S., Tarantino S., Esposti R., Bolzoni F., Cavallari P., Cipriani C., Mattoli V., Greco F. Ultraconformable temporary-tattoo electrodes for electrophysiology. Advanced Science, 5: 1700771 (2018)



3D Soft Micro-NanoDevices

In the past twenty years, micro-devices such as Micro Electro-Mechanical Systems (MEMS) produced a great impact on different areas, due to the important technological applications ranging from automotive and consumer electronics to biology, medicine, and energy. The performances of such systems rely on both the design and the intrinsic properties of the constituent materials, that have to be processed with sub-micron resolution, high precision, and reproducibility. Two-photon lithography, making possible the production of outstanding 3D structures with nanoscale features, could be a key technology toward the direct fabrication of more complex micro-devices. In this perspective, we are investigating new materials and approaches that will make possible the direct fabrication of functional surfaces and of 3D micro-structures, also integrating conformal metal paths, toward a seamless integration with standard silicon electronics.

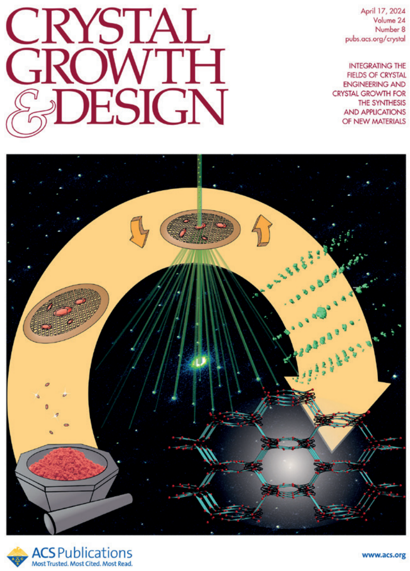
- Den Hoed F.M., Ottomaniello A., Tricinci O., Cesarecciu L., Carlotti M., Raffa P., Mattoli V. Facile handling of 3D two photon polymerized microstructures by ultra conformable freestanding polymeric membranes. Advanced Functional Materials, 33: 2214409 (2023)
- Tricinci O., Pignatelli F., Mattoli V. 3D micropatterned functional surface inspired by Salvinia molesta via direct laser lithography for air retention and drag reduction. Advanced Functional Materials, 33: 2206946 (2023)
- Carlotti M., Tricinci O., Mattoli V. Novel, high-resolution, subtractive photoresist formulations for 3D direct laser writing based on cyclic ketene acetals. Advanced Materials Technologies, 7: 2101590 (2022)



3D Electron Diffraction

When the crystal size gets smaller than a few microns, X-ray diffraction, the standard method for structure determination, can become ineffective. At our Center, we develop new methods of electron diffractions that allow a three-dimensional reconstruction of the reciprocal space from data collected on crystals, as small as a few hundreds of nanometers. These data can be used, as if they were X-ray diffraction data, for solving the crystal structure, obtaining also fine details as the hydrogen positions, partial occupancies, or even the absolute crystal structure. Making the structure analysis independent from the crystal dimension frees the chemist from any constraint in choosing the synthesis strategy, allows the material scientist to investigate phase transition at the nanoscale, and opens to the mineralogist the search of unknown phases in unexplored contexts like micrometeorites or high-pressure inclusions.

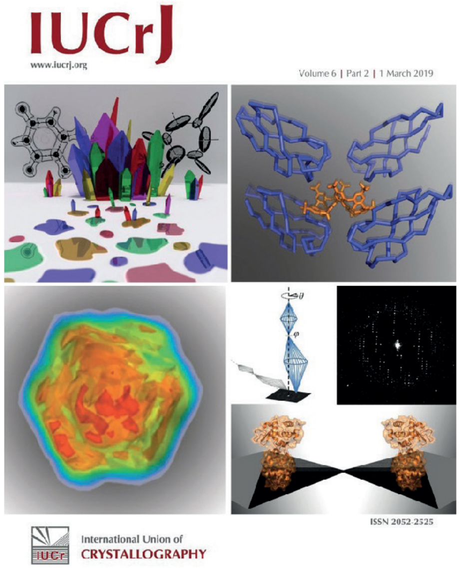
- Gemmi M., Mugnaioli E., Gorelik T.E., Kolb U., Palatinus L., Boullay P., Hovmoller S., Abrahams J.P. 3D electron diffraction: The nanocrystallography revolution. ACS Central Science, 5: 1315-1329 (2019)
- Campanale F., Mugnaioli E., Folco L., Parlanti P., Gemmi M. TiO_2 : The high-pressure Zr-free srilankite endmember in impact rocks. Meteoritics & Planetary Science, 59: 529-543 (2024)
- Sala A., Faye Diouf M.D., Marchetti D., Pasquale L., Gemmi M. Mechanochemical synthesis and three-dimensional electron diffraction structure solution of a novel Cu-based protocatechuate metal–organic framework. Crystal Growth and Design, 24: 3246-3255 (2024)



Electron Nanocrystallography of Beam Sensitive Compounds

Beam sensitive materials are a challenging class of materials to be investigated by 3D electron diffraction (3D ED): unfortunately, a lot of crystalline materials with high scientific and commercial impact belong to this category. Dealing with material sciences, the most promising ones are zeolites and metal-organic frameworks (MOFs), while, concerning organic compounds, pharmaceutical substances and proteins are definitely the most interesting ones. We develop fast 3D ED procedures in low dose mode that allow data collection in a few seconds avoiding the pristine amorphization of the samples. In this way, nanocrystals of all these substances can be investigated, and their crystal structure can be determined. The opportunity of undergoing structural studies on nanocrystalline samples opens the possibility of studying new synthesis routes that usually are unexplored, since their yields remain obscure to the standard diffraction techniques.

- Marchetti D., Pedrini A., Massera C., Faye Diouf M.D., Jandl C., Steinfeld G., Gemmi M. 3D electron diffraction analysis of a novel mechanochemically synthesized supramolecular organic framework based on tetrakis-4-(4-pyridyl) phenylmethane. Acta Crystallographica, B79: 432-436 (2023)
- Anyfanti G., Husanu H., Andrusenko I., Marchetti D., Gemmi M. The crystal structure of olanzapine form III. International Union of Crystallography Journal, 11: 843-848 (2024)
- Husanu E., Emerson Agbemeh V., Andrusenko I., Marchetti D., Sonaglioni D., Gemmi M. Polymorphism in oxyresveratrol studied by 3D ED. ACS Omega 9: 41555-41564 (2024)



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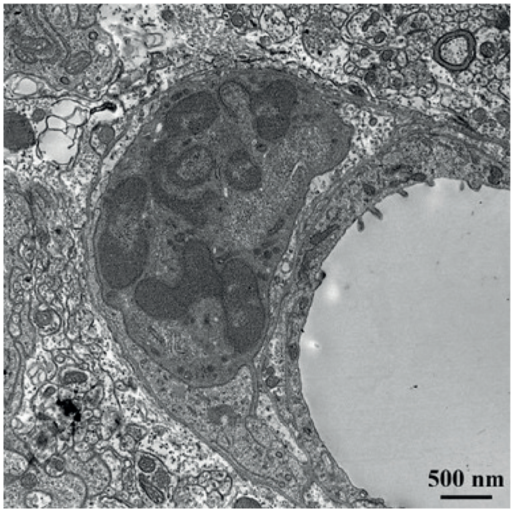
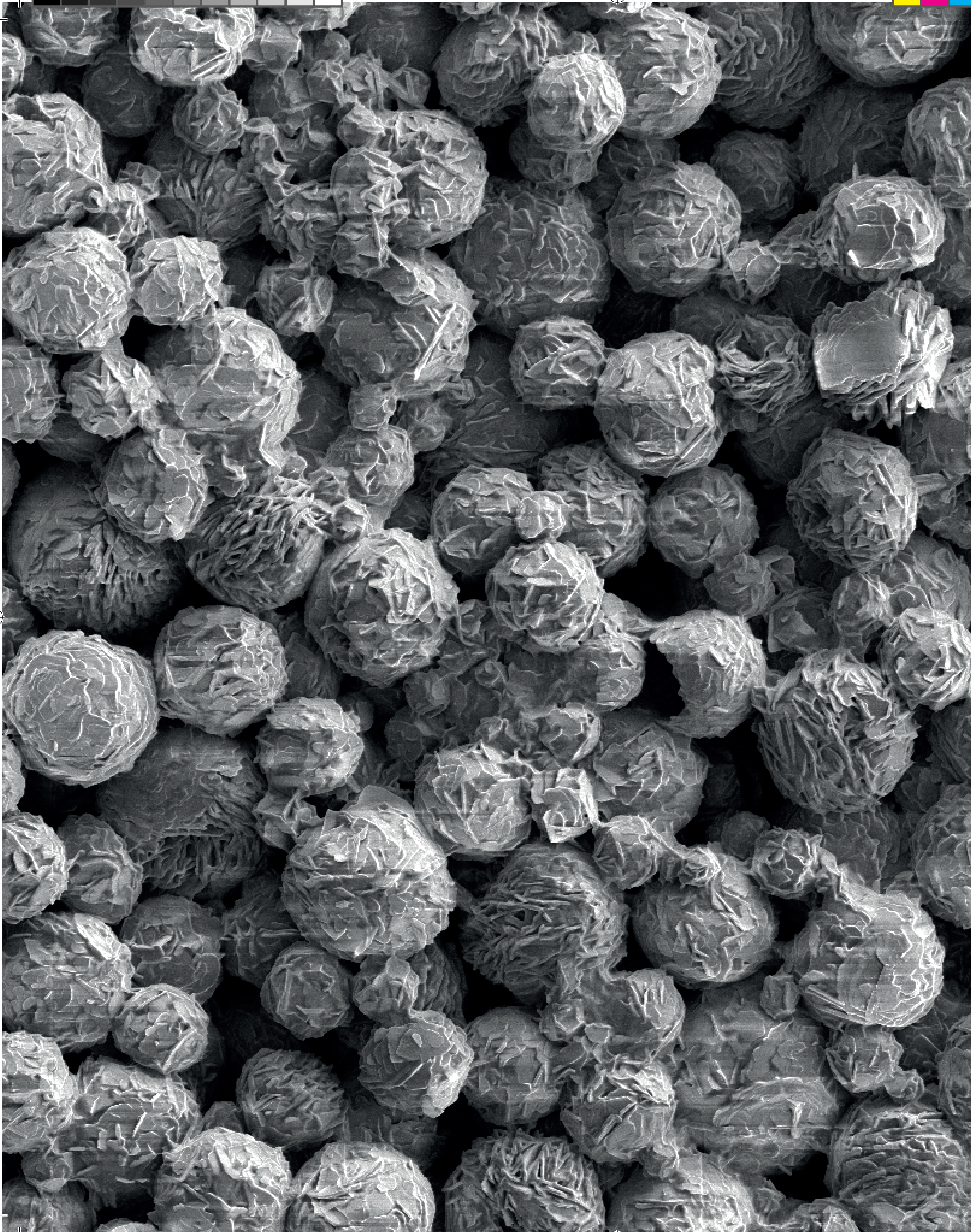
Novel Transmission Electron Microscopy Methods for Biological Samples

The sample preparation in transmission electron microscopy (TEM) biology is the key point for obtaining informative TEM images of cells and tissues. Unfortunately, the standard reagents used in the staining process of biological samples have safety hazards, and the search for "green" ones is a mandatory request of TEM biologists. In our Center, we are developing and patenting a new generation of staining reagents that allow for better performances with respect to the standard ones available in the market, avoiding any chemical hazard. The same reagents are tested for correlative techniques among confocal microscopy, synchrotron radiation micro-tomography, and TEM imaging. We are also envisioning the application of the same methodology to 3D reconstruction in focused ion beam microscopy.

- Parlanti P., Cappello V., Brun F., Tromba G., Rigolio R., Tonazzini I., Cecchini M., Piazza V., Gemmi M. Size and specimen-dependent strategy for X-ray micro-CT and TEM correlative analysis of nervous system samples. Scientific Reports 7: 2858 (2017)
- Moscardini A., Di Pietro S., Signore G., Parlanti P., Santi M., Gemmi M., Cappello V. Uranium-free X solution: A new generation contrast agent for biological samples ultrastructure. Scientific Reports, 10: 11540 (2020)
- Marino A., Arai S., Hou Y., Degl'Innocenti A., Cappello V., Mazzolai B., Chang Y.T., Mattoli V., Suzuki M., Ciofani G. Gold nanoshell-mediated remote myotube activation. ACS Nano, 11: 2494-2508 (2017)





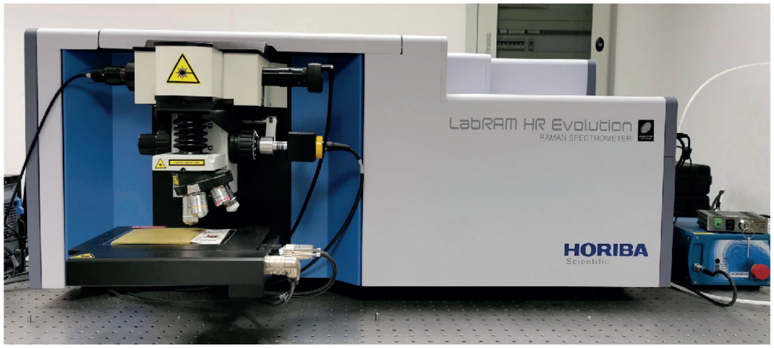
FACILITIES

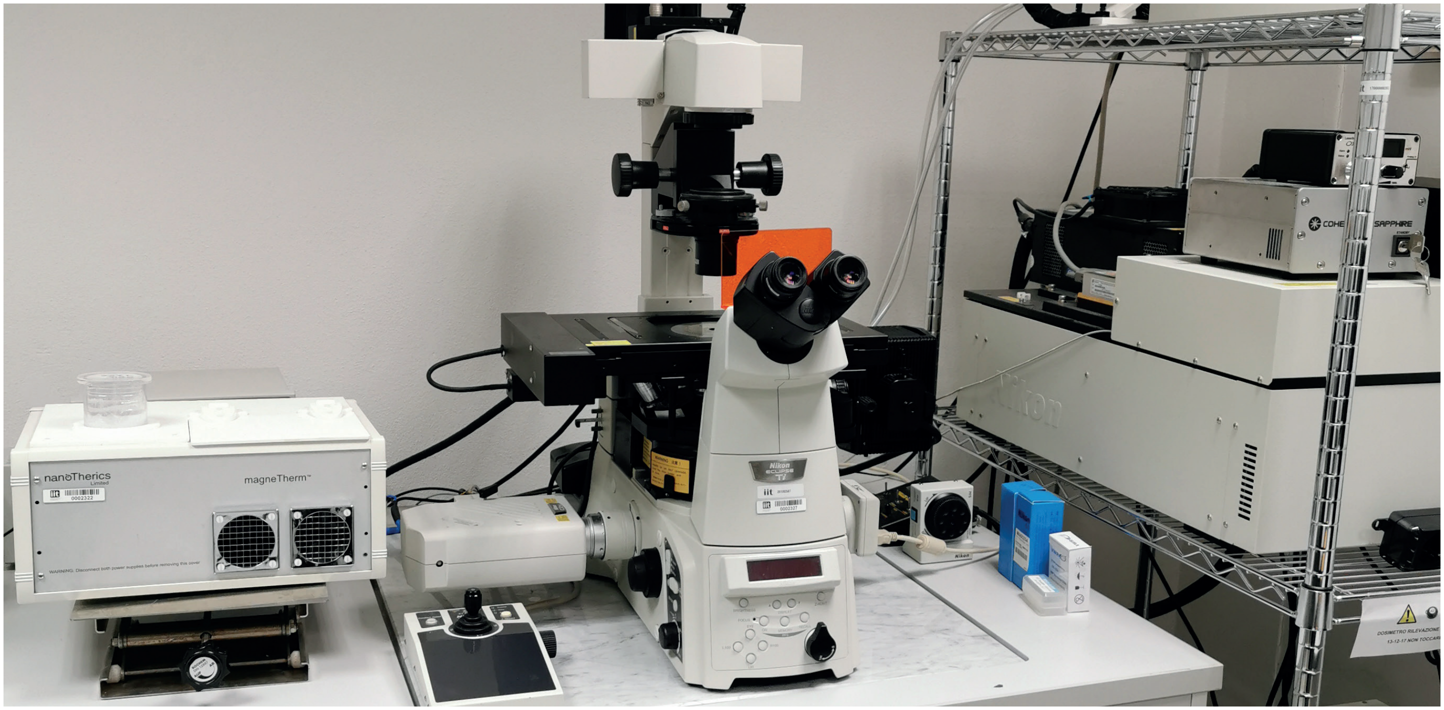
Biological Facility

Our laboratories are equipped with state-of-the-art instruments for performance of cell culture and invertebrate animal (planarian) rearing, including three BLS2 cabinets and seven incubators, two of which can operate under refrigerated conditions. Biological responses are real-time monitored by optical microscopy and stereomicroscopy, whereas end-point experimental data are collected by flow cytometry, electrophoresis, photometry, and quantitative reverse-transcription polymerase chain reaction (RT-PCR). Physical stimulations can be delivered to biological specimens by laser, ultrasound, vibration, and heat sources, often mediated by smart nanovectors acting in selected intracellular compartments. Altered gravity conditions can also be explored through a random positioning machine.

Microscopy Facility

Interaction of biological systems with smart nanomaterials designed to accomplish theranostic functions is carefully studied with confocal and Raman microscopy. Our confocal imaging system is coupled with solenoids for real-time investigations on magnetothermal transduction protocols for selective treatment of tumor cell populations. Raman microscope enables chemical mapping at bio/non-bio interfaces.



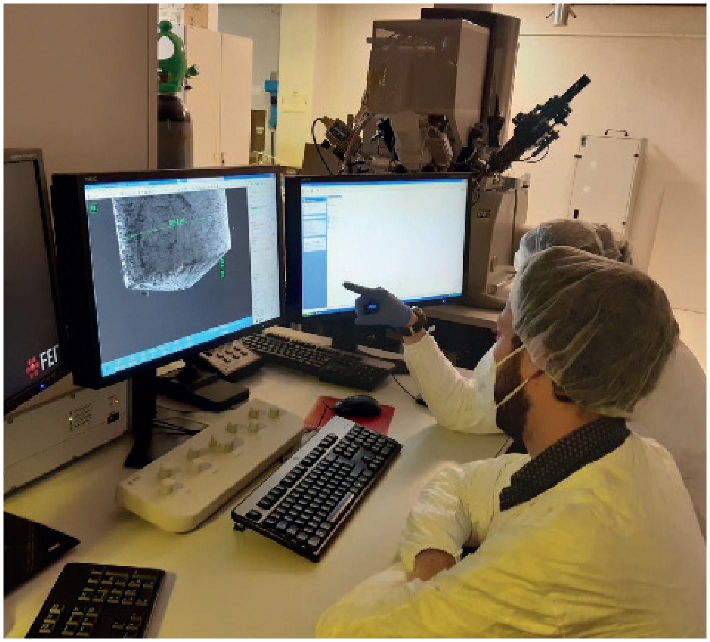


Chemical and Chemical Physical Characterization Facility

The laboratory is equipped with three chemical hoods for synthesis and sample preparation. Several instruments integrate the chemical laboratory to provide chemical, thermal, and optical characterization of materials. Among them, nuclear magnetic resonance spectrometer (NMR, 400 MHz), NMR relaxometer, high-performance liquid chromatography (HPLC), gel permeation chromatography (GPC), differential scanning calorimeter (DSC), dynamic light scattering (DLS), and common spectroscopic instruments (UV-Vis, FTIR, fluorescence) are available.

Micro and Nano-fabrication Facility

The micro - and nano-fabrication facility includes thin film deposition and lithographic techniques equipment. The laboratory area in ISO6 cleanroom is equipped with wet bench, electroplating baths, and mask aligner. A dual-beam focused ion beam / scanning electron microscope (FIB/SEM) FEI Nova 600i NanoLab, in ISO7 cleanroom, allows nanofabrication (milling and deposition) and ultra-high resolution scanning electron microscopy with EDX microanalysis system. The laboratory also includes an inkjet printer for polymers, biomolecules, and nanoparticle dispersion "soft" patterning. Thin films equipment includes thermal evaporator, sputtering, and spin coaters, in ISO7 cleanroom. The facility also has a parylene coater, a 3D printer, a stylus profilometer, and a probe station.



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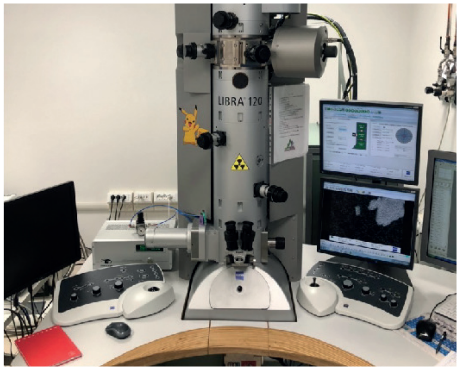
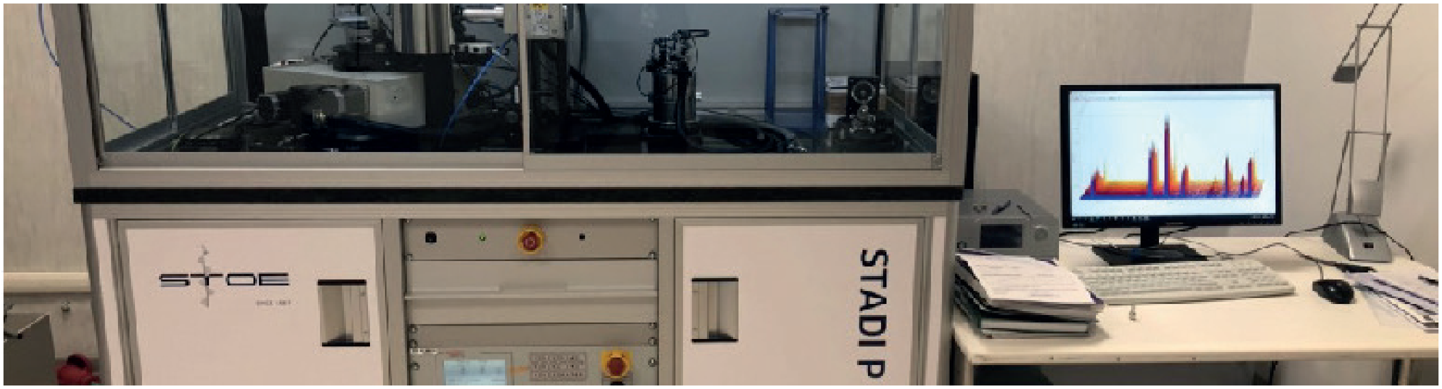
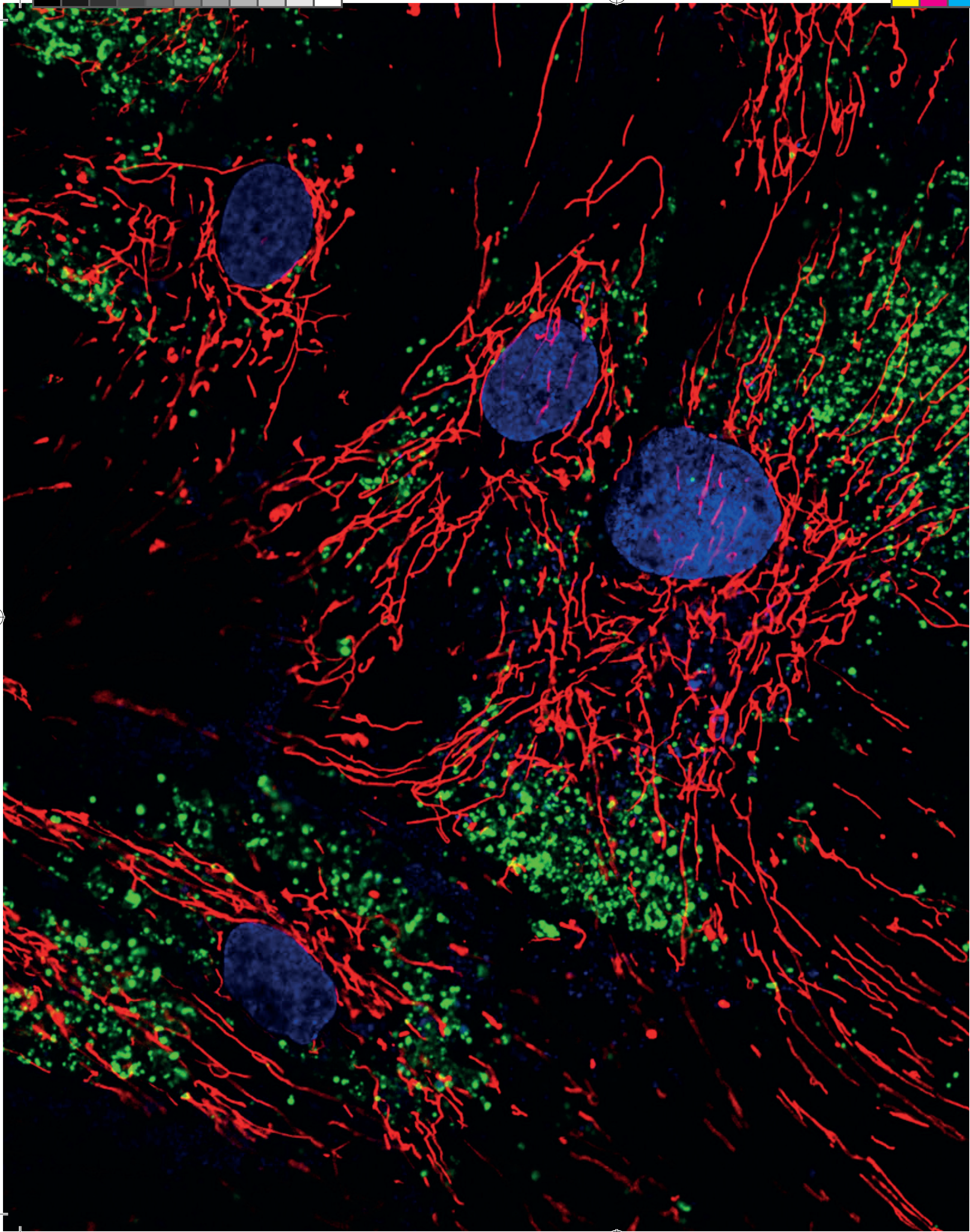
Transmission Electron Microscopy Facility and Powder XRD Laboratory



The laboratory hosts a Zeiss Libra 120 transmission electron microscope (TEM) working at 120 kV with a LaB_6 thermionic source. The TEM is equipped with a HAADF detector for Z-contrast STEM imaging, a Bruker EDX XFlash6T-60 detector for EDS analysis, a 2k × 2k TRS CCD camera, and with a Timepix ASI single electron detector for low dose electron diffraction pattern data collection. The TEM is set up as a state-of-the-art electron diffraction station, able to collect 3D ED data in precession mode, thanks to a Nanomegas Digistar P1000 unit, or in continuous rotation mode. Data collection at liquid nitrogen temperature can be performed with a Gatan 626 cryo transfer holder. The laboratory is also equipped with a FC7-UC7 Leica cryo-ultramicrotome for ultrathin sectioning of biological samples and with a Leica EMPG cryoplunging system for cryo-sample preparation.

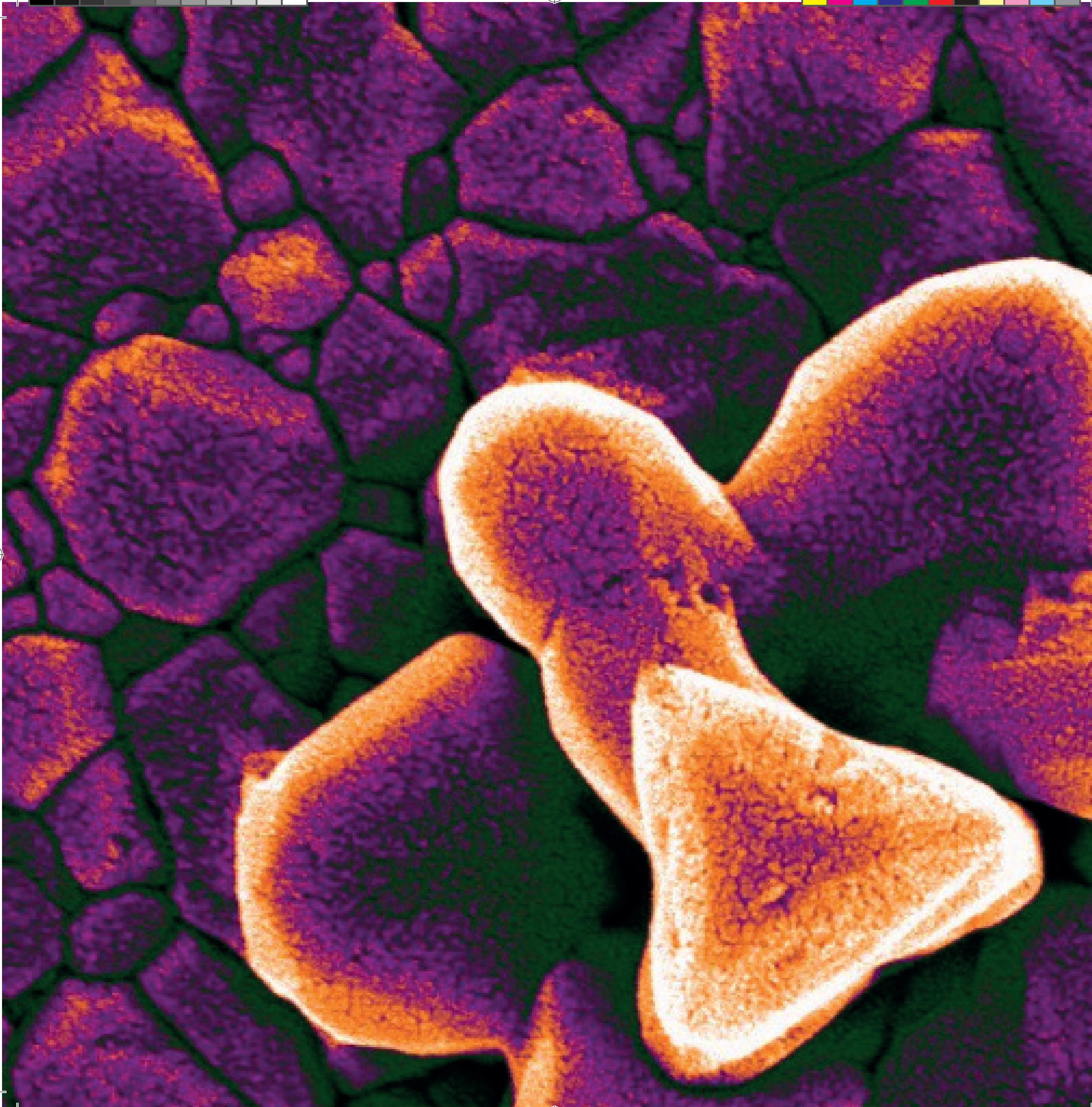
The Center also hosts a Stoe STADI P powder diffractometer equipped with Cu and Mo tubes both monochromated on the $K\alpha_1$ lines. The diffractometer works in Debye-Scherrer geometry with capillary or in transmission mode on a planar dispersion, and has a Dectris Mythen 1K detector. The diffractometer is equipped with a cryo-cooling system to perform experiments down to liquid nitrogen temperature and with a hot chamber for working up to 950°C.





MAIN PROJECTS

- In-vessel implantable smart sensing device for personalised medicine (IV-LAB), grant number 101115545, European Innovation Council (EIC) Pathfinder Challenges, 2023-2027
- Integrated assessment and advanced characterization of neuro-nanotoxicity (iCare), grant number 101092971, Research and Innovation Action, 2023-2026
- Innovative tools to treat and model complex cancer environments (TheraTools), grant number 101073404, Marie Skłodowska-Curie Action - Doctoral Network, 2023-2026
- Biomimetic sensorized barriers-on-a-chip: Unveiling a new generation of market-ready investigation tools (BiSCUIT), grant number 101146025, European Research Council (ERC) Proof of Concept Grant, 2024-2025
- Advanced 3D in vitro models based on magnetically-driven docking of modular microscaffolds (MagDock), grant number 101081539, European Research Council (ERC) Proof of Concept Grant, 2023-2024
- Protection mediated by antioxidant nanotechnology against neuronal damage in space (PROMETEO), grant number 2021-2-R.0, Italian Space Agency, 2022-2025
- Patient-derived hybrid nanocarriers for personalized nanomedicine of glioblastoma multiforme (CyberNano), grant number 24454, Fondazione AIRC, 2021-2025
- Electron nanocrystallography (NanED), grant number 956099, Marie Skłodowska-Curie Innovative Training Networks, 2021-2025
- Functional & dynamic 3D nano-microdevices by direct multi-photon lithography (5D Nanoprinting, grant number 899349, Future and Emerging Technologies Open, 2020-2024
- Wearable sensors for smart injections, industrial project funded by Bracco S.p.A., 2020-2023
- Magnetic solid lipid nanoparticles as a multifunctional platform against glioblastoma multiforme (SLaMM), grant number 709613, European Research Council (ERC) Starting Grant, 2017-2022
- Multi-potent polymer precursor approach for novel conjugated polymers (MP3), grant number 885881, Marie Skłodowska-Curie Individual Fellowship, 2020-2022
- Advanced in vitro physiological models: Towards real-scale, biomimetic and biohybrid barriers-on-a-chip (BBBhybrid), grant number 832045, European Research Council (ERC) Proof of Concept Grant, 2019-2020
- Nanotechnological countermeasures against oxidative stress in muscle cells exposed to microgravity (NOEMI), project number ILSRA-2014-0012 (implementation phase), European Space Agency & grant number 2018-0156, Fondazione CaRiPLo, 2018-2020
- A biomimetic and neuroprotective delivery nanocapsule for the targeted treatment of post-ischemic stroke effects (BIONICS), grant number 793644, Marie Skłodowska-Curie Individual Fellowship, 2018-2020
- Nanotechnology solutions against oxidative stress in muscle tissue during long-term microgravity exposure (NANOROS), grant number 2016-7-U.0, Italian Space Agency, 2016-2019



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