27 AUGUST 2026
FROM 14:00 CEST

CNR BOLOGNA
1° FLOOR CNR-ISMN 8
VIA P. GOBETTI 101

IN PERSON + ONLINE
REGISTRATION

FRONTIERS IN NANOCATALYST DEVELOPMENT FOR ENERGY TRANSITION

Advanced nanocatalysts drive the global energy transition by enabling more efficient **energy conversion**, **carbon circularity**, and **sustainable resource utilization**.

The workshop highlights the latest scientific breakthroughs in **designing high-performance** nanocatalysts bridging **advanced materials synthesis** with **cutting-edge laboratory technologies**, focusing on two main pillars:

1. **Advanced Materials & Energy Applications**: Innovative catalysts to drive decarbonization, carbon circularity, hydrogen generation and environmental remediation;
2. **Automation & Robotics**: The future of materials discovery through AI, automation, and self-driving laboratories for high-throughput screening and composition optimization.

organized by CNR ISMN Istituto per lo Studio dei Materiali Nanostrutturati; KAIST

in collaboration with PROAMBIENTE innovation & environment

as part of the project KIJANA Korea-Italy Joint Development of Advanced Nanosensor for High-Resolution Breath Gas Analysis

Ministry of Foreign Affairs and International Cooperation

This event was supported in part by the Italian Ministry of Foreign Affairs and International Cooperation in the framework of the joint research project KIJANA (grant number PGR00036 within the Scientific and Technological Cooperation Agreement between Italy and the Republic of Korea - CUP B37G25000840001), principal investigators Prof. Il-Doo Kim and Dr. Stefano Zampolli. Organizing committee: Elena Spagnoli, Stefano Zampolli, Vittorio Morandi – CNR-ISMN Bologna

PROGRAM

27 AUGUST 2026 · CNR BOLOGNA + ONLINE

13:30 | Welcome coffee

14:00 | Welcome to CNR Bologna
Vittorio Morandi - CNR-ISMN, Italy

14:05 | Brief presentation of the KIJANA project
Stefano Zampolli - CNR-ISMN, Italy

14:10 | Non-Equilibrium Thermal Shock: A Versatile Synthesis Route to Single-Atom, High-Entropy, and Exsolution Nanocatalysts
Il-Doo Kim – KAIST, Republic of Korea

14:50 | Perovskite Photovoltaics from Device Physics to Autonomous Discovery with Self-Driven Laboratories
Aldo Di Carlo, Antonio Santagata – CNR-ISM, Italy

15:30 | (Photo)-electrochemical Systems for Solar Fuels
Stefano Caramori – University of Ferrara, Italy

16:10 | Coffee break

16:30 | GrafeoPlad-Palladium: Converting Palladium into an Exceptionally Stable Catalyst
Mario Pagliaro – CNR-ISMN, Italy

17:10 | Cu based Layered double hydroxides as single phase for light harvesting and electrochemical CO2RR
Francesco Basile – University of Bologna, Italy

17:50 | Closing the Carbon Loop: Sustainable Hydrogen and CO_2-Derived e-Fuels
Leonarda Liotta – CNR-ISMN, Italy

18:30 | End of Workshop

CNR ISMN Istituto per lo Studio dei Materiali Nanostrutturati · KAIST · KIJANA Korea-Italy Joint Development of Advanced Nanosensor for High-Resolution Breath Gas Analysis · Ministry of Foreign Affairs and International Cooperation · PA PROAMBIENTE innovation & environment

Non-Equilibrium Thermal Shock: A Versatile Synthesis Route to Single-Atom, High-Entropy, and Exsolution Nanocatalysts

Il-Doo Kim*
Department of Materials Science and Engineering, KAIST
**E-mail*: idkim@kaist.ac.kr

This seminar will present our recent advances in designing high-performance nanocatalysts through non-equilibrium, ultrafast thermal processing. The talk will focus on two complementary platforms that our group has been actively advancing: Joule heating (carbothermal shock synthesis) and intense pulsed light (IPL, flash thermal shock synthesis) driven photothermal annealing. Operating on millisecond timescales and far from thermodynamic equilibrium, these processes enable precise kinetic control over nucleation and growth, providing access to catalyst architectures that are difficult to obtain by conventional furnace annealing. I will show how this approach spans a broad compositional and structural landscape, ranging from atomically dispersed single-atom catalysts to multi-element high-entropy alloys and socket-structured exsolution catalysts, each offering exceptional thermal and chemical stability. The talk will then connect these materials to key energy conversion reactions, including CO_2 reduction, the hydrogen evolution reaction (HER), and the oxygen evolution reaction (OER), as well as to exsolution-based chemical sensing. I will also introduce an intriguing facet of photothermal annealing, in which strongly light-absorbing carbon such as carbon black drives structural and compositional transformations, for example the conversion of nanodiamond into carbon nano-onions, illustrating the versatility of light-driven thermal shock for carbon nanostructure engineering. Finally, I will discuss our vision for coupling these rapid synthesis techniques with automation and robotics, enabling high-throughput materials screening and composition optimization for the accelerated discovery of next-generation catalysts. In this context, I will briefly introduce the KAIST–MIT Future Energy Initiative Research Center, a top-tier center that is implementing an AI and robotics based self-driving laboratory to realize this vision. Together, these results establish non-equilibrium rapid thermal processing as a scalable and energy-efficient platform for sustainable energy technologies and beyond.

References

E. Shin, I. D. Kim* et al., "Intense Pulsed Light-Driven Flash Thermal-Shock Synthesis: A Frontier Strategy for Ultrafast Nanomaterial Design," ***Accounts of Materials Research***, Accepted (2026).

Y. Cho†, I. D. Kim* et al., "Electrospinning and Nanofiber Technology: Fundamentals, Innovations, and Applications" ***Advanced Materials*, 37, 28, 2500162 (2025)** Hall of Fame Front Cover-Featured

D. Jeon, S. Y. Choi*, I. D. Kim* et al., "Photothermal Annealing-Enabled Millisecond Synthesis of Carbon Nanoonions and Simultaneous Single-Atom Functionalization," ***ACS Nano***, 19, 38, 34235–34247 (2025). Supplementary Cover-Featured

E. Shin, I. D. Kim* et al., "Flash Thermal Shock Synthesis of Heterostructured Transition Metal Dichalcogenides and Carbides in Milliseconds," ***Advanced Materials***, 37, 30, 2419790 (2025). Back Cover-Featured

D. H. Kim, S. Y. Choi*, I. D. Kim* et al., "Flash-Thermal Shock Synthesis of Single Atoms in Ambient Air," ***ACS Nano***, 17, 23, 23347–23358 (2023). Supplementary Cover-Featured

J. H. Cha, I. D. Kim*, S. Y. Choi* et al., "Flash-Thermal Shock Synthesis of High-Entropy Alloys toward High Performance Water Splitting," ***Advanced Materials***, 35, 46, 2305222 (2023). Inside Front Cover-Featured

J. Ahn, I. D. Kim* et al., "Rapid Joule Heating Synthesis of Oxide-Socketed High-Entropy Alloy Nanoparticles as CO_2 Conversion Catalysts," ***ACS Nano***, 17, 13, 12188–12199 (2023). Supplementary Cover-Featured

D. H. Kim†, S. Y, Choi*, I. D. Kim* et al., "Flash-Thermochemical Engineering of Phase and Surface Activity on Metal Oxides" ***Chem***, 8, 4, 1014-1033 (2022), Front Cover-Featured

Biography

Il-Doo Kim

Il-Doo Kim is an Endowed Chair Professor of Materials Science and Engineering at KAIST and Director of the top-tier KAIST–MIT Future Energy Initiative Research Center (July 2024 to December 2034). He received his Ph.D. from KAIST in 2002 and was a postdoctoral fellow at MIT in the group of Prof. Harry L. Tuller from 2003 to 2005.

Prof. Kim's research centers on the rational design and synthesis of functional nanomaterials, with a particular emphasis on electrospun organic and inorganic nanofibers and, more recently, on non-equilibrium rapid thermal processing such as Joule heating and intense pulsed light driven photothermal annealing. Built on these synthesis platforms, his work extends a single materials foundation across ultra-sensitive chemiresistive and colorimetric gas sensors, high-performance energy devices including catalyst-enhanced electrodes and Li-metal batteries, and advanced catalysis spanning single-atom, high-entropy, and exsolution-type nanocatalysts for energy conversion.

He has published over 457 articles, including 92 cover-featured papers, along with 6 book chapters, and holds 258 international patents, with 14 companies licensing his nanofiber-related technologies. In 2019, he founded IDKLAB Inc., a KAIST technology-based startup.

He served as an Associate Editor of ACS Nano from December 2018 to June 2023 and has been an Executive Editor since July 2023. He has been a Fellow of the Korean Academy of Science and Technology (KAST) since 2022 and an assocaite member of the National Academy of Engineering of Korea (NAEK) since 2025.

Prof. Kim has received numerous prestigious honors. Selected awards include the Knowledge Sharing Grand Prize from the Ministry of Science and ICT (2023), the KAIST Grand Research Prize (2022), the KAIST Grand Prize in International Cooperation (2021), the QIAN Baojun Fiber Award from Donghua University (2019), Scientist of the Year from the Korea Science Journalists Association (2019), the Korea Top 10 Nanotechnology Award (2019), the National R&D Excellence 100 Grand Prize (2018), the Songok Science Award (2018), the KAIST Grand Prize in Technology Innovation (2017), and the Presidential Award on the 51st Invention Day (2016).

Perovskite Photovoltaics from Device Physics to Autonomous Discovery with Self-Driven Laboratories

Aldo Di Carlo*, Antonio Santagata*
Department of Electronic Engineering, CHOSE – Centre for Hybrid and Organic Solar Energy, University of Rome Tor Vergata, Italy
Institute of Structure of Matter (ISM), National Research Council (CNR), Italy
**E-mail:* aldo.dicarlo@cnr.it, antonio.santagata@cnr.it

This seminar will present our recent advances in emerging photovoltaics, following the path that connects the physics of a single perovskite interface to the autonomous, AI-guided discovery of entire material/device systems. Metal halide perovskite solar cells now exceed 27% efficiency in single junction and 35% in perovskite/silicon tandem architectures, yet their industrial translation remains limited by long-term stability, reproducibility, scalability, and the persistent use of hazardous lead precursors and toxic solvents. We will first discuss how compositional and structural engineering of the absorber and of its interfaces addresses these bottlenecks, including two-dimensional perovskite phases that simultaneously improves efficiency and operational stability in large-area modules, and the integration of two-dimensional materials such as graphene and transition metal dichalcogenides into perovskite panels operating in a stand-alone solar farm under real outdoor conditions. Scaling will be a recurring theme that leads in describing how design rules extracted at cell level are validated on modules beyond 100 cm^2, where interfaces, contacts, light management and degradation pathways can no longer be treated separately. We will show how this approach guides the optimisation of tandem and semitransparent architectures, including data-driven design of perovskite/CIGS two-terminal devices, green solvent strategies up to light management with Laser Induced Periodic Surface Structures (LIPSS). Finally, we will introduce MADAM, the self-driving laboratory operational at CNR-ISM in Tito Scalo (Potenza), which autonomously fabricates and characterises up to 768 solar cells per working day through robotic deposition, in-situ optical and electrical diagnostics and automated data capture. Coupled with uncertainty-aware active learning, machine-learning-accelerated first-principles screening and device-physics feedback, MADAM turns photovoltaic research into a closed loop in which both successful and failed experiments become FAIR training data. We will discuss how this closed-loop paradigm, embedding sustainability as a quantitative design constraint rather than a qualitative label, opens the way to lead-free absorbers and green-solvent processing, concluding with our vision of autonomous laboratories as a general platform for the accelerated discovery of sustainable energy materials and devices.

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J. Barichello, G. Calogero, A. Di Carlo, et al., "Beneath the Surface: Investigating Perovskite Solar Cells Under Water" Energy & Environmental Materials, 8, e70069 (2025)

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Biographies

Antonio Santagata

Antonio Santagata graduated summa cum laude in Chemistry at the University of Basilicata (1994) with an experimental thesis on the laser ablation and deposition of tin selenide, obtained an M.Phil. at the University of Sheffield, UK (1997) and a Ph.D. in Chemical Sciences (2003) with a dissertation on the laser ablation and deposition of Group 4 carbides. He was awarded a Marie Curie Fellowship of the European Commission within the Training and Mobility of Researchers programme (Grant Agreement FMBI972734) as Principal Investigator of the project "Depth Profile Analysis of Glassy Materials via Laser Ablation" at the University of Sheffield.

His research spans nearly three decades of laser–matter interaction, from the nanosecond to the femtosecond regime. Core themes include Pulsed Laser Deposition (PLD) of refractory and functional materials; Laser Ablation in Liquid (LAL) for the reagent-free synthesis of nanoparticles, core–shell nanostructures and colloids; and Laser Induced Breakdown Spectroscopy (LIBS). More recently he has focused on Laser Induced Periodic Surface Structures (LIPSS) applied to wide-bandgap semiconductors and dielectrics for energy conversion and storage (selective solar absorbers, thermionic and photon-enhanced thermionic emitters, dendrite-free metal electrodes), room-temperature gas sensing and advanced diagnostics, a line of work that has recently led to the demonstration of black-diamond-based high-temperature solar cells (*Joule*, 2026).

He is Project Leader of the In-LINK-IT research infrastructure (Infrastructure for LINKing Industry to Technologies), funded by the Basilicata Region, and Principal Investigator of the Potenza node of the national iENTRANCE@ENL research infrastructure, funded through the Italian National Recovery and Resilience Plan and connected to the European EuroNanoLab network.

At the Tito Scalo site, these activities converge within MADAM (MAterials and Devices Acceleration platforM), a self-driving laboratory that is unique in Italy and among the few of its kind worldwide. MADAM integrates robotics and advanced processing technologies and will progressively incorporate AI and machine-learning algorithms to enable the fully automated fabrication and characterisation of materials and devices, with the goal of accelerating the transition from fundamental research to market by a factor of 10 to 100.

He has led CNR research units or coordinated entire projects in more than twenty competitive regional, national and European funding programmes, collaborating with both SMEs and major industrial partners. As a scientific expert for the Italian Ministry of Enterprises and Made in Italy, formerly MISE, now MiMIT, he has evaluated several national research and innovation programmes. He is also an elected member of the Technical and Scientific Committee of the Lucano Automotive–Smart Factory Cluster.

Aldo Di Carlo

Aldo Di Carlo is Director of the Institute of Structure of Matter of the National Research Council of Italy (CNR-ISM), Full Professor at the Department of Electronic Engineering at the University of Rome Tor Vergata (Italy) , and President of the CNR Research Area of Rome – RM2, which includes more than 10 research institutes. Di Carlo founded and directed from 2006 to 2019, the Center for Hybrid and Organic Solar Energy (CHOSE), which comprises more than 70 PhD students and experienced researchers in the emerging field of photovoltaics. Di Carlo's research interests include the study, design, and optimization of electronic and optoelectronic devices. His work has focused on the development and scaling-up of emerging photovoltaic technologies, with particular emphasis on Dye Solar Cells (DSCs) and Perovskite Solar Cells for industrial applications. He has authored or co-authored over 600 international scientific publications and holds 14 international patents. Furthermore, he has served as general coordinator or partner coordinator in more than 25 large European projects.

(Photo)-electrochemical Systems for Solar Fuels

Stefano Caramori*, Michele Mazzanti, Edoardo Marchini, Anna Ianniello, Letizia Piffanelli, Silvia Grandi, Alessandro Niorettini and Serena Berardi
Department of Chemical, Pharmaceutical and Agricultural Sciences of the University of Ferrara, Via Luigi Borsari 46, 44121, Ferrara.
**E-mail:* stefano.caramori@unife.it

Photo-electrochemical cells may find significant applications in solar fuel production, water splitting for hydrogen generation, carbon dioxide reduction, environmental remediation, and photovoltaic devices. [1,2] Ongoing research focuses on developing efficient, stable, and cost-effective electrode and photoelectrode materials to improve light absorption, charge separation, and catalytic performance for generating value added chemical species (fuels, chemical building blocks). This lecture will review some case studies from our laboratory, which could be of interest in photoelectrochemistry, concerning the development and application of Mo-doped $BiVO_4$ photoanodes, MXene modified hematite, and copper/copper (I and II) oxide based materials for CO_2 reduction in aqueous and gas diffusion cells. The impact of material engineering on charge transfer dynamics is explored and rationalized, when possible, by applying a combination of time (or frequency) resolved spectrometric techniques.

References

1. Z. G, Schichtl et al, "Chemistry of Materials Underpinning Photoelectrochemical Solar Fuel Production", ***Chem. Rev.*** 125 (10): 4768–4839 (2025)
2. Y. Xiao et al., "Interface engineering for photoelectrochemical oxygen evolution reaction" ***Chem. Soc. Rev***. (2025) 54 (3): 1268–1317 (2025)

Biography

Stefano Caramori

Stefano Caramori is Full Professor of General and Inorganic Chemistry at the University of Ferrara (Italy), where he leads research on molecular and nanostructured materials for solar energy conversion and sustainable electrochemical technologies. His research bridges chemistry, materials science, and electrochemistry, combining fundamental investigations of photoinduced charge-transfer processes with the development of innovative materials for photovoltaic and photoelectrochemical energy conversion. Throughout his career, Prof. Caramori has authored more than 150 peer-reviewed publications and several patents, receiving over 5,000 citations from the international scientific community. He has coordinated and participated in numerous competitive national and European research projects and has established long-standing collaborations with leading research groups across Europe working in photovoltaics, photoelectrochemistry, catalysis, and functional materials. He regularly serves as reviewer for leading journals in chemistry, materials science, and renewable energy. His current research is centered on the development of scalable, efficient, and environmentally benign materials capable of enabling the transition toward carbon-neutral energy systems contributing to the advancement of solar electricity generation, artificial photosynthesis, photoelectrocatalysis, and the broader field of renewable energy materials.

GrafeoPlad-Palladium: Converting Palladium into an Exceptionally Stable Catalyst

Mario Pagliaro,[1]* Matteo Formenti,[2] Rosaria Ciriminna,[1] Cristina Della Pina[2]
[1]Istituto per lo Studio dei Materiali Nanostrutturati, CNR, Palermo, Italy;
[2]Dipartimento di Chimica, Università degli Studi di Milano, Italy;
**E-mail*: mario.pagliaro@cnr.it

Palladium is a key catalytic metal widely employed both in synthetic organic chemistry and in environmental remediation catalysis. The metal is rare and expensive, whereas increasing demand coupled to increasingly difficult supply is driving both price volatility and substantial price increase. The metal cost $588/t in August 2016. Ten years later its price doubled to $1,290/t. The most commonly employed palladium catalyst, Pd/C consisting of Pd nanoparticles dispersed on the outer surface of charcoal, suffers from relatively quick deactivation [1]. Clearly, the development of a catalytically stable form of nanoparticulate Pd would be highly desirable, though prolonged lack of achievements of practical relevance makes the Pd/C catalyst still the catalytic material of choice for most heterogeneously catalyzed processes. To ensure economic viability of Pd catalysis, catalyst suppliers usually retrieve the spent Pd/C catalyst from customers for reactivation usually by extracting the metal in a suitable media and subsequent re-impregnation on carbon support followed by reduction [1].

In 2023, we anticipated the discovery of a completely new class of functional materials, dubbed "GrafeoPlad-Palladium", for designating palladium doped with 3D entrapped graphene oxide (GO@nPd) [2]. Employed in the Suzuki–Miyaura cross-coupling reaction between phenylboronic acid and aryl halogenides conducted in methanol, catalyst reusability tests showed unprecedented stability of the new material toward sintering and deactivation [3]. Clustering to form palladium black is the common deactivation mechanism of most cross-coupling reactions mediated by both homogeneous [4] and heterogeneous [5] Pd catalysts. GrafeoPlad-Pd is significantly more stable than Pd black, showing that the entrapment of GO molecules in the nanoparticle lattice largely improves both its catalytic activity and stability against catalytic deactivation.

In this lecture, I will discuss the outcomes of experimental and computational investigations of the metal-organic alloy GO@(nPd) hybrid material and the stabilizing role of the 3D-entrapped graphene moiety of the GO molecules against sintering, confirmed by DFT calculations [3]. XPS surface investigation prior and after employment in hydrogenation catalysis [6] indicate involvement in catalysis of both metallic Pd and PdO phases. These findings make the discovery of GrafeoPlad-Pd of direct relevance to the global fine chemical industry wherein the increasingly costly use of palladium in catalytic reactions is ubiquitous. This new class of metal-organic alloys (MORALs) [7] opens practically relevant new avenues in many areas of today's material science and technology.

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3. M. Formenti, M. P. Casaletto, G. Barone, et al. "GrafeoPlad Palladium: Insight on structure and activity of a new catalyst series of broad scope" ***Adv. Sust. Syst***. 8, 2300643 (2024)
4. P. W. N. M. van Leeuwen, "Decomposition pathways of homogeneous catalysts" ***Appl. Catal***. A. 212, 61, (2001)
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6. M. Formenti, M. Pagliaro, et al. "Graphene oxide in palladium nanoparticle (GrafeoPlad): a new class of functional materials" ***Green Synth. Catal.*** 6, 297-301, (2025)
7. R. Ciriminna, M. Formenti, M. Pagliaro, et al. "Practical aspects concerning catalysis with molecularly doped metals" ***ChemCatChem*** 15, e202300600, (2023)

Biography

Mario Pagliaro

Ordinary member of the Academia Europaea for the chemical sciences, and Research Director at Italy's National Research Council, Mario Pagliaro leads in Palermo, Sicily, a research Group working in collaboration with research teams from over 20 countries in a broad field encompassing biomedicine, nanochemistry, solar energy, green chemistry, the bioeconomy, and open science. “IntegroPectin”, "CuproGraf", “NiGraf”, “CytroCell”, “GrafeoPlad”, “CytroCav”, “AquaSun”, “SiliOrange”, “AnchoisOil”, “LimoFish”, "AetnAsh", “AnchoisFert”, and “HyTan” are some of the names created by Dr Pagliaro to identify new functional materials and new enabling technologies jointly developed by his Lab. All his team’s papers are self-archived and openly accessible on his Laboratory’s website (qualitas1998.net).

Cu based Layered double hydroxides as single phase for light harvesting and electrochemical CO2RR

Francesco Basile*
Department of Industrial Chemistry University of Bologna
**E-mail*: f.basile@unibo.it

The seminar will describe the recent activities in the development of Layered Double Hydroxide (LDH) as photo-electrocatalysts. The Cu-based LDH have been prepared using two different and easy scalable techniques: a coprecipitation followed by screen printing and electrochemical deposition that was first developed using a potentiostatic technique and then modified using a potentiodynamic technique able to increase the control of the composition. The LDH tested in electrochemical CO2RR was patented before publishing the results and shows high productivity and selectivity in acetic acid at low potential (-0.4 vs RHE). The LDH was modified to perform the photoelectrocatalytic reduction of carbon dioxide (PEC-CO2RR). Usually, PEC systems rely on photocathodes composed by a photoactive phase and a catalytically active one. However, the combination of such heterogeneous surfaces is not easy to optimize. Herein, we propose for the first time the use of Cu-containing LDH as single-phase photocathode material for light-assisted CO_2 reduction providing simultaneous light-absorption and CO_2 electrocatalytic conversion. By exploiting the unique properties of LDH, photoelectrochemical CO_2 conversion into C2 and C3 oxygenated products have been successfully performed in a PEC system operating under low external applied voltage. Using scalable synthetic procedures to produce both powders and photoelectrodes, i.e., coprecipitation and screen-printing technique, two different compositions of LDH, namely Cu/Mg/Al and Cu/Mg/Fe were obtained. Full characterization of structure/morphology, photoelectrochemical, and catalytic properties allowed a deep understanding of the role of metal elements within LDH structure on photocathodes performances and PEC CO2RR, with Fe providing strong benefits to light harvesting and electrocatalytic activity. The LDH shows also interesting activity in photochemical CO_2 reduction thanks to the strong affinity with CO_2 and the generation of reducing species. Molecular dynamics have been developed for studying the interaction of CO_2 with the LDH and its dynamic equilibrium in the interlayer.

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Biography

Francesco Basile

Francesco Basile is Full Professor of Industrial Chemistry at the Department of Industrial Chemistry, University of Bologna (Italy), a position he has held since December 2021. He is also Director of the CIRI FRAME (Interdepartmental Centre for Industrial Research on Renewable Resources, Environment, Sea and Energy) at the University of Bologna.

He received his Ph.D. in Industrial Chemistry from the University of Bologna in 2000. His research focuses on the development of advanced materials and catalysts, bio-based products, and photo- and electrochemical processes, with extensive experience in chemical and energy-related research, having participated in and coordinated more than 25 research projects.

His scientific output includes 112 publications indexed in Scopus, with more than 3,100 citations and an H-index of 33. He is co-inventor of 10 independent patents, author of 15 book chapters, and co-author of the book *Chemicals and Fuels from Bio-Based Building Blocks* (Wiley-VCH, 2016).

Professional EXPERIENCES: Organization, official delegate and coordination of initiatives

- 2025 – present Italian delegate in the Implementation working Group on H2 of SET plan
- 2025 – present: cross cutting task force of EU SET plan (strategic energy and technology plan) on societal impact and needs in the renewable transition.
- 2021 – present: *National representative in the thematic configuration climate, energy and mobility (cluster 5) of Horizon Europe.*
- 2020 – present *Clean Energy transition Partnership: Horizon Europe co-funded partnership: core group proposal and management team member*
- *2022 – 2025 Italian delegate in Agenda Process's task force: pilot on green hydrogen of ERA (European Research Area) and coordinator of the pillar on hydrogen production.*
- 2019 – 2021 *Italian delegate in the "Transitional partnership forum" of Horizon Europe. Representing ther* Ministry of University and Research for Development of the strategic partnership coordination process of Horizon Europe.
- 2019 – 2020 *Advisor and part of the gabinet of the Minister of Education University and Research (Italy) on "climate change and sustainable development".*
- 2019 – 2020 *Deputy for Italy in ERAC (Eu Research Area Committee)*
- 2019 – 2020 *Delegate in the mission structure (CIS institutional development contract for Taranto) of the institutional permanent table under the coordination of the Presidency of the Council refinery port and stainless still production)*
- *2012 – 2016 Scientific referee for Emilia Romagna region on vanguard initiative on Bio-aromatics and the project* "BIOECONOMY PILOT"
- 2009 – 2012 *Expert group ICS-UNIDO member on Biofuel and focal point for Italy*

Closing the Carbon Loop: Sustainable Hydrogen and CO_2-Derived e-Fuels

Leonarda Francesca LIOTTA
Istituto per lo Studio dei Materiali Nanostrutturati (ISMN-CNR), Via Ugo La Malfa 153, Palermo, Italy.
E-mail: leonardafrancesca.liotta@cnr.it

The transition toward carbon neutrality and the decarbonization of the energy and chemical sectors require the implementation of integrated carbon circularity strategies, in which CO_2 capture is coupled with catalytic and electrochemical conversion technologies to produce renewable hydrogen and CO_2-derived e-fuels. The integration of CO_2 capture with advanced catalytic processes and Solid Oxide Electrolysis Cells (SOECs) (Figure 1) establishes an integrated carbon utilization platform for the efficient conversion of captured CO_2 into synthetic natural gas, syngas, hydrogen, and other carbon-neutral fuels, while enabling renewable electricity to be stored as chemical energy in value-added products. Ca/Ce-doped MgO sorbents have demonstrated highly reversible CO_2 capture with excellent cyclic stability, allowing the efficient release of concentrated CO_2 streams for subsequent utilization through optimized carbonation–calcination cycles [1]. The catalytic upgrading of CO_2 has been extensively investigated through methanation, dry reforming of methane (DRM), and chemical looping reforming (CLR) over Ni-based catalysts, where optimized metal–support interactions, controlled Ni dispersion, and rationally engineered perovskite and spinel structures markedly enhance CO_2 activation, hydrogen production, catalyst stability, and resistance to carbon deposition [2–4]. In parallel, high-temperature electrochemical CO_2 conversion has been explored using SOECs equipped with doped and high-entropy perovskite electrodes, which have demonstrated remarkable potential for the co-electrolysis of CO_2 and H_2O to produce syngas, a versatile intermediate for the synthesis of sustainable e-fuels [5,6]. Collectively, these complementary approaches underscore the strategic importance of integrating reversible CO_2 capture, heterogeneous catalysis, and solid oxide electrochemical conversion to establish efficient carbon circularity pathways for renewable hydrogen generation and the sustainable production of CO_2-derived synthetic fuels.

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Biography

Leonarda Francesca Liotta

Leonarda Francesca Liotta is Research Director at the National Research Council of Italy (CNR) and member of the Scientific Board of the CNR Department of Chemical Sciences and Materials Technologies (DSCTM-CNR).

After graduating with a Master's Degree in Chemistry (110/110 cum laude) from the University of Palermo, she carried out doctoral studies supported by a two-year CNR fellowship, including eight months research stay at IRCELYON (Villeurbanne, France), where she specialized in FT-IR and DRIFT spectroscopic characterization techniques.

She joined the National Research Council (CNR) initially as contract researcher and became permanent researcher in 2000. She is co-author of more than 280 peer-reviewed scientific publications, including journal articles and book chapters, and has contributed to more than 600 presentations at national and international conferences and other scientific dissemination activities (Scopus H-index: 58, 2026).

She has participated in several COST Actions in the fields of environmental remediation and sustainable energy, including CA17136 Indoor Air Pollution Network and CA18224 Green Chemical Engineering Network towards Upscaling Sustainable Processes.

She currently leads Working Group 3, Air Cleaning Solutions for Gaseous Contaminants, within COST Action CA23139, Network for Indoor Air Cleaning (Net4CleanAir).

Dr. Liotta is a member of the Italian Chemical Society, where she is active in both the Industrial Chemistry Division and the Interdivisional Catalysis Group. She serves on the Scientific Board of ENERCHEM, the Interdivisional Group of Chemistry for Renewable Energy of the Italian Chemical Society and previously served on the Scientific Board of the Interdivisional Catalysis Group.

She has been a visiting researcher at several leading European research institutions and universities, including those in Lyon, Lille, Dunkirk, Paris (Sorbonne University), Valencia, Seville, Budapest, Sofia, Tomsk State University, and Măgurele. Her research focuses on heterogeneous catalysis for environmental and energy applications, with particular emphasis on the design and development of advanced catalytic materials, including high entropy and exsolution-type catalysts.

Her activities span materials science for environmental remediation (NH_3-SCR of NO_x, VOC abatement, and soot oxidation) and clean energy technologies, including dry and steam reforming, CO_2 methanation, solid oxide fuel cells (SOFCs), and solid oxide electrolysis cells (SOECs). She has coordinated and led several international and national research projects addressing energy production, conversion, and sustainable technologies.