Curriculum Vitae et Studiorum - Martina Fracchia

Last update: March 2025

Department of Chemistry, Via Taramelli 12, 27100, Pavia (PV), Italy

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MF's current research focuses on the synthesis and characterization of novel materials for catalysis and energy production/storage. In particular, her research activity is centered around two main, partially interconnected themes: i) the use of in situ and operando X-ray absorption spectroscopy (XAS) for the study of electrochemical, catalytic, and electrocatalytic phenomena related to sustainable energy production and storage processes ii) the development of high entropy oxides (HEOs) as innovative functional materials for energy applications.

Current position

Tenure-track assistant professor (Ricercatore RTD/b) in Physical Chemistry
Department of Chemistry, University of Pavia

Previous positions

- ***Post-doctoral researcher*** *[01/02/2024 – 31/07/2024]*
  Department of Chemistry, University of Pavia - Research title: "Operando studies of high-entropy oxide based active materials for Na-Ion battery cathodes"

- ***Post-doctoral researcher within the program "L'Oréal-Italia for women in science 2023"*** *[01/09/2023 – 31/01/2024]*
  Department of Chemistry, University of Pavia, in collaboration with Department of Chemistry, University of Milano - Research title: "High entropy oxides as novel sustainable electrocatalysts for the water splitting reaction"

- ***Post-doctoral researcher*** *[01/09/2022 – 31/08/2023]*
  Department of Chemistry, University of Pavia - Research title: "Solid-state reaction mechanisms for the synthesis of pigments for the ceramic industry"

- ***Post-doctoral researcher*** *[01/02/2022 – 31/08/2022]*
  Department of Chemistry, University of Pavia - Research title: "Synthesis and characterization of high entropy oxides"

- ***Post-doctoral researcher*** *[01/10/2021 – 31/01/2022]*
  Department of Chemistry, University of Pavia - Research title: "Preparation of high entropy spinels as pigments for the ceramic industry"

- ***Post-doctoral researcher*** *[01/10/2019 – 30/09/2021]*
  Department of Chemistry, University of Pavia - Research title: "Operando soft XAS spectroscopy on high entropy oxides"

Education

- ***Ph.D. in Chemical and Pharmaceutical Sciences*** *[01/10/2016 – 30/09/2019]*
  University of Pavia - Thesis title: "Operando spectroscopy for the study of reaction mechanisms in electrochemistry". Supervisor: Prof. Paolo Ghigna

- ***Visiting Ph.D. student*** *[01/03/2019 – 30/06/2019] University of Bremen, Fraunhofer-Institut*

- ***Master's Degree (Materials Chemistry) – Final grades: 110/110 cum laude*** *[10/2014 30/06/2016]*
  University of Pavia - Thesis title: " Water splitting photocatalysis: mechanisms of reaction ". Supervisor: Prof. Paolo Ghigna   Co-supervisor: Prof. Alessandro Minguzzi

- ***Bachelor's Degree (Chemistry) – Final grades: 110/110 cum laude*** *[10/2011 – 22/07/2014]*
  University of Pavia - Thesis title: "The oxides as thermoelectric materials". Supervisor: Prof. Giorgio Spinolo

National Scientific Abilitation

[12/12/2023] **National Scientific qualification as associate professor** in the Italian higher education system, in the call 2021/2023 (Ministerial Decree n. 553/2021 and 589/2021) for the disciplinary field of 03/A2 – Models and methods for chemistry.

Teaching activities

- *2024/2025* Professor for the course "Physical-Chemistry of solid-state devices" (CHIM/02) - Master's degree in Chemistry (24 hours)
- *2024/2025* Professor for the course "Integrated Chemistry Lab - B" (CHIM/07) -Bachelor's degree in Chemistry (36 hours)
- *2024/2025* Professor for the course "Chemistry of Materials" (CHIM/02) - Master's degree in Computational and Modelling Engineering For Materials, Structures, And Sustainable Technologies (8 hours)

Honours and awards

1. **"Gian Paolo Brivio International Prize for the Physics and Chemistry of Advanced Materials 2024"** jointly awarded by the Istituto Lombardo – Accademia di Scienze e Lettere, Milan and the European Doctorate PCAM - Physics and Chemistry of Advanced Materials

2. **"L'Oréal-Italia for Women in Science 2023"** award/fellowship issued by L'Oréal-Italia/UNESCO

3. **“Young Physico-Chemist award”** issued by the Physical Chemistry Division of the Italian Chemical Society (SCI) in 2022

4. **“Award for the best oral presentation”** during the "Italian Virtual Workshop on Fuel Cells 2021" (IVWFC 2021)

5. **"Photo Analytical S.R.L."** prize issued by the Electrochemical Division of the Italian Chemical Society for on of the the best master's degree theses in electrochemistry in 2019

6. **Prize awarded by the University of Pavia and Ubi Banca to the top graduates** (a.a. 2015/2016)

7. **"Matteo Bertero" prize** awarded to the graduate student with the highest grades in Chemistry Bachelor’s Degree (promoted by the University of Pavia) in 2015

Publications

MF is author of **36 scientific publications**, of which **7 as corresponding author** and **13 as first author**.

Indicators related to the scientific output (updated in March 4th, 2025):

Total Citations (Scopus): 683   Total Citations (Google Scholar): 806

H-index (Scopus): 15   H-index (Google Scholar): 16

List of publications:

1. X. He, **M. Fracchia**, P. Ghigna, F. D’Acapito, A. Vertova, A. Minguzzi, “Understanding the stability of CuxO photocathodes for photoelectrochemical water splitting: insights by operando XAS”, *Int. J. Hydrogen Energy*, (2025), 113, 1-11
2. A. Gentile, N. Pianta, **M. Fracchia**, S. Pollastri, C. Ferrara, S. Marchionna, G. Aquilanti, S. Tosoni, P. Ghigna, R. Ruffo, “The $Ti_3C_2T_x$ MXene as anode for sodium-ion batteries: the in-situ comprehension of the electrode reaction”, *ACS Appl. Energy Mater.*, (2025), 8, 2229-2238
3. **M. Fracchia***, M. Coduri, S. Bonati, C. Dejoie, P. Ghigna, U. Anselmi Tamburini, “Beyond configurational entropy: the role of solubility equilibria in the stability of the system (Co,Cu,Mg,Ni,Zn)O”, *J. Eur. Ceram. Soc.*, (2025), 45, 117237
4. **M. Fracchia**, T. Roongcharoen, M. Coduri, L. Sementa, S. Saeedi, X. T. Nguyen, D. C. Stoian, E. Pitzalis, B. Campanella, C. Evangelisti, A. Fortunelli, V. Dal Santo, F. Bossola, “Enhancing and understanding the stability of Ni catalysts via In-promotion for the steam reforming of oxygenates: An in-depth operando XRD-XAS and modeling investigation”, *Appl Catal B: Environ.*, (2025), 366, 125074
5. **M. Fracchia**, P. Ghigna, S. Stolfi, U. Anselmi Tamburini, M. Coduri, L. Braglia, P. Torelli, “Mechanisms of CO oxidation on high entropy spinels”, *Phys. Chem. Chem. Phys.*, (2025), 27, 3412-3419
6. M. Coduri, **M. Fracchia**, S. Checchia, M. Manzoli, C. Dejoie, P. Ghigna, U. Anselmi Tamburini, “Phase stability of high entropy (Mg,Ni,Co,Cu,Zn)O from temperature-resolved synchrotron diffraction: tetragonal distortion and guggenite phase”, *Small*, (2025), 21, 2406634
7. X. He, T. Baran, **M. Fracchia***, A. Visibile, A. Vertova, P. Ghigna, A. Minguzzi, “Potential-dependent phase stability and trapped-electrons origin in copper-oxide based photocathodes for water splitting”, *Int. J. Hydrogen Energy*, (2024), 110, 687-694

8. M. Guerrini, L. R. Magnaghi, **M. Fracchia***, M. P. Riccardi, G. Pigoni, G. Debbi, M. Patrini, R. Biesuz, S. C. Tarantino, U. Anselmi Tamburini, P. Ghigna, “Minimizing the cobalt content in black ceramic pigments by Design of Experiments”, *Ceram. Int.*, (2024), 50, 51181-51191
9. I. Ostroman, N. Vallana, S. Marchionna, A. Gentile, C. Ferrara, I. C. Pellini, **M. Fracchia**, N. Pianta, R. Ruffo “Oxidized $Ti_3Al_{(1-x)}Sn_xC_2$ MAX phases as negative electrode materials for Sodium ion batteries, *J. Power Sources*, (2024), 624, 235543
10. X. He, **M. Fracchia**, M. Coduri, M. Scavini, P. Ghigna, M. Marelli, R. Della Pergola "Structure and activity of carbonyl cluster derived PtFe nanoparticles as electrocatalysts for the oxygen reduction reaction in alkaline media”, *ACS Appl. Energy Mater.*, (2024), 7, 4, 1561-1572
11. V. Coviello, D. Badocco, P. Pastore, **M. Fracchia**, P. Ghigna, A. Martucci, D. Forrer, V. Amendola, “Accurate prediction of the optical properties of nanoalloys with plasmonic and magnetic elements”, *Nat. Commun.*, (2024), 15:834
12. M. Coduri, L. R. Magnaghi, **M. Fracchia**, R. Biesuz, U. Anselmi-Tamburini, “Assessing Phase Stability in High Entropy Materials by Design of Experiments: the Case of the System (Mg,Ni,Co,Cu,Zn)O”, *Chem. Mater.*, (2024), 36, 2, 720-729
13. **M. Fracchia***, M. Coduri, P. Ghigna, U. Anselmi-Tamburini, “Phase stability of high entropy oxides: A critical review”, *J. Eur. Ceram. Soc.*, (2024), 44, 585-594
14. M. Coduri, **M. Fracchia***, M. Guerrini, C. Dejoie, P. Ghigna, U. Anselmi Tamburini, “Novel In-based high entropy oxides with tunable lattice parameter”, *J. Eur. Ceram. Soc.*, (2023), 43, 2728-2739
15. **M. Fracchia**, D. Callegari, M. Coduri, U. Anselmi Tamburini, M. Manzoli, E. Quartarone, P. Ghigna, “Electrochemical performance of high and medium entropy oxides for lithium batteries”, *Front. Energy Res.*, (2022), 10, 1-9
16. **M. Fracchia**, M. Coduri, M. Manzoli, P. Ghigna, U. Anselmi Tamburini, “Is configurational entropy the main stabilizing term in rock-salt $Mg_{0.2}Co_{0.2}Ni_{0.2}Cu_{0.2}Zn_{0.2}O$ high entropy oxide? *Nat. Commun.*, (2022), 13, 2977
17. D. Callegari, M. Coduri, **M. Fracchia**, P. Ghigna, L. Braglia, U. Anselmi Tamburini, E. Quartarone, “Lithium intercalation mechanisms and critical role of multi-doping in $LiFe_xMn_{2-x-y}Ti_yO_4$ as high-capacity anode for Lithium-ion batteries”, *J. Mater. Chem. C*, (2022), 10, 8994
18. D. Spada, M. Aramini, M. Fittipaldi, A. Cini, **M. Fracchia**, P. Ghigna, A. Girella, C. Milanese, M. Bini, “Spectroscopic techniques and DFT calculations to highlight the effect of Fe^{3+} on the properties of $FeNb_{11}O_{29}$, anode material for lithium-ion batteries”, *J. Phys. Chem. C.*, (2022), 126, 9, 4698-4709
19. F. Tavani, **M. Fracchia**, A. Tofoni, L. Braglia, A. Jouve, S. Morandi, M. Manzoli, P. Torelli, P. Ghigna, P. D’Angelo, “Structural and mechanistic insights into low-temperature CO oxidation over a prototypical high entropy oxide by Cu L-edge operando X-ray absorption spectroscopy”, *Phys. Chem. Chem. Phys.*, (2021), 23, 26575
20. C. Ferrara, A. Gentile, S. Marchionna, I. Quinzeni, **M. Fracchia**, P. Ghigna, S. Pollastri, C. Ritter, G. M. Vanacore, R. Ruffo, “The missing piece: The structure of the $Ti_3C_2T_x$ MXene and its behavior as negative electrode in sodium ion batteries”, *Nano Lett.*, (2021), 21, 8290-8297
21. **M. Fracchia**, P. Ghigna, M. Marelli, M. Scavini, A. Vertova, S. Rondinini, R. Della Pergola, A. Minguzzi “Molecular cluster route for a facile synthesis of stable and active Pt nanoparticle catalyst”, *New J. Chem.*, (2021), 45, 11292-11303
22. B. Petrovičovà, C. Ferrara, G. Brugnetti, C. Ritter, **M. Fracchia**, P. Ghigna, S. Pollastri, C. Triolo, L. Spadaro, R. Ruffo, S. Santangelo, “Effect of germanium incorporation on the electrochemical performance of electrospun Fe_2O_3 nanofibers-based anodes for sodium-ion batteries”, *Appl. Sci.* (2021), 11, 1483
23. P. Ghigna, L. Airoldi, **M. Fracchia**, D. Callegari, U. Anselmi Tamburini, P. D’Angelo, N. Pianta, R. Ruffo, G. Cibin, D. Oliveira de Souza, E. Quartarone, “Lithiation mechanism in high-entropy oxides as anode materials for Li-ion batteries: an operando XAS study”, *ACS Appl. Mater. Interfaces* (2020), 12, 50344-50354
24. F. Tavani, **M. Fracchia**, N. Pianta, P. Ghigna, E. Quartarone, P. D’Angelo “Multivariate curve resolution analysis of operando XAS data for the investigation of the lithiation mechanisms in high entropy oxides”, *Chem. Phys. Lett.* (2020), 760, 137968
25. F. Malara, **M. Fracchia**, H. Kmentova, R. Psaro, A. Vertova, D. Oliveria de Souza, G. Aquilanti, L. Olivi, P. Ghigna, A. Minguzzi, A. Naldoni “Direct observation of photoinduced higher oxidation states at a semiconductor/electrocatalyst junction”, *ACS Catal.* (2020), 10, 18, 10476-10487

26. **<u>M. Fracchia*</u>**, M. Manzoli, U. Anselmi-Tamburini, P. Ghigna "A new eight-cation high entropy spinel with large configurational entropy in both tetrahedral and octahedral sites: synthesis and cation distribution by X-ray absorption spectroscopy", *Scripta Mater.* (2020), 188, 26-31
27. **<u>M. Fracchia*</u>**, P. Ghigna, A. Minguzzi, A. Vertova, F. Turco, G. Cerrato, D. Meroni "Role of synthetic parameters on the structural and optical properties of N,Sn-copromoted nanostructured TiO_2: a combined Ti K-edge and Sn $L_{2,3}$-edges X-ray absorption investigation", *Nanomaterials* (2020), 10(6), 1224
28. L. Braglia, **M. Fracchia**, P. Ghigna, A. Minguzzi, D. Meroni, R. Edla, M. Vandichel, E. Ahlberg, G. Cerrato, P. Torelli "Understanding solid-gas reaction mechanisms by operando soft X-ray absorption spectroscopy at ambient pressure", *J. Phys. Chem. C* (2020), 124, 26, 14202-14212
29. **M. Fracchia**, P. Ghigna, T. Pozzi, U. Anselmi-Tamburini, V. Colombo, L. Braglia, P. Torelli, "Stabilization by configurational entropy of the Cu(II) active site during CO oxidation on $Mg_{0.2}Co_{0.2}Ni_{0.2}Cu_{0.2}Zn_{0.2}O$", *J. Phys. Chem. Lett.* (2020), 11, 9, 3589-3593
30. A. Visibile, **M. Fracchia**, T. Baran, A. Vertova, P. Ghigna, E. Ahlberg, S. Rondininj, A. Minguzzi "Electrodeposited Cu thin layers as low cost and effective underlayers for Cu_2O photocathodes in photoelectrochemical water splitting", *J. Solid State Electrochem.*, (2020), 24, 339-355
31. **M. Fracchia**, V. Cristino, A. Vertova, S. Rondinini, S. Caramori, P. Ghigna, A. Minguzzi, "Operando X-ray absorption spectroscopy of WO_3 photoanodes", *Electrochim. Acta*, (2019), 320, 134561
32. **M. Fracchia**, P. Ghigna, A. Vertova, S. Rondinini, A. Minguzzi "Time-resolved X-ray Absorption Spectroscopy in (Photo) electrochemistry", *Surfaces*, (2018), 1, 138-150
33. **M. Fracchia**, A. Visibile, E. Ahlberg, A. Vertova, A. Minguzzi, P. Ghigna, S. Rondinini "α-and γ-FeOOH: stability, reversibility and nature of the active phase under hydrogen evolution", *ACS Appl. Energy Mater.*, (2018), 1, 4, 1716-1725
34. E. Achilli, A. Minguzzi, A. Visibile, C. Locatelli, A. Vertova, A. Naldoni, S. Rondinini, F. Auricchio, S. Marconi, **M. Fracchia**, P. Ghigna "3D-printed photo-spectroelectrochemical devices for in situ and in operando X-ray absorption spectroscopy investigation", *J. Synchrotron Radiat.*, (2016), 23, 622-628
35. T. Baran, **M. Fracchia**, A. Vertova, E. Achilli, A. Naldoni, F. Malara, G. Rossi, S. Rondinini, P. Ghigna, A. Minguzzi, A. F. D'Acapito "Operando and time-resolved X-Ray Absorption Spectroscopy for the study of photoelectrode architectures", *Electrochim. Acta*, (2016), 207, 16-21
36. T. Baran, S. Wojtyla, C. Lenardi, A. Vertova, P. Ghigna, E. Achilli, **M. Fracchia**, S. Rondinini, A. Minguzzi "An efficient CuxO photocathode for hydrogen production at neutral pH: new insights from combined spectroscopy and electrochemistry", *ACS Appl. Mater. Interfaces*, (2016), 8 (33), 21250–21260

Congresses and schools

Oral presentations:

1. "*Beyond configurational entropy: understanding the phase stability of high entropy oxide $Mg_{0.2}Co_{0.2}Ni_{0.2}Cu_{0.2}Zn_{0.2}O$ by a chemometric approach*", XXVIII congress of Società Chimica Italiana (SCI2024), Milano, 26-30 August 2024
2. "*Operando X-ray absorption spectroscopy on MAX and MXene-based electrodes for Na and Li-ion batteries*", 2024, Online Webinar "X-Ray Absorption Spectroscopy for the Characterization of Nanostructured Materials" organized by Nanomaterials/MDPI on 30/07/2024, **Invited Speaker**
3. "*Operando and ex situ structural investigations of high entropy oxides as electrodes for Li-ion batteries*", XVIII ECerS: Conference and Exhibition of European Ceramic Society (ECERS23), Lyon, 2-6 July 2023
4. "*Operando and ex situ structural investigations of high entropy oxides as electrodes for Li-ion batteries*", XLVIII National Congress of Physical Chemistry (CNCF 2022)Genova, 4-7 July 2022
5. "*XAS spectroscopy on high entropy oxides: recent advances in the determination of the mechanisms of heterogeneous reactions*", workshop "Operando soft X-ray Absorption Spectroscopy: application and perspectives", Trieste, 4-5 July 2022

6. "*Lithiation mechanism in high entropy oxides (HEOs) as anode materials for Li-ion batteries: an operando XAS study*", CONEXS 2022 (Collaborative Network for X-ray Spectroscopy), Newcastle upon Tyne, 30 March-01 April 2022
7. "*Exploring distortion in $Mg_{0.2}Co_{0.2}Ni_{0.2}Cu_{0.2}Zn_{0.2}O$ high entropy oxide: a dark field X-ray microscopy investigation*", ESRF User meeting 2022, February 7-9, Grenoble, **Invited speaker**
8. "*Operando X-ray absorption spectroscopy as a powerful tool for investigating reaction mechanisms in (photo)electrochemistry*", SILS Meeting 2021, June 21-23, Bologna
9. "*Understanding solid-gas reaction mechanisms by operando soft-XAS at ambient pressure*", presented at CONEXS (Collaborative Network for X-ray Spectroscopy), 17-19 March 2021
10. "*Pt-CO clusters: a facile synthetic route to prepare electrocatalysts at low Pt content for fuel cells*", Italian virtual workshop on fuel cells (IVWFC 2021), 16-19 March 2021, **Invited Speaker**
11. "*Lithiation mechanism in high entropy oxides (HEO) as anode materials for Li-ion batteries: an operando XAS study*", First Italian workshop on energy storage, organized by GISEL Italian group for electrochemical energy storage, 24-26 February 2021
12. "*Operando XAS on atomically precise Pt-CO clusters for oxygen reduction reaction*", ESRF User Meeting 2020 in Grenoble, 3-5 February 2020, **Invited Speaker**
13. "*Fotocatalisi nel water splitting: meccanismi di reazione*", Giornate dell'elettrochimica italiana GEI 2019, Padua, 8th-12th September 2019
14. "*Observing the oxidation state turnover of nickel in α-Fe_2O_3/NiO_x photoanodes through operando XAS*", 69th Annual ISE (international society of electrochemistry) Meeting, Bologna, 2nd-7th September 2018

Funding

- *[2023]* Winner of the "L'Oréal Italia for Women in Science" award/fellowship, amounting to 20000 euros, to carry out the research project "High entropy oxides as novel sustainable electrocatalysts for the water splitting reaction."
- *[2019 – Current]* PI ("Main proposer") of five experiments approved by international selection committees at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, totaling 66 shifts (1 "shift": 5800 €)
- *[2017 – Current]* PI ("Main proposer") of two experiments approved by national selection committees at the ELETTRA synchrotron light facility in Trieste, Italy, totaling 36 shifts. (1 "shift": 10000 €)

Institutional responsabilities

- Member of "Giunta del Dipartimento di Chimica", University of Pavia (since 2024)

Other activities

- Guest editor of Materials (MDPI) for the Special Issue "High entropy materials: from principles to applications".
- Reviewer for peer-reviewed scientific journals (*i.e. Nature Communications, ACS Catalysis, ACS Applied Electronic Materials, Journal of the European Ceramic Society*)
- Evaluator of scientific proposals to access the NFFA-Trieste facility
- Associated with a collaboration assignment with CNR SCITEC Institute, Milan branch, to collaborate on the program "Synthesis and characterization of catalysts under reaction conditions using synchrotron light with diffraction and absorption methods."
- Member of the Italian Chemical Society (SCI) – Physical Chemistry division

Pavia, March 4th, 2025