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Editorial

Featured Papers in Inorganic Materials 2025

Eleonora Aneggi [1,*], Roberto Nisticò [2,*], Hicham Idriss [3] and Torben R. Jensen [4]

1 Department of Agricultural, Food, Environmental and Animal Sciences (Di4A), University of Udine, 33100 Udine, Italy
2 Department of Materials Science, University of Milano-Bicocca, U5, INSTM, Via R. Cozzi 55, 20125 Milano, Italy
3 Department of Chemistry, University College London, London WC1E 6BT, UK; h.idriss@ucl.ac.uk
4 Interdisciplinary Nanoscience Center and Department of Chemistry, Aarhus University, DK-8000 Aarhus C, Denmark; trj@chem.au.dk
* Correspondence: eleonora.aneggi@uniud.it (E.A.); roberto.nistico@unimib.it (R.N.)

1. Introduction and Overview of the Special Issue

Following the success of the previous edition [1], the Inorganic Materials section of Inorganics presents the Special Issue Featured Papers in Inorganic Materials 2025. This Special Issue aims to highlight recent advances and emerging trends in inorganic materials research, with particular emphasis on materials designed to address key societal challenges related to energy transition, environmental sustainability, and biomedical applications [2–7].

In recent years, inorganic materials science has undergone a significant evolution driven by the demand for efficient, sustainable, and multifunctional material systems. Advances in synthesis, characterization [8], and modeling now enable precise control over composition, structure [9,10], and defects across multiple length scales [11,12]. As a result, contemporary inorganic chemistry increasingly focuses on the rational design of materials systems, in which functionality arises from the synergistic interplay between nanoscale architecture, interfaces, and hierarchical organization rather than from composition alone.

This Special Issue collects 10 peer-reviewed contributions, including 7 original research articles and 3 review papers, which together provide a representative overview of the state of the art in inorganic materials research. The selected works demonstrate how controlled structural manipulation at the nanoscale can induce enhanced or entirely new macroscopic properties, enabling progress in both fundamental understanding and technological applications. For clarity, the contributions are grouped into three thematic subsections reflecting major research directions in the field: Energy Production and Storage, Nanostructures and Surfaces, and Environmental and Biomedical Applications. An overview of the published articles is provided in Table 1.

The first subsection, The Challenge of Clean Energy: Production and Storage, comprises four contributions dedicated to inorganic materials for sustainable energy technologies [13–16]. These studies address photocatalytic hydrogen production, electrocatalytic water splitting, solid-state hydrogen storage, and ion-conducting materials for advanced battery systems. Together, they illustrate how compositional tuning, defect engineering, and morphology control can substantially improve energy conversion and storage performance.

The second subsection, Nanostructures and Surfaces, includes three contributions focused on controlled synthesis strategies and surface engineering [17–19]. These works demonstrate that relatively simple and scalable approaches, such as solvothermal synthesis, capacitive coupling, and low-cost chemical deposition, can be effectively used to tailor particle morphology, surface charge distribution, and defect chemistry, with direct implications for electronic, sensing, and catalytic applications.

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Table 1. Overview of the contributions included in the Special Issue Featured Papers in Inorganic Materials 2025 [13–22].

Subsection	Contribution n.	Authors and Title
The Challenge of Clean Energy: Production and Storage	1	Bitsos, D.R.; Salepis, A.; Orfanos, E.; Coutsolelos, A.G.; Kosheleva, R.I.; Mitropoulos, A.C.; Ladomenou, K. Exploring Metal- and Porphyrin-Modified TiO_2-Based Photocatalysts for Efficient and Sustainable Hydrogen Production. Inorganics 2025, 13, 121.
	2	Mane, S.M.; Wagh, K.S.; Lee, S.; Teli, A.M.; Chavan, G.T.; Shin, J.C.; Lee, J. Solvent-Driven Structural Modulation of Co-Ni_3S_2 and Impact on Electrochemical Water Splitting. Inorganics 2025, 13, 359.
	3	Grigorova, E.; Çakmak, G.; Yüce, H.; Markov, P. Electrochemical and Gas-Solid Hydrogen Storage Properties of a Multi-Metal Magnesium-Based Alloy Obtained by Ball Milling. Inorganics 2025, 13, 299.
	4	Milanova, M.; Yang, X.; Vargas, P.; Rosero-Navarro, N.C.; Harizanova, R.; Jivov, B.; Aleksandrov, L.; Iordanova, R.; Shopska, M.; Koleva, S. Structure and Electrochemical Performance of Glasses in the Li_2O–B_2O_3–V_2O_5–MoO_3 System. Inorganics 2025, 13, 285.
Nanostructures and Surfaces	5	Tuccio, C.; Armetta, F.; Chillura Martino, D.F.; Skaudžius, R.; Saladino, M.L. Controlled Synthesis of Alkali Metal Hydroxide Particles via Solvothermal Processing. Inorganics 2025, 13, 373.
	6	Chini, E.; Gentili, D.; Liscio, A.; Cavallini, M. SiO_2 Electret Formation via Stamp-Assisted Capacitive Coupling: A Chemophysical Surface Functionalisation. Inorganics 2026, 14, 21.
	7	Ruvalcaba-Manzo, S.G.; Ramírez-Bon, R.; Ochoa-Landín, R.; Castillo, S.J. A Comprehensive Study of the Optical, Structural, and Morphological Properties of Chemically Deposited ZnO Thin Films. Inorganics 2025, 13, 331.
Environmental and Biomedical Applications	8	Li, M.; Yang, L.; Song, Y.; Hou, H.; Fang, Y.; Liu, Y.; Xie, L.; Lu, D. Research Progress on the Preparation, Modification, and Applications of g-C_3N_4 in Photocatalysis and Piezoelectric Photocatalysis. Inorganics 2025, 13, 300.
	9	Sezanova, K.; Tuparova, Y.; Shestakova, P.; Markov, P.; Kovacheva, D.; Rabadjieva, D. Calcium Phosphate Ceramic Powders Prepared from Mechanochemically Activated Precursors. Inorganics 2025, 13, 313.
	10	Jiang, Z.; Xiang, H.; Tang, X. Smart Inorganic Nanomaterials for Tumor Microenvironment Modulation. Inorganics 2025, 13, 337.

The third subsection, Environmental and Biomedical Applications, highlights the expanding role of inorganic materials in addressing environmental and health-related challenges [20–22]. The included contributions cover piezo-photocatalytic systems for environmental remediation and energy conversion, nanostructured bioceramics for bone regeneration, and inorganic nanomaterials as active modulators of the tumor microenvironment. Collectively, these studies exemplify the transition of inorganic materials from passive components to active, multifunctional systems capable of interacting dynamically with complex biological and environmental environments.

Overall, this Special Issue provides a coherent snapshot of current advances in inorganic materials research, emphasizing the central role of nanoscale design, interfacial control, and functional integration. The collected contributions not only reflect the diversity and vitality of the field but also point toward future directions in which inorganic chemistry will continue to play a key role in the development of sustainable and high-performance technologies.

2. The Challenge of Clean Energy: Production and Storage

The transition toward sustainable energy systems requires inorganic materials capable of improving both energy production and storage efficiency. In this context, four contributions in this Special Issue address key challenges associated with photocatalysis, electrocatalysis, hydrogen storage, and solid-state batteries.

Bitsos et al. (Contribution 1) [13] present a comprehensive review on the integration of porphyrins onto TiO_2 matrices for photocatalytic hydrogen evolution. This hybrid approach mimics natural photosynthetic systems by extending light absorption into the visible region, thereby overcoming intrinsic limitations of TiO_2. Recent studies confirm that organic photosensitizers [23] represent an effective strategy to exploit a broader portion of the solar spectrum.

Mane et al. (Contribution 2) [14] demonstrate the importance of precursor chemistry in electrocatalytic materials. By varying the solvent during the synthesis of Co-doped Ni_3S_2, the authors achieve controlled petal-like morphologies that significantly reduce overpotentials in water-splitting reactions. These results are consistent with current understanding of electrode–electrolyte interfacial dynamics, where surface morphology plays a decisive role in electrochemical performance [24].

Grigorova et al. (Contribution 3) [15] investigate multi-metal Mg–Ni–Al–V–Fe alloys synthesized via high-energy ball milling for hydrogen storage applications. The materials exhibit hydrogen absorption capacities of up to 1.6 wt.% at room temperature, highlighting the effectiveness of ball milling in introducing structural defects that lower kinetic barriers for hydrogenation [25].

Milanova et al. (Contribution 4) [16] focus on glassy materials in the Li_2O–B_2O_3–V_2O_5–MoO_3 system for solid-state battery applications. Partial substitution of boron with molybdenum increases the fraction of non-bridging oxygen, enhancing ionic conductivity. The presence of mixed-valence vanadium and molybdenum oxides facilitates both electronic and ionic transport, making these glasses promising candidates for electrodes or solid electrolytes in next-generation energy-storage devices, in agreement with recent works [26,27] on mixed-conduction glasses.

3. Development of Nanostructures and Surfaces

Surface engineering and controlled synthesis strategies play a central role in the development of advanced inorganic materials [28–30]. The contributions in this subsection demonstrate how morphology and surface properties can be tailored without relying on complex additives or high-cost processes.

Tuccio et al. (Contribution 5) [17] report a one-pot solvothermal method for the synthesis of alkaline and alkaline-earth metal hydroxides (LiOH, NaOH, KOH, $Ba(OH)_2$, $Sr(OH)_2$, and $Mg(OH)_2$). By controlling nucleation in non-aqueous solvent systems, the authors achieve precise tuning of particle size and morphology, yielding acicular, fibrous, or lamellar nanostructures. The proposed approach is scalable, environmentally compatible, and

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suitable for applications ranging from cultural heritage conservation to tissue engineering and advanced construction materials.

Chini et al. (Contribution 6) [18] combine concepts from classical carbonyl cluster chemistry with modern nanotechnology. Metal clusters are investigated as model systems bridging molecular and solid-state chemistry, providing insight into electron-transfer processes relevant to heterogeneous and single-atom catalysis [31]. In addition, the authors introduce the Stamp-Assisted Capacitive Coupling (SACC) technique for fabricating SiO_2 electrets with sub-micrometric charge patterns, achieving surface charge densities up to 300 nC cm^{-2}. This method offers new opportunities for scalable sensor and energy-harvesting devices.

Ruvalcaba-Manzo et al. (Contribution 7) [19] explore low-cost chemical bath deposition as a route to fabricate ZnO thin films. The study highlights the critical role of intrinsic defects, particularly oxygen vacancies, in determining structural and optoelectronic properties [32]. Thermal annealing at 600 °C induces a transformation toward flower-like morphologies, improving crystallinity and phase purity and enhancing the performance of ZnO-based transparent and flexible electronic devices.

4. Environmental and Biomedical Applications

Inorganic materials are increasingly central to environmental protection and biomedical technologies. The contributions in this subsection illustrate how inorganic systems can actively interact with complex chemical and biological environments [7,33,34].

Li et al. (Contribution 8) [20] provide a critical review of graphitic carbon nitride (g-C_3N_4) for piezo-photocatalytic applications. By coupling piezoelectric effects with photocatalysis, mechanical energy from environmental vibrations can generate internal electric fields that enhance charge separation [35]. This synergistic mechanism leads to significant improvements in catalytic efficiency for pollutant degradation, as well as for sustainable hydrogen and hydrogen peroxide (H_2O_2) production.

Sezanova et al. (Contribution 9) [21] report advances in the synthesis of nanostructured tetracalcium phosphate (TTCP) ceramics for bone regeneration. Through mechano-chemical activation of precursors, the authors reduce phase-transition temperatures and obtain highly reactive nanostructured materials. These ceramics exhibit enhanced bioactivity, promoting hydroxyapatite formation, cellular adhesion, and accelerated bone mineralization, in line with current trends in regenerative medicine [36].

Jiang et al. (Contribution 10) [22] review the emerging role of inorganic nanomaterials [6] as active modulators of the tumor microenvironment (TME). Metal oxides such as MnO_2, Fe_3O_4, and CeO_2 are shown to regulate local oxygen levels and pH, supporting catalytic nanomedicine approaches based on chemodynamic therapy. By generating oxygen in situ and alleviating tumor hypoxia, these nanomaterials enhance the effectiveness of radiotherapy and immunotherapy, paving the way for multifunctional and personalized cancer treatments [37,38].

5. Conclusions

This Special Issue highlights the vitality and diversity of contemporary inorganic materials research. The collected contributions demonstrate that progress in the field increasingly relies on the integration of controlled synthesis, advanced characterization, often performed in situ or under operating conditions, and application-driven design.

A recurring theme across the contributions is the central role of precision in materials engineering. Control over defects, interfaces, and hierarchical organization emerges as a key driver for transforming fundamental insights into functional technologies. The convergence of structural control, targeted functionality, and application-oriented performance positions inorganic chemistry as a cornerstone for next-generation materials.

The editors hope that this Special Issue will not only contribute to the advancement of academic knowledge but also stimulate future research toward innovative, sustainable, and translational solutions. The combined focus on synthesis, characterization, and application remains essential for the continued progress of inorganic materials science.

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References

1. Nisticò, R.; Jensen, T.R. Featured Papers in Inorganic Materials 2024. *Inorganics* **2025**, *13*, 110. [CrossRef]
2. Kwasi-Effaha, C.C.; Okpako, O. Comprehensive review of emerging trends in thermal energy storage mechanisms, materials and applications. *Front. Energy Res.* **2025**, *13*, 1651471. [CrossRef]
3. Liang, Z.; Zhang, Y.; Liu, L.; Jiao, M.; Ye, C. Single-Atom Catalysts for Hydrogen Evolution Reaction: The Role of Supports, Coordination Environments, and Synergistic Effects. *Nanomaterials* **2025**, *15*, 1175. [CrossRef] [PubMed]
4. Poudel, T.P.; Oyekunle, I.P.; Deck, M.J.; Chen, Y.; Hou, D.; Ojha, P.K.; Ogbolu, B.O.; Huang, C.; Xiong, H.; Hu, Y.-Y. $Li_{1.6}AlCl_{3.4}S_{0.6}$: A low-cost and high-performance solid electrolyte for solid-state batteries. *Chem. Sci.* **2025**, *16*, 2391–2401. [CrossRef] [PubMed]
5. Zhang, S.; Gao, F.; Qiu, X.; Fang, M.; Tan, X. Research progress of piezocatalysis in energy and environment fields. *Chem. Commun.* **2026**. [CrossRef]
6. Lee, S.; Lee, J.; Park, M.; Kim, J.; Byun, H.; Kim, J.; Kim, W.J. Inorganic nanoparticle-based cancer immunotheranostics. *Coord. Chem. Rev.* **2025**, *542*, 216848. [CrossRef]
7. Zhan, S.; Fu, Y.; Yang, H.Y.; Lee, D.S. Recent developments and prospects of inorganic nanozymes for biomedical applications. *Biomater. Sci.* **2025**, *13*, 6755–6774. [CrossRef]
8. Bonn, M.; Domke, K.; Sulpizi, M.; McCrory, C.; Peng, Z. In situ and operando characterization: Advancing our understanding of functional materials. *J. Chem. Phys.* **2025**, *162*, 140402. [CrossRef] [PubMed]
9. Han, G.; Vasylenko, A.; Daniels, L.M.; Collins, C.M.; Corti, L.; Chen, R.; Niu, H.; Manning, T.D.; Antypov, D.; Dyer, M.S.; et al. Superionic lithium transport via multiple coordination environments defined by two-anion packing. *Science* **2024**, *383*, 739–745. [CrossRef]
10. Wang, Y.; Yu, H.; Wang, H.; Chen, T. Hierarchically Porous Titanosilicate Hollow Spheres Containing TS-1 Zeolite Precursors for Oxidative Desulfurization. *Inorganics* **2025**, *13*, 37. [CrossRef]
11. Mishra, R.K.; Verma, K.; Singh, D.S. Defect engineering in nanomaterials: Impact, challenges, and applications. *Smart Mater. Manuf.* **2024**, *2*, 100052. [CrossRef]
12. Chen, W.; Bao, M.; Meng, F.; Ma, B.; Feng, L.; Zhang, X.; Qiu, Z.; Gao, S.; Zhong, R.; Xi, S.; et al. Designer topological-single-atom catalysts with site-specific selectivity. *Nat. Commun.* **2025**, *16*, 574. [CrossRef]
13. Bitsos, D.R.; Salepis, A.; Orfanos, E.; Coutsolelos, A.G.; Kosheleva, R.I.; Mitropoulos, A.C.; Ladomenou, K. Exploring Metal- and Porphyrin-Modified TiO_2-Based Photocatalysts for Efficient and Sustainable Hydrogen Production. *Inorganics* **2025**, *13*, 121. [CrossRef]
14. Mane, S.M.; Wagh, K.S.; Lee, S.; Teli, A.M.; Chavan, G.T.; Shin, J.C.; Lee, J. Solvent-Driven Structural Modulation of Co-Ni_3S_2 and Impact on Electrochemical Water Splitting. *Inorganics* **2025**, *13*, 359. [CrossRef]
15. Grigorova, E.; Çakmak, G.; Yüce, H.; Markov, P. Electrochemical and Gas-Solid Hydrogen Storage Properties of a Multi-Metal Magnesium-Based Alloy Obtained by Ball Milling. *Inorganics* **2025**, *13*, 299. [CrossRef]
16. Milanova, M.; Yang, X.; Vargas, P.; Rosero-Navarro, N.C.; Harizanova, R.; Jivov, B.; Aleksandrov, L.; Iordanova, R.; Shopska, M.; Koleva, S. Structure and Electrochemical Performance of Glasses in the Li_2O-B_2O_3-V_2O_5-MoO_3 System. *Inorganics* **2025**, *13*, 285. [CrossRef]
17. Tuccio, C.; Armetta, F.; Martino, D.F.C.; Skaudžius, R.; Saladino, M.L. Controlled Synthesis of Alkali Metal Hydroxide Particles via Solvothermal Processing. *Inorganics* **2025**, *13*, 373. [CrossRef]
18. Chini, E.; Gentili, D.; Liscio, A.; Cavallini, M. SiO_2 Electret Formation via Stamp-Assisted Capacitive Coupling: A Chemophysical Surface Functionalisation. *Inorganics* **2026**, *14*, 21. [CrossRef]
19. Ruvalcaba-Manzo, S.G.; Ramírez-Bon, R.; Ochoa-Landín, R.; Castillo, S.J. A Comprehensive Study of the Optical, Structural, and Morphological Properties of Chemically Deposited ZnO Thin Films. *Inorganics* **2025**, *13*, 331. [CrossRef]

20. Li, M.; Yang, L.; Song, Y.; Hou, H.; Fang, Y.; Liu, Y.; Xie, L.; Lu, D. Research Progress on the Preparation, Modification, and Applications of g-C_3N_4 in Photocatalysis and Piezoelectric Photocatalysis. *Inorganics* **2025**, *13*, 300. [CrossRef]
21. Sezanova, K.; Tuparova, Y.; Shestakova, P.; Markov, P.; Kovacheva, D.; Rabadjieva, D. Calcium Phosphate Ceramic Powders Prepared from Mechanochemically Activated Precursors. *Inorganics* **2025**, *13*, 313. [CrossRef]
22. Jiang, Z.; Xiang, H.; Tang, X. Smart Inorganic Nanomaterials for Tumor Microenvironment Modulation. *Inorganics* **2025**, *13*, 337. [CrossRef]
23. Gonuguntla, S.; Kamesh, R.; Pal, U.; Chatterjee, D. Dye sensitization of TiO_2 relevant to photocatalytic hydrogen generation: Current research trends and prospects. *J. Photochem. Photobiol. C Photochem. Rev.* **2023**, *57*, 100621. [CrossRef]
24. Prior, T.; Figueira, J.; Freitas, Â.; Carvalho, D.; Gomes, B.M.; Baptista, M.C.; Lebre, H.; Martins, R.; Pereira, L.; Pinto, J.V.; et al. Surface Morphology and Electrochemical Behavior of Microstructured Cu Electrodes in All-Solid-State Sodium Batteries. *Molecules* **2025**, *30*, 3493. [CrossRef]
25. Hosseinigourajoubi, S.; Schade, C.; Huot, J. Effect of Mechanical Processing on First Hydrogenation of Gas-Atomized $Ti_{0.488}Fe_{0.46}Mn_{0.052}$ Alloy. *Hydrogen* **2025**, *6*, 114. [CrossRef]
26. Tariq, F.; Abdullah, A.; Kulkarni, M.A.; Thaalbi, H.; Ha, J.S.; Lee, J.K.; Ryu, S.-W. Highly efficient visible-light-driven CdS-loaded ZnO-GaN nanowire photoanode fabricated on Si for H_2 evolution. *J. Alloys Compd.* **2024**, *973*, 172901. [CrossRef]
27. Yadav, A.K. Superionic Glasses: Potential and Challenges in Solid-State Batteries and Fuel Cells. *ChemistrySelect* **2025**, *10*, e03258. [CrossRef]
28. Salehi, M.M.; Mohammadi, M.; Akbarzadeh, A.R.; Babamoradi, M.; Maleki, A.; Zare, E.N. Advancements in preceramic inorganic polymers for environmental applications: Properties, synthesis, and potential uses. *RSC Adv.* **2025**, *15*, 25514–25541. [CrossRef]
29. Singh, L.; Balakrishnan, S.; William, J.J.; Parveen, S.; Periasamy, P.A.; Kumar, R.; Srivastava, A.; Kumar, S.; Shringi, A.K.; Kumari, D.; et al. Mechanistic Insights in Surface Engineering of Micro-/Nanocomposite Phase Change Materials for Thermal Energy Storage: A Review. *Adv. Energy Sustain. Res.* **2025**, *6*, 2500067. [CrossRef]
30. Xu, W.; Bai, Y.; Yin, Y. Surface Engineering of Nanostructured Energy Materials. *Adv. Mater.* **2018**, *30*, 1802091. [CrossRef] [PubMed]
31. Fang, J.; Chen, Q.; Li, Z.; Mao, J.; Li, Y. The synthesis of single-atom catalysts for heterogeneous catalysis. *Chem. Commun.* **2023**, *59*, 2854–2868. [CrossRef] [PubMed]
32. Maarisetty, D.; Baral, S.S. Defect engineering in photocatalysis: Formation, chemistry, optoelectronics, and interface studies. *J. Mater. Chem. A* **2020**, *8*, 18560–18604. [CrossRef]
33. Gheisizadeh, A.; Darghiasi, S.F.; Farazin, A. Sustainable chemistry approaches for biomedical applications of energy materials: A converging frontier. *Sustain. Chem. Energy Mater.* **2025**, *2*, 100021. [CrossRef]
34. Zhang, H.; Zhao, Z.; Wu, C. Bioactive Inorganic Materials for Innervated Multi-Tissue Regeneration. *Adv. Sci.* **2025**, *12*, 2415344. [CrossRef]
35. Jiang, Z.; Tan, X.; Huang, Y. Piezoelectric effect enhanced photocatalysis in environmental remediation: State-of-the-art techniques and future scenarios. *Sci. Total Environ.* **2022**, *806*, 150924. [CrossRef]
36. Vallet-Regí, M.; Ruiz-Hernández, E. Bioceramics: From Bone Regeneration to Cancer Nanomedicine. *Adv. Mater.* **2011**, *23*, 5177–5218. [CrossRef]
37. Ghassemifar, V.; Zahedi, A.; Meigoli, M.S.S.; Mokhtari, T.; Zadeh, S.S.M.; Parsafar, M.; Zenjanab, M.K.; Esfahlan, R.J. Harnessing nanotechnology to modulate hypoxic tumor microenvironments: Enhanced strategies for oncological innovations. *Biomed. Pharmacother.* **2025**, *191*, 118543. [CrossRef]
38. Akpe, V.; Cock, I.E. Advances in Cancer Treatment Through Nanotheranostics and Emerging Therapies. *J. Nanotheranostics* **2025**, *6*, 29. [CrossRef]

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