coatings

Editorial

Special Issue "Synthesis, Characterization and Performance Enhancement of Electrode and Biomaterial Coatings"

Chenyu Liu [1], Qing Sun [2] and Shang Wang [2,*]

[1] State Key Laboratory of Fine Chemicals, School of Chemical Engineering, Dalian University of Technology, Dalian 116024, China
[2] State Key Laboratory of Precision Welding & Joining of Materials and Structures, Harbin Institute of Technology, Harbin 150001, China
* Correspondence: wangshang@hit.edu.cn

Citation: Liu, C.; Sun, Q.; Wang, S. Special Issue "Synthesis, Characterization and Performance Enhancement of Electrode and Biomaterial Coatings". *Coatings* **2024**, *14*, 1276. https://doi.org/10.3390/coatings14101276

Received: 24 September 2024
Accepted: 29 September 2024
Published: 7 October 2024

Functional materials are extensively employed across diverse domains, including energy storage systems [1,2], electronic devices [3], and medical implants [4], where their performance significantly influences the efficiency, reliability, and longevity of related technologies [5,6]. However, in real-world applications, these materials often encounter substantial challenges [7], such as inadequate electrical conductivity, limited mechanical strength, severe interfacial side reactions in electrode materials, and poor biocompatibility and corrosion resistance in biomaterials. To address these issues, surface coating modification has emerged as a highly effective strategy to enhance their physical, chemical, and mechanical properties [8], thereby meeting the multifaceted demands of modern applications.

Surface coating technologies for functional materials have garnered significant attention within the materials science and engineering community [9], particularly in improving the performance of critical components such as electrodes and biomaterials. For example, electrode materials in energy storage systems—such as lithium-ion batteries (LIBs) and electrochemical capacitors—are prone to mechanical degradation and undesirable side reactions due to repetitive charge/discharge cycles, which can lead to substantial performance deterioration over time [10]. Coating these electrodes with materials exhibiting superior electrical conductivity and chemical stability, including metal oxides, ceramics, graphene, and conductive polymers, can markedly enhance their structural integrity [11]. This, in turn, optimizes the interfacial reaction kinetics between the electrode and electrolyte [12], resulting in improved cycle stability and enhanced capacity retention [13]. Moreover, surface coatings can significantly lower the intrinsic resistance of electrode materials and boost ion transport rates [14], both pivotal factors for enhancing the power density and operational efficiency of energy storage devices.

Coating technologies also demonstrate remarkable potential in advancing biomaterials [15]. For medical implants, biocompatibility, corrosion resistance, and controlled degradability are paramount for ensuring seamless integration with human tissues and long-term safety. Metals, commonly used in orthopedic and dental implants [16], often exhibit limited corrosion resistance and biocompatibility, potentially triggering adverse biological reactions. By applying bioactive coatings such as bioceramics or biofunctional polymers to metal surfaces, these limitations can be mitigated, leading to improved tissue integration and promoting the regeneration of bone or other tissues. For instance, bioceramic coatings such as hydroxyapatite [17], which closely resemble the inorganic composition of bone, facilitate faster osseointegration, while conductive polymer coatings can enhance the electrical properties of implants, proving especially advantageous in applications such as neural tissue engineering.

Notably, surface coatings not only augment the intrinsic properties of functional materials but also allow for precise optimization of targeted functionalities by carefully controlling parameters such as coating thickness, microstructure, and composition. For example, ceramic coatings are widely adopted in high-temperature electrode materials due to their excellent thermal stability and corrosion resistance, whereas metal oxide coatings are frequently employed in electrochemical storage devices for their robust chemical inertness. Additionally, graphene and two-dimensional materials [18,19], known for their exceptional conductivity and mechanical flexibility as coatings, are optimal for improving the electrochemical performance of LIBs and supercapacitors. By judiciously selecting and designing coating materials, it is possible to enhance conductivity, reinforce mechanical durability, minimize detrimental side reactions, and elevate the overall performance of energy storage systems.

This Special Issue seeks to provide an in-depth exploration of the design, fabrication, and application of surface coatings for functional materials. Emphasis will be placed on the comparative evaluation and optimization of various coating technologies to elucidate the underlying mechanisms by which surface modification strategies improve material performance. The scope includes the investigation of ceramics, metals, metal oxides, graphene, and conductive polymers, both as individual materials and as surface coatings, with a focus on their roles in enhancing mechanical robustness and electronic and ionic conductivity and mitigating interfacial degradation. Furthermore, the Issue will address emerging trends and future directions in coating technology, offering novel insights and guidelines for the development of next-generation coatings for functional materials across a wide range of applications.

Author Contributions: Conceptualization, C.L.; writing—original draft preparation, C.L. and Q.S.; writing—review and editing, S.W. All authors have read and agreed to the published version of the manuscript.

Funding: S.W. acknowledges the financial support provided by the National Natural Science Foundation of China (52105329).

Acknowledgments: C.L., Q.S., and S.W. thank all of the authors for their contributions to this Special Issue, entitled "Synthesis, Characterization and Performance Enhancement of Electrode and Biomaterial Coatings", and the editorial staff of the journal *Coatings*.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Mohamad, I.S.; Norizan, M.N.; Mahmed, N.; Jamalullail, N.; Halin, D.S.C.; Salleh, M.A.A.M.; Sandu, A.V.; Baltatu, M.S.; Vizureanu, P. Enhancement of Power Conversion Efficiency with Zinc Oxide as Photoanode and Cyanococcus, Punica granatum L., and Vitis vinifera as Natural Fruit Dyes for Dye-Sensitized Solar Cells. *Coatings* **2022**, *12*, 1781. [CrossRef]
2. Sun, Q.; Li, J.; Yang, M.; Wang, S.; Zeng, G.; Liu, H.; Cheng, J.; Li, D.; Wei, Y.; Si, P.; et al. Carbon Microstructure Dependent Li-Ion Storage Behaviors in SiOx/C Anodes. *Small* **2023**, *19*, 2300759. [CrossRef] [PubMed]
3. Wu, W.; Li, G.; Wang, S.; Wang, Y.; Feng, J.; Sun, X.; Tian, Y. Study on the Solder Joint Reliability of New Diamond Chip Resistors for Power Devices. *Coatings* **2023**, *13*, 748. [CrossRef]
4. Yang, C.; Luo, Y.; Shen, H.; Ge, M.; Tang, J.; Wang, Q.; Lin, H.; Shi, J.; Zhang, X. Inorganic nanosheets facilitate humoral immunity against medical implant infections by modulating immune co-stimulatory pathways. *Nat. Commun.* **2022**, *13*, 4866. [CrossRef] [PubMed]
5. Yang, R.; Diao, Y.; Liu, H.; Lu, Y. Experimental and Adsorption Kinetics Study of Hg0 Removal from Flue Gas by Silver-Loaded Rice Husk Gasification Char. *Coatings* **2024**, *14*, 797. [CrossRef]
6. Li, G.; Wang, S.; Wen, J.; Wang, S.; Sun, Y.; Feng, J.; Tian, Y. A Manufacturing Method for High-Reliability Multilayer Flexible Electronics by Electrohydrodynamic Printing. *Coatings* **2024**, *14*, 625. [CrossRef]
7. Zeng, G.; Sun, Q.; Horta, S.; Wang, S.; Lu, X.; Zhang, C.Y.; Li, J.; Li, J.; Ci, L.; Tian, Y.; et al. A Layered Bi_2Te_3@PPy Cathode for Aqueous Zinc-Ion Batteries: Mechanism and Application in Printed Flexible Batteries. *Adv. Mater.* **2024**, *36*, 2305128. [CrossRef] [PubMed]
8. Sun, Q.; Yang, M.; Zeng, G.; Li, J.; Hu, Z.; Li, D.; Wang, S.; Si, P.; Tian, Y.; Ci, L. Insights into the Potassium Ion Storage Behavior and Phase Evolution of a Tailored Yolk–Shell SnSe@C Anode. *Small* **2022**, *18*, 2203459. [CrossRef] [PubMed]
9. Nasakina, E.O.; Sudarchikova, M.A.; Demin, K.Y.; Mikhailova, A.B.; Sergienko, K.V.; Konushkin, S.V.; Kaplan, M.A.; Baikin, A.S.; Sevostyanov, M.A.; Kolmakov, A.G. Study of Co-Deposition of Tantalum and Titanium during the Formation of Layered Composite Materials by Magnetron Sputtering. *Coatings* **2023**, *13*, 114. [CrossRef]
10. Sun, Q.; Zeng, G.; Li, J.; Wang, S.; Botifoll, M.; Wang, H.; Li, D.; Ji, F.; Cheng, J.; Shao, H.; et al. Is Soft Carbon a More Suitable Match for SiOx in Li-Ion Battery Anodes? *Small* **2023**, *19*, 2302644. [CrossRef] [PubMed]

11. Chen, Y.; Jiang, B.; Zhao, Y.; Liu, H.; Ma, T. Diatomite and Glucose Bioresources Jointly Synthesizing Anode/Cathode Materials for Lithium-Ion Batteries. *Coatings* **2023**, *13*, 146. [CrossRef]
12. Wang, S.; Zeng, G.; Sun, Q.; Feng, Y.; Wang, X.; Ma, X.; Li, J.; Zhang, H.; Wen, J.; Feng, J.; et al. Flexible Electronic Systems via Electrohydrodynamic Jet Printing: A MnSe@rGO Cathode for Aqueous Zinc-Ion Batteries. *ACS Nano* **2023**, *17*, 13256–13268. [CrossRef] [PubMed]
13. Peng, R.; Zhuang, X.; Li, Y.; Yu, Z.; Ci, L. High Gas Response Performance Based on Reduced Graphene Oxide/SnO_2 Nanowires Heterostructure for Triethylamine Detection. *Coatings* **2023**, *13*, 849. [CrossRef]
14. Sun, Q.; Li, D.; Dai, L.; Liang, Z.; Ci, L. Structural Engineering of SnS2 Encapsulated in Carbon Nanoboxes for High-Performance Sodium/Potassium-Ion Batteries Anodes. *Small* **2020**, *16*, 2005023. [CrossRef] [PubMed]
15. Lee, S.; Lee, J.; Byun, H.; Kim, S.-j.; Joo, J.; Park, H.H.; Shin, H. Evaluation of the anti-oxidative and ROS scavenging properties of biomaterials coated with epigallocatechin gallate for tissue engineering. *Acta Biomater.* **2021**, *124*, 166–178. [CrossRef] [PubMed]
16. Al-Shalawi, F.D.; Mohamed Ariff, A.H.; Jung, D.-W.; Mohd Ariffin, M.K.A.; Seng Kim, C.L.; Brabazon, D.; Al-Osaimi, M.O. Biomaterials as Implants in the Orthopedic Field for Regenerative Medicine: Metal versus Synthetic Polymers. *Polymers* **2023**, *15*, 2601. [CrossRef] [PubMed]
17. Shafiq, F.; Yu, S.; Pan, Y.; Qiao, W. Synthesis and Characterization of Titania-Coated Hollow Mesoporous Hydroxyapatite Composites for Photocatalytic Degradation of Methyl Red Dye in Water. *Coatings* **2024**, *14*, 921. [CrossRef]
18. Slepchenkov, M.M.; Barkov, P.V.; Glukhova, O.E. Electronic and Electrical Properties of Island-Type Hybrid Structures Based on Bi-Layer Graphene and Chiral Nanotubes: Predictive Analysis by Quantum Simulation Methods. *Coatings* **2023**, *13*, 966. [CrossRef]
19. Zhu, Y.; Cao, X.; Tan, Y.; Wang, Y.; Hu, J.; Li, B.; Chen, Z. Single-Layer MoS2: A Two-Dimensional Material with Negative Poisson's Ratio. *Coatings* **2023**, *13*, 283. [CrossRef]