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Editorial

One-Dimensional and Two-Dimensional Nanomaterials for Sensor Applications

Andrew F. Zhou [1,*] and Peter X. Feng [2]

[1] Department of Chemistry, Biochemistry, and Physics, Indiana University of Pennsylvania, Indiana, PA 15705, USA
[2] Department of Physics, University of Puerto Rico, San Juan, PR 00936, USA; peter.feng@upr.edu
* Correspondence: fzhou@iup.edu

The significance of 1D and 2D nanomaterials in sensor technology lies in their unique properties and the potential for high-performance sensing [1,2]. These materials offer several advantages over traditional sensor materials, including a high surface-to-volume ratio, quantum confinement effects, mechanical flexibility, versatile synthesis methods, and multifunctional capabilities [3–5]. This Special Issue entitled "One-Dimensional and Two-Dimensional Nanomaterials for Sensor Applications" presents a collection of 11 papers that delve into various aspects of nanomaterials in sensing applications. These studies cover the synthesis, characterization, and application of different nanomaterials, highlighting their potential to enhance sensor performance, showcasing the latest research in the field, and providing insights into future directions.

This issue focuses on the synthesis and fabrication of 1D and 2D materials, such as nanotubes, nanowires, nanorods, graphene, and other 2D materials. These studies explore different synthesis methods and their impact on the material's properties and sensing capabilities. For example, Ganesh et al. present a study on the synthesis and characterization of pure and Mo-doped ZnO nanoparticles, which have potential applications in photocatalysis, water purification, and sensor technology (contribution 1). Dumitriu et al. report on the fabrication of ZnO nanostructures derived from silk fibroin for amoxicillin sensing, demonstrating good performance for electrochemical detection (contribution 2). Xiong et al. demonstrated the synthsis of N-doped carbon dots using a one-step hydrothermal method for Cu^{2+} ion detection with better selectivity and sensitivity (contribution 6).

The published papers highlight the research on surface functionalization and defect engineering of nanomaterials for enhanced sensor performance. This includes modifying the surface of nanomaterials to improve their selectivity, sensitivity, and stability towards specific analytes. For instance, Saini et al. explore the sensing and detection capabilities of a one-dimensional defective photonic crystal for malaria infection diagnosis, based on the minute sensing of the refractive index of different RBC samples (contribution 3). Zarei et al. present a colorimetric plasmonic hydrogen gas sensor based on a one-dimensional nano-grating and thin-film Pd, which shows high sensitivity and selectivity for hydrogen gas detection (contribution 4).

The applications of 1D and 2D nanomaterials in various sensing fields have been explored, such as gas sensing, biosensing, and environmental monitoring. The papers in this Special Issue demonstrate the potential of these materials in real-world applications. Li et al. report a high-performance In_2O_3 UV photodetector with Pt nanoparticle surface functionalization, which shows excellent responsivity and repeatability to a wide range of UV lights (contribution 5). Kalygina et al. study the effect of UV and IR radiation on the electrical characteristics of $Ga_2O_3/ZnGeP_2$ heterostructures, which can be used as radiation detectors in the IR range (contribution 7). Thach and Khai report on the synthesis and characterization of ZnO nanowires and their application as gas sensors for NO_2 detection (contribution 8).

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Citation: Zhou, A.F.; Feng, P.X. One-Dimensional and Two-Dimensional Nanomaterials for Sensor Applications. *Crystals* **2024**, *14*, 622. https://doi.org/10.3390/cryst14070622

Received: 4 July 2024
Accepted: 5 July 2024
Published: 6 July 2024

This Special Issue also highlights the need for collaboration between different disciplines to address the challenges and opportunities in this area. Li and Yang's study on the strain-modulated electronic transport properties of two-dimensional green phosphorene with different edge morphologies provides valuable insights into the design of electronic nano-devices (contribution 9). Kalygina et al.'s investigation of resistive metal/β-Ga_2O_3/metal structures with different interelectrode distances and electrode topologies for UV sensing contributes to the development of efficient UV detectors (contribution 10). Barzegar et al.'s work on the synthesis and characterization of Pt(tpy)Cl nanocrystals and their application as a vapochromic sensor for the detection of acetonitrile vapors showcases the potential of nanomaterials in chemical sensing (contribution 11).

Overall, the studies presented in this Special Issue highlight the diverse range of applications and the potential of 1D and 2D nanomaterials in sensing, and emphasize the importance of continued research in this field to further advance the development of nanomaterial-based sensors. However, there are still challenges to be addressed, such as improving the sensitivity, selectivity, and stability of sensors, as well as developing scalable and cost-effective fabrication methods [6,7]. Future research should focus on these areas to realize the full potential of nanomaterials in sensor technology. Additionally, interdisciplinary collaboration between materials science, chemistry, physics, and engineering will be crucial for the successful translation of these research findings into practical sensor applications [8–10].

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

List of Contributions

1. Ganesh, V.; Hussien, M.S.; Shaik, U.P.; Ade, R.; Mohammed, M.I.; AlAbdulaal, T.H.; Zahran, H.Y.; Yahia, I.S.; Abdel-wahab, M.S. Impact of Mo-Doping on the Structural, Optical, and Electrocatalytic Degradation of ZnO Nanoparticles: Novel Approach. *Crystals* **2022**, *12*, 1239.
2. Dumitriu, C.; Constantinescu, A.; Dumitru, A.; Pîrvu, C. ZnO Nanostructures Derived from Silk Fibroin for Amoxicillin Sensing. *Crystals* **2022**, *12*, 1511.
3. Saini, S.K.; Awasthi, S.K. Sensing and Detection Capabilities of One-Dimensional Defective Photonic Crystal Suitable for Malaria Infection Diagnosis from Preliminary to Advanced Stage: Theoretical Study. *Crystals* **2023**, *13*, 128.
4. Zarei, M.; Hamidi, S.M.; Chee, K.W.A. Colorimetric Plasmonic Hydrogen Gas Sensor Based on One-Dimensional Nano-Gratings. *Crystals* **2023**, *13*, 363.
5. Li, E.Y.; Zhou, A.F.; Feng, P.X. High-Performance Nanoplasmonic Enhanced Indium Oxide-UV Photodetectors. *Crystals* **2023**, *13*, 689.
6. Xiong, Y.; Chen, M.; Mao, Z.; Deng, Y.; He, J.; Mu, H.; Li, P.; Zou, W.; Zhao, Q. Synthesis of Up-Conversion Fluorescence N-Doped Carbon Dots with High Selectivity and Sensitivity for Detection of Cu^{2+} Ions. *Crystals* **2023**, *13*, 812.
7. Kalygina, V.; Podzyvalov, S.; Yudin, N.; Slyunko, E.; Zinoviev, M.; Kuznetsov, V.; Lysenko, A.; Kalsin, A.; Kopiev, V.; Kushnarev, B.; et al. Effect of UV and IR Radiation on the Electrical Characteristics of Ga_2O_3/ZnGeP2 Hetero-Structures. *Crystals* **2023**, *13*, 1203.
8. Thach, P.H.; Khai, T.V. Thermal Evaporation Synthesis, Optical and Gas-Sensing Properties of ZnO Nanowires. *Crystals* **2023**, *13*, 1380.
9. Li, S.; Yang, H. Strain-Modulated Electronic Transport Properties in Two-Dimensional Green Phosphorene with Different Edge Morphologies. *Crystals* **2024**, *14*, 239.
10. Kalygina, V.; Tsymbalov, A.V.; Korusenko, P.M.; Koroleva, A.V.; Zhizhin, E.V. Effect of Traps on the UV Sensitivity of Gallium Oxide-Based Structures. *Crystals* **2024**, *14*, 268.
11. Barzegar, S.; Karimi Abdolmaleki, M.; Connick, W.B.; Absalan, G. Enhancing Vapochromic Properties of Platinum(II) Terpyridine Chloride Hexaflouro Phosphate in Terms of Sensitivity through Nanocrystalization for Fluorometric Detection of Acetonitrile Vapors. *Crystals* **2024**, *14*, 347.

References

1. Korotcenkov, G. Current trends in nanomaterials for metal oxide-based conductometric gas sensors: Advantages and limitations. part 1: 1D and 2D nanostructures. *Nanomaterials* **2020**, *10*, 1392. [CrossRef] [PubMed]
2. Yadav, V.K.; Malik, P.; Khan, A.H.; Pandit, P.R.; Hasan, M.A.; Cabral-Pinto, M.M.; Islam, S.; Suriyaprabha, R.; Yadav, K.K.; Dinis, P.A.; et al. Recent advances on properties and utility of nanomaterials generated from industrial and biological activities. *Crystals* **2021**, *11*, 634. [CrossRef]
3. Zhou, T.; Zhang, T. Recent progress of nanostructured sensing materials from 0D to 3D: Overview of structure–property-application relationship for gas sensors. *Small Methods* **2021**, *5*, 2100515. [CrossRef] [PubMed]
4. Baig, N. Two-dimensional nanomaterials: A critical review of recent progress, properties, applications, and future directions. *Compos. Part A Appl. Sci. Manuf.* **2023**, *165*, 107362. [CrossRef]
5. Zhou, A.F.; Wang, X.; Pacheco, E.; Feng, P.X. Ultrananocrystalline diamond nanowires: Fabrication, characterization, and sensor applications. *Materials* **2021**, *14*, 661. [CrossRef] [PubMed]
6. Hunter, G.W.; Akbar, S.; Bhansali, S.; Daniele, M.; Erb, P.D.; Johnson, K.; Liu, C.C.; Miller, D.; Oralkan, O.; Hesketh, P.J.; et al. Editors' choice—Critical review—A critical review of solid state gas sensors. *J. Electrochem. Soc.* **2020**, *167*, 037570. [CrossRef]
7. Luo, Y.; Abidian, M.R.; Ahn, J.H.; Akinwande, D.; Andrews, A.M.; Antonietti, M.; Bao, Z.; Berggren, M.; Berkey, C.A.; Bettinger, C.J.; et al. Technology roadmap for flexible sensors. *ACS Nano* **2023**, *17*, 5211–5295. [CrossRef] [PubMed]
8. Tyagi, D.; Wang, H.; Huang, W.; Hu, L.; Tang, Y.; Guo, Z.; Ouyang, Z.; Zhang, H. Recent advances in two-dimensional-material-based sensing technology toward health and environmental monitoring applications. *Nanoscale* **2020**, *12*, 3535–3559. [CrossRef] [PubMed]
9. DeCost, B.L.; Hattrick-Simpers, J.R.; Trautt, Z.; Kusne, A.G.; Campo, E.; Green, M.L. Scientific AI in materials science: A path to a sustainable and scalable paradigm. *Mach. Learn. Sci. Technol.* **2020**, *1*, 033001. [CrossRef] [PubMed]
10. Sobczyk, M.; Wiesenhütter, S.; Noennig, J.R.; Wallmersperger, T. Smart materials in architecture for actuator and sensor applications: A review. *J. Intell. Mater. Syst. Struct.* **2022**, *33*, 379–399. [CrossRef]