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Recent Advances in Light-driven Semiconductor-based Micro/Nanomotors

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Introduction

Micro/nanomotors, driven by various external stimuli, have garnered significant attention in recent years due to their potential applications in drug delivery, environmental remediation, and nanotechnology. Among various driving mechanisms, light-driven micro/nanomotors have emerged as promising candidates owing to their remote controllability and high energy efficiency. In this article, we delve into the recent advances in light-driven semiconductor-based micro/nanomotors, exploring their design principles, fabrication techniques, and applications.

Light-driven semiconductor-based micro/nanomotors typically consist of a semiconductor material that can efficiently convert light energy into mechanical motion. Common semiconductor materials used include Silicon (Si), Titanium Dioxide (TiO_2), Zinc Oxide (ZnO), and various semiconductor quantum dots. The design of these motors involves integrating the semiconductor component with other functional elements such as catalytic coatings and propulsion mechanisms.

Description

Fabrication techniques for light-driven semiconductor-based micro/nanomotors vary depending on the desired size, shape, and functionality. Common methods include template-assisted synthesis, chemical vapor deposition, and lithography-based approaches. Template-assisted synthesis involves the growth of semiconductor nanostructures within porous templates, enabling precise control over size and morphology. Chemical vapor deposition techniques allow for the growth of semiconductor thin films on substrates, offering scalability and uniformity. Lithography-based approaches enable the patterning of semiconductor materials at the micro and nanoscale, facilitating the fabrication of complex motor geometries.

Recent advances in light-driven semiconductor-based micro/nanomotors have focused on enhancing their performance, controllability, and functionality. Key advancements include: Improved Efficiency: Researchers have developed semiconductor materials with enhanced light absorption and conversion efficiencies, leading to more efficient energy conversion and higher propulsion speeds. Novel Propulsion Mechanisms: New propulsion mechanisms such as self-electrophoresis and photophoresis have been explored, enabling precise control over motor motion and directionality.

Autonomous Navigation: Integration of light-responsive sensors and feedback mechanisms has enabled autonomous navigation of micro/nanomotors in complex environments, paving the way for applications in targeted drug delivery and environmental monitoring. Multifunctionality: Light-driven semiconductor-based micro/nanomotors have been engineered to perform multiple functions simultaneously, such as cargo delivery, sensing, and environmental remediation, expanding their utility in diverse applications. The versatility of light-driven semiconductor-based micro/nanomotors has led to various potential applications across different fields:

Biomedical Applications: These motors hold promise for targeted drug delivery, where they can navigate through the body's fluids to deliver therapeutics to specific sites with high precision, minimizing side effects and improving treatment efficacy. Environmental Remediation: Light-driven micro/nanomotors can be employed for environmental remediation tasks such as pollutant degradation and oil spill cleanup, offering a cost-effective and efficient solution for environmental challenges. Lab-on-a-Chip Systems: Integration of light-driven micro/nanomotors with microfluidic devices enables the development of lab-on-a-chip systems for high-throughput screening, biochemical analysis, and diagnostics. Light-driven semiconductor-based micro/nanomotors find applications in nanoscale assembly, manipulation, and nanorobotics, facilitating the construction of complex nanostructures and devices [1-5].

Conclusion

In conclusion, recent advances in light-driven semiconductor-based micro/nanomotors have paved the way for their widespread adoption in various fields, ranging from biomedicine to nanotechnology. Continued research efforts aimed at improving their performance, controllability, and functionality will further expand their applications and accelerate their integration into real-world systems, driving innovation and addressing key societal challenges.

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Conflict of Interest

None.

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