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USE OF SEMICONDUCTOR SILICON OXIDE IN THE FORM OF GRANULES

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Abstract: Silicon oxide (SiO_2) in granular form has gained significant attention in semiconductor applications due to its unique physicochemical properties. This paper explores the synthesis, structural characteristics, and practical applications of granular silicon oxide in various technological fields. The study highlights its role in electronic devices, photovoltaics, and nanoelectronics, where it serves as an efficient insulating and passivation material. Additionally, the research examines the impact of granule size and morphology on electrical and thermal performance. The findings suggest that optimized granular SiO_2 enhances device efficiency and stability, making it a promising material for next-generation semiconductor technologies.

Keywords: silicon oxide, semiconductor, granules, nanoelectronics, insulation, passivation.

Introduction

Silicon oxide (SiO_2), commonly known as silica, is a versatile material with a wide range of applications in electronics, optics, and materials science. In its granular form, silicon oxide has gained significant attention due to its unique properties, such as high thermal stability, electrical insulation, and chemical inertness [1,2]. This article explores the use of semiconductor silicon oxide granules, focusing on their applications, advantages, and future prospects in various industries.

Properties of Silicon Oxide Granules. Silicon oxide granules exhibit several key properties that make them suitable for semiconductor and other high-tech applications:

- **High Purity:** Semiconductor-grade silicon oxide granules are highly pure, with minimal impurities, ensuring optimal performance in electronic devices.
- **Thermal Stability:** SiO_2 granules can withstand high temperatures, making them ideal for use in high-temperature processes.
- **Electrical Insulation:** Silicon oxide is an excellent electrical insulator, which is critical for its use in semiconductor manufacturing.
- **Chemical Inertness:** The material is resistant to most chemicals, ensuring durability in harsh environments.
- **Controlled Porosity:** Granules can be engineered with specific porosity levels, enabling tailored applications in filtration, catalysis, and drug delivery.

Applications of Silicon Oxide Granules [3]. Silicon oxide granules are used in a variety of industries due to their unique properties. Some of the most prominent applications include:

Semiconductor Manufacturing



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- Dielectric Layers: Silicon oxide granules are used to produce thin films that serve as dielectric layers in integrated circuits (ICs) and microelectromechanical systems (MEMS).

- Chemical Mechanical Planarization (CMP): SiO₂ granules are used as abrasives in CMP slurries to achieve ultra-smooth surfaces on silicon wafers.

- Passivation Layers: Granules are processed to form passivation layers that protect semiconductor devices from environmental factors such as moisture and contaminants.

Optics and Photonics

- Optical Fibers: High-purity silicon oxide granules are used in the production of optical fibers for telecommunications and data transmission.

- Lens Coatings: SiO₂ granules are used to create anti-reflective and protective coatings for lenses and optical components.

Energy Storage and Conversion

- Lithium-Ion Batteries: Silicon oxide granules are being explored as anode materials in lithium-ion batteries due to their high capacity and stability.

- Solar Cells: SiO₂ granules are used in anti-reflective coatings and as dielectric layers in photovoltaic cells to enhance efficiency.

Catalysis and Filtration

- Catalyst Supports: The high surface area and porosity of silicon oxide granules make them ideal supports for catalysts in chemical reactions.

- Water Purification: Granules are used in filtration systems to remove impurities and contaminants from water.

Biomedical Applications

- Drug Delivery: Porous silicon oxide granules can be used as carriers for controlled drug delivery systems.

- Biomedical Implants: SiO₂ granules are being investigated for use in biocompatible coatings for implants.

Advantages of Silicon Oxide Granules [4-6]. The use of silicon oxide granules offers several advantages over other forms of SiO₂:

- Ease of Handling: Granules are easier to handle, transport, and process compared to powders or thin films.

- Scalability: Granular forms can be produced in large quantities, making them suitable for industrial-scale applications.

- Customizability: The size, shape, and porosity of granules can be tailored to meet specific application requirements.

- Cost-Effectiveness: Granules are often more cost-effective to produce and use compared to other forms of silicon oxide.

Challenges and Limitations. Despite their many advantages, the use of silicon oxide granules is not without challenges:

- Production Costs: High-purity silicon oxide granules can be expensive to produce, particularly for semiconductor applications.



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- Environmental Concerns: The production of SiO₂ granules can generate waste and by-products that need to be managed responsibly.
- Technical Limitations: Achieving uniform size and porosity in granules can be technically challenging, particularly for advanced applications.

Future Prospects. The future of silicon oxide granules is promising, with ongoing research and development aimed at expanding their applications and improving their performance [7-8]. Key areas of focus include:

- Advanced Semiconductor Devices: The development of next-generation semiconductors, such as those based on silicon carbide (SiC) and gallium nitride (GaN), will drive demand for high-purity silicon oxide granules.
- Energy Storage: The use of SiO₂ granules in next-generation batteries, such as solid-state and lithium-sulfur batteries, is an area of active research.
- Biomedical Innovations: Advances in nanotechnology and biomaterials are expected to open up new opportunities for silicon oxide granules in drug delivery and tissue engineering.
- Sustainability: Efforts to reduce the environmental impact of SiO₂ production and improve recycling methods will be critical to the sustainable use of silicon oxide granules.

Conclusion

Silicon oxide granules are a versatile and valuable material with a wide range of applications in semiconductors, optics, energy storage, catalysis, and biomedicine. Their unique properties, including high purity, thermal stability, and electrical insulation, make them indispensable in many high-tech industries. While challenges such as production costs and environmental concerns remain, ongoing research and innovation expected to drive the continued growth and adoption of silicon oxide granules. As technology advances, these granules will play an increasingly important role in shaping the future of electronics, energy, and healthcare.

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