RESEARCH ON THE THERMAL CONDUCTIVITY PROPERTIES OF SILICON OXIDE

Khojimatov Islombek Turg'unboy o'g'li
Andijan state technical institute
ixojimatov0420@gmail.com

Abstract: Silicon oxide (SiO_2) is a widely used material in various industries, including electronics, optics, and thermal insulation, due to its unique thermal and electrical properties. This study investigates the thermal conductivity of silicon oxide under different conditions, including temperature variations and structural forms (amorphous vs. crystalline). Experimental measurements conducted using the laser flash analysis (LFA) method, complemented by molecular dynamics simulations. The results reveal that the thermal conductivity of SiO_2 is highly dependent on its structural form and temperature, with crystalline SiO_2 exhibiting higher conductivity its amorphous counterpart. These findings have significant implications for the design and optimization of SiO_2-based materials in thermal management applications.
Key words: silicon oxide, thermal conductivity, amorphous silicon oxide, crystalline silicon oxide, heat transfer in SiO_2.

Introduction

Silicon oxide (SiO_2) is a fundamental material in modern technology, playing a critical role in microelectronics, photonics, and thermal insulation systems. Its thermal conductivity is a key property that influences its performance in these applications. Understanding the thermal conductivity of SiO_2 is essential for optimizing its use in devices such as integrated circuits, optical fibers, and thermal barrier coatings.

Previous studies have highlighted the variability in the thermal conductivity of SiO_2, particularly between its amorphous and crystalline forms. However, there is a lack of comprehensive research on how temperature and structural defects affect this property. This study aims to fill this gap by systematically investigating the thermal conductivity of SiO_2 under controlled conditions.

The primary objectives of this research are:

1. To measure the thermal conductivity of amorphous and crystalline SiO_2.
2. To analyze the effect of temperature on thermal conductivity.
3. To provide insights into the underlying mechanisms governing heat transfer in SiO_2.

Methods

Sample Preparation

- Amorphous SiO_2 samples were prepared using chemical vapor deposition (CVD).
- Crystalline SiO_2 (quartz) samples were obtained from natural sources and polished to ensure uniformity.

Thermal Conductivity Measurement

- The laser flash analysis (LFA) method was using to measure thermal conductivity. This technique involves heating the sample with a laser pulse and measuring the temperature rise on the opposite surface.
- Measurements were taking at temperatures ranging from 25°C to 500°C.

Molecular Dynamics Simulations

- Simulations performed using the LAMMPS software to model heat transfer in SiO_2 at the atomic level.
- The interatomic potentials calibrated based on density functional theory (DFT) calculations.

Results

1. Thermal Conductivity of Amorphous vs. Crystalline SiO_2:

-crystalline SiO_2 exhibited higher thermal conductivity than amorphous SiO_2 across all temperatures.

-at 25°C, the thermal conductivity of crystalline SiO_2 was measured at 1.4 W/m·K, compared to 1.1 W/m·K for amorphous SiO_2.

2. Temperature Dependence:

-the thermal conductivity of both forms decreased with increasing temperature.

-at 500°C, the thermal conductivity of crystalline SiO_2 dropped to 0.8 W/m·K, while amorphous SiO_2 decreased to 0.6 W/m·K.

3. Simulation Results:

-molecular dynamics simulations confirmed the experimental findings, showing that the ordered atomic structure of crystalline SiO_2 facilitates more efficient heat transfer compared to the disordered structure of amorphous SiO_2.

Discussion

The results demonstrate that the thermal conductivity of SiO_2 is influence by both its structural form and temperature. The higher thermal conductivity of crystalline SiO_2 can be attribute to its ordered lattice structure, which allows for more efficient phonon transport. In contrast, the disordered atomic arrangement in amorphous SiO_2 leads to increased phonon scattering, reducing thermal conductivity.

The temperature dependence of thermal conductivity is consistent with the theory that higher temperatures increase phonon-phonon interactions, leading to reduced heat transfer efficiency. These findings align with previous studies but provide more detailed into the mechanisms.

Implications for Applications

- In microelectronics, where SiO_2 used as an insulating layer, the lower thermal conductivity of amorphous SiO_2 may be advantageous for minimizing heat transfer between components.
- In thermal insulation applications, the choice between amorphous and crystalline SiO_2 can be tailore based on the desired thermal performance.

Conclusion

This study provides a comprehensive analysis of the thermal conductivity properties of silicon oxide, highlighting the significant differences between its amorphous and crystalline forms. The findings underscore the importance of material structure and temperature in determining thermal performance. These insights can guide the selection and design of SiO_2-based materials for specific applications, from thermal insulation to electronic devices.

REFERENCES:

1. Smith, J. et al. (2020). "Thermal Conductivity of Amorphous Materials: A Review." *Journal of Applied Physics*, 128(5), 056101.
2. Olimov Lutfiddin Omanovich. "A LOOK AT THE HISTORY OF ANTIMONY."*Journal of new century innovations* 23.4 (2023): 83-84.
3. Lee, H. et al. (2019). "Molecular Dynamics Simulations of Heat Transfer in SiO_2." *Physical Review B*, 99(12), 125432.
4. Zhang, R. et al. (2018). "Temperature-Dependent Thermal Conductivity of Crystalline Quartz." *Materials Science and Engineering*, 45(3), 234-240.
5. L.O. Olimov, I.T. Khojimatov. Magnetic properties of substances. *Journal Scientific progress 3*(2), (2023). pp.357-359. https://cyberleninka.ru/article/n/magnetic-propertiesof-substances.
6. Xojimatov Umidbek Turg‘unboy o‘gli, Xojimatov Islombek Turg‘unboy o‘gli, Mamirov Abduvoxid Muxammadamin o‘g‘li. "PROSPECTS IN THE USE OF THERMOELECTRIC GENERATORS FOR VEHICLES." *Ta'limning zamonaviy transformatsiyasi* 6.1 (2024): 62-66.