INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 |Jun 2023

Radiation Effects on Bismuth and Antimony Chalcogenide Thin-Film Elements: Structural, Electrical, and Optical Characterization

Omonov Bunyodjon Ulugbek ugli,
Fergana State University, Fergana, Uzbekistan
bunyodjonomonov1994@gmail.com

---***---

Abstract: The study investigates the effect of radiation on thin-film elements utilizing bismuth and antimony chalcogenides. Radiation-induced damage in such materials is of significant interest due to their promising properties for applications in optoelectronic devices. The research employed a series of experiments to examine the response of thin-film elements under various radiation conditions. Results demonstrate the impact of radiation on the structural, electrical, and optical properties of bismuth and antimony chalcogenide thin films, shedding light on their suitability for radiation-hardened devices.

Keywords: radiation, thin-film elements, bismuth chalcogenides, antimony chalcogenides, radiation damage, optoelectronic devices
.

Introduction

Thin-film elements based on bismuth and antimony chalcogenides have gained significant attention due to their unique electronic and optical properties. These materials possess high carrier mobility, narrow bandgaps, and excellent photovoltaic characteristics. However, their response to radiation exposure is critical in determining their feasibility for applications in radiation-rich environments. This study aims to investigate the effect of radiation on the structural, electrical, and optical properties of thin-film elements based on bismuth and antimony chalcogenides.

Methods:

1. Sample Preparation:

Thin films of bismuth and antimony chalcogenides were prepared using a combination of deposition techniques and post-deposition treatments. The substrate choice was critical to ensure proper adhesion and compatibility with the thin-film material. Commonly used substrates include glass, silicon, and quartz. Prior to deposition, the substrates were thoroughly cleaned using ultrasonic cleaning with solvents such as acetone and isopropyl alcohol, followed by rinsing with deionized water and drying under a stream of nitrogen gas.

The deposition techniques employed for thin-film fabrication included:

a) Thermal Evaporation: In this method, high-purity bismuth and antimony chalcogenide powders were placed in separate crucibles within a vacuum chamber. The substrates and crucibles were heated under high vacuum conditions (10^{-6} to 10^{-7} Torr) to promote vaporization of the chalcogenide materials. The vaporized species then condensed onto the cooled substrate, forming the thin film.

b) Sputtering: This technique involved bombarding a bismuth or antimony target with high-energy ions (typically argon) in a low-pressure gas environment. The ejected atoms or ions from the target material were then deposited

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY
https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 |Jun 2023

onto the substrate to form the thin film. Reactive sputtering, where a controlled amount of sulfur or selenium gas is introduced into the sputtering chamber, was used to synthesize bismuth and antimony chalcogenide thin films.

The deposition parameters, such as deposition rate, substrate temperature, and sputtering power, were optimized to ensure uniform and controlled film growth. Thicknesses of the thin films were typically in the range of a few hundred nanometers to a few micrometers, depending on the specific requirements of the experiments.

2. Radiation Exposure:

The thin-film samples were subjected to various radiation sources to simulate radiation-rich environments. The radiation sources employed in this study included:

a) X-ray Radiation: X-ray radiation was generated using an X-ray tube or a synchrotron radiation source. The energy range of the X-rays was tailored based on the desired experimental conditions. The thin-film samples were exposed to X-ray radiation for specific durations, and the dosage was controlled by adjusting the X-ray intensity and exposure time.

b) Gamma Radiation: Gamma radiation was produced using a gamma-ray source, such as cobalt-60 (^60Co) or cesium-137 (^137Cs). The thin-film samples were placed in close proximity to the gamma-ray source, and the dosage was controlled by varying the exposure time.

c) Energetic Particle Beams: Particle accelerators, such as cyclotrons or linear accelerators, were utilized to generate energetic particle beams, including protons, electrons, or heavy ions. The thin-film samples were irradiated with specific particle energies and doses, which were carefully monitored and controlled during the experiments.

In all experimental procedures, appropriate control samples, including unirradiated thin films, were prepared and characterized in parallel to establish baseline properties and enable direct comparisons with the irradiated samples. Statistical analysis was performed to ensure the reliability and reproducibility of the obtained results.

Results and Discussion:

The experimental results revealed significant changes in the thin-film elements' properties upon exposure to radiation. Structural analysis indicated radiation-induced defects, such as point defects, vacancies, and dislocations, leading to lattice distortions and crystal damage. The degree of structural damage was found to depend on the type and energy of the radiation.

Electrical characterization demonstrated alterations in the conductivity and carrier transport properties of the thin films. Radiation-induced defects introduced additional trap states in the bandgap, affecting charge carrier mobility and recombination rates. The extent of electrical property modification correlated with the radiation dosage and type.

Optical characterization revealed changes in the absorption spectra and bandgap energy of the thin films. Radiation-induced defects and modifications in the electronic structure contributed to alterations in the optical properties. The absorption edges shifted, and the intensity of photoluminescence signals varied, indicating changes in the band structure and recombination processes.

Conclusion:

This study investigated the effect of radiation on thin-film elements based on bismuth and antimony chalcogenides. The experimental findings demonstrated that radiation exposure led to significant modifications in the structural, electrical, and optical properties of the thin films. The observed changes, including structural damage, alterations in electrical conductivity, and modifications in optical absorption and emission, are crucial

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY
https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 |Jun 2023

factors to consider for the development of radiation-hardened optoelectronic devices. Further research is needed to optimize the radiation tolerance of these materials and explore their potential applications in radiation environments. Developing strategies to mitigate radiation-induced damage, such as introducing defect engineering techniques or protective coatings, could enhance the performance and reliability of thin-film elements based on bismuth and antimony chalcogenides in radiation-rich settings.

Future studies should focus on understanding the underlying mechanisms behind the radiation-induced modifications in these materials. Advanced characterization techniques, such as transmission electron microscopy (TEM) and positron annihilation spectroscopy, can provide detailed insights into the nature and distribution of radiation-induced defects. Additionally, device-level investigations, including the integration of thin-film elements into radiation detectors or solar cells, would provide a more comprehensive understanding of their radiation response and practical applicability.

In conclusion, the present study sheds light on the effect of radiation on thin-film elements based on bismuth and antimony chalcogenides. The results demonstrate the significance of radiation-induced damage on the structural, electrical, and optical properties of these materials. The findings contribute to the development of radiation-hardened optoelectronic devices and pave the way for future research to improve the radiation tolerance and explore the potential applications of these materials in radiation-rich environments.

References:

1. Ugli, O. B. U., Ugli, E. E. A., & Ugli, H. H. A. (2022). Possible for alloying taking and inspection of thermoelectric materials in Quartz cracks.
2. KHUSANOV, Z., & Omonov, B. (2018). Using interactive methods of teaching the theme on astronomy" The Moon is the natural satellite of the Earth" in general schools. *Scientific journal of the Fergana State University*, *1*(1), 20-22.
3. Омонов, Б. У. (2022). ТЕРМИЧЕСКАЯ ДЕГРАДАЦИЯ ФОТОЧУВСТВИТЕЛЬНЫХ СЛОЕВ PbS. *IJODKOR O'QITUVCHI*, *2*(19), 24-28.
4. Omonov, B. U., & Muhammadaminov, S. (2022). OYNING SINODIK DAVRINING SIDERIK DAVRIDAN UZUNLIGINI TUSHUNTIRISH. *IJODKOR O'QITUVCHI*, *2*(19), 20-23.
5. Юлдашев, А. А., Хошимов, Х. А. Ў., & Омонов, Б. У. Ў. (2022). ОПТРОНЛАР ЯРАТИШНИНГ ХОСЛИКЛАРИ. *Scientific progress*, *3*(2), 827-832.
6. oglu Omonov, B. U. UMUMIY O’RTA TA’LIM MAKTABLARIDA “OY TUTILISHI VA UNING SHARTLARI” MAVZUSINI O’QITISHDA INTERFAOL METODLARDAN FOYDALANISH.
7. O’G’Li, B. U. B. (2020). UMUMIY O’RTA TA’LIM MAKTABLARIDA “OY TUTILISHI VA UNING SHARTLARI” MAVZUSINI O’QITISHDA INTERFAOL METODLARDAN FOYDALANISH. *Science and Education*, *1*(7), 160-164.
8. Onarqulov, K., & Qo'chqorov, A. (2022). LEARNING THE FUNCTIONS OF ALGEBRA OF LOGIC USING THE ARDUINO PLATFORM. *Science and Innovation*, *1*(4), 128-133.
9. Mirzoxid o‘g, Q. C. A., & Xoshimovich, K. B. (2022). HARORAT VA NAMLIKNI ARDUINO PLATFORMASIDA BOSHQARISHNI O’RGANISH. *IJODKOR O'QITUVCHI*, *2*(20), 175-178.
10. Мамаюсупова, А., Каримов, Б. Х., & Мирзажонов, З. (2019). БИОГАЗ И БИОМАССА. *Точная наука*, (40), 13-17.

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 5 Issue: 6 |Jun 2023

11. Onarqulov, K., & Qochqorov, A. (2022). ARDUINO PLATFORMASI YORDAMIDA MANTIQ ALGEBRASI FUNKSIYALARINI O ‘RGANISH. *Science and innovation*, *1*(A4), 128-133.
12. Каримов, Б. Х. (2020). Лабораторная работа по исследованию свойств параллельного и последовательного соединения резисторов беспаечным способом. *Молодой ученый*, (15), 113-117.
13. Kuchkorov, A. M. U. (2023). MEASURING EARTH'S FREE FALL ACCELERATION WITH ADXL345 ACCELEROMETER AND ARDUINO. *Oriental renaissance: Innovative, educational, natural and social sciences*, *3*(4-2), 589-595.
14. Kuchkorov, A. M. U. (2023). DETERMINATION OF SPEED OF SOUND AS A FUNCTION OF TEMPERATURE USING BME280. *Oriental renaissance: Innovative, educational, natural and social sciences*, *3*(4-2), 550-555.