

Growth of Chalcogenide Semiconductor Single Crystals for Radiation Detector Applications

Room-temperature radiation detectors are needed for medical imaging, nuclear safety, security, and defense. Effective detector materials require high density/atomic number, a suitable band gap, high resistivity, and mechanical robustness. Here we investigate two chalcogenide semiconductors: α -AgSbS₂ and Pb₂P₂Se₆ as candidates for radiation detection.

Silver antimony sulfide (α -AgSbS₂) is an emerging ternary semiconductor material to be used in photovoltaics, optoelectronics, and radiation detector applications. It is a non-toxic and environmentally friendly semiconductor material with a bandgap of (E_g) of 1.79 eV, a large absorption coefficient (α) of 10^5 cm^{-1} , and an electrical resistivity of 10^9 - $10^{10} \Omega \cdot \text{cm}$. Single crystals of monoclinic α -AgSbS₂ were grown using the vertical Bridgman method and confirmed its phase purity by powder X-ray diffraction. Grown crystals have an exceptional hardness (121 kg/mm²), higher than CdZnTe and many reported chalcogenides used in radiation detection. Ag/AgSbS₂/Ag devices exhibit, strong photosensitivity, and an α -particle response demonstrating its potential as a semiconductor radiation detector material.

Pb₂P₂Se₆ is a semiconductor material that has shown spectroscopic responses to X-rays and γ -rays. It has an indirect band gap of 1.88 eV and exhibits an electrical resistance of $10^{11} \Omega \cdot \text{cm}$. There are challenges persist in the growth of single crystalline Pb₂P₂Se₆ using modified vertical Bridgman methods, including the presence of secondary phase particles, grown-in point defects, and engineering hurdles in material purification and crystal growth processes. We have used the physical vapor transport (PVT) method to overcome these limitations and obtain single crystals of up to ~12 mm in length. Confirmation of its phase purity was attained through powder X-ray diffraction (pXRD) analysis. Ag/Pb₂P₂Se₆/Ag detectors showed a stable X-ray photocurrent under 10 V and 100 V biases, and strong visible-light response across 1–1000 V.