Melt growth of 1 inch $CsPbBr_3$ single crystal and photoconductivity studies

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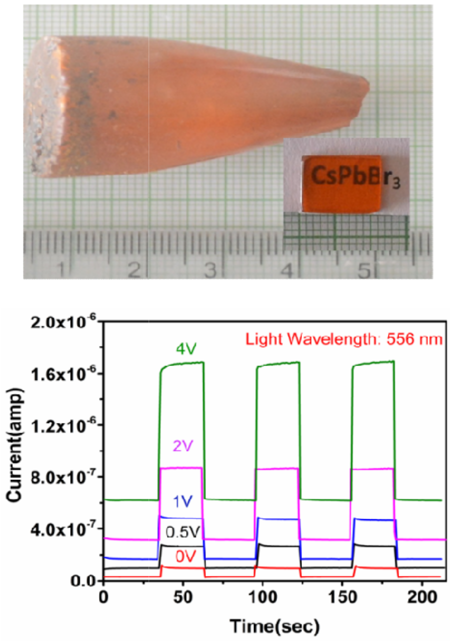
Room-temperature semiconductor radiation detectors are preferred for a wide range of applications in defense, industry, medical imaging, and research. Among emerging materials, $CsPbBr_3$ has attracted significant attention as a promising room-temperature radiation detector[1]. To realize detector-grade material, $CsPbBr_3$ single crystals were grown using a four-zone Bridgman technique in a carbon-coated quartz crucible. The $CsPbBr_3$ precursor was synthesized by mixing stoichiometric amounts of CsBr and $PbBr_2$ followed by ball milling at 300 rpm for 4 h. The XRD patterns obtained from the ball-milled material show good agreement with the CIF data, confirming the formation of phase-pure orthorhombic $CsPbBr_3$. The resulting material was dehydrated at 300 °C for 24 h under a vacuum of 10^{-5} mbar and subsequently sealed under the same vacuum conditions. Crystal growth was carried out with the furnace zone temperatures set to 620, 580, 460, and 450 °C, which were reached gradually over 10 h. After complete melting, the melt was held for an additional 10 h to ensure thermal homogenization. The crucible was then translated at a rate of 0.5-1 mm/hour through an adiabatic region having a temperature gradient of approximately 15 ^{o}C/cm, allowing controlled solidification over a translation length of 200 mm. The furnace was cooled at a rate of 3^{o} - 10^{o}/hour to room temperature. The presence of two structural phase transitions in $CsPbBr_3$,cubic to tetragonal (at ~130 °C) and tetragonal to orthorhombic (at ~88 °C) , put constrained on cooling rate for minimizing thermal stress and obtaining crack-free single crystals[2].



Photograph of as-grown $CsPbBr_3$ single crystal, , photo response under different voltages at 556 nm

Optical transmission measurements of grown crystal exhibit a sharp absorption edge near ~550 nm, and indicates band gap of 2.25 eV. The figure presents the 1-inch as-grown $CsPbBr_3$ single crystal and photo conductivity measurement. Photo conductivity measurements were carried out using Ga–In contacts on both sides of the sample under 556 nm illuminations. The photocurrent increases with applied voltage indicates efficient charge collection. Further, the current remains stable with time at a fixed applied voltage. Further experiments toward detector fabrication are currently in progress.

1. Lei Pan, Yuanxiang Feng, Praneeth Kandlakunta, Jinsong Huang, and Lei R. Cao.“Performance of Perovskite $CsPbBr_3$ Single Crystal Detector for Gamma-Ray Detection” *IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 67, NO. 2, FEBRUARY 2020*
2. S Hirotsu, J Harada, M Iizumi, K Gesi. “Structural Phase Transitions in CsPbBr3”, *Journal of the Physical Society of JAPAN*, 1974, **1**, 100 (2009).

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