

Influence of Cd-related inclusion defects on X/ γ -ray response in Cd-rich nominally undoped CdTe single crystals for radiation detection

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Date:

Abstract

Cadmium telluride (CdTe) has been widely investigated as a room-temperature semiconductor for X/ γ -ray detection. For detector-grade CdTe, high resistivity is necessary to suppress dark current, but resistivity alone is not sufficient to ensure efficient charge collection or stable spectroscopic response. Here, Cd-rich nominally undoped CdTe single crystals were grown by the vertical Bridgman method, with emphasis on the influence of excess-Cd-related defects on electrical uniformity and radiation response. Multi-position current-voltage measurements on a macroscopically continuous wafer revealed a resistivity variation of more than three orders of magnitude. Infrared transmission microscopy showed that the internal defects were spatially heterogeneous and appeared as isolated inclusions, needle-like features, radial clusters and inclusion-aggregation bands. Representative low-resistivity (LR) and high-resistivity (HR) specimens showed similar crystalline quality and near-infrared transmittance, indicating that the large electrical difference was mainly associated with the internal defect distribution rather than average structural degradation. Te-atmosphere annealing slightly increased the resistivity of the LR specimen, while residual inclusion cores remained after annealing. Au/CdTe/Au devices fabricated from the HR specimen exhibited a linear X-ray dose-rate response, and the average sensitivity increased from 20.8 to 71.5 mC Gy⁻¹ cm⁻² as the electric field increased from 50 to 200 V mm⁻¹. A measurable 241 Am γ -ray response was also obtained, with the energy resolution improving from 22.01% to 12.57% under higher bias. These results indicate that Cd-rich growth can produce HR undoped CdTe with measurable X/ γ -ray response, but Cd-related inclusion heterogeneity remains major obstacles to detector-grade performance. Control of excess-Cd distribution is therefore essential for developing undoped CdTe crystals for room-temperature radiation detection.

Note: Figure translations are in progress. See original paper for figures.

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