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Low-Temperature Photoluminescence Study of CdTe:In Crystals Annealed in Molten Bismuth

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We used a low-temperature photoluminescence (PL) technique to investigate CdTe:In crystals after annealing in molten bismuth (Bi). The two annealed samples showed different resistivities after the treatment. For both samples, we observed very strong emissions in the excitonic spectral region and revealed fine structures of exciton emissions in the PL spectrum. In the sample with high resistivity, we found one ionized donor-bound exciton peak, (D^+,X), that we ascribed to incorporated Bi atoms occupying Cd sites in the CdTe. The temperature dependence of the (D^+,X) peak emission had an associated activation energy of 3.59 meV for the exciton bound to this ionized donor. Meanwhile, a donor–acceptor pair peak at 1.5315 eV, which was absent from the PL of the low-resistivity sample, suggested the likelihood of some Bi atoms occupying Te sites in the high-resistivity sample. Our findings highlight the need for detailed investigation of annealing conditions to ensure precise control of the electrical properties of the material during annealing in molten Bi.

Key words: CdTe, postgrowth annealing, bismuth, photoluminescence

INTRODUCTION

The II–VI compound CdTe is a direct-bandgap semiconductor with widespread applications including room-temperature x-ray and gamma-ray detection, substrates for epitaxial growth of HgCdTe infrared detectors, and high-efficiency solar-cell structures. However, the presence of impurities in CdTe crystals is a major concern, since they play a key role in determining the performance of CdTe devices;[1–3] For example, different defect energy levels caused by impurities can alter the electrical properties of CdTe radiation detectors, e.g., their resistivity and charge-transport parameters. Furthermore, in terms of infrared substrate applications, the impurities can diffuse from the CdTe substrate into the HgCdTe epilayer, thus reducing the minority-carrier lifetime of the latter. Consequently, it is very important to explore different approaches to purify CdTe. Researchers have adopted various approaches to do so; thus, besides removing the impurities from the raw elements, Cd and Te, by distillation and zone-refining, attempts have been made to purify CdTe-based compounds by annealing them in certain "wash" melts. Sen et al.[4] demonstrated that annealing CdTe and CdZnTe in molten Bi is a promising way to eliminate impurities. More specifically, Bi melt demonstrably has some favorable properties as a solvent for CdTe, such as a low melting point (271°C), nontoxicity, reasonable solubility of CdTe in Bi, and high surface tension for wipe-off/cleaning. Photoluminescence (PL) spectroscopy is a highly sensitive, nondestructive method to characterize impurities and point defects in semiconductors, making it well suited to investigation of the properties of CdTe-based compounds.[5,6] The different features of the emissions in the PL spectrum provide useful information on the nature of impurity-related acceptors and donors. In this work, we used a low-temperature PL technique to investigate the properties of CdTe:In crystals that had been annealed in molten bismuth (Bi). We also evaluated and analyzed the temperature dependence of some

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