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Photoluminescence of CdTe Crystals Grown by Physical-Vapor Transport

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High-quality CdTe crystals with resistivities higher than 10^8 Ω cm were grown by the physical-vapor transport (PVT) technique. Indium, aluminum, and the transition-metal scandium were introduced at the nominal level of about 6 ppm to the source material. Low-temperature photoluminescence (PL) has been employed to identify the origins of PL emissions of the crystals. The emission peaks at 1.584 eV and 1.581 eV were found only in the In-doped crystal. The result suggests that the luminescence line at 1.584 eV is associated with Cd-vacancy/In complex. The intensity of the broadband centered at 1.43 eV decreases strongly with introduction of Sc.

Key words: Physical-vapor transport (PVT), photoluminescence (PL) spectra, CdTe:Al, CdTe:In, CdTe:Sc

INTRODUCTION

Cadmium telluride (CdTe) is the primary semiconductor material for room-temperature gamma- and x-ray detectors.[1] One of the basic material requirements for the detector applications is high-quality single crystals with very high electrical resistivity ($>10^9$ Ω cm). Because of the existence of a high concentration of cadmium vacancies (V_{cd}), the resistivity of undoped-CdTe crystals grown by conventional (melt) methods is usually very low.[2–4] The physical vapor transport (PVT) crystal-growth technique allows growing of crystals well below the melting point under conditions close to stoichiometric composition of the materials and without the presence of a second condensed phase. In addition, the resublimation process itself may serve as an additional purification step. Under such conditions, high-quality single crystals with reduced impurity content can be grown.[5]

Cadmium vacancies formed during the crystal-growth process may lead to p-type conductivity of undoped-CdTe crystals. To provide electrical compensation for the vacancies, elements from group III, such as In and Al, and elements from group VII of the periodic table have been introduced during synthesis as dopants. The elements of groups III and VII act as donors by substituting Cd and Te atoms, respectively. Their presence in the lattice site can also create new Cd vacancies and form acceptor-like complex centers. Photoluminescence (PL) spectroscopy is an effective tool to provide information on the defect centers present in the lattice. The PL of CdTe has been extensively studied for decades, but the exact nature of the compensation mechanisms and the origin of the emission peaks are still under investigation. In this work, we studied the PL and electrical resistivity of undoped and In-, Al-, and Sc-doped CdTe crystals.

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EXPERIMENTAL

The crystals were grown by the PVT method. The source materials were synthesized from m6N elemental Cd and Te in the atmosphere of 0.1 atm (at room temperature) of hydrogen. The synthesized material was ground and sifted (mesh 80), then annealed at 900°C, first in 0.5 atm of hydrogen and then under vacuum. The dopants In, Al, and Sc were added (in the form of the respective tellurides) to the source materials at the nominal level of about 6 ppm. The material was loaded into the growth ampoule, annealed at 700°C under 0.5 atm of hydrogen and then under vacuum, and sealed with a small amount of elemental