Binding energy study from photocurrent signal in $CdIn_2Te_4$ crystal

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Abstract : The single crystals of p-$CdIn_2Te_4$ were grown by the Bridgman method without the seed crystal. From photocurrent measurements, it was found that three peaks, A, B, and C, correspond to the intrinsic transition from the valence band states of Γ_7(A), Γ_6(B), and Γ_7(C) to the conduction band state of Γ_6, respectively. The crystal field splitting and the spin orbit splitting were found to be 0.2360 and 0.1119 eV, respectively, from the photocurrent spectroscopy. The temperature dependence of the $CdIn_2Te_4$ band gap energy was given by the equation of $E_g(T) = E_g(0) - (9.43 \times 10^{-3})T^2/(2676 + T)$. $E_g(0)$ was estimated to be 1.4750, 1.7110, and 1.8229 eV at the valence band states of A, B, and C, respectively. The band gap energy of p-$CdIn_2Te_4$ at room temperature was determined to be 1.2023 eV.

Key Words : p-$CdIn_2Te_4$ single crystals, Bridgman method, photocurrent, band gap energy

1. INTRODUCTION

Cadmium indium telluride ($CdIn_2Te_4$), which belongs to a chalcopyrite structure[1] with space group S^2_4–I4-, is an attractive material because it is practically applicable to electro-optical devices.[2-5] For these applications, it is of primary importance to grow high quality crystals and to characterize the fundamental material parameters such as the band gap and its temperature dependence.

In this study, the single crystals of p-$CdIn_2Te_4$ were grown by the Bridgman method without the seed crystal. We also present the results of the temperature dependence of the p-$CdIn_2Te_4$ band gap energy obtained through PC spectroscopy. The valence band splitting for electronic transitions restricted by a selection rule is also discussed

2. RESULTS AND DISCUSSION

The p-$CdIn_2Te_4$ single crystal was grown in a three-stage vertical electric furnace by using the Bridgman method without the seed crystal[1]. The carrier density and the Hall mobility of the p-$CdIn_2Te_4$ single crystal obtained at 300 K were 8.61×10^{17} cm^{-3} and 2.42 $\times 10^2$ $cm^2/V \cdot sec$, respectively. From the PC measurement, three peaks in the PC spectra were observed at the temperature range of 10 to 250 K. However, only two peaks at 300 K were obtained. This indicates that the electrons in the valence band are scattered because of the mutual interaction of electrons caused by carrier concentration. The peaks A, B, and C obtained are the intrinsic transitions from the valence band state of Γ_7(A), Γ_6(B), and Γ_7(C) to the conduction band state of Γ_6, respectively. The Δ_{cr} and Δ_{so} of p-$CdIn_2Te_4$ obtained are 0.2360 eV and 0.1119 eV, respectively. The temperature dependence of the band gap energy is well described by the equation of $E_g(T) = E_g(0) - (9.43 \times 10^{-3})T^2/(2676 + T)$. The $E_g(0)$ is estimated at 1.4750, 1.7110, and 1.8229 eV at the valence band states of A, B, and C, respectively. The band gap energy of p-$CdIn_2Te_4$ obtained at room temperature is 1.2023 eV.

REFERENCES

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