Binding energy study from Photocurrent signal in $CdGa_2Se_4$ layers

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ABSTRACT : The photoconductive $CdGa_2Se_4$ layer has been investigated using photocurrent (PC) spectroscopy as a function of temperature. Three peaks corresponding to the band-to-band transitions were observed in the PC spectra for all temperature ranges. Also, contrary to our expectation, the PC intensities decreased with decreasing temperatures. From the relation of log J_{ph} *vs* 1/T, where J_{ph} is the PC density, two dominant levels by the exponential variation of the PC with varying temperature were observed, one at high temperatures and the other at low temperatures.

Key Words : $CdGa_2Se_4$ layer, trapping center, photocurrent signal, photocurrent intensity

1. INTRODUCTION

Cadmium gallium selenide ($CdGa_2Se_4$), which has a defect chalcopyrite structure with space group S^2_4–I4-, is an attractive material because of its applicability to electro-optical devices.[1] In this paper, we measured the PC variation in $CdGa_2Se_4$ at different temperatures. From the PC experiment, the positions and intensities of the PC spectra were observed to the blue shift and the decrease with decreasing PC measurement temperature, respectively.

2. RESULTS AND DISCUSSION

Figure 1 presents a plot of log J_{ph} *vs* 1/T for the PC response of the A, B, and C peaks as a function of temperature. The PC intensities of each peak decrease with decreasing temperature. The PC increased with increasing temperature. Therefore, for the exponential trap distribution of $n_E dE = A\exp(-E/kT)dE$, it is expected that the PC changes somewhat more rapidly with varying temperatures. Here, T is related to the equilibrium temperature corresponding to the trap distribution. At the low-temperature region, σ_{ph} does not show any temperature dependence as stated above. From the hypothesis of Simmons and Taylor, σ_{ph} for the region (ii) is expressed by

$$\sigma_{ph} = e\mu_p[GN_o/(\upsilon\sigma_t N_t)]^{1/2}\exp[-(E-E_v)/2kT], \qquad (2)$$

where υ is the thermal velocity of holes, E the trap level energy in the forbidden gap of a photoconductor, σ_t the capture cross section of E, and k the Boltzmann constant. ΔE_{ph} obtained from the plots of log J_{ph} *vs* 1/T at high-temperature regions is extracted out to be 33.4 meV

3. CONCLUSIONS

The PC spectroscopy on the photoconductive $CdGa_2Se_4$ layer grown by using the HWE method, was performed at temperatures ranging from 10 to 293 K. Also, contrary to our expectation, the PC intensities decreased with decreasing temperature. In the log J_{ph} vs 1/T plot, two dominant levels were observed, one at high temperature and the other at low temperature. The PC signal in a low-temperature region below 100 K remains constant. Therefore, it suggests that trapping centers in the $CdGa_2Se_4$ layer, due to native defects and impurities, limit the PC signal with decreasing temperatures.

REFERENCES

[1] O. Madelung, *Numerical Semiconductors-Basic Data*, 2nd ed. (Springer, Berlin, 1996), p. 222.