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THE RECOMBINATION CROSS SECTION-ELECTRON ENERGY RELATION OF THE (e,A°) EMISSION IN CdTe:Li

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By means of the effective mass approximation, the recombination cross section-electron energy relation of the free electron-acceptor emission in CdTe:Li has been studied. This relation has been compared with the relative theory.

1. INTRODUCTION

The photoluminescence investigation in CdTe crystal were made by several authors[1-3]. In this paper, the recombination cross section (RCS) was introduced to character the probability. For the shallow acceptor A^{O}_{Li} (E_A=52meV), the effective mass approximation is valid. We have got RCS-electron energy relation by processing the photoluminescence line shape of the (e,A^{O}) emission in CdTe:Li.

2. EXPERIMENT

The impurity Li was diffused into CdTe crystal by two steps[4]. First, anneal of sample is made in a quartz tube at 350°C, under Te atmosphere for 320 hours. Second, Li diffusion is made from Li_2CO_3 solution deposited on a polish surface of CdTe crystal and in a horizontal furnace, under a continuous flow of H_2-N_2 mixture. The temperature is about 350°C and diffusion time is 1 hour.

For photoluminescence measurements were performed with Ar^+ laser emitting about 100 mW power at 488 nm. The sample temperature was maintained at 11K by a cryogenic system.

3. RESULTS AND DISCUSSION

The energy position of the (e, A^{O}_{Li}) emission band is about at 12535 cm^{-1}. Both the (e,A^{O}_{Li}) emission band and the recombination band of the bound to the neutral acceptors (A^{O}_{Li},X) were well separated[4]. The (e, A^{O}) emission line shape is given by the product[5]

$$I(\hbar\omega) \propto \rho(E_c)\, f(E_c)\, |M_{e,A^o}(k)|^2 \qquad (1)$$

where $E_c = \hbar\omega - E_g + E_A$, $\rho(E_c)$ and $f(E_c)$ are the electron density of states and the electron distribution function respectively. The transition probability-energy relation has been considered in (1). But we can not obtain RCS-electron energy relation from (1) directly. However, we know that $I(\hbar\omega)$ are proportional to the recombination rate R. The recombination rate R in the (e,A^{O}) emission is given by[6]

$$R = \sigma(\hbar\omega)\; V\, n_e\, N^{O}_{A} \qquad (2)$$

where $\sigma(\hbar\omega)$ is RCS, $V = (2E_c/m_c)^{\frac{1}{2}}$ is the electron velocity before recombination. $n_e = \rho(E_c)\, f(E_c)$ is the electron distrubution in the conduction band, and N^{O}_{A} is the neutral acceptor concentration. RCS-electron energy relation, $\sigma(\hbar\omega) \propto E_c^{-\frac{1}{2}}$, has been determined by fitting (2) to the curve a which is the photoexcited emission spectrum of the sample in Fig. 1.

By the Ridley's theory, RCS of the (e,A^{O}) transition can be represented by[7]

$$\sigma(\hbar\omega) \propto \frac{P_{CV}^2}{[1 + (E_c/R_{HV})]^4\, E_c^{\frac{1}{2}}} \qquad (3)$$

where R_{HV} is the effective Rydberg energy, P_{CV} is the interband matrix element of the momentum operator. Using the formula (3) and the effective mass approximation, we have got the theoretical value of RCS (curve a in Fig. 2).

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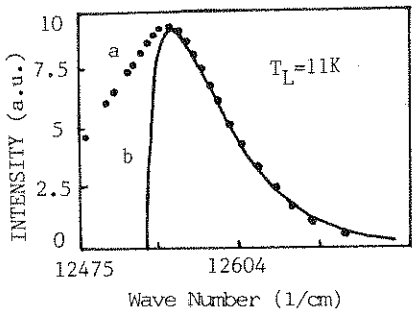

FIGURE 1
The point curve a is the (e,A^o) emission at 11K. The solid curve b has been obtained by fitting formula (2) to the spectrum data.

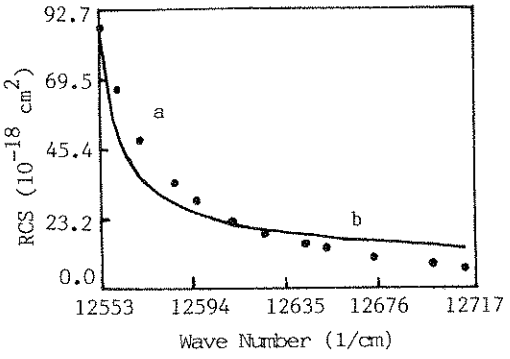

FIGURE 2
The curve b, the relation $\sigma(\hbar\omega) \propto E_c^{-\frac{1}{2}}$ has been compared with the theoretical value calculated by (3), curve a.

For the comparison $\sigma(\hbar\omega) \propto E_c^{-\frac{1}{2}}$ is also given as curve b in Fig. 2. Obviously, both curves a and b decrease with the increase of the electron energy. This means that the larger electron energy is, the smaller RCS is. The relation $\sigma(\hbar\omega) \propto E_c^{-\frac{1}{2}}$ is simpler for discribing RCS than formula (3). The maximum of RCS in our experiment is $\sigma(\hbar\omega)_{max} = 8.73 \times 10^{-17}$ cm^2 which is smaller than the geometric area of the acceptor A^o_{Li}, $\pi a^2 = 7.25 \times 10^{-16}$ cm^2.

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