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GROWTH AND PHOTOLUMINESCENCE OF CdTe SINGLE CRYSTALS

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High-purity CdTe single crystals with near stoichiometry and many Cd vacancies were grown using a sublimation method under controlled partial pressure of cadmium or tellurium, respectively. The very strong peaks of exciton emission for the former and a broad emission band for the latter are observed by photoluminescence at 10K. The broad emission band is considered to arise from the formation of V_{Cd} complexes.

1. INTRODUCTION

CdTe is a very promising II-VI compound material for use in solid-state nuclear detectors and solar cells. In general, grown crystals of CdTe contain high concentration of native defects such as Cd vacancies (V_{Cd}) which could then form a deep-level complex such as (V_{Cd}-In_{Cd}) with the In donors. This deep level affects the mobility or lifetime of the free carriers produced by the gamma-ray irradiation and solar energy excitation.

To study the behaviour of Cd vacancy, in this paper, high-purity CdTe single crystals with different concentration of V_{Cd} were grown by a sublimation method under controlled partial pressure of the constituent elements. Exciton emission spectra and a broad emission band are studied and discussed using photoluminescence.

2. EXPERIMENTAL PROCEDURES

The source material of CdTe is synthesized by the element reaction between the 7-N Cd and 7-N Te. Synthesized CdTe was refined through vapor phase transport two or three times under a controlled partial pressure of Cd corresponding to the minimum total pressure. A nucleating capsule with special shape, was designed[1] and single crystals were grown at 820 °C by sublimation method under controlled patial pressure of Cd corresponding to the minimum total pressure or partial pressure of Te which is the Te-rich side on the stoichiometric departure, respectively. The former crystal is labelled as sample (a) and the latter is labelled as sample (b).

Wafer specimens were cut from the grown crystal along the cleavage planes parallel to the growth direction <111>. The surface of wafer was etched using 5% Br-methanol for 20 sec. The photoluminescence spectra were measured on samples mounted in a cryostat and cooled to 10K. A Ar^+ laser was used as the excitation source. Spectra were recorded using a grating monochromator and a photomultiplier.

3. RESULTS AND DISCUSSION

On keeping ΔT=3-5 °C which is the temperature difference between the source chamber and the growth chamber, a single nucleus had been formed at the neck part of growth chamber. An x-ray diffraction study revealed that the CdTe single crystals have zinc-blende structure with their growth direction along <111> and the six columnar planes were {110} Planes.

The photoluminescence spectra at 10K are shown in Fig. 1. The first notable characteristic of sample (a) is that a broad emission band can barely be observed in the energy region lower than 1.57eV, several emission peaks are observed, which are amplified on the inset in Fig. 1. The peak Ex at 1.595eV is belived to be due to free exciton emission[2]. I_d at 1.592eV

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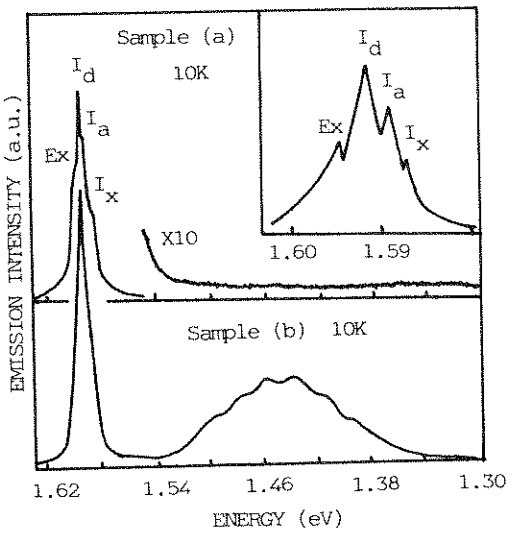

FIGURE 1
Photoluminescence emission spectra of CdTe at 10 K. (a) as-grown and nearly stoichiometric; (b) High-concentration of Cd vacancy; inset in Fig. 1(a): exciton emission spectra.

and I_a at 1.590eV are considered to originate from to neutral donors[3] and neutral acceptors[2], respectively. The peak at 1.587eV have not yet been identified, which is labelled as I_x. The peak at 1.590eV and emission band in the region 1.52-1.33eV are observed for the sample (b). This emission band consists of a lot of small peaks which are separated from each other by LO phonon energy about 20meV. Compared with the spectra of sample (a), the spectra of smaple (b) have strong emission band around 1.40eV with strong classical phonon replicas showing a Poisson distribution in energy. The band is sensitive to the partial pressure Cd in crystal growth process, and is virtually absent in crystal prepared by evaporation of Cd from Te rich melt. We considre that the emission band is connected with the formation of V_{Cd} complexes.

4. CONCLUSIONS

The concentration of V_{Cd} in CdTe crystals has relation with the partial pressure of Cd in the crystal growth precess. The strong emission band in the region 1.52-1.32eV is considered to be due to V_{Cd} acceptor complexes.

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