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THE LUMINESCENCE OF HIGHLY EXCITED CdS

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We measure the emission spectra of single crystal CdS from $10^6 W/cm^2$ to $10^7 W/cm^2$ excitation intensity at 4.2K, and observe a new luminescence peaking at 4910Å after the excitation intensity increases to 1.0 X $10^7 W/cm^2$.

1. INTRODUCTION

CdS single crystal is a very typical direct band semiconductor material, which is paid wide attention to in basic and applied research. There are a large number of papers dicussing the emission spectra of CdS, the luminescence characteristic of CdS under very low and very high excitation intensities having been known basically[1-4], that is, the luminescence of bound excitons in CdS is important on low excitation intensity, and the luminescence of electron-hole plasma is dominant on very high excitation intensity. The luminescence of CdS is quite complex on middle excitation intensity, so the causes of M band P band are not well known.

2. THE RESULTS OF EXPERIMENTS

The samples used in our experiments are very pure CdS crystals which are grown by the vapour phase epitaxy method, whose thickness is about hundreds μm. The samples are held in cryostat ESR-900 and cooled down at 4.2K±0.5, excited by a light beam of wavelength 308nm from the excimer laser EMG-102 XeCl, the single pulse energy is about 150mJ, the pulse duration is about 10ns and the pulse repetitions rate is 10Hz.

Fig. 1 shows the four emission spectra of CdS in the range of excitation intensities 10^6-- $10^7 W/cm^3$ at 4.2K. unter lower excitation intensity (a), the luminescence has mainly both 4869Å peak and 4888Å peak, which are the luminescence of excitons bounded to neutral donors(I_2) and excitons bounded to neutral accepters (I_1), respectively. A new luminescence band arises on the long wavelength of I_1 peak with an increase of excitation intensity while the intensity of I_2 peak is weakened. After the excitation intensity is increased to 1.74 X $10^7 W/cm^2$ the spectra is led by a new peak 4910Å, which we call U peak. U peak has only 3Å halfwidth. Fig. 2 shows variation with excitation intensities of U peak luminescence intensity. The front of the curve is approxiamately quadratic and the rear straight. We measure variation with temperature of U peak on constant exciation intensity, see Fig. 3.

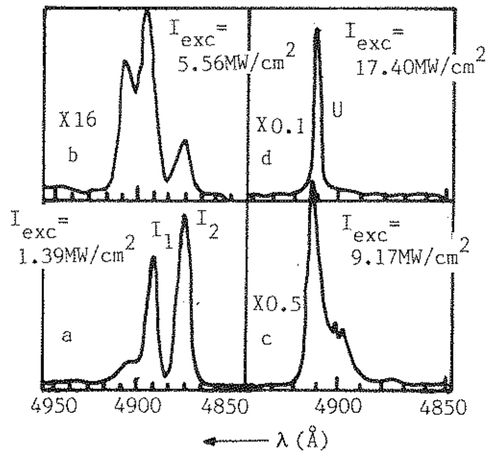

FIGURE 1
Luminescence spectra of CdS for different excitation intensities at 4.2K, hv_{exc}=4.02eV.

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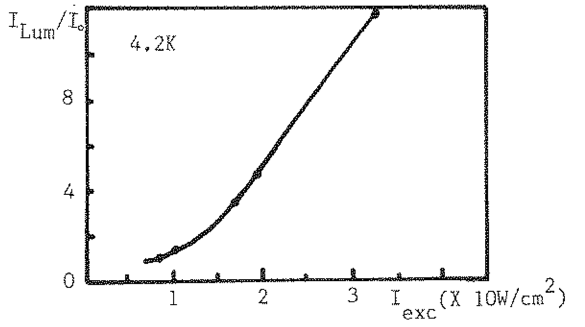

FIGURE 2
Variation with excitation intensities of U peak luminescence intensity I_{Lum} at 4.2K. (The luminescence intensity of I_0=9.17MW/cm^2 is regarded as an unit of luminescence.)

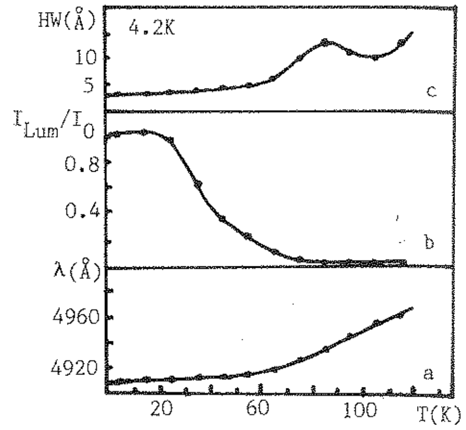

FIGURE 3
Variation with teperature of the emission maxima (a), luminescence intensity (b) and half width (c) of U peak. (Luminescence intensity I_0 at 4.2K is regarded as an unit of luminescence in (c).)

3. DISCUSSION

According to a reduction of I_2 peak when U peak arise, and ultra-linear variation of its luminescence intensity with excitation intensity, we think U peak as the luminescence of inelastic scattering of excitons with excitons bounded to neutral donors. When the density of excitons is very high in luminescence bodies, the scattering possibility of excitons with bound excitons becomes greater. After the scattering takes place, excitons are excited to higher energy states (n=2,3,...,) and bound excitons turn to luminescence by recombination. According to a prinple of energy converation in scattering course, we give energy formula of the peak,

$$h\omega_{max} = Eg(T) - E^b_x - E^b_{bx}(1-1/n^2) \qquad (1)$$
$$n = 2, 3, \ldots,$$

where Eg(T) is a width of forbidden band; E^b_x is a bound energy of excitons; E^b_{bx} is a bound energy of exciton bounded to neutral donor. When n = 2, $h\omega_{max}$ = 4909Å (T = OK). We derivate the relation between luminescence intensity of U peak and excitation intensity by means of the luminescence model of inelastic scattering of excitons with bound excitons

$$I_{Lum} = \frac{a}{1 + b\, I_{exc}} I^2_{exc} \qquad (2)$$

where a and b are all constant not relative to excitation intensity I_{exc}. We see that I_{Lum}–I_{exc} is ultra-linear on low excitation intensity and linear on high excitation intensity. This is basically agreement with behaviour of U peak.

4. CONCLUSION

We observed a new luminescence peak in CdS at 4.2K after excitation intensity is increased to 1.0 X 10^7W/cm^2. The peak is at 4910Å of the spectra and has only 3A halfwidth and quite high luminescence intensity. We propose the luminescence model of inelastic scattering of excitons with excitons bounded to neutrals donors for the peak.

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