Journal of Luminescence 40&41 (1988) 487–488
North-Holland, Amsterdam

PHOTOLUMINESCENCE AND THERMAL QUENCHING OF FREE EXCITONS UNDER NORMAL PRESSURE IN GaP:N*

Kai DOU, Xinyi ZHANG and Qiang HONG

Changchun Institute of Physics, Academia Sinica, Changchun, P. R. China

The free exciton of GaP:N under normal pressure has been observed for the first time with high density excitation. We have measured the value of binding energy of free exciton experimentally and discussed its binding energy.

1. INTRODUCTION

In 1966, D.G. Thomas and J.J. Hopfild[1] have studied the spectra of GaP:N, they proposed that the level of the free exciton in GaP doped with nitrogen is approximately 11 meV above that of the isolated nitrogen and the binding energy is about 22 meV. M.D. Sturge, E. Cohen and K.F. Rodgers[2] obtained the same results from the absorption spectra of GaP:N. Up to now no one observes directly the peak of free exciton in GaP:N in photoluminescence spectra. We have studied the photoluminescence spectra of GaP doped with nitrogen under high density excitation at low temperature. The zero phonon line of free exciton under an atmosphere pressure has been observed for the first time. We have also obtained its binding energy from the thermal quenching experiment.

2. EXPERIMENT RESULTS

The high density excitation experiment was carried out with an Excimer EMG 102 which can reach a maximum density of about 10^8 W/cm^2. The samples were GaP doped with nitrogen whose concentration range is from $5x10^{17}$ to $7x10^{18}$ cm^{-3}.

In figures 1 and 2, the photoluminescence spectra of GaP:N for various excitation densities are shown and the concentrations of N are $7x10^{18}$ and $5x10^{17}$ cm^{-3} respectively. We make use of the above-gap excitation. The excitation source is the 308 nm line of Excimer. The excitation density I_0 is 10^7 W/cm^2 in figures 1 and 2. The isolated nitrogen trapped exciton is labelled N_x and its TA phonon is lablled N_x-TA. The peak N_x increases with the excitation density at low temperature. When the excitation density is about 10^7 W/cm^2, we find a new peak N_0 which is 10.7±0.3 meV above the line N_x. We suppose that the peak N_0 comes from the luminescence of free exciton.

At the excitation density of $2x10^7$ W/cm^2 for [N]: $5x10^{17}$ cm^{-3} and $8x10^7$ W/cm^2 for [N]: $7x10^{18}$ cm^{-3} respectively, from the temperature dependence of peak N_0 we get its activation energy that is about 21±2 meV.

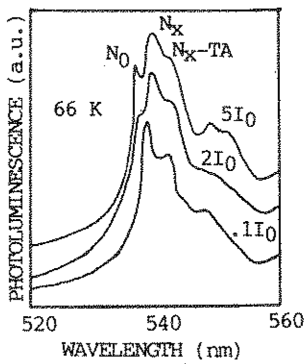

FIGURE 1

*Project supported by the Science Fund of Academia Sinica.

0022-2313/88/$03.50 © Elsevier Science Publishers B.V.
(North-Holland Physics Publishing Division)

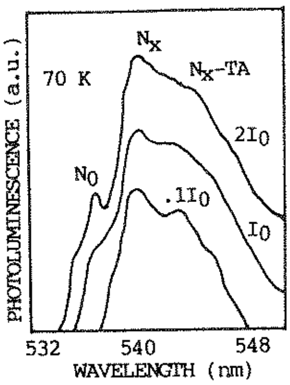

FIGURE 2

3. DISCUSSION

According to ref. 1 and ref. 2, it is well known that the energy level of free exciton is approximately 11 meV above that of the isolated nitrogen and its binding energy is about 22 meV. In the experiment error our results are in good agreement with ref. 1 and 2. Therefore we believe that the new peak N_0 appeared in spectra is due to the luminescence of free exciton.

As in our model of above-gap excitation[3,4], when GaP:N is excited by the light of above-gap energy, the free excitons are first created, then trapped by nitrogen impurities, then become into the bound excitons. They can transfer from one center to the others, and in the same center exists there the nonradiative relaxation between the substates A and B. The excitons may decay to the ground state by radiation or nonradiation. If the excitation density is not strong enough, free excitons are mainly trapped rapidly to become into bound excitons, in such case the luminescence of free excitons is too weak to be observed. The excitation density is so high that the deep centers of nitrogens and nitrogen pairs have been saturated with excitons, therefore the free exciton luminescence can be observed.

On the other hand, we have also found the luminescence of free exciton at 10 K with selected high density excitation of NN_1[5]. The reason is that excitons can transfer from deep level to shallow level, that is, from bound excitons to free excitons. This kind of inverse -transfer increases with the excitation density. We may conclude that the inverse-transfer caused by high density excitation is the reason why the free exciton luminescence is observed.

4. CONCLUSION

In the photoluminescence spectra of GaP:N, the peak N_0 comes from the radiative recombination of free excitons and its binding energy determined by our experiment is about 21±2 meV.

REFERENCES

1. D.G. Thomas and J.J. Hopfild, Phys. Rev. 150 (1966) 680.

2. M.D. Sturge, E. Cohen and K.F. Rodgers, Phys. Rev. B15 (1977) 3169.

3. Zhang Xinyi, C. Hirliman, M. Kanehisa and M. Balkanski, Scientia Sinica, A25 (9) (1982) 942.

4. Zhang Xinyi, Chinese J. of Luminescence, 5 (3) (1984) 1.

5. Hong Qiang, Dou Kai and Zhang Xinyi, Study on the luminescence of GaP:N under selective excitation of excitons bound to NN_1 centers, this volume.