CHARACTERISTICS OF LASER INDUCED LUMINESCENCE IN POLYACETYLENE*

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Characteristics of trans-(CH)₉₉ luminescence near the interband absorption edge and the doping effect on luminescence by implanted erbium have been investigated for the first time.

1. INTRODUCTION

Polyacetylene (PA) is the prototype conducting polymer because of the simplicity of its molecular structure. Its uniquely simple electronic structure has been a model for theoretical studies of 1-D semiconductors. However, due to its complicated fibrillar morphology, such important issues as the characteristic origin of laser induced luminescence of PA and the role of the doping effect have unresolved well as yet. In this contribution we give a study on the characteristics of luminescence near the interband absorption edge of trans-(CH)ₓ, and the variations of luminescence intensity after doping rare earth ion are reported in order to get a better understanding of the origin of the luminescence in PA.

2. EXPERIMENTAL

For photoluminescence studies, thin (5-10 micron) films of PA were synthesized by the methods of Shen Zhiquan et al. and Shirakawa et al. The trans-(CH)ₓ was obtained by the heat treatment of cis-(CH)ₓ at 190 °C for about 20 min. With cis-(CH)ₓ films at 300 K implantation fluences of 5x10⁻¹⁴-5x10⁻¹⁵ ions/cm² at an ion flux of 0.2 micro A/cm² and a beam energy of 80 Kev were used. Photoluminescence spectra were taken using a CDM-1000 double grating monochromator equipped with a photo-counting detector. An Ar⁺ laser (5145 Å) and a He-Ne laser (6328 Å) were used as light sources.

3. RESULTS AND DISCUSSION

In trans-(CH)ₓ, the degenerate ground state leads to free soliton excitations, absence of band-edge luminescence, but the photoluminescence of trans-(CH)ₓ in the near infrared range was observed experimentally. We have investigated further the characteristics of luminescence in trans-(CH)ₓ at 10−300 K. We find for the first time the strong luminescence peaked at 1.34 ev (excitation line 6328 Å) or 1.38 ev (excitation line 5145 Å) near the interband absorption edge. The luminescent intensity decreases with decreasing temperature. The intensity is quite weak at temperatures below 77 K.

These characteristics of luminescence of trans-(CH)ₓ cannot be interpreted simply by confinement of the photogenerated solitons. Alternatively, the behaviours of the luminescence originate in excited states of some segments.

In Fig.1 we show the effect of ion-implanted Er⁺ on luminescence at room temperature. Curve A shows the relatively broad photoluminescence band peaked at 2.19 ev and the multiple overtone Raman structure from cis-(CH)ₓ obtained at 300 K using 5145 Å laser line excitation; curve B shows the luminescence after cis-(CH)ₓ ion-implanted by erbium. The results show significant decrease in intensity even at the temperature as high as 300 K. Strong multiple order Raman lines

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The effect on luminescence of cis-(CH)$_x$ by erbium ion implantation, 300 K

We have estimated the time of intersoliton hopping in lightly erbium-doped (CH)$_x$ on the basis of phonon-assisted intersoliton hopping mechanism. In iodine-doped (CH)$_x$, the time required for an intersoliton hopping much less to the order of $10^{-13}$-10$^{-14}$ sec. In erbium-doped (CH)$_x$, this hopping time has the same order of $10^{-13}$-$10^{-14}$ sec at least, because of the ion radius (0.88 Å) of Er$^{3+}$ is smaller than the ion radius (2.20 Å) of I$^-$. The results indicate that the assistance from the vibrational motion of the dopant along the axis between two (CH)$_x$ chains can decrease the intersoliton hopping time. The present idea of intersoliton hopping will be important in the discussion of (CH)$_x$ conductivity.

REFERENCES