Photoluminescence Intensity Change of InGaAsN Quantum Well by Laser Irradiation

°(D)Sultan Md. Zamil[1,2*], Shuhei Yagi[1], Kengo Takamiya[1] and Hiroyuki Yaguchi[1]
[1]Saitama University, [2]Hajee Mohammad Danesh Science and Technology University
[*]E-mail: md.z.s.287@ms.saitama-u.ac.jp

Introduction

InGaAsN exhibits interesting properties and differs considerably from the conventional III–V alloys, such as InGaAs, AlGaAs and GaInAsP [1]. The large band gap bowing of InGaAsN makes it suitable to be used as an active material in long wavelength (1.3 or 1.55 μm) laser diodes [2] and multi-junction solar cells with improved efficiency [3,4]. The large difference in size between As and N atoms causes deformation of the crystal lattice in InGaAsN. Also, decreasing the epitaxial growth temperature for incorporating N atoms further results in poor crystal quality and defect generation. Since the generation of some defects causes the degradation of device performance during the operation, it is of great importance to evaluate such potential defects. In this study, therefore, we investigated the photoluminescence (PL) intensity degradation in InGaAsN quantum well (QW) due to laser irradiation.

Experimental Procedure

The samples used in this study was InGaAsN QW grown on GaAs (001) substrate by MOVPE. The N and In concentration of the sample were 0.5% and 25% respectively. Micro-PL was used for both the laser irradiation and the measurement of the emission intensity. To investigate the degradation of the PL intensity, the sample was exposed to the DPSS laser (532 nm) with the power densities ranging from 0.025 to 40 MW/cm^2 for 1000 s.

Results and Discussion

Figure 1(a) shows the time evolution of the PL spectrum observed from InGaAsN QW by laser excitation with a power density of 40 MW/cm^2. As seen from the figure, the PL intensity decreases significantly with the irradiation time. Figure 1(b) depicts the normalized integrated PL intensity as a function of irradiation time for various laser power densities. The decay curves were analyzed using the following expression based on the stretched exponential function

$$I(t) = I(0)\left[1 - A\left\{1 - e^{-\left(\frac{t}{\tau}\right)^{\beta}}\right\}\right],$$

The parameters A and τ represent the magnitude and time constant of the PL intensity degradation, respectively. It can be seen from figure 1(c) that A does not strongly depend on the laser power density. However, laser power strongly affects the parameter τ such that with increasing laser power densities, the PL decay becomes faster.

Conclusion

Detailed micro PL measurements were carried out to investigate the PL intensity change of InGaAsN by laser irradiation. The PL degradation is relatively constant for all laser power densities.

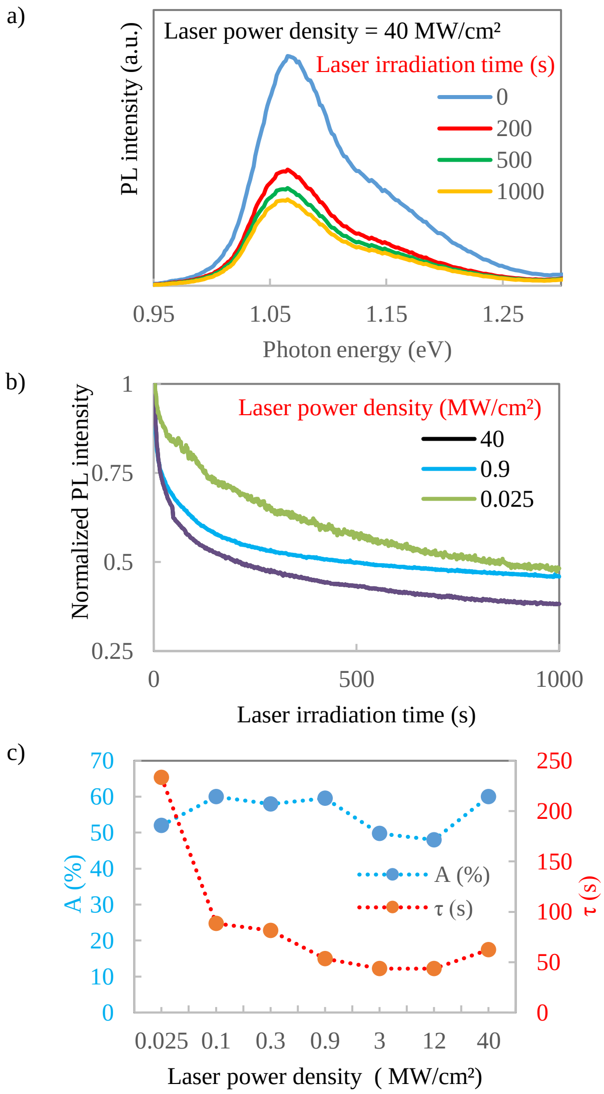

Fig. 1: (a) Time evolution of PL spectrum in InGaAsN QW by laser irradiation. (b) Irradiation time dependence of the PL intensity for various laser power densities. (c) Fitting parameters A and τ as a function of laser power densities.

Stronger laser irradiation leads to faster decrease in the PL intensity. The way proposed in this study would be very useful to evaluate potential defect generation which causes the deterioration of optoelectronic device during the operation.

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