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Recombination center in p-GaAsN grown by chemical beam epitaxy

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1. Introduction

(In)GaAsN alloys are attractive materials for application to ultra-high efficiency solar cell. They have significantly short minority carrier lifetime (τ < 1 ns), which is ascribed to the formation of non-radiative recombination centers [1, 2]. However, such recombination centers have not yet been clarified. We reported the hole trap H5 (E_a ~ 0.6 eV) in p-GaAsN acts as a recombination center [3]. DLTS signals of H5 had asymmetric shapes, which indicated that H5 signal was obtained as superposition of several signals. In this study, we experimentally show that H5 signal consist of one small signal and two dominant signals using Deep Level Transient Spectroscopy (DLTS) and Isothermal Capacitance Transient (ICT). DC-DLTS results indicated that one of dominant components acts as a recombination center.

2. Experiment

GaAsN (n^+-GaAs/n^+-$GaAs_{0.995}N_{0.005}$/p-$GaAs_{0.995}N_{0.005}$/ p^+-GaAs) was grown by Chemical Beam Epitaxy (CBE). In DLTS, filling pulse voltage (V_P) was 0.8 V with filling pulse times (t_P = 1 ms and 100 ms). Reverse bias voltage (V_R) was 2.0 V. Capacitance change (ΔC) at 300 K was obtained with duration of filling pulse width (t_p = 1 μs - 1 s).

3. Result and Discussion

DLTS spectra are shown in Fig.1 (A) as a function of temperature. Gaussian functions fitting indicated that H5 signal consists of three deep level states, a small signal C1 and two dominant signals, C2 and C3, (Fig.1 (A)). DLTS intensities of C2, C3 at 300 K corresponded to ΔC of C2, C3 obtained by ICT at 300 K. To clarify which components act as a recombination center, the changes of each DC-DLTS peak intensities were investigated (Fig.1 (B)). Only the peak intensity C2 of DC-DLTS signal decreased as compared with that of DLTS signal C2. This is direct evidence that the dominant component C2 acts as a recombination center. On the other hand, the peak intensities of C1 and C3 were constant. Therefore, these states are not recombination centers.

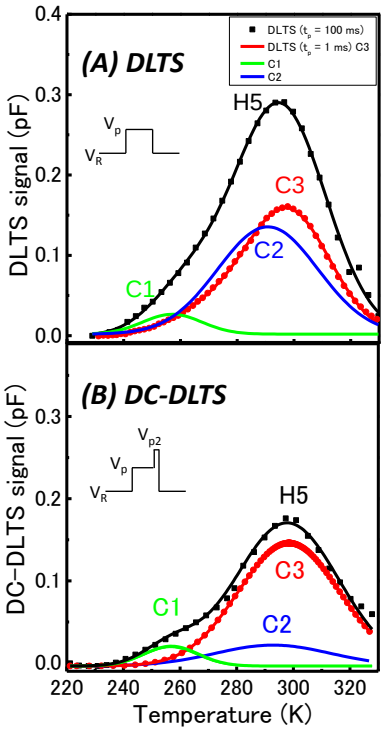

Fig.1. Effect of double carrier pulse injection in DLTS on the peak intensities.

4. Reference

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[3] H. Kowaki *et al.*, 74th JSAP autumn meeting, 19p-D3-4 (2013).