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## EFFECTS OF GROWTH CONDITIONS ON DEEP-LEVEL DEFECTS IN VPE AND LPE GaAs\*

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**Abstract.** - Studies of the deep-level defects in the VPE and LPE GaAs layers under various growth conditions have been made in this work, using DLTS and C-V techniques. In the VPE grown GaAs, characterization of grown-in defects vs. Ga/As ratio (i.e., 2/1, 3/1, 4/1, and 6/1) were made on GaAs layers grown on <100>, <211A>, and <211B> substrates. The two common electron traps observed in these samples were due to the EB-4 (i.e.,  $E_c - 0.71$  eV) level and the EL-2 (i.e.,  $E_c - 0.83$  eV) level. The density of these two electron traps was found to depend on the stoichiometry as well as substrate orientation. For examples, in the <211> orientation samples, the density of EL2 was found to decrease with increasing Ga/As ratio (e.g.,  $N_T = 1.2 \times 10^{14} \text{ cm}^{-3}$  for Ga/As = 2/1, and reducing to  $5.4 \times 10^{11} \text{ cm}^{-3}$  for Ga/As = 6/1). A similar result was also observed in the EB-4 electron trap. Low temperature (230°C) thermal annealing and recombination enhanced annealing studies on these samples showed significant reduction in the density of EB-4 trap and slight reduction in EL-2 trap density. For the LPE grown GaAs layers, two growth temperatures (700 and 800°C) and two temperature dropping rates (1°C/min. and 0.4°C/min.) were used. The DLTS and C-V measurements were made on these samples, and the results showed that only EB-4 electron trap (i.e.,  $E_c - 0.71$  eV) was observed in the LPE GaAs samples with 1°C/min. dropping rate. Details of our DLTS analysis of the grown-in defects vs. growth conditions in both LPE and VPE grown GaAs layers will be discussed in this paper.

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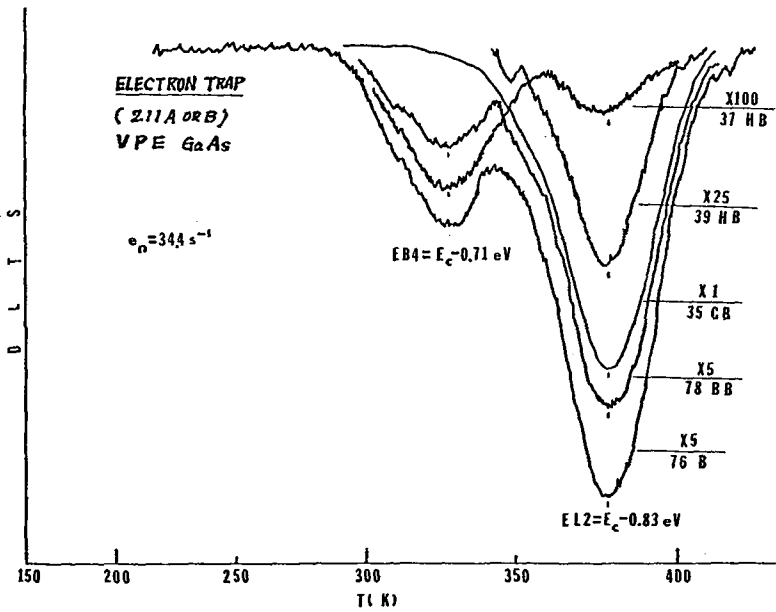


Fig. 1 DLTS scans of electron traps for VPE GaAs with <211> orientation

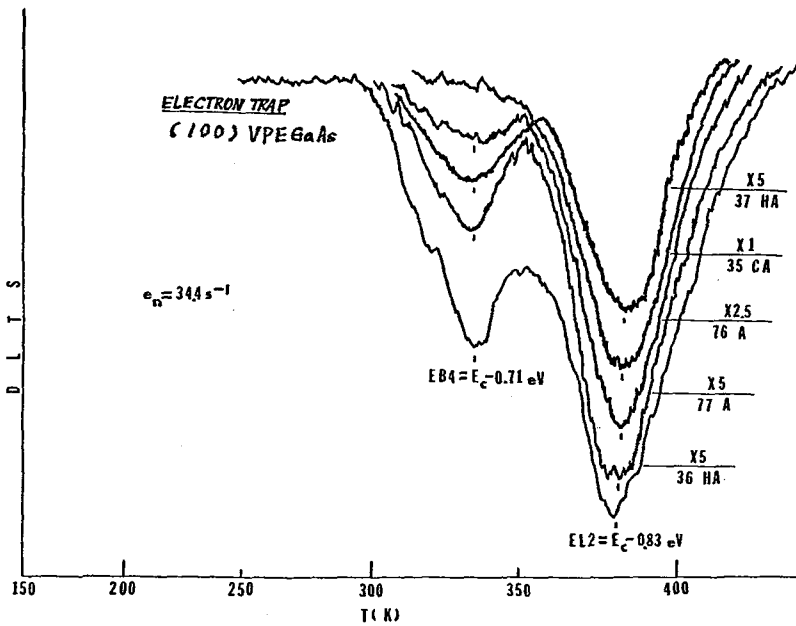


Fig. 2 DLTS scans of electron traps for VPE GaAs with <100> orientation

Sample No.	Orientation	$N_D$ ( $\text{cm}^{-3}$ )	Electron Traps				$N_{TT}/N_D$	$N_{TT}$ ( $\text{cm}^{-3}$ )	$N_{TT}/N_D$	Ga/As ratio	Growth Temp. ( $^{\circ}\text{C}$ )
			$E_T$ (eV)	$N_{TT}$ ( $\text{cm}^{-3}$ )	$N_{TT}/N_D$	$E_T$ (eV)					
75A	100	$7.2 \times 10^{14}$	-	-	-	$E_B = 0.71$ $E_C = 0.83$	$2.1 \times 10^{-2}$	$1.5 \times 10^{13}$	3/1	725	
76A	100	$3 \times 10^{15}$	-	-	-	$E_C = 0.83$	$7.3 \times 10^{-3}$	$2.2 \times 10^{13}$	4/1	725	
76B	211A	$5.5 \times 10^{15}$	EB4	$4 \times 10^{13}$	$7.3 \times 10^{-3}$	"	$9.6 \times 10^{-2}$	$9 \times 10^{13}$	4/1	725	
77A	100	$10^{15}$	"	$8 \times 10^{11}$	$8 \times 10^{-4}$	"	$2.6 \times 10^{-3}$	$2.6 \times 10^{12}$	4/1	725	
77B	211A	$7.2 \times 10^{15}$	"	$1 \times 10^{13}$	$1.4 \times 10^{-3}$	"	$1.7 \times 10^{-3}$	$1.2 \times 10^{13}$	4/1	750	
77BB	211B	$5.6 \times 10^{15}$	"	$1 \times 10^{13}$	$1.8 \times 10^{-3}$	"	$2.8 \times 10^{-3}$	$1.6 \times 10^{13}$	4/1	750	
78BB	211B	$1 \times 10^{16}$	"	$2.9 \times 10^{13}$	$2.9 \times 10^{-3}$	"	$1.4 \times 10^{-2}$	$1.43 \times 10^{14}$	5/1	725	
35CA	100	$6.7 \times 10^{14}$	-	-	-	"	$1.1 \times 10^{-2}$	$7.6 \times 10^{12}$	2/1	715	
35CB	211A	$1.7 \times 10^{15}$	-	-	-	"	$7 \times 10^{-2}$	$1.2 \times 10^{14}$	2/1	715	
36HA	100	$4 \times 10^{15}$	EB4	$2.4 \times 10^{12}$	$6 \times 10^{-4}$	"	$1 \times 10^{-3}$	$4.5 \times 10^{12}$	3/1	725	
37HA	100	$1.3 \times 10^{15}$	-	$2.5 \times 10^{12}$	$1.9 \times 10^{-3}$	"	$3.8 \times 10^{-3}$	$4.9 \times 10^{12}$	6/1	725	
37HB	211A	$3.1 \times 10^{15}$	-	$6 \times 10^{11}$	$1.9 \times 10^{-4}$	"	-	$10^{10}$	6/1	725	
39HB	211A	$7 \times 10^{14}$	-	-	-	"	$1.8 \times 10^{-3}$	$1.24 \times 10^{12}$	6/1	720	
78B	211A	$3.8 \times 10^{15}$	-	$4.3 \times 10^{13}$	$1.1 \times 10^{-2}$	"	-	-	5/1	725	

Table 1. Electron Traps in VPE GaAs as functions of Ga/As ratio and substrate orientation