Surface Photovoltage in Electron Beam Irradiation Semi-insulating GaAs

Jae-In Yu†, Jin-Hwan Lim*, Jae-Yong Yu* and Ki-Hong Kim**

Abstract - Surface photovoltage (SPV) measurements were performed to investigate the optic-electrical properties in the electron beam irradiation semi-insulating GaAs (e-beam irradiation SI-GaAs) and semi-insulating GaAs (SI-GaAs). The signal intensity showed stronger dependency on the frequency in the SI-GaAs than it did in the e-beam irradiation SI-GaAs. This result indicates that the number of the generated photo-carriers depends on the surface state. Also, the B region of the e-beam irradiation SI-GaAs found a weak signal. This result was explained by the surface and internal damage with e-beam irradiation.

Keyword: Surfacephotovoltage, GaAs, E-Beam

1. Introduction

Surface photovoltage (SPV) spectroscopy is a powerful contact-less technique to study the diffusion length of minority carriers, variation of surface potentials, distri-*bution of surface states and band bending at surfaces and interfaces [1, 2].

Knowledge of the behavior of the band bending at semiconductor surfaces and interfaces under photo-excitation, i.e. the SPV, is important for the photovoltaic device modeling, and for the correct analysis of the surface techniques, that apply light probes

and sense the surface electric field (e.g. light-modulated contact potential difference measurements [3, 4, 5]).

In this work, we report on SPV studies of e-beam irradiation Semi-insulating GaAs (SI-GaAs). The SPV signal originates from a modulation of the built-in field in the samples due to the formation of a steady-state distribution of photo-generated carriers. In order to establish an SPV signal, carrier photo-generation should occur in a space-charge region (SCR) or within a minority diffusion length of the SCR [6, 7]. Consequently, an SPV measurement contains information about optical and electrical processes occurring in the structure (main research project: explain damage effect by e-beam irradiation). The sample response was measured using a digital lock-in amplifier while maintaining a constant photon flux throughout the spectral region under study.

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Received July 20, 2006 ; Accepted October 10, 2006

2. Experiment

The SI-GaAs samples used in this study were grown by molecular beam epitaxy (MBE). A 6^{o} off-axis electron implantation at room temperature has been performed at the doses of 10^{16} and 10^{15} cm^{-2} by the used linear acceleration (Model: varian 21EX, by its exposure to 6 MeV electron beam). The SPV measurements were performed at 300 K. SPV spectra were taken using light from a quartz halogen lamp dispersed by a 0.75 m monochromator as the excitation source. This light was modulated at a frequency of 100 ~ 800 Hz using a mechanical chopper.

3. Results and discussion

Room temperature SPV spectra from SI-GaAs and e-beam irradiation SI-GaAs samples are shown in Fig. 1. The curves reveal two transitions indicated by A and B in the figure. Feature A in the e-beam irradiation SI-GaAs curve originates from the GaAs band gap transition (E_o). Also the same feature in the SI-GaAs sample is related GaAs band gap transition. Feature B in the e-beam irradiation SI-GaAs curve originates from e-beam irradiation induced defect. However, this B feature is not seen in the SI-GaAs sample. And the value of the physical parameters calculated from the SPV measurements at 300 K is summarized in Table 1.

The peak position of E_o for the e-beam irradiation SI-GaAs is a small difference for the SI-GaAs. This result is due to the increased concentration of electron in the e-beam irradiation SI-GaAs. The frequency dependence of the SPV spectrum intensity of the SI-GaAs and e-beam irradiation SI-GaAs are shown in Fig. 2 (a and b).

Table 1. The values of the physical parameters calculated from the SPV measurements at 300 K.

Samples	"A" region	"B" region
SI-GaAs	GaAs band gap transition (E_o : 1.40 eV)	No appearance
e-beam irradiation SI-GaAs	GaAs band gap transition (E_o : 1.41 eV)	Defect Induced e-beam irradiation (1.58 eV)

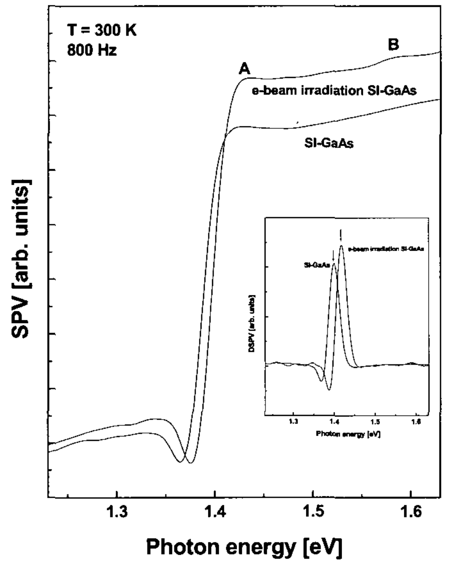
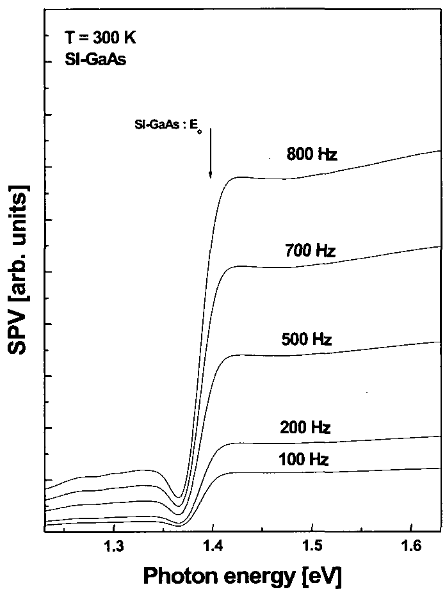


Fig. 1. Room temperature SPV spectra. Inset, DSPV spectra of SI-GaAs and e-beam irradiation SI-GaAs at 300 K.



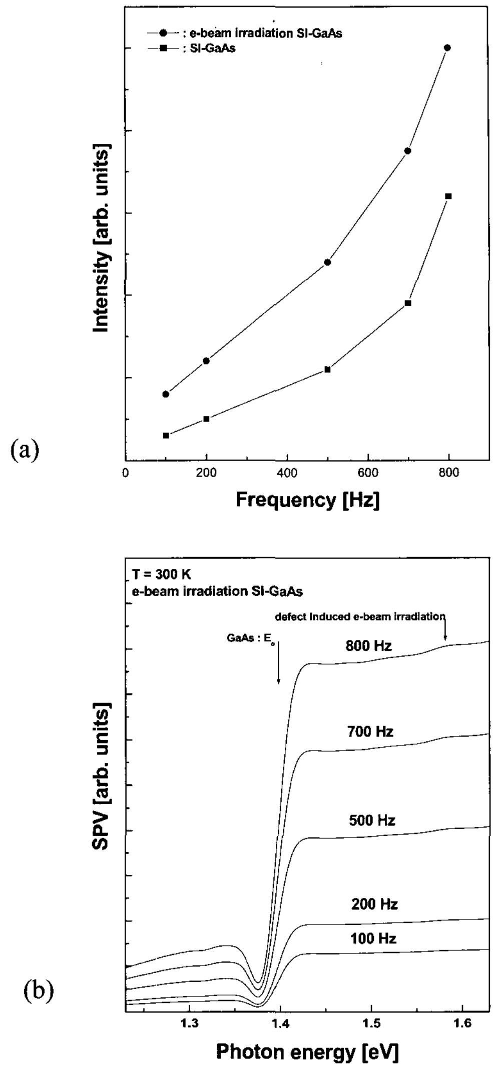


Fig. 2. (a) The frequency dependence of the SPV signal intensity of the SI-GaAs and e-beam irradiation SI-GaAs. (b) The graph concerning frequency dependence of the SPV signal intensity of the SI-GaAs and e-beam irradiation SI-GaAs.

In Fig. 2(a), in the SI-GaAs the signal intensity strongly depends on the frequency more than the e-beam irradiation SI-GaAs. This result indicates that the number of the generated photo-carriers depends on the surface state. Furthermore, the B region of the e-beam irradiation SI-GaAs found a weak signal. This result was explained by the surface and internal damage with the e-beam irradiation

4. Conclusion

The SI-GaAs samples grown by MBE were characterized by room temperature SPV measurements. In SPV spectra, the curves reveal two transitions indicated by A and B in the figure. Feature A in the e-beam irradiation

SI-GaAs curve originates from the GaAs band gap transition. And the B region of the e-beam irradiation SI-GaAs found a weak signal. This result was explained by the surface and internal damage with the e-beam irradiation.

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