Time-Resolved Photocurrent Spectroscopy of an LPE-Grown GaAs/AlGaAs Heterojunction Device

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INTRODUCTION

GaAs-based devices have recently found widespread use in modern telecommunications. Being a direct band-gap semiconductor, GaAs- boasts of better efficiency and faster carrier recombination rates than its more popular indirect-gap silicon counterpart (Sze, 1969). GaAs LED's, lasers, and photodetectors are the common choice used in fiberoptic communications. Discrete components such as high-electron mobility transistors (HEMT) used in satellite communication are now fabricated using GaAs-based devices (Laniog, 2000). The Condensed Matter Physics Laboratory of the National Institute of Physics, UP Diliman has recently been successful in growing a GaAs/AlGaAs pn heterojunction by Liquid Phase Epitaxy (LPE) (Laniog, 2000). In this paper, the authors present results on the study of the optoelectronic characteristics of this device by photocurrent (PC) spectroscopy. Direct pump-and-probe methods were also employed to measure the transient response of the PC signal of the GaAs/AlGaAs pn junction.

METHODOLOGY

The details of the sample's growth and preparation are discussed elsewhere and will not be elaborated in this paper (Laniog, 2000). The spectral response of the GaAs/AlGaAs pn junction was obtained by operating the sample in a photodetector configuration. Figure 1 shows the optical setup that was used for the room temperature PC measurements. The wavelength-dispersed broadband excitation system is similar to the setup that was used for photoreflectance spectroscopy of GaAs quantum well structures (Salvador et al, 1998).

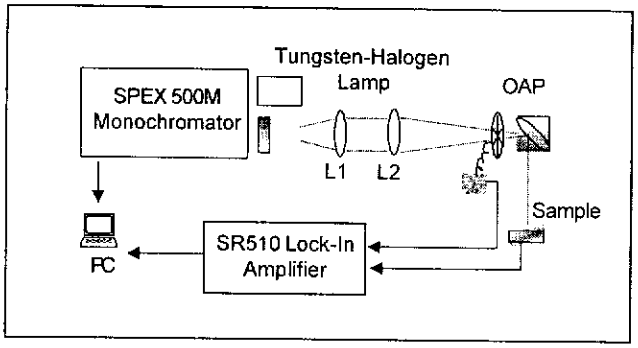

Fig. 1. The experimental setup for the PC spectroscopy experiment

Ohmic indium contacts were soldered on the sample and the photo-induced current was fed to an SR510 lock-in amplifier. System control and data acquisition were done by computer.

Time resolved PC measurements were also performed to determine the transient response of the PC signal. The pump wavelength was fixed at the peak of the PC output (8960 Å). It was mechanically chopped at ~200Hz, producing a nearly square optical pulse with a 50% duty cycle and a pulse width of ~2ms (the pump was sampled using a New Focus InGaAs/PIN photodetector with a response time of 1 ns). The temporal characteristics of the pump and the PC signal were both monitored by a Tektronix TDS420A digital oscilloscope. Signal to noise ratio was improved by passing both the pump and the PC signals through an SRS570 low-noise pre-amplifier in lieu of the lock-in amplifier. We emphasize that pulse broadening and pulse delays introduced by the data acquisition electronics were all taken into account and the temporal resolution we achieved was largely limited by the time response of the sampling commercial photodetector.

RESULTS AND DISCUSSION

Photoluminescence spectroscopy was done to confirm the quality of the GaAs and the AlGaAs layers and the I-V characteristics of the device were also previously determined (Salvador et al., 1998). The breakdown voltage was found to be ~−1.5V. Fig. 2 shows the sample's PC spectrum for different applied reverse-bias voltages across the junction. An increase in the PC signal is observed for increasing reverse-bias down to the breakdown voltage region; after which the PC signal begins to deteriorate. At this point, the device is beyond its normal operation. The increase in the photocurrent is due to better collection efficiency of photoinduced carriers effected by the applied electric field.

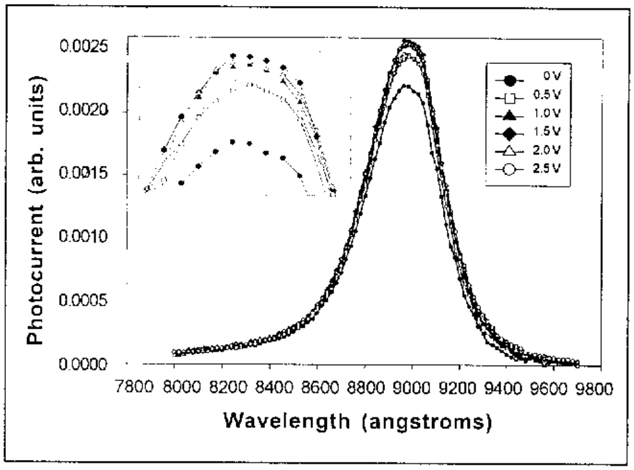

Fig. 2. PC spectra of the LPE-grown GaAs/AlGaAs heterojunction for different reverse-bias voltages

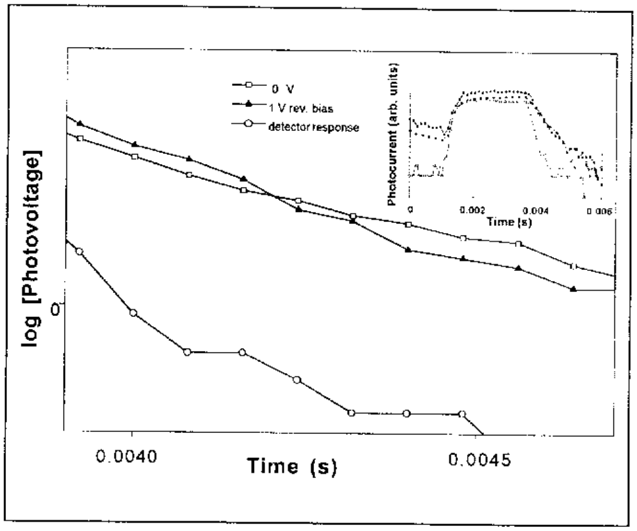

Fig. 3. Temporal profile of the PC signal of the pn junction showing a faster time constant for an applied reverse bias voltage

Fig. 3 shows the transient response of the PC signal in comparison to the excitation pulse as sampled by the InGaAs/PIN photodiode. The decay times for the time-resolved data were all fitted with a first-order exponential decay model. The decay time of the excitation pulse is found to be 0.25 ms. This observed decay time is mainly attributed to the mechanical chopper not being able to produce a true square pulse. With the detector having a much faster response of 1 ns, this decay time may be presumed to be characteristic of the excitation pulse. A faster decay time of 0.33 ms is observed with the application of a reverse bias voltage of 1V as compared to a 0.41 ms decay time of the PC signal for the unbiased sample. The faster decay time of the biased sample is again attributed to the increased collection efficiency of photoinduced carriers across the pn junction. The effect is such that the photoinduced carriers are swept to the other side of the junction at a faster rate.

ACKNOWLEDGMENTS

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