Simulation and Measurement of Optoelectronic Performances of InP/InGaAs Heterojunction Bipolar Phototransistor

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Abstract

Physical modeling of an InP/InGaAs phototransistor using a two dimensional finite elements program was performed. A good agreements were found with measurements. A large-signal model of the phototransistor has been developed and implemented in MDS.

Introduction

Over the years, Heterojunction Bipolar Phototransistor (HPT) have been found to be extremely fast and low noise detectors of optical signals [1]. Combining detection, amplification and mixing in the device results in considerable simplification of the receiver design, and provide an opportunity for new applications [2]. InP/InGaAs HPT offers numerous advantages due to superior material properties [2] [3]:

* High Γ-L valley separation which leads to pronounced velocity overshoot and shorter transit times.
* Large valence band discontinuity to suppress hole injection which results in higher current gain.
* Lower surface recombination (10^3 cm/s as opposed to 10^6 cm/s for GaAs) velocity which allows lateral scaling of the emitter without compromising gain
* Small bandgap which reduces the turn on voltage and minimizes power consumption.
* High carrier mobility .
* Compatibility with 1.3-1.55 μm lightwave communication systems.

A two dimensional numerical simulation of different configurations of phototransistors with different types of optical illuminations have been performed using a finite elements with ATLAS simulators. Results are compared to measurements done on phototransistors realized in InP technology of CNET. These different structures are simulated to study the effect of the beam of light position on the performances of the HPT. Physical modeling allows to optimize the performance and understanding the interaction phenomena between material and light.

Phototransistor static and small signal simulations

A first step consisted in the validation of the software. All important parameters of the device such as carriers lifetimes, recombination's coefficients, etc. were fitted. It was realized by comparison with results of measurements. Figure 1 shows the structure used in 2D simulation. Figure 3 shows a comparison between the collector currents obtained with the previous structures versus light intensity. The frequency response of the HPT to a modulated optical signal is shown in fig.4. This characteristic shows the linearity of the HPT as a function of optical power and the good associated dynamic range. This static and AC simulations were used to develop a new large signal HPT model (Fig.2) witch is in good agreement with numerical simulations.

Bibliography

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Figure 1

HPT lightened between emitter and collector

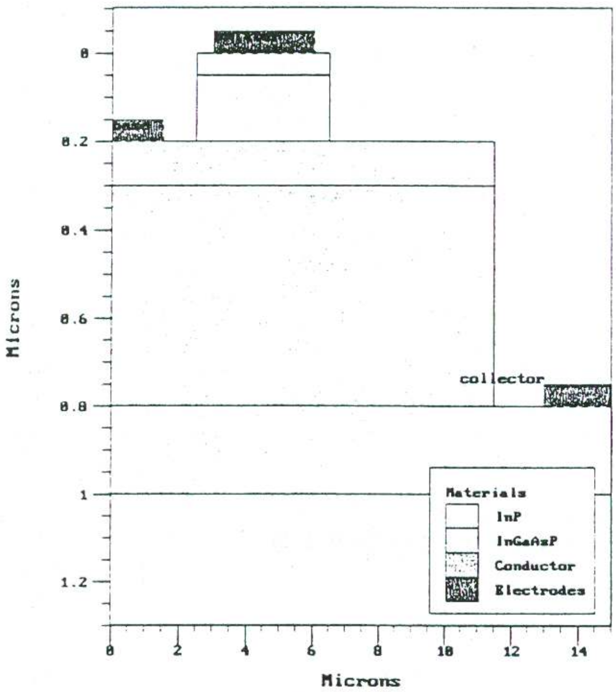

Figure 2
Large signal HPT model

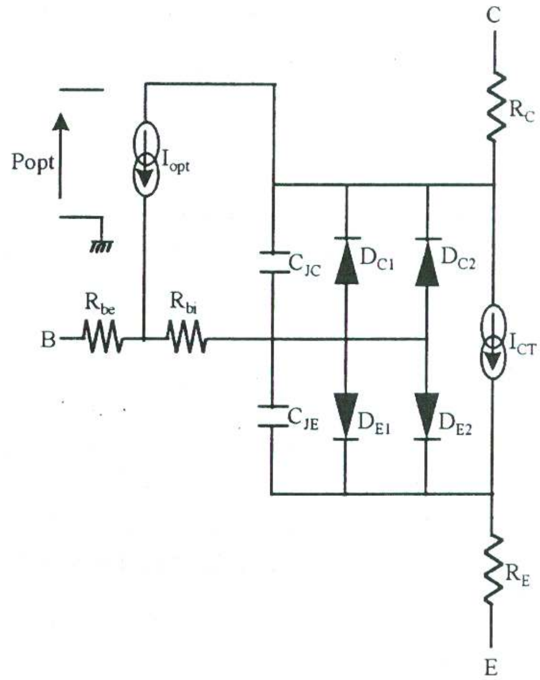

Figure 3

HPT collector current versus light intensity

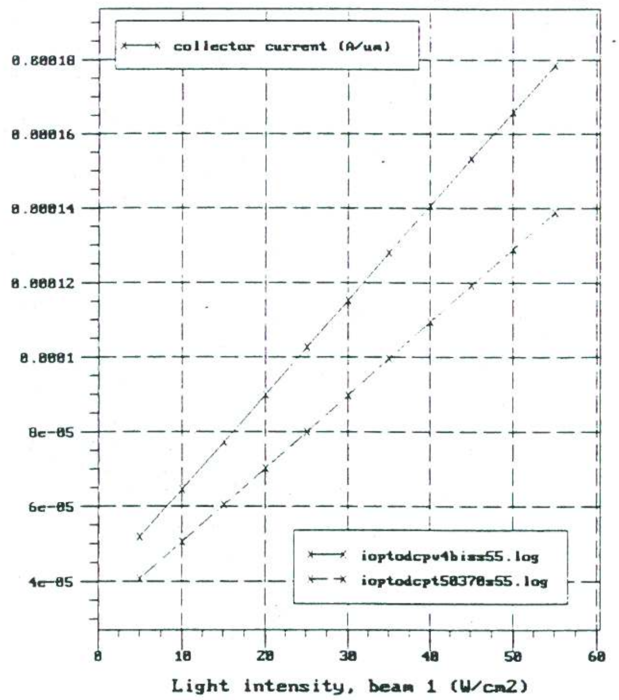

Figure 4

HPT collector current versus frequency