Monte Carlo Analysis of Transient Response for MSM photodetector

Y. Amiri and M.Soroosh*
Department of Electrical Engineering, Islamic Azad University, Abadan, Iran
* Department of Electrical Engineering, Shahid Chamran University, Ahwaz, Iran
e-mail: m.soroosh@scu.ac.ir

Introduction

Metal semiconductor metal photodetectors (MSM-PDs) have become attractive for optical communication systems. They have several advantages such as the low dark current, low capacitance and high speed [1].

In this paper, we present a 2D ensemble Monte Carlo (EMC) model to calculate the transient response for optical pulse illumination of a GaAs MSM photodetector. We simulate the trajectory of electrons and holes to solve the Poisson equation. In next section, we introduce the MC model and finally, we compare our results with another simulation results [2].

Monte Carlo Model

Our model includes two valleys (Γ and L) and two bands (heavy and light) for electrons and holes respectively. We assume the non parabolic-spherical bands for both electrons and holes. As a initial condition, electrons and holes moves in Γ valley and heavy hole respectively.

The charge of each particle is assigned to a particular mesh point using the cloud-in-cell (CIC) scheme. All carriers are followed for an interval of time δt, the field adjusting time step, chosen to be 70 fs. At the end of this time step, the distribution of electric potentials and fields is obtained from Poisson equation to determine the electrostatic potential at the mesh points. In connection to EMC simulation, a finite difference (FD) scheme is used. The photons are equally absorbed in the same surfaces, whereas are exponentially absorbed in depth of device. To do this issue, we employ the rejection technique and use two random numbers.

The number of absorbed photon in time steps is obtained by optical energy, duration of illumination and light wavelength. Each photon is equaled by an electron-hole pair and difference of its energy and band gap is divided to electron and hole equally.

Results

we simulate the time response of a MSM photodetector (Fig.1) whose parameters are given in Table I. Figure 2 compares MC simulation results for the pulse energy of 2pJ and bias voltage, 3V (L=2W=3 μm) with [2].

Figure 2 shows that the time response initially consists mainly of electrons and holes are responsible for tailing of response. The initial dominance of electrons is due to their higher mobility or lower effective mass than holes. The response time was found to consist of three components: a fast initial peak due to velocity overshoot in the Γ valley electrons, a slow secondary steady state electron response, and a slow steady state hole response. The potential and electric filed distributions are shown in Fig. 3 and 4 respectively.

CONCLUSION

We have presented an efficient Monte Carlo model which can solve Poisson equation and calculate the transient response of GaAs MSM photodetector for an optical pulse illumination.

REFERENCES

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[2] S. V. Averine, R. Sachot, *Effect of optical excitation signal intensity on the impulse response of a metal-semiconductor-metal photodiode* ,Technical phys **54,** 1490 (2009).

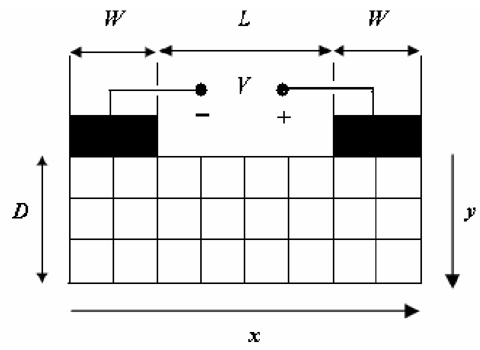

Fig. 1. Mesh layout in the MSM-PD model.

Parameters	Value (unit)
Finger width	3 (μm)
Finger spacing	3 (μm)
Depth	10 (μm)
Wavelength	850 (nm)
Bias voltage	3 (V)
Optical energy	2 (pJ)

Table I. Parameters of the simulated devices.

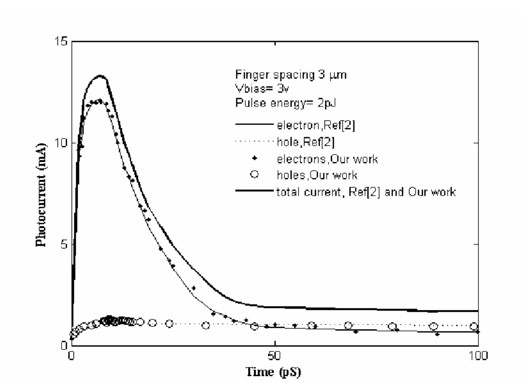

Fig. 2. compare our Monte Carlo simulation results with [2].

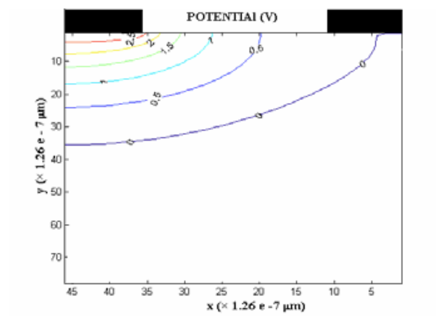

Fig. 3. Spatial distribution of the electric potential in the unit cell of GaAs MSM–PD.

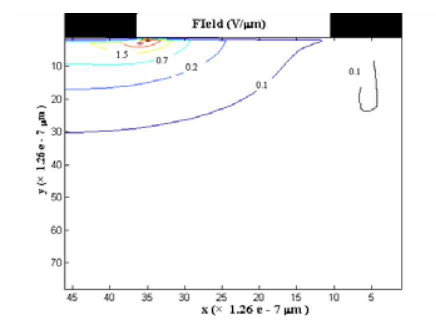

Fig. 4. Spatial distribution of the electric field in the unit cell of GaAs MSM–PD.