Implementation of Light Activated Opening Switch in Silvaco

Maryam Shafiei, Benyamin Davaji
University of Tehran
Tehran,Iran
shafiei_maryam@yahoo.com,bendavaji@yahoo.com

Abstract- in this paper we are going to implement a bulk silicon material as a light activated opening switch and obtain the characteristics and relations of different parameters of a light activated opening switch by simulation in Silvaco software.

I. INTRODUCTION

Light activated opening switches(LAOS) use external optical excitation to create photocarriers in the device in a controlled manner. properties of low capacitance and inductance, sub-nanosecond rise time and jitter and extremely fast recovery have attracted interests for many applications. ultra-wideband Radar transmitters have a need for high power, fast rise time switches ,recover rapidly and operate reliably for over 10^{18} shots.[3] also these switches are used in generation of high power microwaves (HPM) [2]and in inductive power systems which there is need to handle high commutation voltage and current. optical trigger control can be used to avoid avalanche breakdown and current constriction during commutation.[1]

this paper describes characteristics of LAOS by implementing a test device in SILVACO Technology Copmuter Aided Design (TCAD) tools. Lot's of reports remark that Silvaco models and simulations preformed close to the actual exprimental results [6].

II. LIGHT ACTIVATED SILICON OPENING SWITCH APPROACH

A LAOS we intend to design is a bulk silicon material with two Schottky contact barrier electrodes as illustrated in fig.1.illuminating the bulk region generates electron-hole pairs that carry external circuit current. the device is turned off when eliminating optical trigger source.

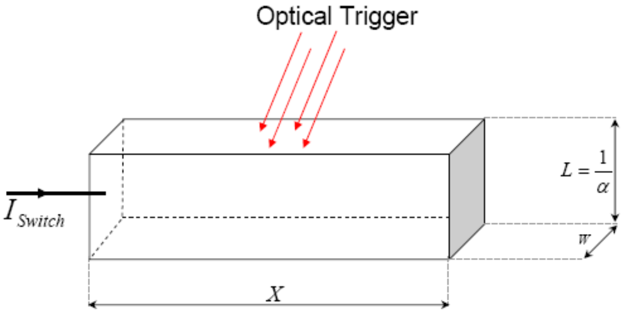

Fig.1.a silicon bulk with tow electrodes as a light activated opening switch

To obtain the dimensions of the bulk, we use the following equation:

$$\frac{I_{abs}}{I_{ill}} = 1 - \exp(-\alpha L) \qquad (1)$$

Where α is absorption coefficient. Equation (1) shows the proportion of light intensity absorbed to the light intensity illuminated . Thus for high absorption we should have[4]:

$$L > \frac{1}{\alpha} \qquad (2)$$

We choose a silicon bulk thickness of about 50um.[4]. We choose the wavelength of source beam λ=0.9um to provide the optical energy $h\nu = 1.37ev$ more than $E_{g(Si)} = 1.1ev$.

III. IMPLEMENTATION

The on-state resistance of the photoswitch is [1]:

$$R_{on} = \frac{x^2.E_{ph}}{\eta P_0 \tau_r \mu} \qquad (3)$$

Where x is contact separation, E ph is bandgap separation, η is quantum efficiency which represents the number of carrier pairs generated per photon observed., P_0 is optical power, μ is carrier mobility and τ_r is carrier lifetime less than carrier transit time.[1]

quantum efficiency can be readily calculated by dividing the current from one of the device electrodes by either the source photocurrent or the available photocurrent.[5]

As we know, when voltage has a constant value, $R \propto \frac{1}{I}$ .notice that in (3), $R_{on} \propto \frac{1}{p_0}$. we can observe the direct relation between optical power and switch on state current if there is enhancement in Po ,Ion will linearly increase. it is illustrated in fig. 2 .

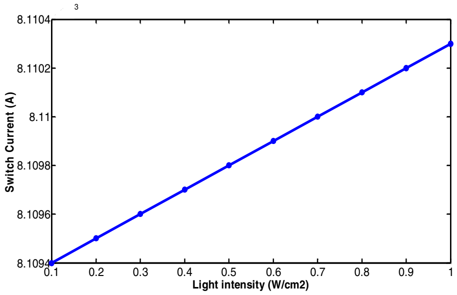

Fig.2 .Switch current versus light intensity.

The available photocurrent can be thought of as a measure of the rate of photo absorption in the device expressed as a current density. It is given by(4)

$$I_A = q\frac{B\lambda}{hc}\sum_{i=1}^{N_R} w_R \int_0^{x_i} P_i \alpha_i e^{-\alpha_i L} dl \qquad (4)$$

Where λ is source wavelength , w is the width of the beam including the effects of clipping and B is beam intensity in the units of w/cm^2.

The sum is taken over the number of rays traced, NR. *WR* is the width of the ray. The integral is taken over the length, X*i*, associated with the ray. *Pi* accounts for the attenuation before the start of the ray due to non-unity transmission coefficients and absorption prior to the ray start. αi is the absorption coefficient in the material that the ray is traversing[5]. available photocurrent versus light intensity is shown in figure 3.

the photogeneration rate is[5] :

$$G_0 = \eta\frac{p^*\lambda}{hc}\alpha e^{-\infty L} \qquad (5)$$

Where :

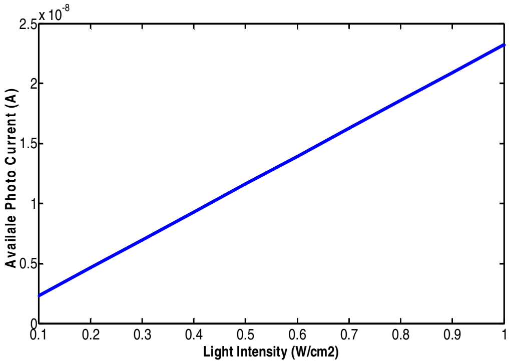

Fig.3.Available photocurrent as a function of light intensity

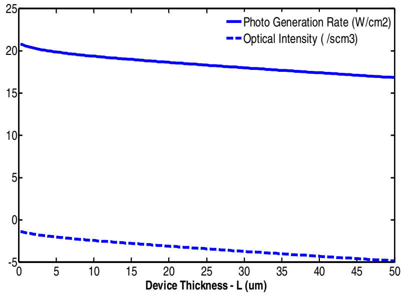

Fig.4.Photogeneration rate as a function of thickness.

*P** contains the cumulative effects of reflections, transmissions, and loss due to absorption over the ray path[5]. *L* is a relative distance from the beam illuminated .Photogeneration versus thickness of device is shown in fig.4. as we prospect by increasing the thickness, photogeneration rate decrease as a function of optical intensity.

IV. CONCLUSION

We designed and tested a bulk silicon material with two electrodes , and an optical gate to illuminating on, biasing with a constant voltage, as a LAOS . Simulation results reveal a good current interruption behavior depending on trigger optical intensity and device dimensions. This concept could be applied for other light activated semiconductor devices and materials in which doping is an issue. Topics such as switching behavior and leakage current reduction remain points for future research.

V. REFRENCES

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