IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper **Volume-5, Issue-3** **E-ISSN: 2347-2693**

Nano- Wire Structure Optimization to Achieve High Sensibility and Frequency Response

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Available online at: www.ijcseonline.org

Received:16/Jan/2017 Revised: 23/Jan/2017 Accepted: 20/Feb/2017 Published: 31/Mar/2017

***Abstract*—In this paper the structure of Nano- Wire would be optimized to achieve high sensibility and frequency response. To perform this optimization, the length of Nano- Wire g region and the thickness of absorber layer will be optimized. Silvaco software is used for simulation and optimization. The proposed structure includes a window profile is used for Nano- Wire.**

***Keywords*— Nanowire, Doping, Grating.**

I. INTRODUCTION

A Nanowires have a broad range of application including infrared sensors for optical fiber communication, computer, military and electronic system. Nano- Wire is the most widely known detector in optical applications because its sensitivity in the operating wavelength is so high, high response speed and low noise. This is because the depletion region thickness (the intrinsic layer) can be tailored to optimize the quantum efficiency , transient response and frequency response [1]. The development of a lateral Nano- Wire based on silicon absorption layer is pursued because of its compatibility in monolithic integration of CMOS-based photonic devices as well as low cost and robustness of the silicon material itself. The main properties of a Nanowire often considered in analysis are its responsivity and frequency response. Ramaswamy et al. [2] reported a frequency response of 4.38 GHz at 5-V bias for a 7.4 µm intrinsic. width photo detector on silicon-on-insulator (SOI (technology exhibited frequency response of 8.7 GHz and responsivity of 0.018 A/W at 11.4-V bias [3]. In another research by Fujikata et al. [4] silicon nano- Nanowires produced a frequency response of 5 GHz at 850 nm optical wavelength. Feng et al. [5] produced a Nano- Wire -modulator on silicon-on-insulator (SOI) substrate, with a frequency response of 12 GHz at 8-V bias voltage. Totsuka et al. [6 [reported a responsivity of 0.34 A/W at 590 nm optical wavelength for the dimension of 1.18 mm (width) x 3.8 mm) length) x 5.0 mm (thickness). The active photo absorption layer of Nano- Wire must be as thick as 1 µm to obtain high quantum efficiency and low bias voltages from 2 to 7 V and can be used for optimum operation with low dark current and high speed [7 .[In this paper, an investigation on the optimization of process parameters on the frequency response and responsibility Nano- Wire - Nanowire.

II. NANO- WIRE Simulation

In this part, a NANO- WIRE with conventional doNano- Wire g profile is presented and then its structure parameters will be optimized. Then, a proposed doNano- Wire g profile is used to increase responsibility. Figure 1 shows the 3-D structure of conventional NANO- WIRE . The figure shows the profile of doNano- Wire g as well.

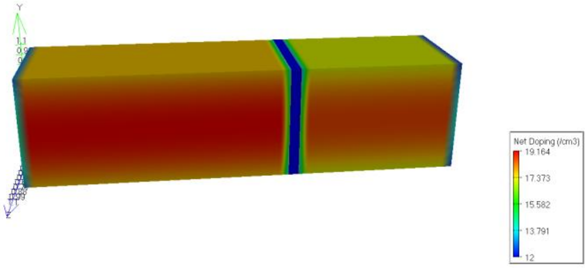

Figure 1 the structure of NANO- WIRE

Figure 2 shows simulation results of this structure. In fact, this figure shows photo current as a function of the intensity of incident light. One can see that as incident light is increased the produced photo current is increased and the maximum of photo current is 2 nA. In the next, an optical pulse is incident to and the photo current response is simulated. Figure 3 shows the simulation result of this response. Then, light with different wavelengths is incident and the influence of wavelength on current of Nanowire is investigated. The simulation results of this is shown in figure 4. One can see that with increase of wavelength, the photo current is increased and its maximum is 0.7 um.

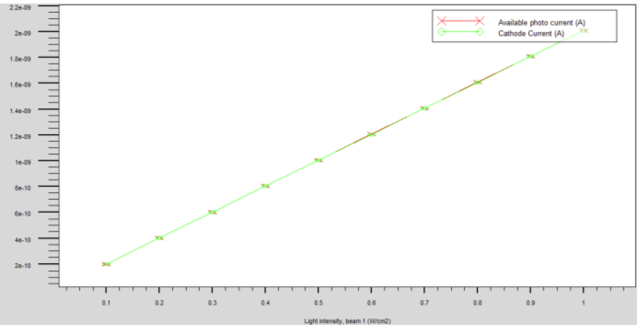

FIGURE 2. PHOTO CURRENT AS A FUNCTION OF INCIDENT LIGHT.

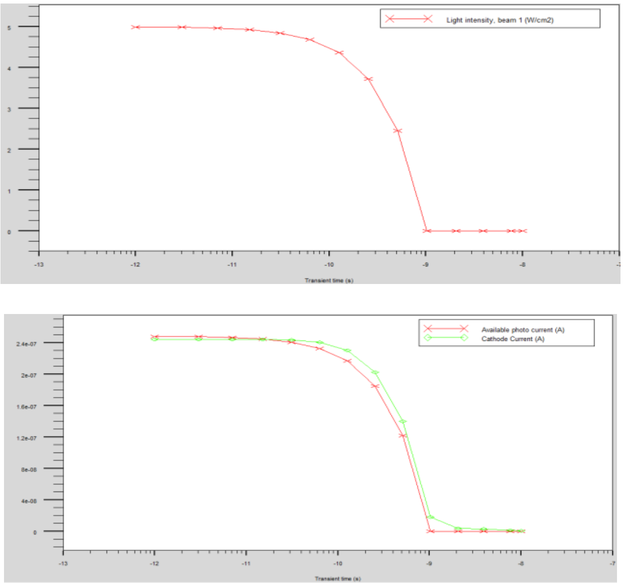

Figure 3. transient response of Nanowire.

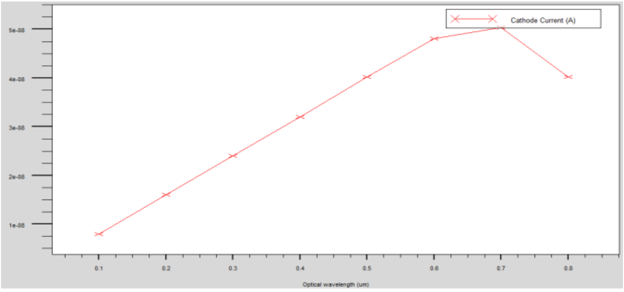

Figure 4. photo current as a function of wavelength.

In the next the structure of this   including the length of doNano- Wire g region and the thickness of absorber layer is optimized. Figure 5 shows capacitance of Nanowire as a function of voltage for different structures. As is clear from the figure, the capacitance of the structure can be minimized by changing the structure parameters.

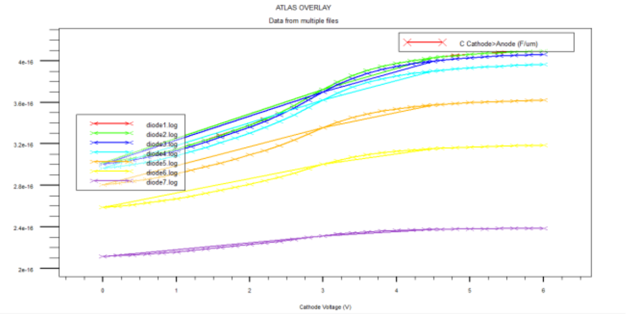

Figure 5 capacitance of Nanowire as a function of voltage for different structures

Figure 6 shows the cathode current versus incident light. One can see that the cathode current is 1 nA.

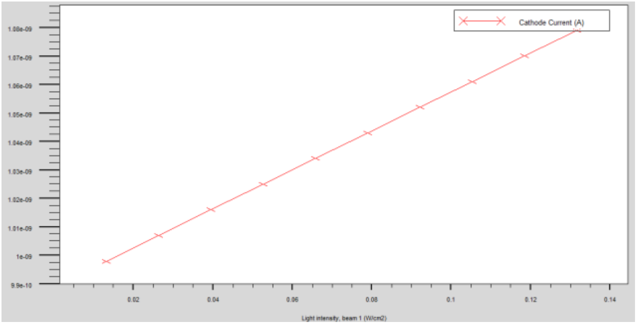

Figure 6 the cathode current versus incident light

Figure 7 shows the cathode current as a function of wavelength. As is clear, in the wavelength of 500 nm the maximum current is 2.4 nA that is higher than conventional structure.

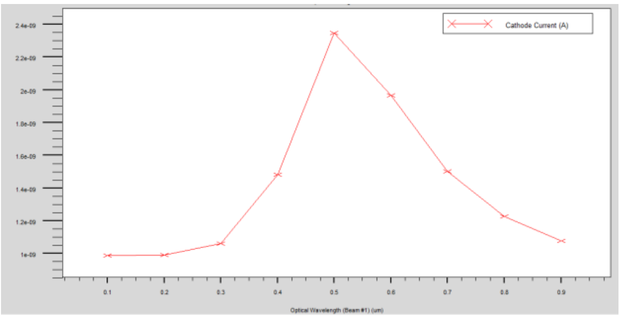

Figure 7 the cathode current as a function of wavelength

The absorption and transition diagram is plotted in figure 8. One can see that the absorption is 1 until the wavelength of 500 nm and after this wavelength the absorption is decreased and is reached to 0 in 900 nm.

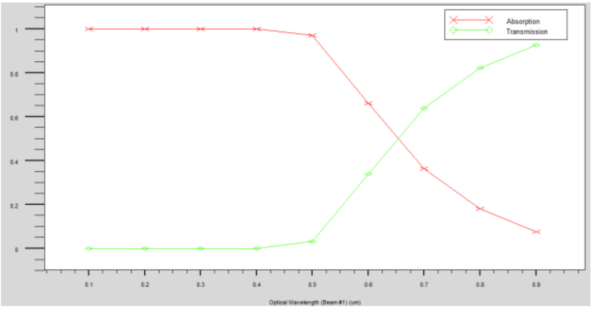

Figure 8 The absorption and transition diagram

Frequency response of is plotted in figure 9.

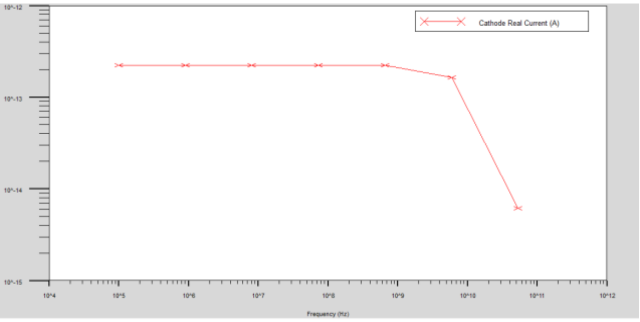

Figure 9 Frequency response

III. THE PROPOSED DONANO- WIRE G PROFILE

Figure 10 shows the proposed structure with proposed doNano- Wire g profile to have high responsibility. In this structure, instead of a uniform doNano- Wire g profile, a window-window profile is used. This causes to different pn junctions is created in Nanowire structure and different Nanowires will be in series together. This is like the situation in which multiple small s create a big . So, the responsibility of Nanowire is increased.

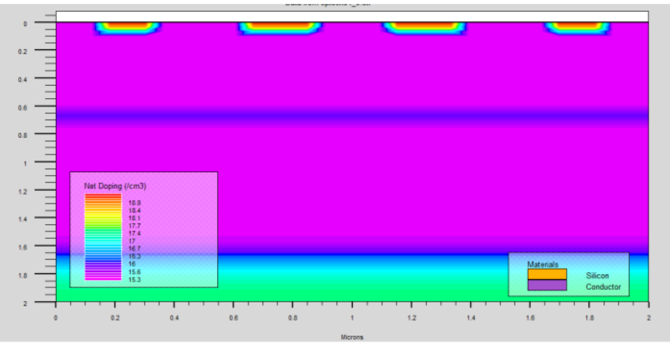

Figure 10 the proposed structure with proposed Nano- Wire g profile

In this structure an additional layer is used as well showing in blue in the figure. This additional layer causes to energy levels increases and so the responsibility and photocurrent will be increased. The simulation result of this structure is shown in figure 11. In compare with conventional structure, the current of proposed structure is 4000 times higher and is reached to 4 uA that is considerable improvement. Other characteristics of Nanowire including maximum frequency and absorption is similar to previous structure. Figure 12 shows its frequency response.

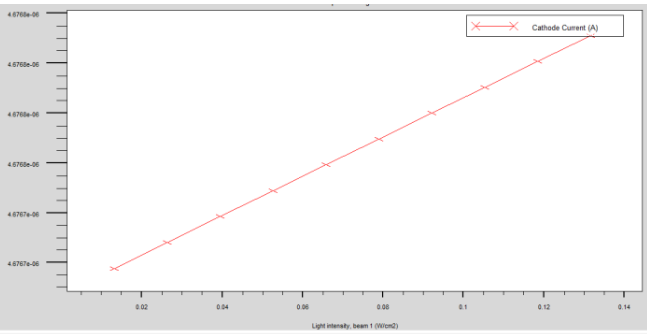

Figure 11 The simulation result of proposed structure.

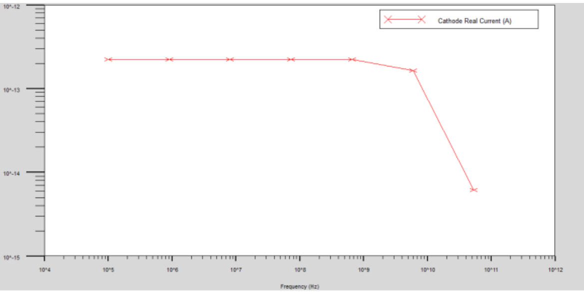

Figure 12 frequency respons

IV. CONCLUSION

In this paper the structure of Nano- Wire is optimized to achieve high sensibility and frequency response. To perform this optimization, the length of doNano- Wire g region and the thickness of absorber layer will be optimized. Silvaco software is used for simulation and optimization. The proposed structure includes a window profile is used for doNano- Wire g. The photocurrent is reached from 2 nA to 2 uA.

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