MULTI-JUNCTION PC1D SOLAR CELL: CONSTRUCTION AND SIMUATION

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ABSTRACT

This article will concentrate mostly on a similarity of the effectiveness of multi-layer GaAs solar cells (2,3,5 layer). The effectiveness of multi-layer solar cell is dependent on a variety of design factors, including the kind of material used, the thickness of the layers, the concentration of doping, the type of texturing employed, as well as the thicknesses of the anti-reflective coatings. The performance of one-dimensional solar cells was analyzed using PC1D (personal computer in one dimension), a piece of software that mimics one-dimensional solar cells. PC1D's Batch mode permits the execution of parameter-specific optimization studies. Computer modeling in PC1D reveals the accessible voltage, short-circuit current, voltage-level threshold, and conversion efficiency of power for a single sun, AM1.5G solar radiation, and a constant intensity of 0.1w/cm2.

Keywords: Gallium arsenide (GaAs), Solar Cells, Simulation

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INTRODUCTION

Modern national development depends on energy more than anything else. Coal, oil, and natural gas are being used to generate electricity. Problems with fossil fuel security and rising greenhouse gas emissions are only two examples of the difficulties associated with these energy options. Wind, solar, and hydroelectric power generation are just a few examples of renewable energy sources that might one day replace finite fossil fuels. Considered one of the most rapidly expanding renewable energy sources, solar power is gaining popularity. Almost everywhere on Earth, solar power is readily available. Solar energy has quickly gained popularity as a viable energy option due to its zero upfront cost and almost infinite potential. Over the course of a year, the sun's energy that reaches Earth's surface exceeds the energy needs of the whole planet by a factor of more than 10,000. Scientists' ultimate objective is to find a practical, low-cost way to tap into this massive power source. Thin-film cells, single-junction cells, organic cells, quantum dot cells, and many more are all under investigation, and each year brings the development of new materials and technologies. [2] The absorption of electromagnetic light by a material causes the material to release or generate electrically charged particles, a process known as the photoelectric effect. When light strikes a metal plate, electrons are ejected. [2] The photoelectric effect is exhibited in solar cells. [4]. GaAs solar cells are very efficient technologies. GaAs has a straight band gap and a high absorption coefficient, making it excellent for thin solar cells. Along with modeling crystalline solar cells, the PC1D software suite allows for sophisticated and better visualization of cell design and operation. In addition to producing accurate findings, the software's numerical model saves precious time for laboratory tests. [3, 5] The paper is formatted as followed. Section 2 discusses PC1D software. Section 3 contains the simulation findings. Section 4 concludes.

PC1D SOFTWARE

For solar cell modeling, PC1D is the gold standard. PC1D solves two-carrier transport equations in semiconductors using analysis of finite elements. PC1D's advantages include its high computation speed, easy user interface, broad list of material and physical characteristics, and batch mode for inserting numerous parameters like Error reduction, Large material database, Reduce manual graph preparation time, Improved generation and recombination models.

RESULTS & DISCUSSION

Three cases are considered namely design of two-layer, three-layer and five-layer solar cells using PC1D software. Input Data for present simulation with Intrinsic concentration, Free carrier absorption, Bulk recombination value of 1e10 cm^{-3} (300k), enabled and 7.208us(tn=tp) respectively. Input parameters are as given below in tables:

Table 1 Includes Input Data for present simulation.

Layer No.	Type of material	width	Doping
1	GaAs	3µm	1.513e16 cm^{-3}(P-type)
2	GaAs	10µm	1.513e16 cm^{-3}(P-type)
3	GaAs	10µm	1.513e16 cm^{-3}(P-type)
4	GaAs	10µm	1.513e16 cm^{-3}(P-type)
5	GaAs	10µm	1.513e16 cm^{-3}(P-type)

Table 2 Includes Input Data for present simulation.

Region	Intrinsic concentration	Free carrier absorption	Bulk recombination
1-5	1e10 cm^{-3} (300k)	enabled	7.208us(tn=tp)

Table 3 Includes Area of Device, Surface parameters as a INPUT

Parameters	5-layer	3-layer	2-layer
Device area	1cm^2	1cm^2	1cm^2
Front surface	3um	3um	3um
peripheral face reflectance	90%	90%	90%
Emitter	Enabled	enabled	enabled
Base	Enabled	enabled	enabled
interior conductor	0.3S	0.3S	0.3S
Light Source	one-sun.exe	one-sun.exe	one-sun.exe

Figure 1 shows one-sun I-V plot and power diagram for 2 layer

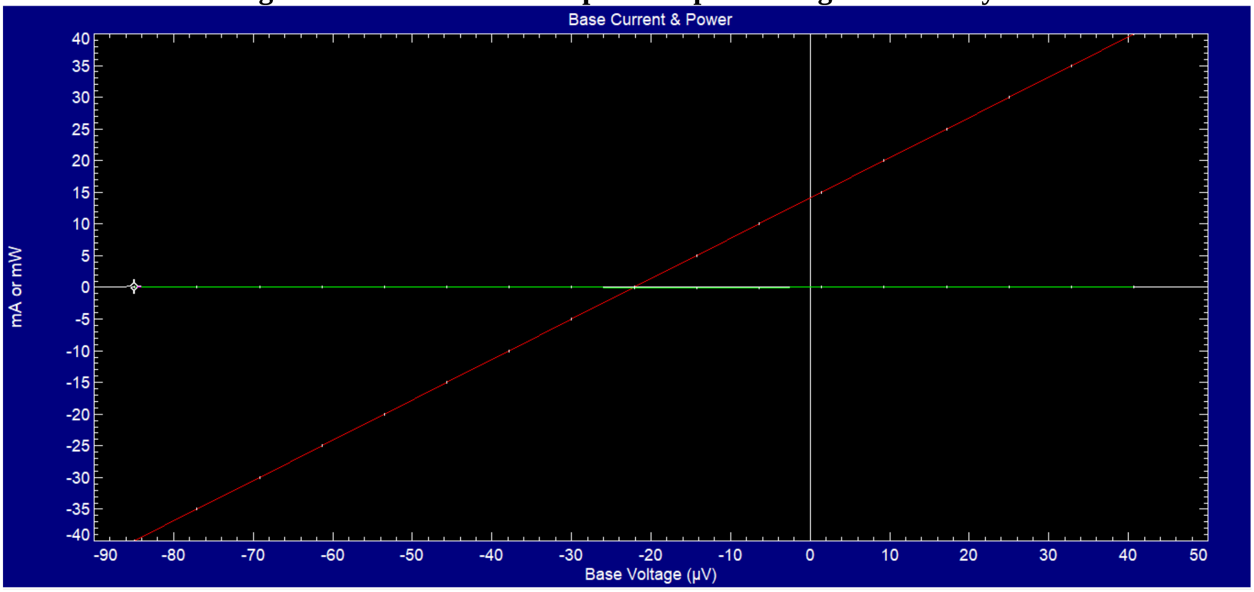

Figure 2 shows one-sun I-V plot and power diagram for 3 layer

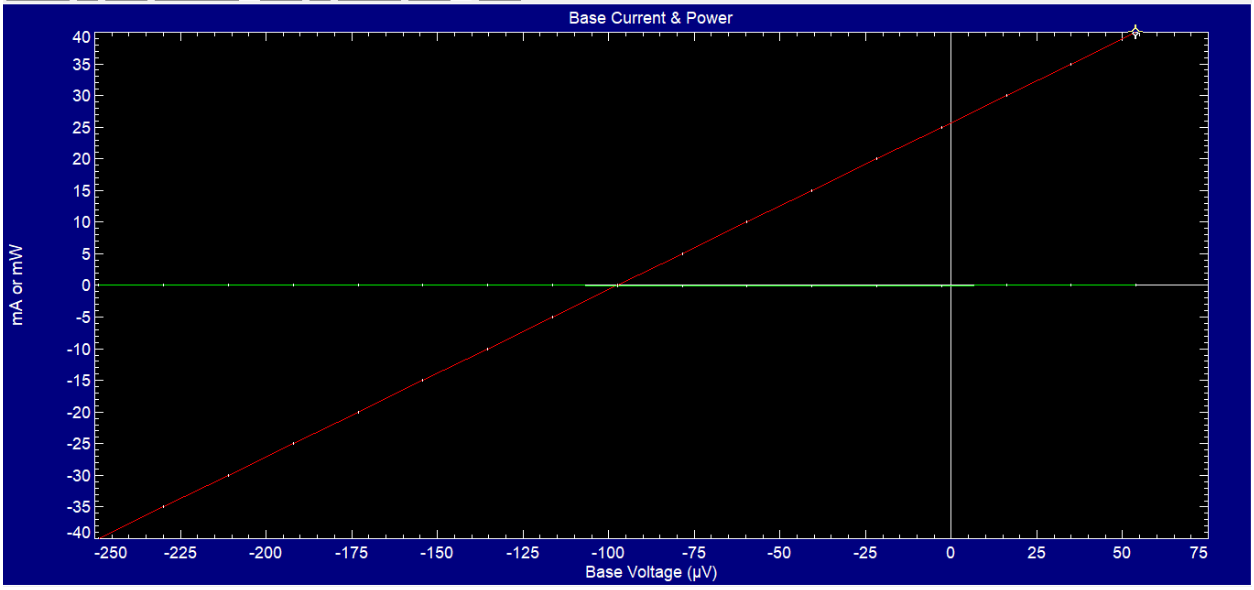

Figure 3 shows one-sun I-V plot and power diagram for 5 layer

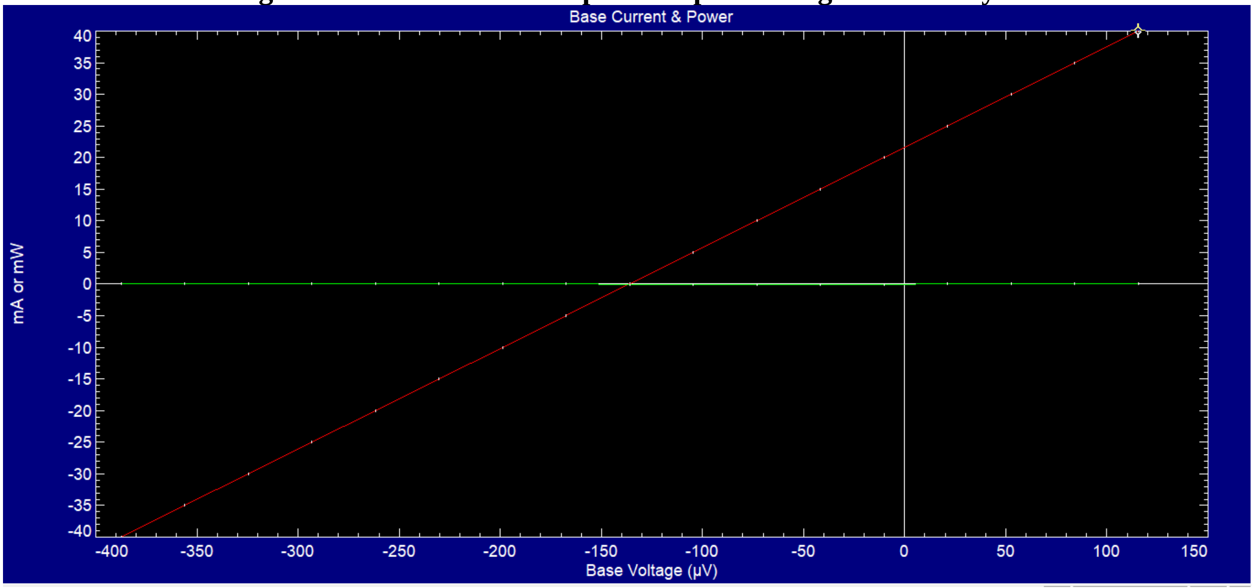

Table 4 shows conversion efficiency with respect to different layers.

Performance	2-layer	3-layer	5-layer
Short circuit current	0.0141 A	0.0257A	0.0216A
Open circuit voltage	-2.212e^{-5}Volts	-9.745e^{5}Volts	-1.36e^{-4}volts
P_{max}	2.79e^{-8} watts	1.272e^{-7} watts	3.358e^{-7}watts
Conversion Efficiency	27.9e^{-8}%	12.72e^{-7}%	33.58e^{-7}%

CONCLUSION

In this exercise, we test out many different designs for a solar cell using the one-dimensional solar cell modeling application PC1D. These designs include a solar cell with two junctions, three junctions, and five junctions respectively. The results showed that the efficiency of a two-junction solar cell was 27.9e-8%, the effectiveness of a three-connection solar cell was 12.7%, and the efficiency of a five-junction solar cell was 33.5%.

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