B—4—1 Theoretical Analysis of a Novel MPN GaAs Schottky Barrier Solar Cell

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Theoretical analysis for a novel Au-p-n GaAs Schottky barrier solar cell has been conducted in this paper. It is shown for the first time that barrier height equal to the energy band gap of GaAs can be obtained in the proposed metal-p-n Schottky barrier structure if the thickness and dopant density of the p-GaAs layer are property chosen. Calculations of the barrier height as function of the thickness and dopant density of the p-layer have been carried out for a Au-p-n GaAs Schottky barrier cell. It is shown that AMO (i.e., P_{in} = 135.3 mW/cm^2) conversion efficiency around 22% can be achieved in a Au-p-n GaAs Schottky barrier solar cell when $N_D = 10^{16}$ cm^{-3}, $N_A = 8\times10^{18}$ cm^{-3} and d_p = 100Å are used. The proposed structure can be readily fabricated by growing a thin p-layer (from 100Å to 3000Å) of GaAs (using epitaxial or ion-implantation technique) on the n-GaAs substrate, and followed by depositing a 100Å gold film on top of this p-n structure. The calculated AMO conversion efficiency and other important physical constants for a Au-p-n GaAs Schottky barrier solar cell for different values of N_a, N_d, and W_p are summarized in Table I.

TABLE I M-P-N GaAs Schottky Barrier Solar Cell
Calculated under AMO Conditions (135.3 mW/cm^2)

N_D(cm^{-3})	N_A(cm^{-3})	W_p(μm)	W_n(μm)	ϕ_{Bn}* (eV)	J_D(A/cm^2)	J_L(A/cm^2)	V_{OC}(V)	η_C(%)
10^{16}	3×10^{19}	5×10^{-3}	0.426	1.41	7.03×10^{-19}	3.41×10^{-2}	0.944	22.1
10^{16}	8.2×10^{18}	1×10^{-2}	0.429	1.43	3.17×10^{-19}	3.26×10^{-2}	1.01	21.45
10^{16}	2.2×10^{18}	2×10^{-2}	0.428	1.43	3.14×10^{-19}	3.03×10^{-2}	1.01	19.91
10^{16}	4.4×10^{17}	5×10^{-2}	0.424	1.43	3.9×10^{-19}	2.63×10^{-2}	1.0	17.16
10^{16}	7×10^{17}	3×10^{-2}	0.388	1.20	2.3×10^{-15}	2.89×10^{-2}	0.78	14.63
10^{16}	1.3×10^{17}	1×10^{-1}	0.401	1.35	7.79×10^{-18}	2.29×10^{-2}	0.922	13.75
10^{16}	7.7×10^{16}	1.5×10^{-1}	0.404	1.43	3.49×10^{-19}	2.02×10^{-2}	0.999	13.2
10^{16}	5×10^{16}	2×10^{-1}	0.392	1.43	2.97×10^{-19}	1.86×10^{-2}	1.0	12.1
10^{16}	2.7×10^{16}	3×10^{-1}	0.366	1.43	3.83×10^{-19}	1.61×10^{-2}	0.99	10.37

* $\phi_{Bn} = \phi_{Bo} + V_m$; ϕ_{Bo} = 0.90eV for a Au-GaAs Schottky barrier diode.