6. Appendix A - Model Confirmation

6.1 Test 1 - Depletion Region Field

This test compares an analytical result for the electric field in the depletion region of a Si pn diode with the SimWindows calculation. A 1.0 micron Si pn diode is doped p-type with 10^{17} acceptors and n-type with $3x10^{17}$ donors. Listing 8 in Appendix B has the device file for this device. The relations for the depletion region length and the electric field [43] employ the standard complete depletion approximation. Figure 43 compares the equilibrium electric field computed from SimWindows and using the complete depletion approximation.

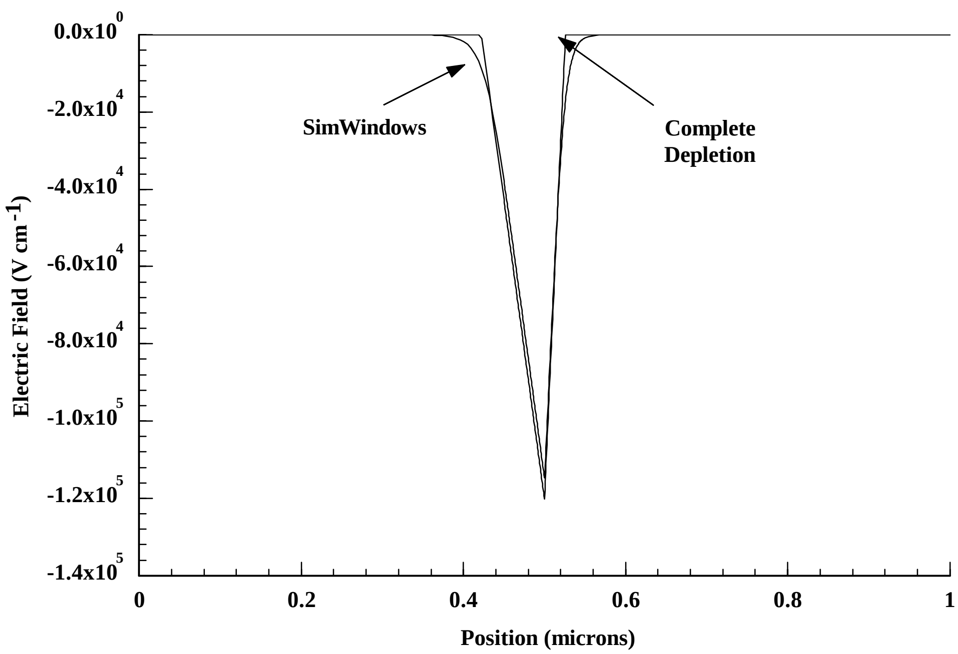

Figure 43 - Electric field comparison between the complete depletion approximation and the SimWindows result

6.2 Test 2 - Short Circuit Current

This test compares the short circuit current of a GaAs photodetector calculated from an analytical expression with the SimWindows result. A 1.0 micron GaAs pn diode is doped p-type with 10^{17} acceptors and n-type with 3×10^{17} donors. Listing 9 in Appendix B has the device file for this device. The photodetector is illuminated from the left with 100 mW cm^{-2} of 2.0 eV monochromatic light. The absorption coefficient is 2.656×10^{4} cm^{-1}. The illumination was also from 0.45 to 0.55 microns only as shown by the optical generation rate in Figure 44. The analytical expression under these conditions for the short circuit current in the absence of recombination is:

$$J_{sc} = \frac{I_0(1 - e^{-ad})}{E_{ph}} = 11.6 \text{ mA cm}^{-2}$$

SimWindows computes the short circuit current to be 12.1 mA cm^{-2}. This 4% error results from the method that SimWindows uses to integrate the optical generation rate. SimWindows assumes that the optical generation rate is linear between nodes. The jump in the optical generation rate from 0 to 8×10^{21} at 0.45 microns and from 6×10^{21} to 0 at 0.55 microns contributes to a slightly higher short circuit current than calculated analytically.

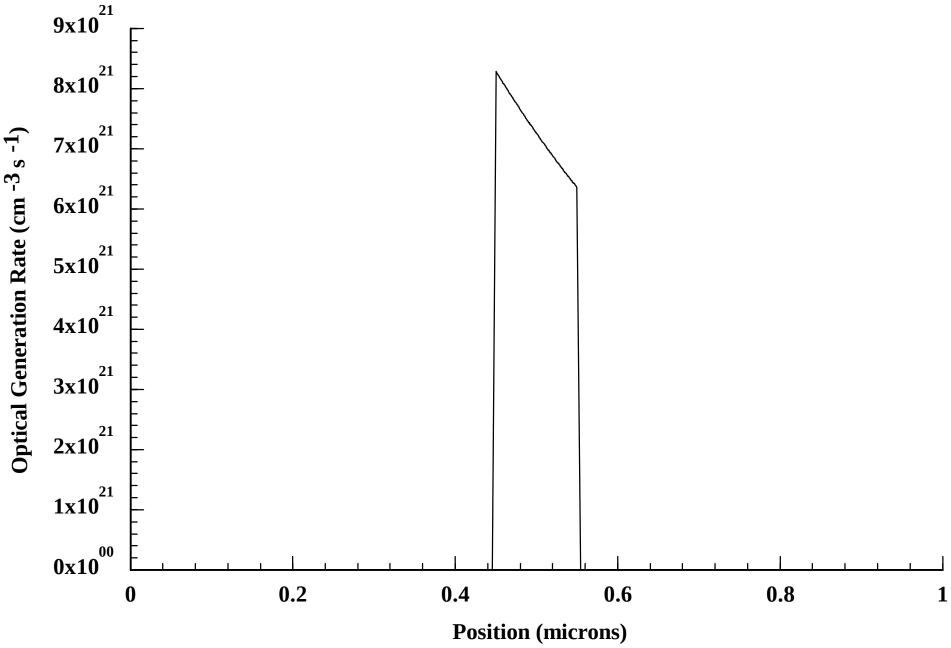

Figure 44 - Optical generation rate for the GaAs photodetector

6.3 Test 3 - Lattice Temperature

This test compares an analytical calculation of the lattice temperature in a GaAs resistor with the SimWindows calculation. A 1.0 micron GaAs resistor is doped n-type with 10^{17} donors and biased to 1.0 Volts. Listing 10 in Appendix B has the device file for this test device. The mobility is 8000 cm^2 V^{-1} s^{-1} and the thermal conductivity is 0.44 W cm^{-1} K^{-1}. The analytical calculation of the current is:

$$\mathbf{J}_n = qn\mu_n\mathcal{E} = 1.28\text{x}10^6 \text{ A cm}^{-2}$$

This equation ignores the diffusion current resulting from the temperature gradient. SimWindows calculates the total current as $1.25\text{x}10^6$ A cm^{-2}. The right contact uses a fixed temperature of 300K, and the left contact uses and finite thermal conductance of 10,000 W cm^{-2} K^{-1}. Under these conditions, the differential equation for the lattice temperature is:

$$-k\frac{d^2T}{dx^2}+\frac{\mathbf{J}_n}{-q}\frac{dE_c}{dx}=0$$

which yields:

$$T(x)=-1.454\text{x}10^{10}x^2+1.009\text{x}10^6x+344.5$$

Figure 45 shows the comparison between the analytical temperature equation and the SimWindows results. The difference is due to neglecting the temperature gradient in the analytical expression for current.

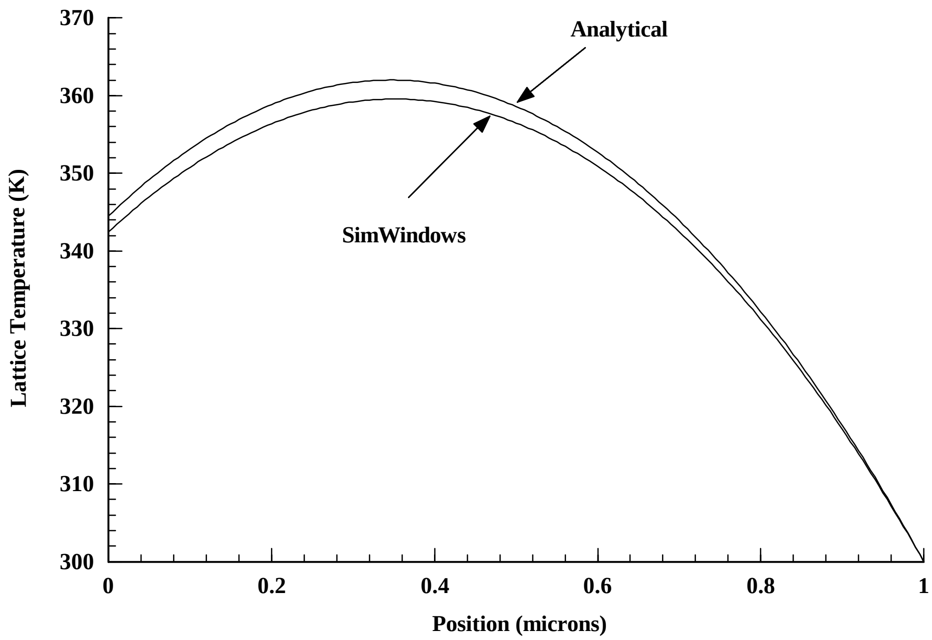

Figure 45 - Lattice temperature comparison for the test resistor between the analytical and SimWindows results