Verification of the Validity of the PN-Junction Tool

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The best verification for the validity and the accuracy of the PN-junction lab is to compare the numerical results for the electric field profile under equilibrium conditions and the results obtained with the depletion charge approximation. The linear extrapolation of the numerical electric field data gives accurate value for the depletion region width that can be compared with the depletion approximation result. Also, the equivalency of the peak electric field is another indicator for the validity of the numerical solution. This, however might not necessarily be true for all cases. Only for symmetric junctions the numerical peak electric field and the peak electric field calculated using the depletion charge approximation are almost the same. When the junction is asymmetric, the depletion charge approximation underestimates the peak electric field value. This is negligible for small doping concentrations but becomes significant for large doping concentrations (larger than $10^{17}$ cm$^{-3}$). These observations are reinforced with the simulated and depletion charge approximation results for a symmetrical (Figure 1) and asymmetrical (Figures 2-4) pn junction.

Figure 1. Electric field profile for $N_A=N_D=5\times10^{15}$ cm$^{-3}$. Straight lines are depletion approximation result.
Figure 2. Electric field profile for $N_A=5\times10^{15}$ cm$^{-3}$ and $N_D=5\times10^{16}$ cm$^{-3}$. Straight lines are depletion approximation result.
Figure 3. Electric field profile for $N_A = 5 \times 10^{15} \text{ cm}^{-3}$ and $N_D = 5 \times 10^{17} \text{ cm}^{-3}$. Straight lines are depletion approximation result.
Figure 4. Electric field profile for $N_A = 5 \times 10^{15} \text{ cm}^{-3}$ and $N_D = 5 \times 10^{18} \text{ cm}^{-3}$. Straight lines are depletion approximation result.