微电子器件物理　第三周作业

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作业内容：pn 结作业（见 hw03-pnjunction.pdf）

Problem 1

SubProblem a

$$V_{bi} = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2} = 0.59524V$$

SubProblem b

$$x_p = x_n = \left[\frac{2K_s\epsilon_0}{q} \frac{N_A}{N_D(N_A + N_D)} \right]^{1/2} = 0.000062291cm$$

$$W = x_n + x_p = 0.00012458cm$$

SubProblem c

$$V(x = 0) = \frac{qN_A}{2K_S\epsilon_0} x_p^2 = 0.29762V$$

$$E(x = 0) = -\frac{qN_A}{K_S\epsilon_0} x_p = -9555.8V/cm$$

SubProblem d

如 **图 1**

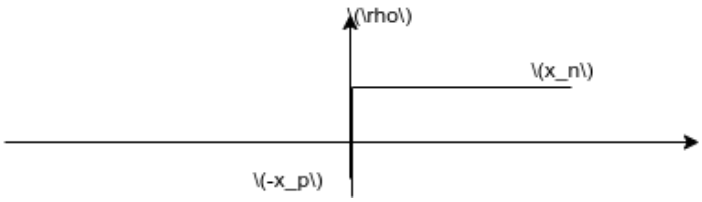

图 1: 草图

Problem 2

SubProblem a

$$V_{bi} = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2}$$

$$W \approx \left[\frac{2K_S \epsilon_0}{q} \frac{1}{N_D} V_{bi} \right]$$

$$E(0) = -\frac{qN_A}{K_S \epsilon_0} \left[\frac{2K_S \epsilon_0}{q} \frac{N_D}{N_A^2} \right]^{1/2}$$

$$V(x) = \begin{cases} \frac{qN_A}{2K_S \epsilon_0} (x + [\frac{2K_S \epsilon_0}{q} \frac{N_D}{N_A^2} V_{bi}]^{1/2})^2 \\ V_{bi} - \frac{qN_D}{2K_S \epsilon_0} (-x + [\frac{2K_S \epsilon_0}{q} \frac{1}{N_D} V_{bi}]^{1/2})^2 \end{cases}$$

$$\rho(x) = -qN_A, \text{ if } -x_p \leq x \leq 0; 0 \text{ else}$$

SubProblem b

$$V_{bi} = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2} = 0.83334V$$

SubProblem c

$$x_n = \left[\frac{2K_s \epsilon_0}{q} \frac{N_A}{N_D(N_A + N_D)} \right]^{1/2} = 0.00010423cm$$

$$x_p = \frac{N_D}{N_A} x_n = 0.000000010423cm$$

$$W = x_n + x_p = 0.00010424cm$$

SubProblem d

$$V(x = 0) = \frac{qN_A}{2K_S \epsilon_0} x_p^2 = 0.000083325V$$

$$E(x = 0) = -\frac{qN_A}{K_S \epsilon_0} x_p = -15989.04177V/cm$$

SubProblem e

如 **图 2**

Problem 3

SubProblem a

图 2: 草图

$$\rho = \begin{cases} qN_D, -x_n \leq x \leq 0 \\ 0,0 \leq x \leq x_i \\ -qN_A, x_i \leq x \leq x_i + x_p \end{cases}$$

如 **图 3**，由于掺杂浓度差距过大，图中大小仅作示意，不为真实大小。

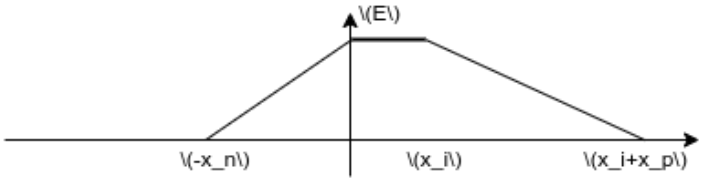

图 3: 电场

电场大小表示为

$$E = \begin{cases} \frac{qN_D}{K_S\epsilon_0}(x + x_n), -x_n \leq x \leq 0 \\ \text{const}, 0 \leq x \leq x_i \\ -\frac{qN_A}{K_S\epsilon_0}(x - x_i - x_p), x_i \leq x \leq x_i + x_p \end{cases}$$

连续性得到：$x_n N_D = x_p N_P$

设在 P 侧中性区电势为 0，那么 N 侧的中性区电势为 V_{bi}。由于 $x_p > x_i$ 近似忽略后者。

$$V_{bi} = \frac{1}{2}(x_i + x_i + x_n + x_p) \cdot \frac{qN_A x_p}{K_S\epsilon_0} \approx (\frac{N_A + N_D}{2N_D})\frac{qN_A}{K_S\epsilon_0}x_p^2 \approx \frac{N_A q}{2K_S\epsilon_0}x_p^2$$

解得 $x_p = \sqrt{\frac{2K_S\epsilon_0 V_{bi}}{N_A q}}$

SubProblem c

由电场表示**图 3**