EE 566
SPR 2004
02/10/2004

SOLID STATE DEVICES

ASSGN III — SOLNS

(a)

$$V_{bi} = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right) = \boxed{1.22\ V}$$

$$W = \left[\frac{2\epsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right) V_{bi}\right]^{1/2} \approx \boxed{440\,nm}$$

Since $\frac{N_A}{N_D} = 10$, $x_n = \frac{1}{1+10} * W \approx \boxed{40\,nm}$

$x_p = \frac{10}{1+10} * W \approx \boxed{400\,nm}$ $x_p \sim 10\, x_n$

$$F_{max} = \frac{2V_{bi}}{W} \approx \boxed{55.5\ kV/cm}$$

$\ll F_{breakdown} = 400\ kV/cm$.

$$C_{depl} = \frac{\epsilon_s}{W} \approx \boxed{26\,nF/cm^2}$$

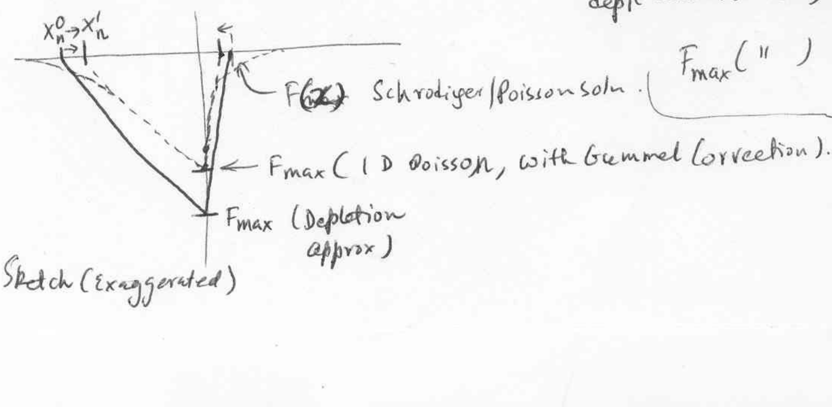
Sketches & Plots: Next pages by QIN.

(b) Plots - next pages.

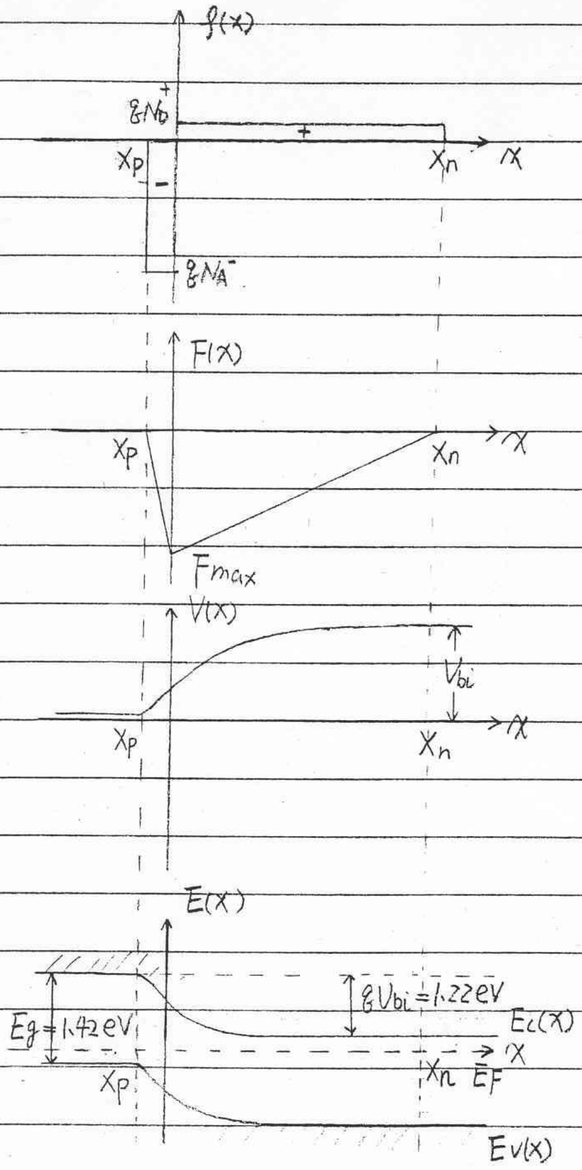
W_{depl}(Gummel correction) $<$ W_{depl}(Depl. approx)

F_{max}(") $<$ F_{max}(")

BUT: V_{bi} remains the SAME!!



Sketch (Exaggerated)

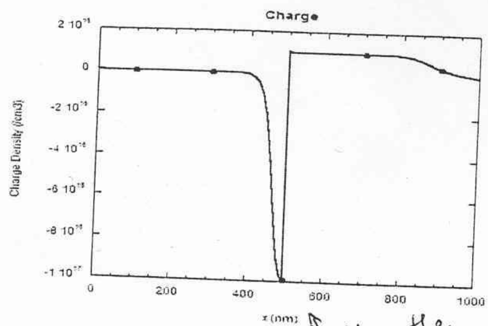

ρ(x)
qN_D^+
+
x_p
-
x_n
x
qN_A^-
F(x)
x_p
x_n
x
F_max
V(x)
V_bi
x_p
x_n
x
E(x)
qV_bi = 1.22 eV
E_c(x)
E_g = 1.42 eV
x_p
x_n
E_F
x
E_v(x)

Plot - by Qin.

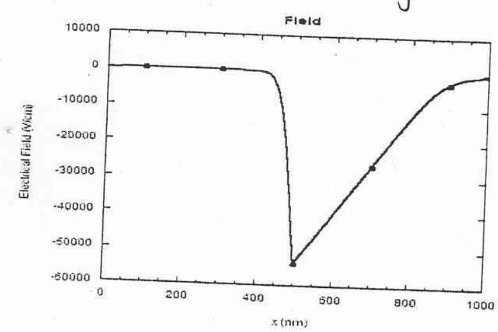
✓

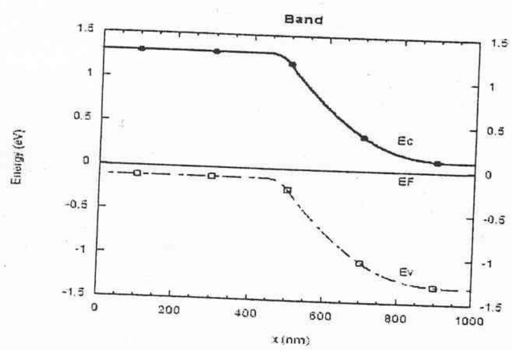
(3)

Plot - by Qin.

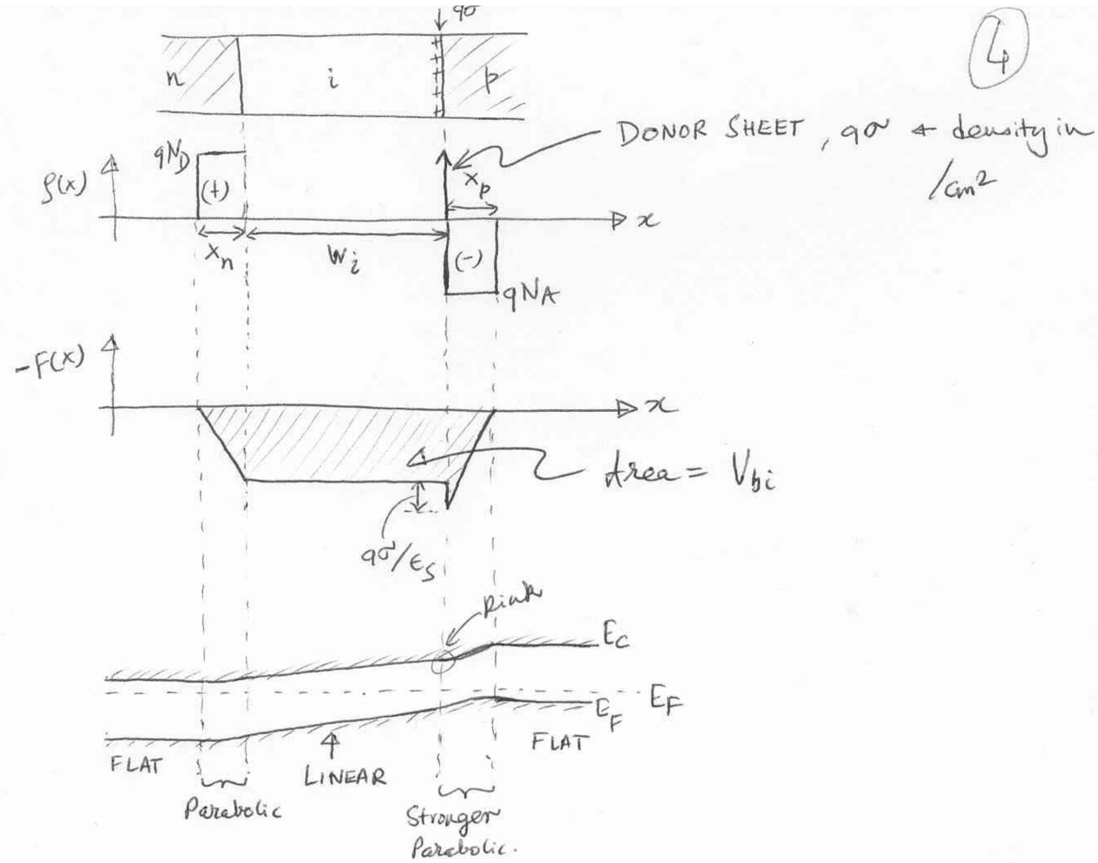


Use the junction as x = 0.





(c)



Charge Neutrality: $qN_A x_p = qN_D x_n + q\sigma$.

$\therefore \quad x_p = x_n + \frac{\sigma}{N_A} \quad \rightarrow \quad V_{bi} = \frac{qN_A}{\epsilon_s}x_p^2 + \left(\frac{W_i qN_A}{\epsilon_s} - \frac{q\sigma}{\epsilon_s}\right)x_p$

(a) — $+ \frac{1}{2}\frac{q\sigma^2}{\epsilon_s N_A} - \frac{W_i q\sigma}{\epsilon_s}$ } AREA UNDER F(x) − x plot.

$C_{p-i-n} = C_{p-n}$

(b) — $\frac{\epsilon_s}{x_n + x_p + W_i} = \frac{\epsilon_s}{W}$ ← $\left(\frac{2\epsilon_s}{q}\cdot\frac{2}{N_A}\cdot V_{bi}\right)^{\frac{1}{2}}$

↑ With i-layer + sheet doping ↑ No i-layer.

Solve (a) & (b) together to get −

$$\boxed{W_i = (\sqrt{2}-1)\frac{\sigma}{N_A}} \Rightarrow W_i \approx (\sqrt{2}-1) * \frac{10^{11}\times 5}{10^{17}}\ \text{cm}$$

$$\boxed{W_i \approx 20.7\ \text{nm}}$$