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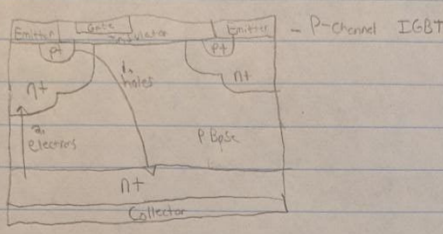
ECE 542

Homework #13

4/22/19

Riley Worstell ECE 542 4/22/2019 HW #13

① Draw a cross-section of P-channel IGBT, similar to fig 11.1, Indicate path for electrons & holes



② N-channel IGBT transistor! Collector:  $N_A = 10^{19} \text{ cm}^{-3}$  Base:  $N_D = 10^{17} \text{ cm}^{-3}$   
emitter:  $N_A = 10^{18} \text{ cm}^{-3}$ ;  $N_D = 10^{19} \text{ cm}^{-3}$ ;  $N_A$  for collector;  $N_D$  for base  
Gate insulator:  $\text{SiO}_2$ ,  $t_i = 25 \text{ nm}$ ;  $N_D = 300 \frac{\text{cm}^2}{\text{V} \cdot \text{s}}$ ;  $V_T = 2 \text{ V}$   
Gate length:  $1 \mu\text{m}$ ; Gate width:  $0.5 \text{ mm}$

③  $\gamma = \left(1 + \sqrt{\frac{D_n}{D_p} \frac{N_D}{N_A}} \left(\frac{N_D}{N_A}\right)^{-1}\right)^{-1}$ ;  $\tau_n = 2.27 \cdot 10^{-8} \text{ sec}$  ( $N_A = 10^{19}$ )  $\tau_p = 1.25 \cdot 10^{-5} \text{ s}$  ( $N_D = 10^{17}$ )  
 $D_n = \frac{kT}{q} \mu_n = 0.0259 (114) = 2.953 \frac{\text{cm}^2}{\text{s}}$ ;  $D_p = 0.0259 (331) = 8.573 \frac{\text{cm}^2}{\text{s}}$   
 $N_D \otimes N_A = 10^{19}$   $N_D \otimes N_D = 10^{17}$   
 $\gamma = \left(1 + \sqrt{\frac{2.953}{8.573}} \sqrt{\frac{1.25 \cdot 10^{-5}}{2.27 \cdot 10^{-8}}} \left(\frac{10^{17}}{10^{19}}\right)^{-1}\right)^{-1} = \left(1 + 0.587 (23.46) (0.01)\right)^{-1} = \frac{1}{1.137} = 0.879$

④ What is current gain  $\beta$ ;  $\beta = \frac{1}{1-\gamma} = \frac{1}{1-0.879} = 8.264$

⑤  $10 \text{ V to } \infty$ . How much current through Cathode IGBT?

$$I_C = \frac{N_D \mu_n}{2(1-\gamma)} \frac{W}{L} (V_{GS} - V_T)^2 = \frac{300 (3.9) (8.854 \cdot 10^{-14}) / (65 \cdot 10^{-9})}{2(1-0.879)} \frac{(0.5 \cdot 10^{-3} \text{ cm})}{(1 \cdot 10^{-4} \text{ cm})} (10-2)^2$$
$$= 0.00171226 (500) (64) = 5.479 \text{ A}$$