

ECSE-2210 Microelectronics Technology
Class Activity 17 – Solution

1. What is the root cause of the delay in switching from the on-state to the off state?

There are stored minority carriers in the quasi-neutral region immediately adjacent to the depletion region when the device is on state. When moving from the on state to the off state removal of these charges does not happen instantaneously. This is the cause of delay in switching from the on to the off state.

2. Name the two mechanisms that act to remove the stored excess charge during the turn-off transient.

- i) Recombination
- ii) Reverse Current Flow

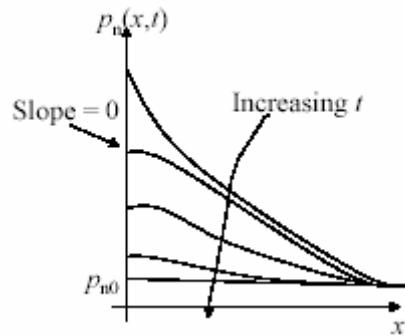
Carriers can be eliminated by recombination, but this would require several minority carrier lifetimes to move from the on state to the off state. On the other hand, when a reverse bias is applied the carriers drift back across the depletion region leading to a reverse current flow. But the number of carriers removed by this method is limited by the switching circuitry. In either case, neither method is considered rapid enough to be thought as instantaneous.

3. An ideal p⁺-n diode carrying a forward current I_F is suddenly reverse biased such that a current I_R flows through it at $t = 0^+$. The storage time measured was t_s . Determine what happens to t_s (increase or decrease) if:

- a. Only I_F is increased. t_s will increase
As I_F increases there are more stored charges in the quasi neutral region adjacent to the depletion region. Hence it takes longer for the charges to be removed.
- b. Only $|I_R|$ is increased. t_s will decrease
As I_R increases, stored charge carriers can be removed by the reverse current flow. Hence t_s will decrease as less time will be required to remove the stored charges.
- c. The hole lifetime, τ_p , is increased. t_s will increase
As the hole lifetime is increased, the carriers can exist in the quasi neutral region for a longer time before they can recombine. As a result the storage delay time increases.

4. a. An ideal p⁺-n diode carrying a forward current I_F is suddenly open circuited at $t = 0$. Sketch the expected variation of $p_n(x, t)$ versus x at progressively increasing times after open circuiting the diode.

The hole concentration profile will progressively decrease exponentially.



- b. Repeat the same if the diode above is reverse biased at $t = 0$ such that a current I_R flows through it at $t = 0^+$.

Decay of stored hole charge in a pn junction

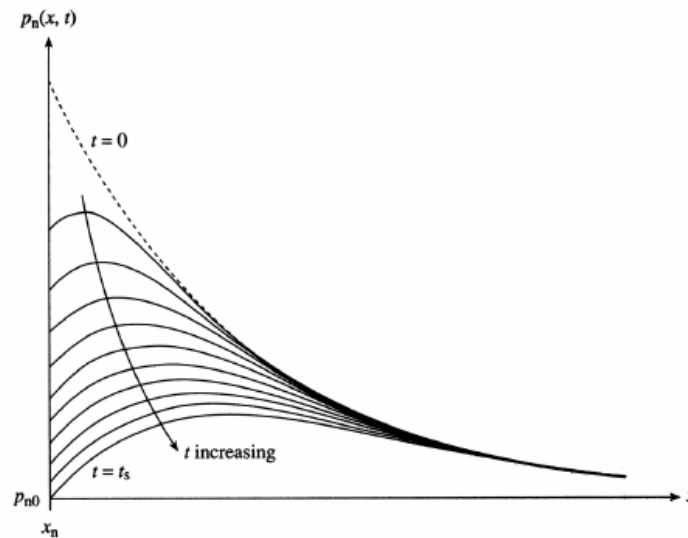


Figure 8.3

5. The hole lifetime of a p^+ -n junction diode is measured by the diode recovery method. When the applied voltage is as shown in figure, the current through the diode was as shown. Determine the hole lifetime.

$$I_F = 10V / 10 \text{ k}\Omega = 1\text{mA}$$

$$I_R = 20V / 10 \text{ k}\Omega = 2\text{mA}$$

$$t_s = \tau_p \ln\left(1 + \frac{I_F}{I_R}\right)$$

$$30 \text{ ns} = \tau_p \ln(1.5) \text{ From the figures below.}$$

$$\tau_p = 74 \text{ ns}$$

