DIC L8: MOSFET (2)

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2.2. Long-channel (1)

- Current through the channel depends on
  - How much “electron” charge is in the channel?
    - Number of mobilie carriers
  - How fast is the charge moving?
- Charge

$$Q_{channel} = C_g\left(V_{gc} - V_t\right) \qquad \text{Eq. (2.1)}$$

  - Note) $Q_{channel}$ for electrons. (It should be negative, but in Eq. (2.1), it is understood.)
  - Note) V_{gc} appears instead of V_{gb}.

2.2. Long-channel (2)

- Capacitance

$$C_g = C_{OX} W L \qquad \text{Eq. (2.2)}$$

  - The "oxide capacitance," C_{OX}, is given as

$$C_{OX} = \frac{\epsilon_{OX}}{t_{OX}}$$

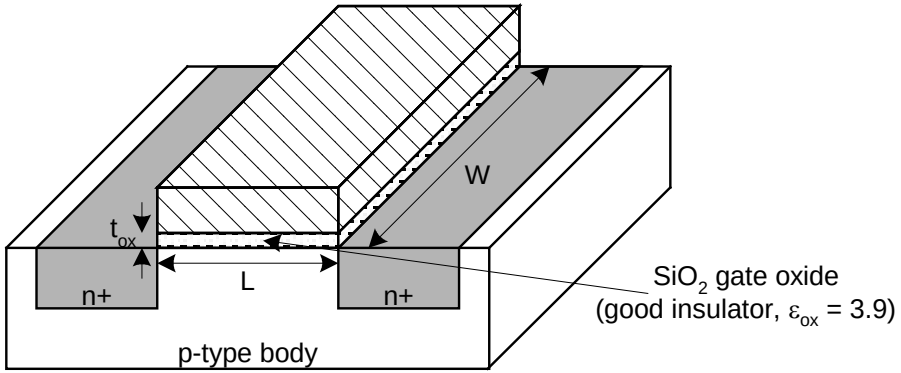


Fig. 2.6

2.2. Long-channel (3)

- IV characteristics
  - After some manipulation, we have

Subthreshold $$I_d = 0$$

Linear $$I_d = \beta\left(V_{gs} - V_t - \frac{V_{ds}}{2}\right)V_{ds}$$ Eq. (2.10)

Saturation $$I_d = \frac{\beta}{2}\left(V_{gs} - V_t\right)^2$$

  - Here,

$$\beta = \mu_n C_{OX}\frac{W}{L}$$

2.3. Capacitance (1)

- Any two conductors separated by an insulator have capacitance.
- Gate to channel capacitor is very important.
  - It creates channel charge which is necessary for operation.
- Source and drain have capacitance to body across the reverse-biased diodes.
  - It is called the diffusion capacitance because it is associated with source/drain diffusion regions.

2.3. Capacitance (2)

- Gate capacitance

$$C_g = C_{ox}WL$$

Eq. (2.2)
(You have seen it before!)

- Overlap capacitance, C_{gs} and C_{gd}

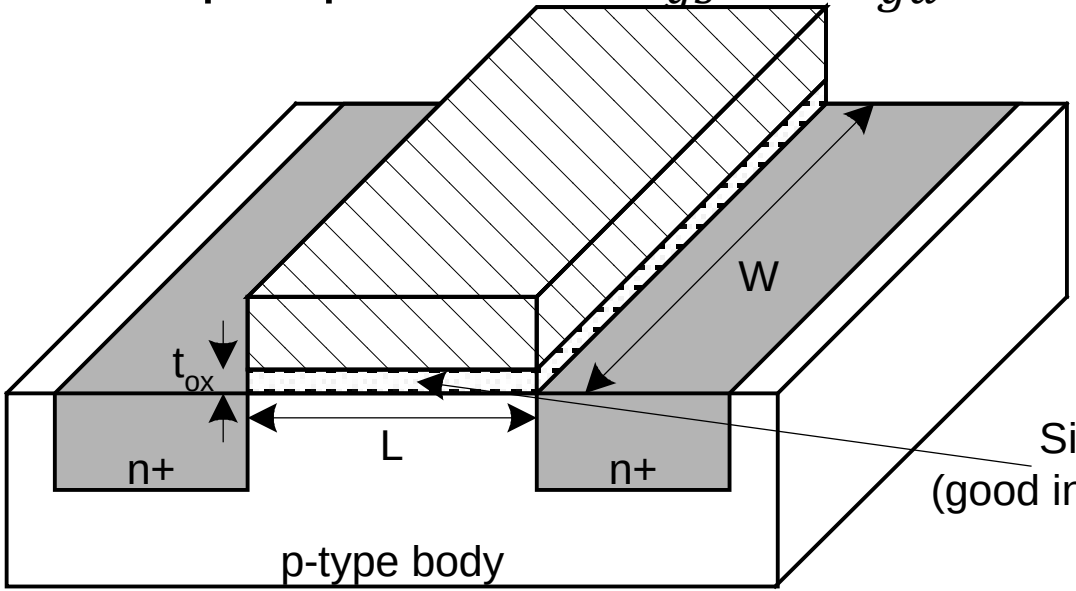


Fig. 2.6

2.3. Capacitance (3)

- Diffusion capacitance, C_{sb} and C_{db}
  - Due to the PN junction between a diffusion region and the substrate.

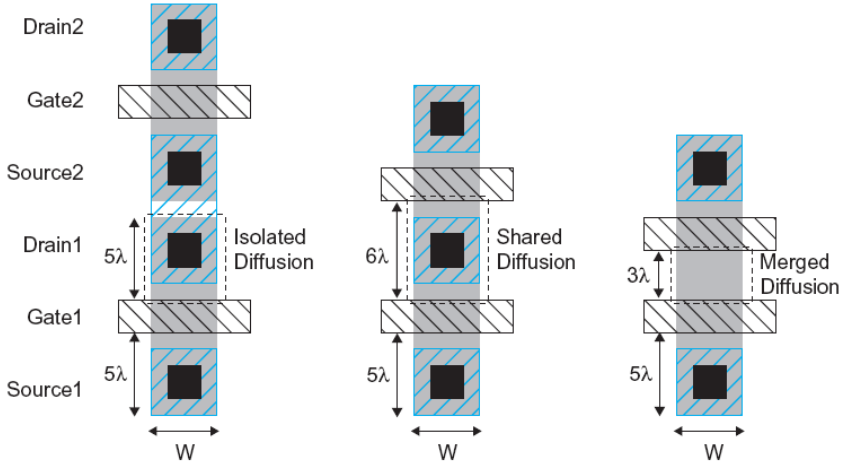
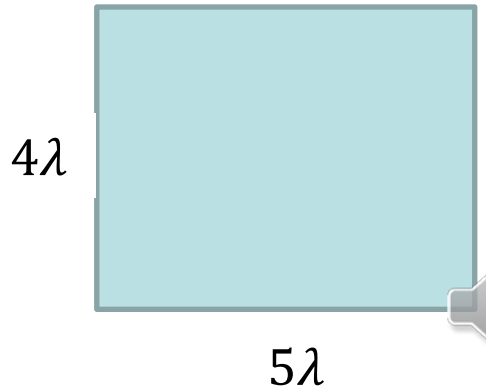


Fig. 2.8

2.3. Capacitance (4)

- Example 2.2 (Assume that λ is 25 nm.)
  - Area is $4\lambda \times 5\lambda = 20\lambda^2 = 0.0125\ \mu\text{m}^2$.
  - Perimeter is $2(4\lambda + 5\lambda) = 18\lambda = 0.45\ \mu\text{m}$.
  - Since $C_{jbd} = 1.2fF/\mu\text{m}^2$, the capacitance is 0.015 fF.
  - Assume that $C_{jbdsw} = 0.1fF/\mu\text{m}$ and $C_{jbdswg} = 0.36fF/\mu\text{m}$.
  - Contribution from sidewalls is 0.071 fF.
  - The overall diffusion capacitance is 0.086 fF.



Homework#3

- Solve the exercise problems of the textbook.
  - Exercises 2.1, Excercise 2.2, Exercise 2.3, Exercise 2.4, and Exercise 2.5 (Five problems)
- Consider a NMOS with V_g=1.8 V. Its V_t is 0.4 V. The channel length is 180 nm.
  - Draw that “potential” as a function of the position.
  - Consider the drain voltage up to 1.4 V.

- Due: October 15, 2019 (Before the lecture starts)
  - Upload your Homework to our GitHub repository.