

**M R**

*Ahmed Mahdy*



|                  |            |
|------------------|------------|
| فيزياء           | استاتيكا   |
| دوائر كهربية     | الكثرونيات |
| ميكانيكا الانشآت | هيدروليكا  |

مدرس خصوصي

حضورى

اونلاين

محصل الطالب علي

مقاطع فيديو هات لشرح اقرر بشكل وافي

ملخص للمادة Pdf للمذكرة واطراجة

محاضرات مباشرة علي برنامج زووم

مناقشة الأجزاء الغير مفهومة

تواصل مستمر مع معلم المادة



للتواصل

0567630097

0565657741



*n-type*

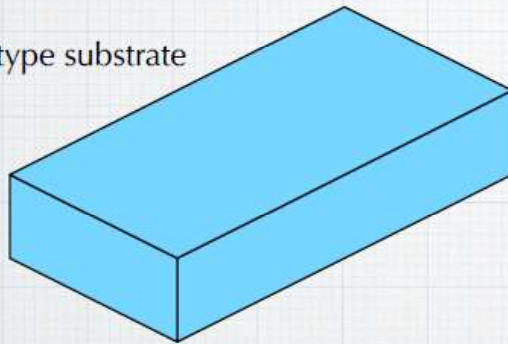


*p-type*

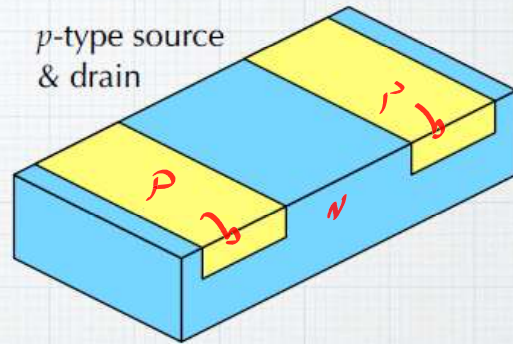
## Basic PMOS structure

*p-channel device (n- and p-type regions reversed.)*

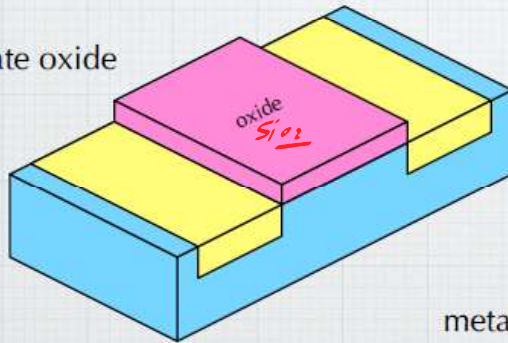
*n-type substrate*



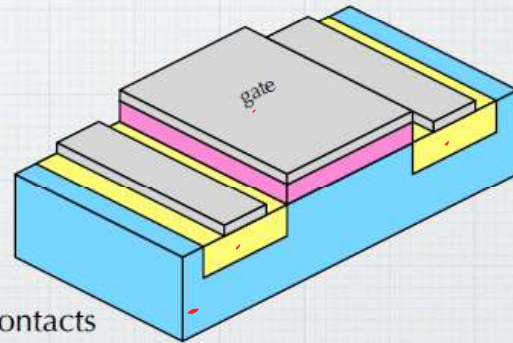
*p-type source & drain*



*gate oxide*



*metal contacts*

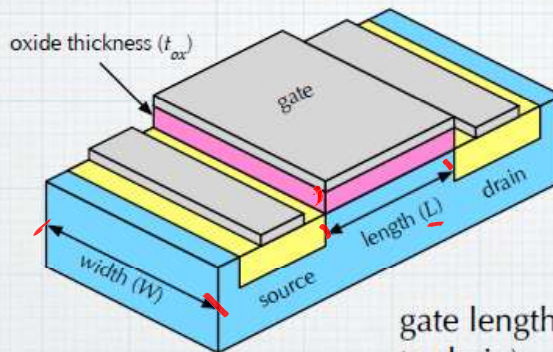


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PMOS - 1

## Critical dimensions

oxide thickness: typical 1 - 10 nm.

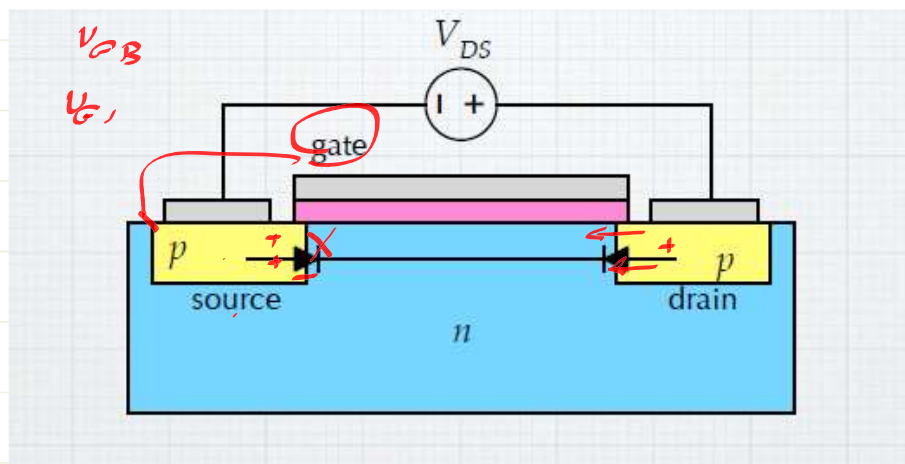


width: typical  $L$  to  $10 L$   
( $W/L$  ratio is important)

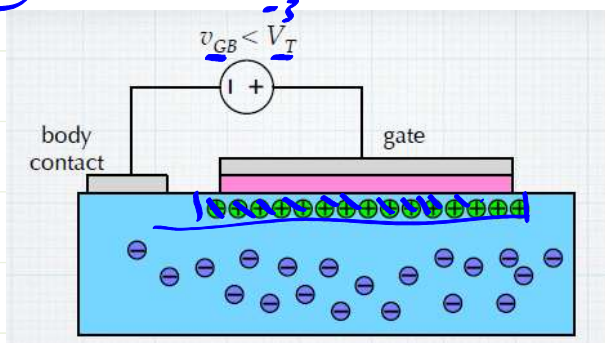
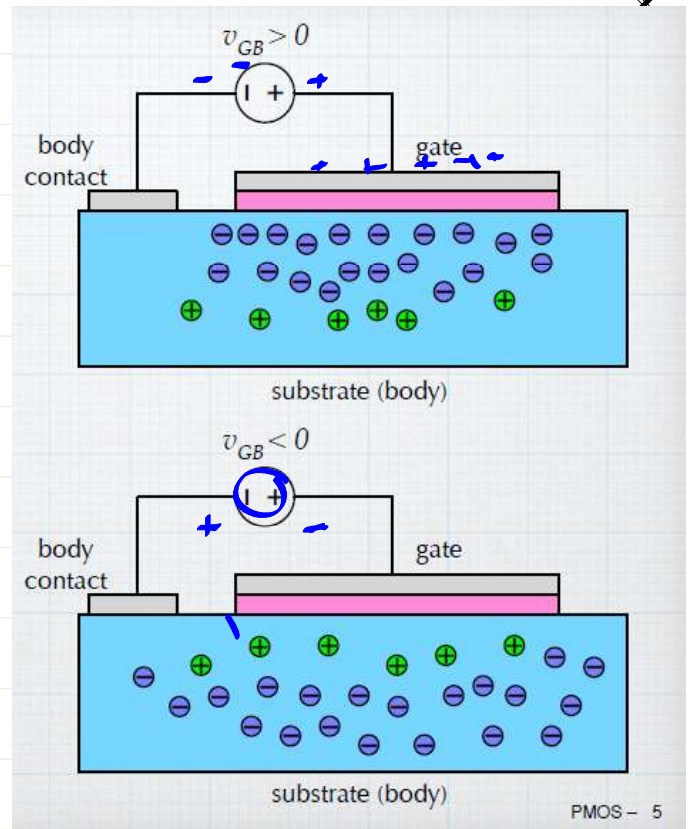
gate length (distance from source to drain) – currently as small as 20 nm.

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PMOS – 2

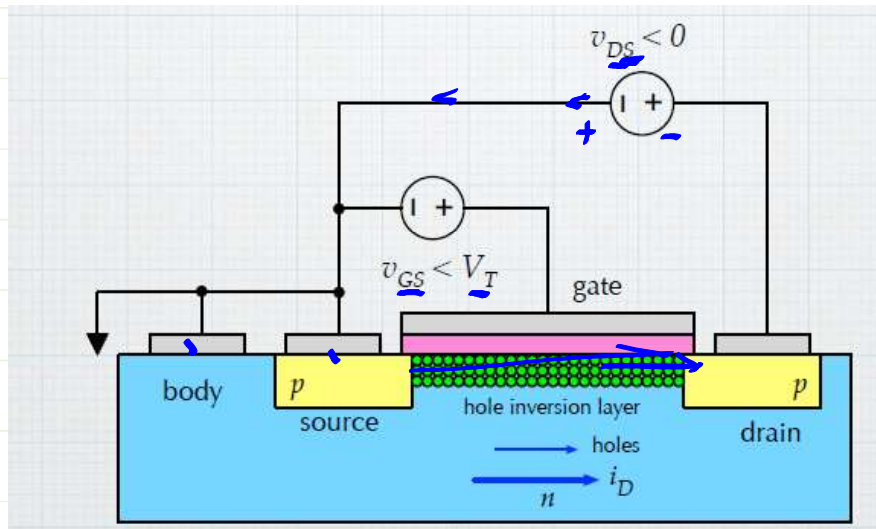






|                    |                                                                       |
|--------------------|-----------------------------------------------------------------------|
| $v_{GB} > 0$       | electron accumulation                                                 |
| $V_T < v_{GB} < 0$ | carrier depletion                                                     |
| $v_{GB} < V_T$     | inversion –<br>hole <u>sheet</u> forms.<br>(Note: $V_T$ is negative.) |

$$v_{DS} > v_{GS} - v_T$$

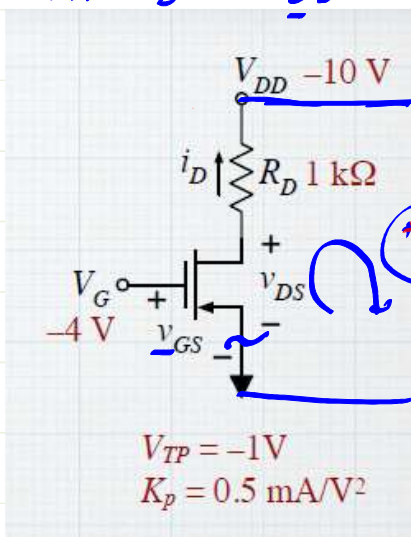


$$I_D = \frac{1}{2} k [ 2 ( v_{GS} - v_T ) v_{DS} - v_{DS}^2 ] , \quad v_{DS} > v_{GS} - v_T$$

$$I_D = \frac{1}{2} k [ v_{GS} - v_T ]^2 \quad v_{DS} < v_{GS} - v_T$$

### PMOS example

Calculate  $I_D$  and  $v_{DS}$



$$I_D = \frac{1}{2} k [ v_{GS} - v_T ]^2$$

$$= 0.5 [ -4 - (-1) ]^2 = 4.5 \text{ mA}$$

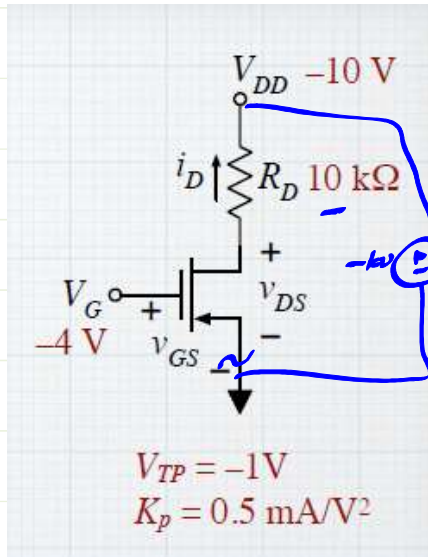
$$-v_{DS} + 1 \times 4.5 - 10 = 0$$

$$v_{DS} = -5.5 \text{ V}$$

$$v_{DS} < v_{GS} - v_T$$

$$-5.5 < -4 - (-1)$$

$$-5.5 < -3$$



$$-v_{DS} + I_D \times 10 - 10 = 0$$

$$I_D = \frac{v_{DS} + 10}{10} = \frac{v_{DS}}{10} + 1$$

$$I_D = K \{ 2(V_{GS} - V_T) v_{DS} - v_{DS}^2 \}$$

$$\frac{v_{DS}}{10} + 1 = 0.5 \{ 2(-3)v_{DS} - v_{DS}^2 \} = -3v_{DS} - 0.5v_{DS}^2$$

$$0.5v_{DS}^2 + \left(\frac{1}{10} + 3\right)v_{DS} + 1 = 0$$

$$v_{DS1} = -0.34V, \quad v_{DS2} = -5.86V$$

$$-0.34 > -3 \quad | \quad -5.86 < -3$$

✓

$$I_D = \frac{-0.34}{10} + 1 = 0.966 \text{ mA}$$

## Summary of PMOS equations

|                                           |                                             |                 |
|-------------------------------------------|---------------------------------------------|-----------------|
| $v_{GS} > \underline{V_T}$                | $i_D = 0$                                   | <u>off</u>      |
| $v_{GS} < V_T$<br>$v_{DS} > v_{GS} - V_T$ | $i_D = K[2(v_{GS} - V_T)v_{DS} - v_{DS}^2]$ | ohmic or linear |
| $v_{GS} < V_T$<br>$v_{DS} < v_{GS} - V_T$ | $i_D = K[\underline{v_{GS}} - V_T]^2$       | saturation      |