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~~Mosft~~ MOSFET operation

The threashold voltage of N-channel mosfet denoted at V_{TN} is defined as the applied gate voltage needed to create an inversion layer.

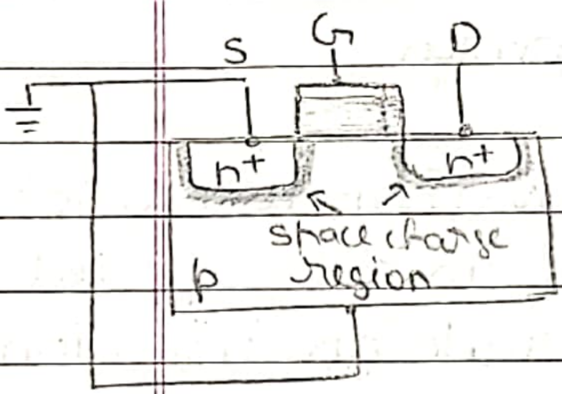
In simple terms the threashold voltage is gate voltage required turn ON the transister.

For the n-channel enhacement mode MOSFET the threashold voltage is +ve because +ve gate voltage is required to create inversion layer.

If the gate voltage is less than V_{TN} the current in the device is essentianlly zero If gate voltage is greater than V_{TH} a, drain to source current is generated as the drain to source voltage is applied.

The gate and drain voltages are measured with respect to source.

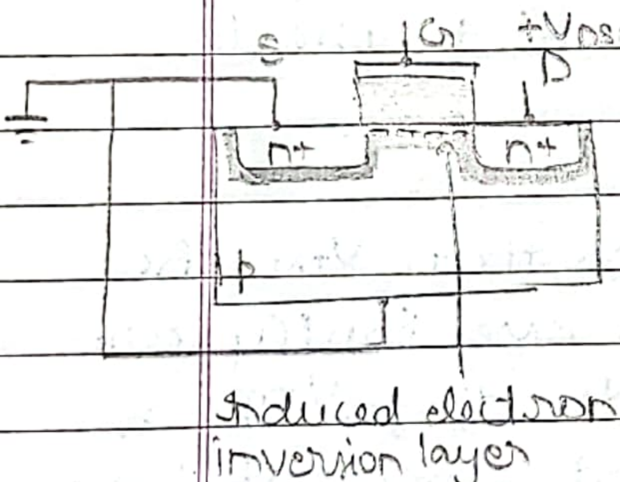
$V_{GS} < V_{TH}$



As you can see in the diagram the source and ~~drain termi~~ substrate terminals are connected to ground.

When gate to source voltage is less than threashlod voltage i.e. $V_{GS} < V_{TH}$ and there is small drain to substrate voltage. There is no electron inversion layer the drain to substrate pn junction is reverse biased and drain current is zero.

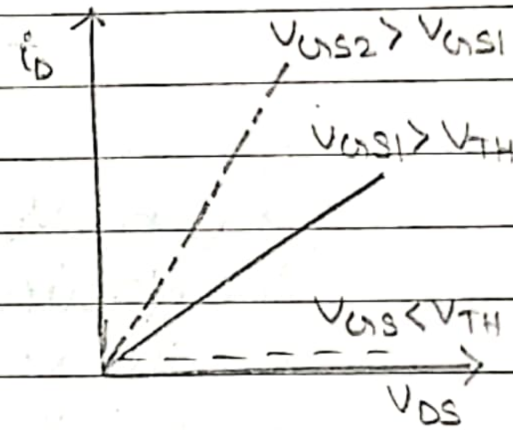
$V_{GS} > V_{TH}$



When $V_{GS} > V_{TH}$ the electron inversion layer is created and when a small drain voltage is applied electrons ~~from~~ in the inversion layer ~~from~~ flow from the source to +ve drain terminal.

Note that a +ve drain voltage. creates a reversed biased drain to substrete pn junction so current flows through the channel region and not through a pn junction.

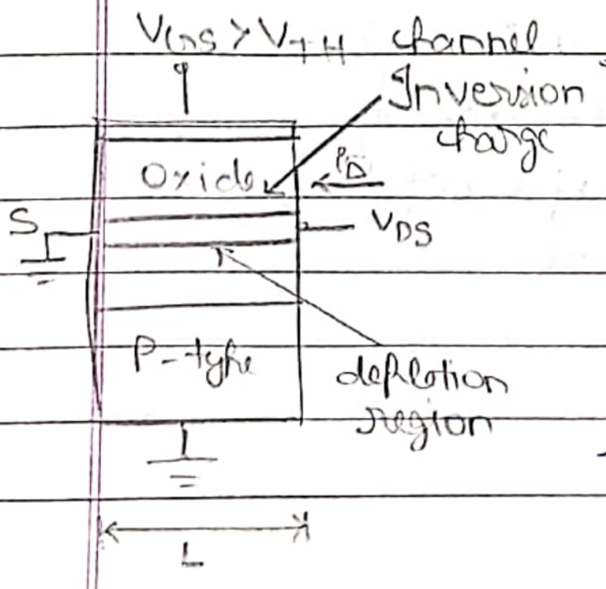
The i_D vs V_{DS} characteristics for small values of V_{DS} is as shown.



when $V_{GS} > V_{TH}$, the drain current is zero.

When $V_{GS} > V_{TH}$, the inversion layer is formed and drain current increased with V_{DS}.

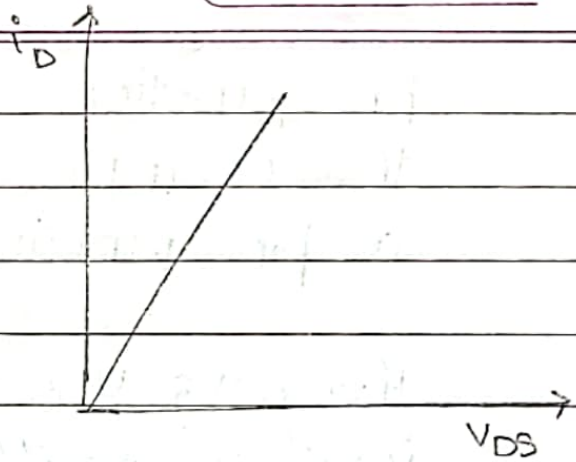
when V_{GS} is increased further large inversion charge density increased and the ~~gate~~ drain current is greater for given value of V_{DS}.



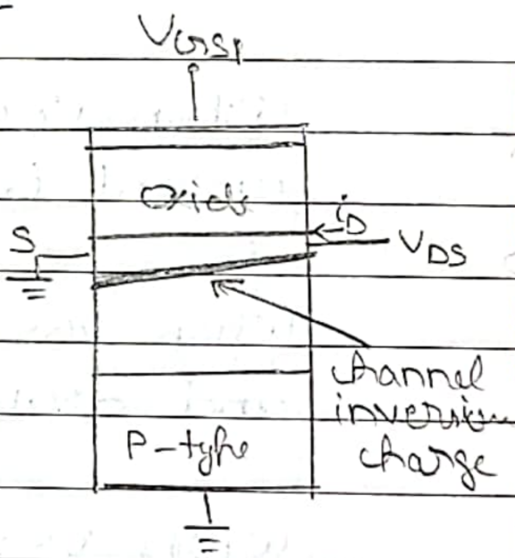
$V_{GS} > V_{TH}$ and small applied V_{DS}.

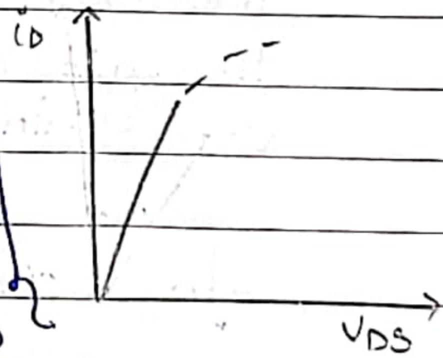
In the diagram the thickness of inversion channel layer indicates the

The relative charge density is constant along the entire channel.



when V_{DS} increases. As the drain voltage increases the voltage drop across the oxide near the drain terminal decreases which means the induced inversion charge density near the drain decreased.





The incremental conductance of the channel at the drain then decreases which causes the slope of i_D Vs V_{DS} curve to decrease.

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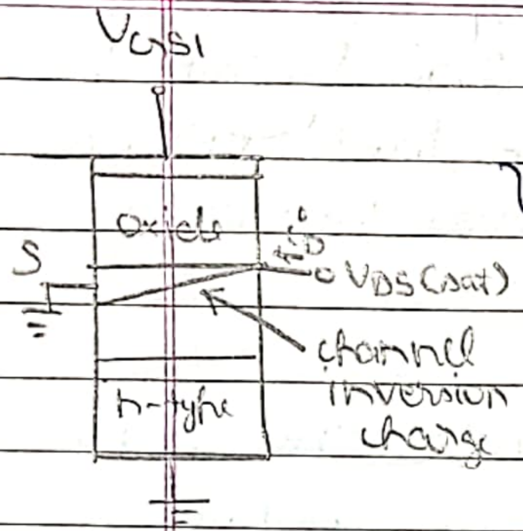
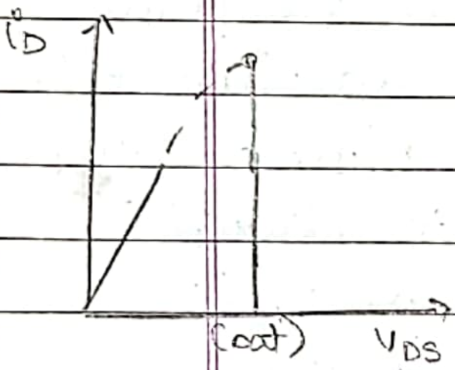
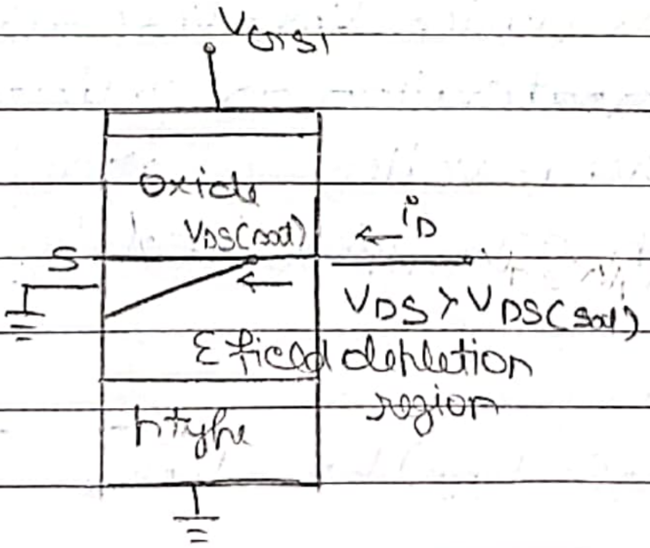


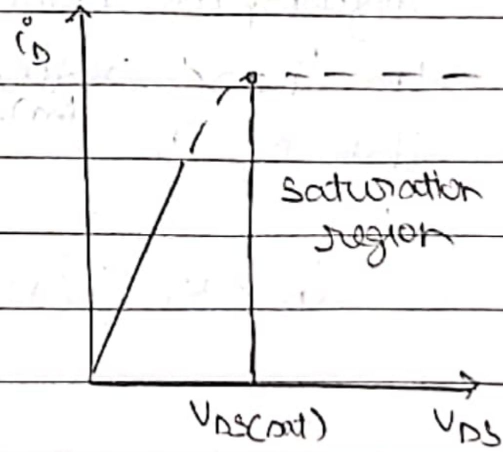


As V_{DS} increases to the point where potential diff. ~~$V_{DS}-V_t$~~ $V_{GS}-V_{DS}$ across the oxide across the drain terminal is equal to V_{TH}, the induced ~~that~~ inversion charge density at the drain is zero.

For this condition the incremental channel conductance at the drain is zero, which means the slope of i_D vs V_{DS} curve is zero.

$$V_{GS} - V_{TH} = V_{DS(sat)}$$





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When V_{DS} becomes greater than $V_{DS(sat)}$ the point the channel at which the inversion charge density is zero moves towards the source terminal.

In this case electrons enter the channel at source travel through the channel towards the drain and then at the point where the charge goes to zero are injected into the space charge region where they are swept by the E field to drain contact.

In ideal MOSFET the drain current $V_{DS} > V_{DS}^{(sat)}$ is constant.

The region for which $V_{DS} < V_{DS(sat)}$ is known as nonsaturation or triode region. The ideal current-voltage characteristics in this region are described by the eq^n.

$$i_D = K_n[2(V_{GS} - V_{TH})V_{DS} - V_{DS}^2]$$

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In the saturation region the ideal current-voltage characteristics for $V_{GS} > V_{TH}$ are described by equation.

$$i_D = K_n (V_{GS} - V_{TH})^2$$

since

In saturation region, the ideal drain current is independent of drain to source voltage, the incremental or small signal resistance is infinite.

The parameter K_n is sometimes called the transconductance paramter for n channel device. given by

$$K_n = \frac{W \mu_n C_{ox}}{2L}$$

where C_{ox} is the oxide capacitance per unit area.

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} \begin{array}{l} \rightarrow \text{oxide permittivity} \\ \rightarrow \text{oxide thickness} \end{array}$$

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and μ_n is the mobility of the electrones in inversion layer, W and L are channel width and length.

~~For~~ The eq^n indicates the conduction parameter is a function of both electrical and geometric parameters. The oxide capacitance and carrier mobility are essentially constant for given fabrication technology. However the gemotary is a variable in design of MOSFET that is used to produce specific current voltage characteristics.