EI-27003: Electronics Devices and Circuits
Lecture - 13

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LECTURE - 13

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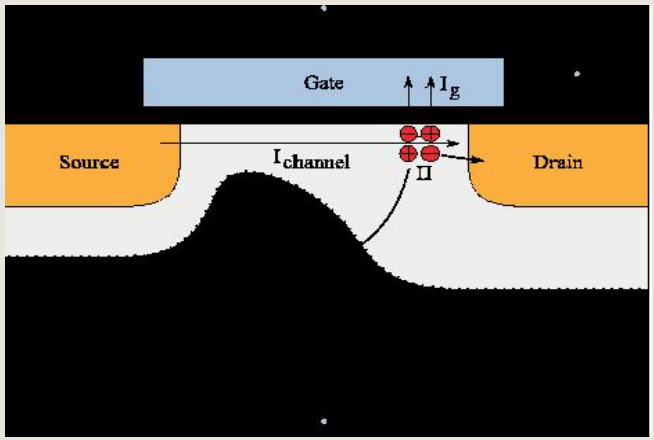
Short Channel Effects

- Various short channel effects are:
  1. Drain Punch through
  2. Drain Induced Barrier Lowering (DIBL)
  3. Hot electron effect
  4. Velocity Saturation effect
  5. Impact Ionization
- Hot Carrier(Electron) effect: In short channel (very small L) MOS, if VDS is very large then electrons from source are accelerated in the channel and arrive at the drain with high velocities and hence high kinetic energies.
- These electrons with high kinetic energies (called as 'HOT') can cause degradation of Transistor or instability. This Phenomenon is called as Hot Carrier Effect.

Short Channel Effects

- One of the problems that can arise due to Hot Carrier effect is that, electron which are travelling randomly at very high velocity may go through the gate oxide into the gate and constitute the gate current Ig, which is highly undesirable.

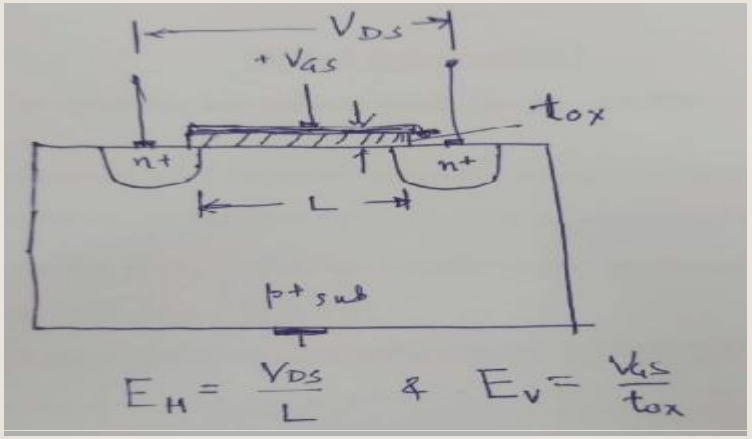


- To overcome this hot electron effect, the electric field at drain channel junction must be reduced. How?

- The doping concentration at reversed bias drain-channel is reduced, which increases depletion width at this junction and hence electric field reduces.

Velocity Saturation Effect

- In Short channel MOS transistor there are two electric fields: Horizontal electric field due to V_{DS}.
  Vertical electric field due to V_{GS}.
- Horizontal electric field is : $E_H = \frac{V_{DS}}{L}$
- Vertical electric field is : $E_V = \frac{V_{GS}}{t_{ox}}$



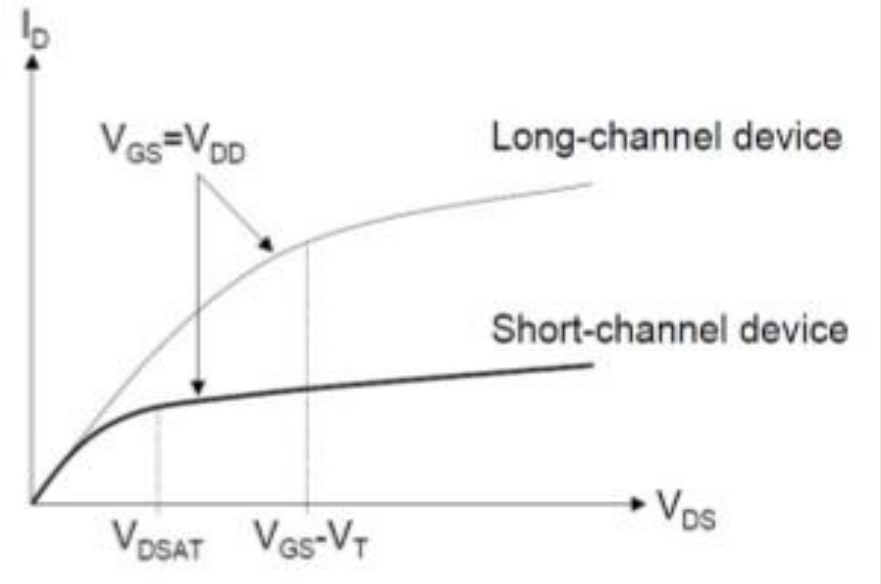
- As channel length is reduce, the electric field increases (if voltage is constant).
- The electron velocity is related to electric field through mobility:

$$V=\mu E$$

- For higher fields the velocity does not increase with electric field, we have degradation of mobility due to scattering by vertical electric field.
- This leads to earlier saturation of drain current i.e. before (V_{GS}-V_t).

Velocity Saturation Effect

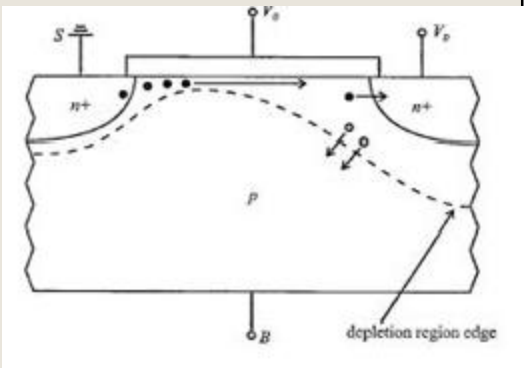
- The net result is reduction in drain current.



- The velocity saturation reduces the trans-conductance of short channel MOS in saturation region.

Impact Ionization

- If the drain-Source voltage is sufficiently high, impact ionization of carriers near the drain can occur.
- When a high voltage VDS is applied, it will result in high electric field near Drain as length L is very small. Due to this high electric field, the electrons(Carriers) accelerate at very high speed and gain kinetic energy (HOT) and may collide with depletion layer at drain side.
- This collision of HOT electrons with drain depletion layer will dislodge the covalent bonds(electron-hole pair).
- This is known as Impact Ionization.
- This is undesirable effect as it will result into a subtract current.



Its Quiz Time

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