

2013 Qualifying Exam
Simon Wong

An n-channel MOSFET with $V_{TH} = 0.5V$, $V_G = 1V$, $V_S = 0V$, sketch I_D versus V_D .

Why does I_D saturate ?

Channel pinches off near the drain.

Will I_D stay saturated at very high V_D ?

No, at high V_D , I_D will increase rapidly.

What is the mechanism responsible for the rapid increase in I_D ?

There are at least 4 possible mechanisms:

1. Drain-induced-barrier-lowering, also known as punch through
2. Avalanche (in the channel) induced breakdown
3. Drain-substrate junction breakdown
4. Drain-gate oxide breakdown

The dominant mechanism depends on the channel length, gate oxide thickness, and doping levels in the junction, channel and substrate.

How can you distinguish which mechanism is responsible for the rapid increase in I_D ?

Measure all currents, I_D , I_S , I_G , and I_{SUB} . Assume the device has been destroyed yet.

1. Drain-induced-barrier-lowering
 $I_D \cong I_S$, $I_G \cong 0$, $I_{SUB} \cong 0$
2. Avalanche induced breakdown
 $I_D \cong I_S$, $I_G \cong 0$, $I_{SUB} \neq 0$ but $\ll I_D$
3. Drain-substrate junction breakdown
 $I_D \cong I_{SUB}$, $I_S < I_D$, $I_G \cong 0$
4. Drain-gate oxide breakdown
 $I_D \cong I_G$, $I_S < I_D$, $I_{SUB} \cong 0$