

NCN@Purdue Summer School: July 14-25, 2008

“Electronics from the Bottom Up”

Exercises on Carrier Scattering in Nanoscale MOSFETs

Mark Lundstrom
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Discovery Park, Purdue University

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Objective:

To help you gain familiarity with comparing measured data against the ballistic limit, you will be asked to perform an analysis similar to the one done in Lecture 5.

- 1) Consider a silicon PMOS technology with the following characteristics;

Nitrided gate oxide ($k = 5$, $t_{inv} = 2.5$ nm, $EOT = 1.7$ nm)

Polysilicon gate

$V_{DD} = 1.2$ V

Not intentionally strained

All measurements at $T \sim 300$ K

Minimum mask channel length = 100 nm

Minimum physical channel length (SEM) = 85 nm

Note that this is an older, unstrained technology. Modern PMOS technology uses strained silicon to boost performance (i.e. on-current).

The measured characteristics of the devices are:

$V_T(\text{sat})$ (V)	0.22
$V_T(\text{lin})$ (V)	0.32
I_{ON} ($\mu\text{A}/\mu\text{m}$)	360
I_{OFF} ($\mu\text{A}/\mu\text{m}$)	2.89×10^{-2}
S (mV/dec)	94

DIBL (mV/V)	101
R_{TOT} (Ω - μm)	1217
$g_m(\text{MAX})$ ($\mu\text{S}/\mu\text{m}$)	483

Perform an analysis of this device and estimate $B_{lin} = T = I_{Dlin}/I_{Dlin}(ball)$ and $B_{sat} = T/(2 - T) = I_{ON}/I_{ON}(ball)$. Assume that the series resistance is $R_{SD} = 200 \pm 50 \Omega - \mu\text{m}$. To keep the analysis simple, just treat the heavy hole and assume it is a single parabolic sub-band with a heavy hole effective mass of $m^*/m_0 = 0.54$.

Matlab scripts that compute the ballistic channel resistance and the ballistic injection velocity for electrons are attached and can be modified for this exercise.