SIMULATION, FABRICATION AND CHARACTERIZATION OF NMOS TRANSISTOR

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SIMULATION, FABRICATION AND CHARACTERIZATION OF NMOS TRANSISTOR

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To my parents; for your love and support

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ABSTRACT

This thesis explains the recipe module development for the first Long Channel NMOS transistor device fabrication process at cleanroom laboratory of KUiTTHO. A recipe for the NMOS transistor fabrication process has been successfully produced. Threshold Voltage and Leakage Current, with different channel length and oxide gate for the Long Channel NMOS transistor too has been investigated. The data from the experiment conducted have shown that the threshold voltage is more influenced by the thickness of the oxide gate as compared with the channel length. The threshold voltage increased in linear form with the increase of the oxide gate thickness; and there is almost no change for different channel length. Leakage Current reduces exponentially with the increase of the oxide gate thickness and the channel length.

ABSTRAK

Tesis ini menerangkan pembangunan modul resepi bagi proses fabrikasi peranti transistor kesan medan logam-oksida semikonduktor salur panjang (*Long Channel NMOS transistor*) yang pertama kali di makmal bilik bersih KUiTTHO. Resepi bagi proses fabrikasi peranti transistor kesan medan logam-oksida semikonduktor telah berjaya dihasilkan. Voltan ambang dan arus bocor salir, dengan panjang salur dan oksida get yang berbeza bagi transistor kesan medan logam-oksida semikonduktor salur panjang telah di kaji. Data dari eksperimen yang telah dilakukan menunjukkan voltan ambang banyak di pengaruhi oleh ketebalan oksida get berbanding dengan panjang salur. Voltan ambang naik secara *linear* dengan kenaikan ketebalan oksida get dan hampir tidak ada perubahan bagi panjang salur yang berbeza. Arus bocor salir berkurangan secara eksponen dengan kenaikan ketebalan oksida get dan panjang salur.

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LIST OF SYMBOLS

A	Area
Å	Symbol for 10^{-10}cm or 10^{-8}m
c	Speed of light in vacuum
C	Capacitance
C_j	Junction capacitance per unit area
C_{ox}	Oxide capacitance per unit area
D	Diffusion coefficient
$\mathcal{E}$	Electric field
E_a	Acceptor energy
E_c	Conduction band energy of a semiconductor
E_d	Donor energy
E_F	Fermi energy (thermal equilibrium)
E_g	Energy bandgap of a semiconductor
E_i	Intrinsic Fermi energy Joule
E_v	Valence band energy of a semiconductor
F_n	Quasi-Fermi energy of electrons
F_p	Quasi-Fermi energy of holes
h	Plank's constant
I	Current
J	Current density
J_n	Electron current density
J_p	Hole current density
k	Boltzmann's constant

L	Length
m	Mass
n	Electron density
n_i	Intrinsic carrier density
N	Doping density
N_a	Acceptor doping density
N_c	Effective density of states in the conduction band
N_d	Donor doping density
Q	Charge
$Q_{p,B}$	Hole charge in the base
Q_d	Charge density per unit area in the depletion layer of an MOS structure
$Q_{d,T}$	Charge density per unit area at threshold in the depletion layer of an MOS structure
R	Resistance
t	Thickness
t_{ox}	Oxide thickness
T	Temperature
v	Velocity
v_{th}	Thermal velocity
V_a	Applied voltage
V_B	Base voltage
V_D	Drain voltage
V_B	Body voltage
V_G	Gate voltage
Vt	Thermal voltage
V_{TH}	Threshold voltage
x_d	Depletion layer width
xd,T	Depletion layer width in an MOS structure at threshold
x_j	Junction depth
x_n	Depletion layer width in an n-type semiconductor
xp	Depletion layer width in a p-type semiconductor

ε_{ox}	Dielectric constant of the oxide F/m
ε_s	Dielectric constant of the semiconductor F/m
μ_n	Electron mobility
μ_p	Hole mobility
Φ_M	Workfunction of a metal V
Φ_{MS}	Workfunction difference between a metal and a semiconductor V

CHAPTER I

PROJECT OVERVIEW

1.1 Overview

This chapter will explain the project overview and scopes of project.

1.2 Introduction

The history of microelectronics began on December 1947 at the Bell Labs, United States of America, when three scientists John Brdeen, Wafter Brattain and William Shockley invented the first semiconductor device which is called the transistor that was able to replace the functions of the vacuum tube as an amplifier. The said invention had opened the path in producing electronic circuitry designs that were small and cheap. Entailing the discovery, large numbers of electronics companies were incorporated including one by William Shockley himself in the year 1955 in Santa Clara