ECE 474L/574L (also offered as NSMS 574L)
Microelectronics Processing

Overview

Course Catalog Description: Materials science of semiconductors, microelectronics technologies, device/circuit fabrication, parasitics and packaging. Lab project features small group design/fabrication/testing of MOS circuits.

Prerequisites: None

Textbook: "Fabrication Engineering at the Micro- and Nanoscale", 3rd EDITION, by Stephen A. Campbell, Oxford University Press, ISBN:978-0-19-532017-6

Class Goals: This course is intended to provide a detailed understanding of the unit processes used in microelectronics processing. The course covers the science and theory underlying each of these processes, and shows how these processes combine in real device technologies. The laboratory sessions use professional processing equipment and give hands-on experience of these unit processes. During the laboratory sessions students fabricate and test working MOSFET devices.

Course Coordinator: Prof. Stephen D. Hersee

Course Delivery: This course is delivered using classroom lectures, lab sessions and an online component where homeworks, homework solutions, news about the laboratory sessions will be posted. Other online resources include a 24/7 bulletin board, where students can discuss any of the material covered in the class. Students are expected to be familiar with UNM's WebCT system and must sign up for a WebCT account when they register for this class.

Grading:
Homeworks 40%, MIDTERM Exam 20%, LAB Report 15%, FINAL Exam 25%

Assignment of Letter Grade: uses the following system (rounding to the nearest integer)

95 to 100 %= A+,	90 to <95 %= A ,	85 to <90 % = A-
80 to <85%= B+,	75 to <80%= B,	70 to <75% = B-
65 to <70%= C+,	60 to <65%= C,	55 to <60% = C-
	< 55% = F	

Table I: Objectives, Implementation, and Assessment

Objectives		Implementation	Assessment	A	B	C	D	E	F	G	H	I	J	K
1	Understand the importance of safety in the laboratory . Learn the safety rules for the MTTC process laboratory	1 Lecture and off-line study of additional material	HMWK# 1 Safety Test (Students must pass this test before they can work in the MTTC Laboratory	3	3			3	3		3		3	3
2	Learn basic crystallography, defect types in crystals, phase diagrams. Understand fabrication of silicon substrates and dopant segregation issues	2 Lectures	HMWK#2 Midterm Final	3	3	3		3		3	3		3	3
3	Understand dopant diffusion using Fick's Laws. Understand Fair vacancy model and use in analysis of concentration dependent diffusion	2 Lectures	HMWK#2 Midterm Final	3	3	3		3		3	3		3	3
4	**Lab session 1:** Learn layout of MTTC facility, clean procedures, wafer handling, photolithography	Half-day lab session	Observation of student skills in cleanroom. Lab Report	3	3		3	3	3		3		3	3
5	Understand thermal oxidation using Deal-Grove model. Understand atomic scale of SiO_2 Understand dopant segregation during oxidation, LOCOS	2 Lectures	HMWK#3 Midterm Final	3	3	3		3		3	3		3	3

6	**Lab session 2:** Perform FOX lithography (Mask 1) and etch	Half-day lab session	Observation of student skills in cleanroom. Lab Report	3	3		3	3	3		3		3	3
7	Understand ion implantion (physics and operation of each part of an ion implanter) Understand interaction of implanted ions with silicon. Analyze and manipulate the maths of ion implant profiles. Understand channeling effects, implant damage and annealing. Understand implantation through a mask.	2.5 Lectures	HMWK#3 Midterm Final	3	3	3		3		3	3		3	3
8	**Lab session 3:** Perform FOX lithography (Mask 2) and etch	Half-day lab session	Observation of student skills in cleanroom. Lab Report	3	3		3	3	3		3		3	3
9	Understand photo-lithography Manipulate maths of diffraction and modulation transfer function. Understand trade-offs of resolution and depth of field. Analyze spatial frequency. Analyze basic chemistry of photoresists, contrast curves. Understand how optical effects and resist response combine to determine minimum printable size. Understand advanced resist effects (bleaching, phase contrast, multilayer resists)	4 Lectures	HMWK#4 Final Exam	3	3	3		3		3	3		3	3

10	**Lab Session 4:** Lithography (Mask 3) and GOX etching. Understand integration of unit processes to make a device process	Half-day lab session	Observation of student behavior in cleanroom. Lab Report	3	3		3	3	3		3		3	3
11	Understand REDOX etching of semiconductor materials. Analyze selectivity, faceting, isotropic and non-isotropic effects. Understand plasma creation and dry etching at high and low pressures. Understand plasma etch chemistry and effects of adding oxygen and polymer formation.	3 Lectures	HMWK#5 Final Exam	3	3	3		3		3	3		3	3
12	**Lab Session 5:** Metal deposition, lithography (Mask 4) and etching to form MOSFET contacts	Half-day lab session	Observation of student behavior in cleanroom. Lab Report	3	3		3	3	3		3		3	3
13	Understand CVD chemistry and hydrodynamics. Compare mass-transport and reaction-limited CVD regimes. Understand operating principles of CVD equipment	1 Lectures	Final Exam	3	3	3		3		3	3		3	3
14	Understand process integration using examples of CMOS technology, bipolar technology	2 Lectures	Final Exam	3	3	3		3		3	3		3	3
15	**Lab Sessions 6, 7 and 8:** Learn MOSFET probe testing. Measure threshold voltage, MOSFET type, breakdown voltage.	Half-day lab sessions	Observation of student behavior in cleanroom. Lab Report	3	3			3	3		3		3	3

16	Understand importance of metal contact conductivity. Understand copper damascene process	2 Lectures	Final Exam	3	3	3		3		3	3		3	3
17	Understand MEMS devices. Understand piezo-resistive pressure sensor and cantilever. Understand MEMs cantilever fabrication.	2 Lectures	Final Exam	3	3	3		3		3	3	3	3	3

Sample Course Schedule

Week	Date	Lect.	Topic	Assignment
1	22 Jan	01	Introduction & Course Overview	
	24 Jan		Safety Briefing	
2	29 Jan	02	Crystallography, Silicon substrate fabrication	Ch. 2
	31 Jan		**Safety Exam**	
			MTTC Laboratory walk-through	
3	05 Feb	03	Crystallography, Silicon substrate fabrication	Ch. 2
	07 Feb	04	Diffusion	Ch. 3
4	12 Feb	05	Diffusion	Ch. 3
	14 Feb	06	Oxidation	Ch. 4
5	19 Feb	07	Oxidation	Ch. 4
	21 Feb	08	Oxidation (end), Ion Implantation (start)	Ch. 4/5
6	26 Feb	09	Ion Implantation	Ch. 5
	28 Feb	10	Optical Lithography	Ch. 7
7	04 Mar	11	Optical Lithography	Ch. 7
	06 Mar		-	
8	11 Mar	12	Photoresists	Ch. 8
	13 Mar	13	Etching	Ch. 11
9	18 Mar		Spring Break	
	20 Mar		Spring Break	
10	25 Mar	14	Etching	Ch. 11
	27 Mar		**Midterm Exam**	
11	01 Apr	15	CMOS Process Integration	
	03 Apr	16	Chemical Vapor Deposition	Ch. 13
12	08 Apr	17	Chemical Vapor Deposition	Ch. 13
	10 Apr	18	Metallization, Copper Damascene	Ch. 15
13	15 Apr	19	MEMs	Ch. 19
	17 Apr	20	MEMs, CMOS scaling	Ch. 19/16
14	22 Apr	21	Prof. R. Blewer (Invited) : Cleanroom Operation	
	24 Apr	22	Bipolar process integration	Ch. 17
15	29 Apr		-	
	01 May	23	Bipolar process integration	Ch. 17
16	06 May	24	Applications of processing	
	08 May	25	Course review	
17	13 May		**Final Exam**	