EE5343 – Silicon Integrated Circuit Fabrication Technology
Fall 2016 Course Syllabus

	Lab Professor	Lecture Professor
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Section Information:

Section 001, Lecture:	Campus Center 109F, Mondays, 9:00 AM – 12:00 PM
Section 101, Lab:	NANO 104, Wednesdays, 9 AM-12:50 PM
Section 102, Lab:	NANO 104, Fridays, 9 AM-12:50 PM

Course GTA: TBA
Course GTA O/Hs: TBA

Prerequisite: Attend the NanoFAB Safety and Clean Room training.

Required Textbooks and Other Course Materials:
Fabrication Engineering at the Micro and Nanoscale, 4th Edition, by Stephen A. Campbell, Oxford University Press, 2007. ISBN-13: 978-0195320176, ISBN-10: 0195320174.
Reference: Introduction to Microelectronic Fabrication, Modular Series on Solid State Devices Vol. V, Second Edition, by Richard C. Jaeger, Prentice-Hall, 2002. ISBN 0-201-44494-7

Description of Course Content: Course comprises of lectures and labs. Introduction to the basic steps and processes of fabricating integrated circuit semiconductor devices: crystal growth (thin film and bulk), thermal oxidation, dopant diffusion/implantation, thin film deposition/etching, and lithography. Introduction to process simulators, such as SUPREM. Fabrication and characterization of resistors, MOS capacitors, junction diodes and MOSFET devices. Specifically, in the lectures we will cover:

Chapter 1. An Introduction to Microelectronic Fabrication

Chapter 2 Semiconductor Substrates
2.1 Phase Diagrams and Solid Solubility
2.2 Crystallography and Crystal Structure
2.7 Wafer Preparation and Specifications
2.8 Summary and Future Trends

Chapter 3. Diffusion
3.1 Fick's Diffusion Equation in One Dimension
3.2 Atomistic Models of Diffusion
3.3 Analytic Solutions of Fick's Law
3.4 Diffusion Coefficients for Common Dopants
3.5 Analysis of Diffused Profiles

Chapter 4. Thermal Oxidation
4.1 The Deal-Grove Model of Oxidation
4.2 The Linear and Parabolic Rate Coefficients
4.3 The Initial Oxidation Regime
4.4 The Structure of SiO24.5 Oxide Characterization
4.6 The Effects of Dopants During Oxidation and Polysilicon Oxidation

Chapter 7. Optical Lithography
7.1 Lithography Overview
7.3 The Modulation Transfer Function and Optical Exposures
7.4 Source Systems and Spatial Coherence
7.5 Contact/Proximity Printers
7.6 Projection Printers
7.8 Surface Reflections and Standing Waves
7.9 Alignment

Chapter 8. Photoresists
8.1 Photoresist Types
8.2 Organic Materials and Polymers
8.3 Typical Reactions of DQN Positive Photoresist

Chapter 11. Etching
11.1 Wet Etching
11.2 Chemical Mechanical Polishing
11.3 Basic Regimes of Plasma Etching
11.4 High Pressure Plasma Etching
11.5 Ion Milling
11.6 Reactive Ion Etching
11.8 High Density Plasma (HDP) Etching
11.9 Liftoff

Chapter 12. Physical Deposition: Evaporation and Sputtering
12.1 Phase Diagrams: Sublimation and Evaporation
12.2 Deposition Rates
12.3 Step Coverage
12.4 Evaporator Systems: Crucible Heating Techniques
12.5 Multicomponent Films
12.6 An Introduction to Sputtering
12.7 Physics of Sputtering
12.8 Deposition Rate: Sputter Yield
12.9 High Density Plasma Sputtering
12.10 Morphology and Step Coverage
12.11 Sputtering Methods
12.12 Sputtering of Specific Materials

Chapter 13. Chemical Vapor Deposition (If time allows)
13.1 A Simple CVD System for the Deposition of Silicon
13.2 Chemical Equilibrium and the Law of Mass Action
13.4 Evaluation of the Simple CVD System
13.5 Atmospheric CVD of Dielectrics
13.6 Low Pressure CVD of Dielectrics and Semiconductors in Hot Wall Systems
13.7 Plasma-enhanced CVD of Dielectrics

Student Learning Outcomes:

The desired learning outcomes for a student of this course are:

- Able to design integrated silicon based devices' process steps
- Understand all silicon fabrication processes, their metrologies and related theory
- Develop an understanding of the complexities involved in a complete fabrication cycle of an integrated circuit.
- Learn theory and practical techniques for optical lithography processes
- Gain the basic concept of FEOL/BEOL integration flow
- Describe the basic processes of FEOL
- Understand challenges of new materials and 3D CMOS devices for lithography
- Identify the challenges and interactions between lithography and all the critical processes
- Describe BEOL copper/low-k dual damascene integration schemes

To achieve these outcomes, the following learning objectives are established:

#	Course Learning Objective (CLO)	Assessment approach
1	Ability to design and analyze at least two-mask level silicon based device	Exam Problems
2	Ability to use equipment, process and chemical reactivity data to define a process flow for a particular fabrication module	Project Lab Notebook
3	Ability to differentiate and analyze basic trade-offs in processing parameters and how these affect the desired process output	Exam Problems
4	Knowledge of basic limitations of different processes and how	Homework/Exam

	these integrate to achieve final device	Problems
5	Experimentally test and characterize the fabricated devices	Project Lab Notebook
6	Working knowledge of basic equations that govern the processes used in fabrication	Exam Problems
7	Understanding of fundamental challenges in fabrication techniques and possible solutions	Project Lab Reports
8	Compare theory with experiments and identify sources of error and discrepancy	Homework Problems
9	Clarity in written communication to explain approaches and results, and to compare with expected results	Project Lab Reports
10	Write critical report(s) on the fabrication process	Project Lab Reports

Requirements of Lab Work:

- Lab work will be done in Nanotechnology Research Center (NanoFAB), room 104.
- Every student has to attend the "NanoFAB Safety & Protocol Class" and pass the associated quiz on BLACKBOARD.
- Every student has to undergo "General HAZCOM Online Training."
- The students who do not pass these trainings will be administratively dropped from the course.
- Details are given at following link on how to register for the trainings:
  http://www.uta.edu/sirt/nano/user_information.php
- **Until all required training is completed, a student will not be given access to lab facilities, will not be able to participate in any lab activities, and will earn a grade of zero for any uncompleted work.**
- In the lab part of the course, the basics of each step of the process will be practiced. This includes oxidation, metallization, photolithography, etch, etc.
- Each student is assigned to a ~4 hour lab session every week. Be in the lab on time.
- Lab sections and times cannot be changed, switched or altered.
- **Missed labs will result in a 25% penalty per lab for the experiment missed. The lab sessions cannot be made up.**
- Students will use the available facilities to construct a capacitor with different oxide films (one oxide film will be processed at the UTA facility and two types will be provided to them from NSC) as their project. All capacitors will be tested.

Descriptions of major assignments and examinations with due dates:

The course requires several homework assignments, properly maintained lab notebook, lab project reports and two exams. Wikipedia and/or other websites cannot be used as a reference in any of the assignments of this course. Most of the assignments/projects are to be submitted through the BLACKBOARD (http://www.uta.edu/blackboard/). Name your file with your First and Last name followed by assignment name. For all assignments, present your original work. Each individual assignment has to be worked out by individual student. Look under "Academic Integrity" for further details.

Homework: Not more than once a week, a set of problems related to the current course material will be assigned. These will be generally due at the start of lecture after a week.

Lab: The lab notebooks will be collected at least twice during the semester without prior announcement. The lab notebooks should have detailed records of all activities and experiments carried out in the lab under the headings of Objective, Procedure, Equipment and Supplies, Precautions, Observations, Diagrams. The lab notebook should have numbered pages. Include details like data, data plots, data analysis, figures, sketches, diagrams, micrographs, pictures, etc. to support your observations. The other factors in grading for project lab will include reports of the experiments and performance in the lab.

Exams: All exams will be closed book, closed notes. No aid sheet will be allowed. Midterm exams will be on **October 17, and December 5, 2015 during class time**. **There is no final exam.**

Grading Policy:
The final grade will be calculated as per the following breakdown:

Homeworks:	10%
Lab Projects and Notebook:	35%
Midterm Exams:	55%

Attendance Policy: The course content will evolve around class-discussions and laboratory fabrication. It is important to attend the lecture and **mandatory** to be in the lab during the assigned days to grasp the concepts and follow the material.

Make-up Exam/Assignment Policy: Make-up exam can be requested in case of a serious illness if officially documented with verifiable information. No credit will be given for the missed homework assignments or labs.

Drop policy: The UTA drop policy will be adhered to. For a timetable see links at http://www.uta.edu/universitycollege/current/academic-planning/uac/policies/add-drop.php

Americans with Disabilities Act: The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the *Americans with Disabilities Act (ADA)*. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Only those students who have officially documented a need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

Academic Integrity: It is the philosophy of The University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspension or expulsion from the University. According to the UT System Regents' Rule 50101, §2.2, "Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts."

You are required to carefully read and sign the form titled "STATEMENT ON ETHICS, PROFESSIONALISM, AND CONDUCT FOR ENGINEERING STUDENTS." The statement can be found at http://www.uta.edu/engineering/current-students/academic-honesty.php. A copy is also placed on BLACKBOARD. .

This is a zero-tolerance policy. Any occurrence of academic dishonesty by a student (individual or in a team) will result in an automatic zero in that assignment/exam/lab report. The Office of Student Judicial Affairs will be informed in writing of academic dishonesty cases.

Plagiarism has many shapes, but can be explained in a few examples under the scope of this course. It may be presenting someone else's published words (and work) in a way that these words (and works) do not clearly show the source. Any text from someone else's work cannot be used "verbatim" unless in double quotes and followed by a citation and appropriate credit. If in doubt, ask the instructor/GTA.

Student Support Services Available: The University of Texas at Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. These resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals to resources for any reason, students may contact the Maverick Resource Hotline at 817-272-6107 or visit www.uta.edu/resources for more information.

E-Culture Policy: The University of Texas at Arlington has adopted the University "MavMail" address as the sole official means of communication with students. MavMail is used to remind students of important deadlines, advertise events and activities, and permit the University to conduct official transactions exclusively by electronic means. For example, important information concerning registration, financial aid, payment of bills, and graduation are now sent to students through the MavMail system. All students are assigned a MavMail account. ***Students are responsible for checking their MavMail regularly.*** Information about activating and using MavMail is available at http://www.uta.edu/oit/email/. There is no additional charge to students for using this account, and it remains active even after they graduate from UT Arlington.

To obtain your NetID or for logon assistance, visit https://webapps.uta.edu/oit/selfservice/. If you are unable to resolve your issue from the Self-Service website, contact the Helpdesk at helpdesk@uta.edu.

The instructor/GTAs will send important course-related information to your MavMail e-mail address ONLY. Your email to the instructor/GTA should also come from MavMail email account. Your email message sent from non-UT-Arlington accounts may never reach the instructor/GTA. You will be responsible for any misplaced or misdirected email that is sent from non-UT-Arlington email address.

Grade Grievance Policy: If you have any grievance regarding a grade, consult with the instructor/GTAs. Information about the UT-Arlington grievance policy is at http://www.uta.edu/gradcatalog/general_info#grievances .

Final Review Week: A period of five class days prior to the first day of final examinations will be designated as FINAL REVIEW WEEK. The purpose of this week is to allow UT-Arlington students sufficient time to prepare for final exams. During this week, there will be no schedule or required activities such as field trips, seminars, or performances; and no themes, research problems or exercises of similar scope that have a completion date during or following this week will be assigned *unless specified in the class syllabus*. During Final Review Week, no exams constituting 10% or more of the final grade will be given, except make-up tests and laboratory examinations. In addition, no portion of the final exam will be given during Final Review Week.