Syllabus – Microelectronics Manufacturing and the Environment

Ara Philipossian

Department of Chemical & Environmental Engineering

CHEE, MSE & ECE 415 & 515

Course Description

- **This course will focus on the presentation of basic semiconductor fabrication unit operations as they relate to:**
  - **Theory of operation**
  - **Materials**
  - **Equipment**
  - **Fabrication processes**
  - **Key environmental impacts and challenges**
- **Prerequisites:**
  - **None**

Instructor Information

- **Instructor:**
  - **Name:** Ara Philipossian
  - **Office:** Electrical & Computer Engineering Building, Room 223
  - **Phone:** 520 621 6101
  - **E-Mail:** ara@engr.arizona.edu

- **Office Hours:**
  - **Wednesdays 2 to 4 PM (No office hours this week).**
  - **There will be no TA for this course**
  - **Other times by appointment only (send me an e-mail please)**
  - **Office hours are subject to change**

Method of Instruction

- **Class location: McClelland Hall – No. 133 – Mondays 3:30 to 5:50 PM**

- **Course will be delivered in the form of traditional lectures as well as instructional videos:**

– Prof. Ara Philipossian	UA – Lectures
– Prof. Farhang Shadman	UA – Video
– Dr. Michael Goldstein	Intel – Video
– Prof. Srini Raghavan	UA – Video
– Dr. Robert Meagley	Intel – Video
– Dr. Larry Larsen	Sematech – Video

- **Self-discipline will be paramount in order to keep up with the pace and the volume (and format) of information delivered**

Method of Instruction (continued)

- **Homework:**
  - **Ten or so assignments**
- **Exams:**
  - **Mid-Term No. 1**
  - **Mid-Term No. 2**
- **Group Project Proposal (Written and Oral):**
  - **Please see the next 5 slides**

Project Proposal

- **ORAL PRESENTATION AND SUBMISSION DEADLINE**
  - Monday May 2, 2016
  - Deliver a hardcopy to Ara Philipossian in the class
  - Present to the entire class (no more than 10 minutes and 9 PPT slides)

- **WRITTEN PROPOSAL LENGTH**
  - No more than 14 pages including figures and list of references
  - Keep it crisp and to the point
  - Font size: 11
  - Spacing: Double

Project Proposal (continued)

- **MAXIMUM OF 5 STUDENTS PER GROUP**

- **FOCUS AREAS**
  - Process consumables replacement
  - Process consumables reduction
  - Process consumables re-use

- **TOPICS TO CHOSE FROM**
  - Electroplating of copper
  - CMP of copper or dielectrics
  - CMP of Shallow Trench Isolation
  - Thermal oxidation
  - LPCVD of dielectrics
  - LPCVD of tungsten
  - Wet cleaning and surface preparation
  - Dry cleaning & surface preparation
  - Rinsing
  - Drying
  - Post-CMP cleaning

Project Proposal (continued)

- **TOPICS TO CHOSE FROM (CONTINUED)**
  - Wet etching of silicon nitride or silicon dioxide
  - Dry etching of silicon dioxide
  - PVD of copper
  - Plasma etching
  - Lithography

- **RESEARCH OBJECTIVE**
  - What problem are you solving?
  - What opportunities are you suggesting to be exploited?
  - What technology or usage issues motivate this problem?
  - What has been done in this area in the past?
  - How does your proposed work differ from what's already been done by other researchers?
  - What is your research hypothesis?
  - How will you verify that hypothesis?
  - What is the potential impact on industry practice if the hypothesis is verified?

Project Proposal (continued)

- **RELATIONSHIP TO OTHER RESEARCH OR PRATICE**
  - What similar research to this proposal is being conducted by other universities?
  - How does this proposal differ from that research
- **RESEARCH POTENTIAL IMPACT**
  - What concrete results are expected?
  - How could those results be put into practice?
  - How could an IC manufacturer benefit from the completion of this work?
  - What technological advances must happen for that benefit to be realized?
- **RESEARCH PLAN (ASSUME A 2-YEAR DURATION)**
  - Deliverables
  - Timeline
  - Technical tradeoffs that may have to be made
  - Risks in this research and how they will be managed

Project Proposal (continued)

- **BIBLIOGRAPHY**
  - Roughly 10 publications relating to state-of-the-art and your proposed work
  - Attach hardcopies of all referenced publications and submit it with your report (note that these pages are in addition to the 14 pages containing your report)

- **GRADING**
  - Your grade will be based on the following:
    - Creativity
    - Originality
    - Aesthetics & professionalism of the report
    - Impact to industry
    - Completeness & relevance of previous work cited in the bibliography and your ability to structure your proposal recognizing what's been done before by other researchers
    - Likelihood of success of your proposal

YOUR Final Grade

- **Homework** — **ZERO – I will not be collecting or grading any of the HWs**
  I will post all solutions on D2L
  Exams will be based on HW
- **Mid-Term Exam 1** — **30%**
- **Mid-Term Exam 2** — **40%**
- **Proposal** — **30%**

Facts About This Course

- **Total of 166 students have taken this course under Prof. Philipossian:**
  - **A = 45 %**
  - **B = 25 %**
  - **C = 20 %**
  - **D, E and DROP = 10 %**
- **Evaluation of the Instructor and the course over the past 7 years:**
  - **Instructor's teaching effectiveness = 4.55 / 5.00**
  - **Overall rating of course = 4.25 / 5.00**
  - **How much learned = 4.15 / 5.00**
  - **Usefulness of lectures & discussions = 4.50 / 5.00**
  - **Usefulness of homework = 4.10 / 5.00**
  - **Treated with respect = 4.80 / 5.00**
  - **Difficulty level = 4.00 / 5.00**

Books

- **Required Textbook:**
  - **Microchip Manufacturing by S. Wolf, Lattice Press (2004).**
- **Recommended Books:**
  - **Microchip Fabrication: A Practical Guide to Semiconductor Processing, 4th Edition, by Peter Van Zant, McGraw-Hill Publishers (2000).**
  - **VLSI Fabrication Principles: Silicon and Gallium Arsenide, by Sorab K. Ghandhi, John Wiley (1994)**
  - **Handbook of Semiconductor Wafer Cleaning Technology, by Werner Kern, Noyes Publications (1993)**
  - **Chemical Mechanical Planarization of Microelectronic Materials, by Steigerwald, Murarka & Gutmann, John Wiley & Sons (1997).**
  - **Process Engineering Analysis in Semiconductor Device Fabrication, by Middleman and Hochberg, McGraw-Hill Publishers (1993).**

Groundrules

- **There will be no make-up exams whatsoever**
- **Turn off all mobile devices in the classroom**
- **Lectures start promptly at 3:30 PM and end at 5:50 PM**
  - **Please be on time**
  - **Students arriving after 3:35 PM are requested to wait outside the classroom. Late students will be admitted into the classroom when there is a natural break in the lecture (usually around 4:45 PM).**
  - **There is an exception for 2 students due to class overlap!**
  - **Being 5 minutes late means:**
    - **(5 minutes) x (26 students + 1 instructor)**
    - **More than 2 hours of other people's time wasted**
  - **If you miss a lecture, please do not ask me for a tutorial on the subjects covered during the lecture**
- **Complete your reading assignment prior to each lecture**

Groundrules (continued)

- **Do not seek the instructors' help in solving homework problems if you have not given the problem your best shot.**

- **You must show the instructor in writing your logic and deductive reasoning in attempting to solve a problem before the instructor proceeds to help you**

Course Structure (subject to change)

- **Lecture No. 1 by Ara Philipossian … January 25**
  - **Review of the Syllabus**
  - **Introduction to Device Fabrication**
  - **Introduction to Design for the Environment**
  - **Silicon Wafer Manufacturing – Part 1**
  - **Silicon Wafer Manufacturing – Part 2 (Please watch video on D2L ASAP)**

Course Structure

- **Lecture No. 2 by Ara Philipossian … February 1**
  - **Impurity Diffusion**
  - **Thermal Oxidation**
- **Lecture No. 3 by Ara Philipossian … February 8**
  - **Thermal oxidation (continued)**
  - **Dielectric Deposition**
- **Note: There will ne NO CLASS on February 15th due to a school holiday – Please watch the videos mentioned in the section re: Lecture No.4 (next page)!**

Course Structure

- **Lecture No. 4 by Ara Philipossian, Srini Raghavan and Larry Larsen … February 22**
  - **Low k Dielectrics**
  - **Wet Etching, Cleaning and Surface Preparation**
  - **Drying (by Srini Raghavan – Please watch video on D2L ASAP)**
  - **Ion Implantation (by Larry Larson – Please watch video on D2L ASAP)**
  - **You need to download SRIM in order to solve the Implantation HW problems.**
- **Review Lecture (No. 5) by Ara Philipossian… February 29**
- **Review Lecture (No. 6) by Ara Philipossian … March 7**

Mid-Term Exam 1 … March 21 (Duration = 2 Hours)

Course Structure

- **Lecture No. 7 by Ara Philipossian … March 28**
  - **Chemical Mechanical Planarization - Part 1**
- **Lecture No. 8 by Ara Philipossian … April 4**
  - **Chemical Mechanical Planarization - Part 2**
- **Lecture No. 9 by Farhang Shadman, Michael Goldstein and Robert Meagley … April 11 (Watch Video on D2L – No Class)**
  - **Ultra-Pure Water Production, Use and Re-Use**
  - **Rinsing**
  - **Photolithography**
  - **Metallization**

Course Structure

- **Review Lecture (No. 10) by Ara Philipossian … April 18**
- **Review Lecture (No. 11) by Ara Philipossian … April 25**
- **Proposal Presentations … May 2**

Mid-Term Exam 2 … May 9 at 3:30 PM (Duration = 2 Hours)