IMPORTANT:
Please refer to the USC Center for Excellence in Teaching for current best practices in syllabus and course design. This document is intended to be a customizable template that primarily includes the technical elements required for the Curriculum Office to forward your proposal to the UCOC.

Course ID and Title: Integrated Memory Device and Technology

Units: 4
Term—Day—Time: Spring 2022,
Mon. Wed., 4PM – 5:20PM

Location: SOS B44

Instructor: J. Joshua Yang
Office: PHE 608
Discussion: Wed. 2:00-4:00PM
Contact Info: jjoshusy@usc.edu (213) 740-4709.

Teaching Assistant: TBD
Office: TBD
Office Hours: TBD
Contact Info: TBD

Course Description

This graduate course introduces students to the fundamental device physics, advanced integration technology and cutting-edge innovations in memory device innovations and applications in Artificial Intelligence and Machine Learning.

Learning Objectives

Upon completion of this course, students will be able to do the following:
1. Understand the basic device physics and materials principles of semiconductor memory devices.
2. Demonstrate a familiarity with major memory device structures and integration technology.
3. Establish a good knowledge base about the emerging advance memory technologies.
4. To understand the principles of novel Artificial Intelligence and Machine Learning enabled by emerging memory technologies.

Prerequisite(s): Understanding of basic semiconductor device physics and fabrication technology will be useful, but is not required.

Co-Requisite(s): none

Concurrent Enrollment: none

Recommended Preparation: introduction courses on semiconductor physics or solid state physics

Course Notes

This course will have Letter grading and lecture slides posted. There will be lab sessions for the students to operate some emerging electronic devices experimentally. There will also be course presentations for the students to practice literature search, reading, team working, presentation and Q&A on topics interesting to them.

Technological Proficiency and Hardware/Software Required

N/A

Required Readings and Supplementary Materials

Course Materials

Lectures and lecture notes are the primary course materials.

Recommended Text

- 'Resistive switching materials for information processing', *Nature Review Materials* 5, 173 (2020) etc.
- Electronic Properties of Materials, by Rolf E. Hummel, Springer, 2001, 3rd Ed.
- Artificial Intelligence for Humans: Volumes 1-3, by Jeff Heaton, Heaton Research, Inc., 2013.
- Neural Computing: An Introduction, by R. Beale and T. Jackson, Taylor & Francis Group LLC, 1990.
- Materials Science and Engineering: An Introduction, by William D. Callister and David G. Rethwisch, Wiley, 2013, 9rd Ed.

Useful Reference Texts

- Nanoelectronics and Information Technology, by Rainer Waser, Wiley-VCH, 2012, 3rd Ed.
- Physics of Semiconductor Devices, by Simon. M. Sze, Wiley, 2006, 3rd Ed.
- Materials Thermodynamics, by Y. Austin Chang and W. Alan Oates, Wiley, 2010.
- The Chua Lectures: From Memristors and Cellular Nonlinear Networks to the Edge of Chaos, by Leon O. Chua, World Scientific, 2020.
- Materials Science Of Thin Films, by Milton Ohring, Academic Press, 2002. 2nd Ed.

Description and Assessment of Assignments

There will be Homeworks, Midterm and Final exams, Labs and Course Project (presentation), based on which the students are evaluated for grading.

Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Attendance	10	10
Homeworks	10	10
Labs	10	10
Midterm exam	25	25
Final exam	30	30
Course Project	15	15
TOTAL	100	100

Grading Scale

Course final grades will be determined using the following scale

A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

Each assignment is expected to be submitted on time; late submissions within a week will result in 30% point deduction; late submission over a week will not be accepted.

Grading Timeline

Within two weeks of the submission time.

Additional Policies

N/A

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Issues of exsiting computer hardware for AI and ML	Lecture Notes	Background survey
Week 2	Soutions with memory based hardware	Lecture Notes	
Week 3	Materials basics (structure, defects, classifications, bonds etc.)	Lecture Notes	Homework 1
Week 4	Electronic properties of materials (electrical, optical, magnetic etc.)	Lecture Notes	
Week 5	Thermodynamics and Kinetics principles in memory device design	Lecture Notes	
Week 6	Device physics for CMOS devices	Lecture Notes	Homework 2
Week 7	Midterm exam	Review Lecture Notes and Homeworks	exam
Week 8	CMOS based memories	Lecture Notes	
Week 9	Magnetic memories	Lecture Notes	
Week 10	Phase change memories	Lecture Notes	
Week 11	Redox memories	Lecture Notes	
Week 12	Machine learning accelerators using emerging devices	Lecture Notes	
Week 13	bio-inspired computing with intelligent materials and devices	Lecture Notes	
Week 14	Machine Learning Lab	Review ML and Computing Lecture Notes	Lab Report
Week 15	Course project	Form teams, chose topics, lieterature search, prepare slides	Slides and Presentations
FINAL	Final exam	Reviewing Lecture Notes and Homeworks	exam