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: ECE599 Emerging Devices for AI/ML

Units: 4
Term—Day—Time: Fall 2022,
Day Time: Monday, Wednesday: 4:00 - 5:50 pm

Location: VHE 217

Instructor: J. Joshua Yang
Office: PHE 608
Office Hours: TBD (The general guideline is for one weekly office hour for each class taught. Office hours do not count as contact hours.)
Contact Info: jjoshusy@usc.edu (213) 740-4709.

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

Course Description

In the era of 'big data' and 'Internet of Things', the traditional computing architecture based on CMOS hardware has become increasingly inefficient to support Artificial Intelligence (AI) and Machine Learning (ML). This course will cover the fundamentals of emerging materials, devices and how to use them to enable novel Artificial Intelligence and Machine Learning. Recent progress, current challenges and future directions will be reviewed and discussed. Application examples, such as memory devices for Machine Learning, Neuromorphic Computing and Artifical Intelligence, will be highlighted.
The course is intended to be self-contained by covering principles of materials and devices as well as basics of AI and ML enabled by the novel devices. The course is designed in a way to better prepare senior and master students for jobs in AI & ML with emgerging hardware and Ph. D students for interdisplinary research topics in unconventional computing.

Learning Objectives

• To understand the current status, challenges and possible solutions of the traditional computing hardware systems.
• To understand the principles of novel Artificial Intelligence and Machine Learning enabled by emerging materials and devices.
• To understand materials science fundamentals that are critical for designing, fabricating and understanding emerging devices for intelligent systems.
• To understand electronic and ionic devices that enable non von Neumann computing paradigms.
• To equip the students with broad knowledge in materials, devices, novel hardware based AI and ML, for a more intelligent job interview and a jump-start in related jobs.

Prerequisite(s): none
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

- Recent review articles: 'A historical survey of algorithms and hardware architectures for neural-inspired and neuromorphic computing applications' *Biologically Inspired Cognitive Architectures* (2017); '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.
- 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	15	15
Labs	10	10
Midterm exam	25	25
Final exam	25	25
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 emerging device based hardware	Lecture Notes	
Week 3	Materials properties	Lecture Notes	Homework 1
Week 4	Electronic properties	Lecture Notes	
Week 5	Seconductor memory devices I	Lecture Notes	
Week 6	Seconductor memory devices II	Lecture Notes	Homework 2
Week 7	Midterm exam	Review Lecture Notes and Homeworks	exam
Week 8	Emerging Memory devices I	Lecture Notes	
Week 9	Emerging Memory devices II	Lecture Notes	
Week 10	Emerging Logic devices	Lecture Notes	
Week 11	Device Testing Lab	Review Device Lecture Notes	Measurement results
Week 12	ML accelerators	Lecture Notes	
Week 13	AI enabled by emerging 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