ECE580B6 - Syllabus

Instructor: Prof. Mahdi Nikdast (E-mail: Mahdi.Nikdast@colostate.edu).

Office Hours: Monday: 4:00 pm to 5 pm; Wednesday: 10:00 am – 11:30 am; and walk-in subject to availability. Office: C103A Engineering Building.

Course Assistant: Asif Mirza (E-mail: Mirza.Baig@colostate.edu). Office hours: Mondays from 2:00 pm to 3:00 pm at C1 Engineering Building.

Lectures: Tuesday and Thursday, 15:30 to 16:45, Room 229, Scott Bioengineering.

Course Learning Objectives

Here is a summary of ECE580B6 learning objectives:

1. Learn fundamental concepts and operating principles of silicon photonics devices and circuits.
2. Evaluate, analyze, and design primary passive and active silicon photonics devices.
3. Evaluate, analyze, and design passive and active silicon photonic integrated circuits and interconnects.
4. Work with Lumerical MODE, FDTD, INTERCONNECT (simulations) and Klayout for chip layout design and verification.
5. Explore applications of silicon photonics in high-performance computing systems and data centers, while studying various performance metrics, design challenges and opportunities.

Course Textbook and Materials

- Instructor will introduce and discuss some Research Papers during the lectures;
- [TXT1] Lukas Chrostowski, Michael Hochberg, "Silicon Photonics Design: From Devices to Systems," ISBN-13: 978-1107085459, ISBN-10: 1107085454, Cambridge University Press 2015. (**main textbook**)

Other useful/OPTIONAL references:

- [TXT2] Amnon Yariv, Pochi Yeh, "Photonics: Optical Electronics in Modern Communications," 6th Edition, ISBN-13: 978-0195179460, ISBN-10: 0195179463, Oxford 2007.
- [TXT3] Michael J. Flynn, Wayne Luk, "Computer System Design: System-on-Chip," ISBN: 978-1-118-00991-8, Wiley 2011.
- [TCT4] Mahdi Nikdast, Gabriela Nicolescu, Sebastien Le Beux, and Jiang Xu, "Photonic Interconnects for Computing Systems," ISBN-13: 978-8793519800, ISBN-10: 879351980X, River Publishers, 2017.

Homework Assignments	20%
Lab Assignments	35%
Course Project (40%)	Project proposal and presentation: 15% (Midterm) Project final presentation: 10% Project final report: 15%
Class Reports and Discussions	5%

Grading Policy
The +/- grading scheme will be used, with the following scale

>95%	90 – 94%	85 – 89%	80 – 84%	75 – 79%	70 – 74%	65 – 69%	55 – 64%	40 – 54%	<40%
A+	A	A-	B+	B	B-	C+	C	D	F

Homework and Lab Assignments Procedures, Submission Policy

Homework Assignments: To receive full credit for your homework, show all reasonable steps in solving problems. All the homework assignments should be uploaded electronically on DropBox (upload link will be made available for each homework, link is at the top of the first page of each homework).
Lab Assignments: Lab assignments are a very important component of this course. You will learn how to design and simulate silicon photonics components and devices, and by the end of the semester, will be able to design more sophisticated circuits. We use a set of simulation tools from Lumerical Inc.. After the first two to three labs, you will become comfortable with the tools and will be on your way to designing some interesting devices/circuits. Lumerical webpage is a good resource to learn the tools. Similar to homework assignments, lab reports should be uploaded electronically on DropBox (upload link will be made available for each lab, link is at the top of the first page of each lab).

Late Submission Policy: Late homework **will not be accepted** unless the lateness is due to circumstances beyond your control **(proof is required)**. To receive full credit, lab reports must be turned in on the date due. Late lab reports will be accepted, but points will be deducted from the score **(-10 per day)**.

Instructions to submit your files: All the submitted files should be in **PDF format.** Use the following instructions to name your file:
Homework assignments: FamilyName_FirstName_StudentID_SiPhFA19_HW"number"
Lab reports: FamilyName_FirstName_StudentID_SiPhFA19_LB"number"
Replace "FamilyName" with your family name. Replace "FirstName" with your first name. Replace "StudentID" with your CSU student ID. Replace "number" with either the homework or the lab report number.**Submitted files NOT based on these instructions will NOT be graded!**

Academic Integrity
This course will adhere to the CSU Academic Integrity Policy as found in the General Catalog (http://www.conflictresolution.colostate.edu/academic-integrity) and the Student Conduct Code (http://www.conflictresolution.colostate.edu/conduct-code). At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.
All submitted work should be your own. Copying of language, structure, images, ideas, or thoughts of another, and representing them as one's own without proper acknowledgement (from web sites, books, papers, other students, solutions from previous offerings of this course, etc.) and failure to cite sources properly is not acceptable. Sources must always be appropriately referenced, whether the source is printed, electronic, or spoken. My policy is that of **zero tolerance**. Minor first infraction in HWs and presentations will lead to a zero score as well as one letter level (e.g. A to B) reduction in the course grade. Project or Major or repeated infractions in HWs and presentations will result in "F" grade for the course as well as reporting to the Dean's Office.

Diversity Statement
As the instructor in ECE580B6, I am deeply committed to helping build an inclusive culture in this classroom, in the Department of Electrical and Computer Engineering, in the Walter Scott, Jr. College of Engineering, and at CSU. Each individual brings diversity to our class in the identities they hold, the ways they think, their interests and skills, their background and past experiences. To me, inclusion means not only accepting these differences, but embracing them and understanding that we can leverage these differences to be better engineers.

My goal for this class is to create an environment where we do not discriminate against individuals because of their identities (e.g., race, ethnicity, sex, gender identity, sexual orientation, religion, nationality, age, levels of ability). It is also important to understand that even when we hold egalitarian beliefs, we can hold implicit or unconscious biases that can also influence the way we treat others or approach engineering design. It is my expectation that students in this class will:

1. Adhere to the CSU Principles of Community https://diversity.colostate.edu/principles-of-community/;
2. Work in teams in ways that recognize the contributions of all team members and provide all team members the opportunity to learn;
3. Examine their own behaviors and refrain from acting in biased ways;
4. Reflect on the ways bias can influence engineering work;
5. Speak with the professor when biased behaviors may occur from other students, their TAs, and the professor;
6. Be sensitive to context and acknowledge that hurtful comments can sometimes be inadvertent but they still have an impact.

Topics (Dates/Topics may change with reasonable notice. Important dates are in **red**)

Week	Summary of Topics	Readings	HW	Lab
W1 (Aug. 27)	**Introduction to Silicon Photonics:** limitations of electrical interconnects, history of silicon photonics, primary building blocks of a silicon photonics link, applications of silicon photonics.	Chapters 1, 2 [1-9]	HW1	
W2 (Sep. 3)	**Optical Waveguides I:** fundamental concepts and properties of silicon photonics waveguides, basics of guided waves, Silicon on Insulator (SOI) wafers, strip and rib waveguides.	Chapter 3, [10], Chapters 1 and 2 from [11]		LB0
W3 (Sep. 10)	**Optical Waveguides II:** approximate methods to model optical waveguides (effective index method, Marcatili's approach), numerical methods and simulations, MODE simulation.	Chapter 3 from [TXT1] and Chapter 3 from [TXT2], [12-15]		LB1
W4 (Sep. 17)	**Optical Waveguides III:** waveguide loss, waveguide bends, Y-branches, splitters, fundamentals of interferometers. **Project Proposals Due**	Chapters 3 and 4 from [TXT1], [16]		
W5 (Sep. 24)	**Coupling Light into Chips:** fundamentals of edge coupling and vertical coupling, grating couplers, brag gratings.	Chapters 4 and 6 from [TXT1], [20-26]	HW2	
W6 (Oct. 1)	**Silicon Photonics Devices I:** Mach-Zehnder Interferometers (MZIs), design, simulation and analysis.	Chapter 4 from [TXT1], [27-31]		LB2
W7 (Oct. 8)	**Silicon Photonics Devices II:** miroring resonators (MRs), applications, design, simulation and analysis.	Chapters 4 and 6 from [TXT1], [32-42]		LB3
W8 (Oct. 15)	**Silicon Photonics Devices III:** directional couplers, layout design and simulation of mircoring resonators, KLayout, layout design and optimization, KLayout, programmable design kits (PDKs).	Chapters 4 and 6 from [TXT1], [43-48]		
W9 (Oct. 22)	**Compact Models:** compact photonic models, circuit simulation and design using compact models.	Chapter 9 from [TXT1] and [49-52]	HW3	

W10 (Oct. 29)	**Silicon Photonics Interconnects for HPC Systems:** optical interconnects in manycore system, optical routers, communication protocols, performance.	[53-58] [J9-J11], [J16]		LB4
W11 (Nov. 5)	**Advanced Topics I:** optical loss and crosstalk in silicon photonics.	[J6], [J8], [J14], [J17], [J19], [C6], [C16], [59]	HW4	
W12 (Nov. 12)	**Advanced Topics II:** fabrication non-uniformity and design for manufacturability (DFM).	Chapter 11 and 12 from [TXT1], [61]-[66]		
W13 (Nov. 19)	**Advanced Topics III:** fabrication process variation modeling and analysis, design for reliability/robustness.	[J20], [C20], [C21], [C25], [C26]		LB5
W14 (Nov. 26)	**No Classes (University Break)**	Semester Break		
W15 (Dec. 3)	**Advanced Topics IV:** Nanophotonics neural networks, deep learning and silicon photonics.	[67]-[71]		LB6