ECE/BIOM 527F Biosensors: Biophotonic Sensors Using Refractive Index

Fall 2023 (last 5 weeks)
10:00 – 10:50 am MWF in Engineering B4

Instructor: Kevin Lear
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Important note: You must include “ECE527F” as part of the subject line for all emails regarding this class, or else my email filters will not highlight them.
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Office Hours: See Canvas webpage

This course is a module in the GAUSSI series, developed in part to support the NSF-sponsored GAUSSI program. Courses in this biosensors series include:
Cells as Circuits - ECE 527A (Lear)
Signal and Noise in Biosensors - ECE 527B (Lear)
Sensor Circuit Fundamentals - ECE 527C (Chen)
Affinity Sensors – ECE 527D (Chen)
Electrochemical Sensors - ECE 527E (Chen)
Biophotonic Sensors Using Refractive Index - ECE 527F (Lear)

COURSE DESCRIPTION: Operating principles of optical biosensors based on changes in refractive index such as thin films, ring-resonators, Mach-Zehnder interferometers, and other evanescent wave sensors. Basic supporting optical concepts including thin-film interference, optical waveguides and evanescent waves.

COURSE OBJECTIVES: Upon successful completion of this class, students will be able to:

- Describe the operating principles of primary examples of interferometric and evanescent wave biosensors and discuss relative advantages and disadvantages.
- Calculate changes in optical signals for optical biosensors from the surface concentration of proteins.
- Distinguish between sandwich assays and real-time optical sensors and discuss the utility of the later for chemical kinetics measurements.

PREREQUISITES: ECE 527E; PH 142; MATH 340 or MATH 345, may be taken concurrently

REQUIRED MATERIALS: There is no required textbook for this class. Readings and notes will be provided as needed.

Canvas: canvas.colostate.edu will have the syllabus, reading and homework assignments, course grades, useful links, and other postings. It is your responsibility to check the course website each week for new postings.

COURSE TOPICS: The planned topics for this course are:

Week 1	Introduction: two commercial optical biosensor systems: Biacore and Genalyte. Transmission spectra of Fabry-Perot interferometers, dependence on refractive index, associated spectroscopic equipment for readout.
Week 2	Inherent optical properties of proteins including refractive index and apparent size, use of molecular probes to obtain specificity, indirect mechanisms for transducing analyte concentration to changes in refractive index. Optical waveguides: total internal reflection, dielectric waveguide structure, a wave picture.
Week 3	The wave equation and boundary conditions, existence of evanescent waves, impact of core and cladding refractive index, confinement factor. Mach-Zehnder interferometer: principles, recent examples, requirements on optical source.
Week 4	Ring-resonator: principles, single particle performance, instrumentation requirements, use for kinetic binding. System design considerations: roles of optics and chemistry, metrology limit vs. limit of detection, surface chemistry, kinetics measurements of continuous binding.
Week 5	Alternative biosensor mechanisms such as surface plasmon resonance, waveguide gratings, and local evanescent array coupled sensor. Final exam.

GRADING:

Quizzes / participation in discussions 10%
Homework assignments 45%
Final exam or project 45%

Homework will be due at the start of class one week after it is assigned, typically each Monday, but check the website for updates. Links to the homework can be found on Canvas. I request that you record the time spent on each question on your paper.

The final exam for this course will may occur either during the last class session (a Thursday), or if this course is during the last five weeks of the semester, during the usual time scheduled during finals week. (No out-of-class time is typically scheduled for a final exam for classes ending before the semester.)

Final grades will be determined by the following scale:

≥ 90% A	80-83.99% B	70-73.99% C
87-89.99% A-	77-79.99% B-	60-69.99% D
84-86.99% B+	74-76.99% C+	≤ 59.99% F

ACADEMIC INTERGRITY: Students are expected to adhere to the Academic Integrity Policy of Colorado State University, outlined in the CSU General Catalog. Students are also expected to follow the Student Conduct Code which can be found at www.conflictresolution.colostate.edu. Academic dishonesty is not accepted in this course, and any form of cheating (including plagiarism) will be reported. Penalties may include a lowered course grade including an F, loss of course credit, transcript marking, and expulsion from the university.

Students are **not allowed to copy another past or current student's work or access any prior solution on homework or exams**. Students must cite the sources they use on all work done outside the classroom, including discussions with other students. Students are encouraged to discuss course topics and approaches to problems with each other or other knowledgeable sources, but should not collaborate when writing up their solutions. Work duplicating that of another student is likely to result in a significant academic penalty.