792-067
Principles of Optical Biosensing

(If no section number, contact Greg Byrd to create one.)

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Objective or Description:
Optics-based biosensing technologies are widespread across academic, industry and clinical settings owing to its inherent non-invasive/remote interrogation nature and high sensitivity. This course covers the foundations of light-matter interaction such as light propagation, scattering, and absorption that are fundamental to all standard spectroscopic techniques such as UV-Visible, NIR, MIR and Raman spectroscopies. The course will also cover evanescent wave biosensing that is widely used in affinity label-free plasmonic devices such as those that exploit surface plasmon resonance (SPR), localized surface plasmon resonances (LSPR), and optical fiber biosensors. Furthermore, the intense nearfield produced in plasmonic devices that are key to surface enhanced spectroscopy techniques such as surface enhanced Raman spectroscopy (SERS) and surface enhanced infrared absorption (SEIRA) spectroscopy that allow biosensing and molecular identification at ultra-low concentrations, even down to single molecule. Finally, the course will cover light propagation in tissue and its application in transdermal biosensing strategies that are extensively employed in a broad range of clinical and research settings, such as oximetry, OCT, and functional NIR spectroscopy.

Prerequisites:
Programing and plotting skills in MATLAB or Python are required.
Students should have completed at least one of the following courses.

- ECE 523 Photonics and Optical Communications
- ECE 540 Electromagnetic Fields
- BME 563/BME 463 Biomedical Optics and Lasers
- BME 564/BME 464 Microscopy

Textbook:
There is not a mandatory textbook. The instructor will distribute lecture notes and technical documentation, including research articles, relevant to the course.

Topics:

- Light propagation in dispersive and complex media.
- Light process for biosensing: absorption, scattering, fluorescence.
- Label-free affinity optical biosensors.
- Spectroscopy biosensing: UV-Vis, NIR, MIR, Raman.
- Photonic and plasmonic biosensors.
- Surface enhanced biosensing: SERS, SEIRA.
- Transdermal biosensing: oximetry, OCT, functional NIR spectroscopy.

Grading:
Course activities consist in 5 homework assignments, one 5-min research presentation, one midterm exam. Attendance is mandatory.

Attendance and participation	10%
Midterm	20%
Homework	40%
Research presentation	30%

Cross-listing in other departments:
None.

Include anything else that is unique to the course - this information will be posted on the ECE Current Graduate/Undergraduate Student Portals for all students to view

Optical biosensing stands as a captivating and cutting-edge technology that harnesses the power of light to decipher the exciting properties of biological systems non-invasively and in in real time. This captivating field finds itself at the intersection of numerous disciplines such as optical science and engineering, lasers, chemistry, physics, biology, and medicine. While it is important to note that a single light-based biosensing strategy is not a one-size-fits-all solution, the multiple optical biosensing techniques available has undeniably reshaped the landscape of applications such as medical diagnostics, environmental monitoring, smart biotechnology, drug discovery, etc. Consider, for instance, Optical Coherence Tomography (OCT), an innovation that grants us the extraordinary capability to dive into the eye and other biological tissues to find tumors, tissue anomalies, or even retina injuries. Or, ponder upon Raman spectroscopy, a versatile and robust chemical fingerprinting platform with applications spanning across medicine, environmental monitoring, homeland security, or food safety. The horizon of this course stretches across the foundational principles of light-based biosensing, specific field of use, and brings the fundamental challenges in the field that are subject to ongoing multidisciplinary research.