Syllabus – EEE598 "Advanced Biosensor Concepts"

Instructor: Dr. Michael Goryll
Assistant Professor of Electrical Engineering
ERC109
Michael.Goryll@asu.edu

Office hours: TBA

Course description: The recent development in the field of biosensors is driven by creating robust and reliable devices for a vast variety of analytes while constantly improving the detection speed and the specificity. Biosensors use a bio-(chemical) process as a signal transduction mechanism to produce an electrical signal that can be used to perform electronic data analysis. By being able to use the current data processing technology, these devices are extremely easy to use and do not require special training to operate them, which makes them ideally suited for small labs and point-of care diagnostics. However, there are still a lot of challenges to meet with a lot of the current biosensor devices. In particular, the complexity of the tools has to be taken into account, which gets reflected in the price per measurement. Thus there is a strong drive in research towards using the least complex solution towards a biosensing problem, without sacrificing selectivity and specificity.
This course will provide an introduction into the most common biosensing principles, giving background information on the underlying theory as well as the current limitations of these technologies. The most prominent example here is the amperometric glucose sensor, which proves to be a huge success. Besides covering the sensing principle itself, the course will go into detail on fabrication aspects, stressing how microfabrication can be used to miniaturize these sensors. From here, the course will address field-effect-based biosensing techniques, such as the measurement of nerve cell action potentials using MOSFETs.
Moreover, the course will cover emerging biosensor technologies based on whole-cell patch clamping for pharmaceutical drug screening. An emphasis will be put on the instrumentation required to accomplish reliable noise-free measurements of electrical currents in the picoampere range. Various high-throughput screening concepts (planar patch-clamp) will be introduced and discussed. Taking the patch-clamp approach one step further, the course will cover the technology of ion channel reconstitution and show how engineered ion channels can be used as specific detectors or as nanopores to detect DNA translocation events. Finally, various DNA sensing concepts will be introduced, ranging from translocation through natural and artificial nanopores or nanowires to cantilever-based hybridization sensors to the widely used optical detection arrays.

Course format: Lectures

Grading Policy: A 90%+, B 80%+, C 60%+, Failure below 60%.
Weight: Assignments 30%, Midterm exam 30%, Project and presentation 40%.

Textbook: Since this class covers current research topics, there is no comprehensive textbook available that covers all aspects. Instead, review articles, book chapters and references will be provided during the semester.

Additional reading: Bert Sakmann and Erwin Neher, eds.: “Single-Channel Recording”, 2nd edition, Kluwer Academic/Plenum Publishers, NY (1995). ISBN 0-306-44870-X.

Project: Each student is supposed to select a topic related to the material covered in class and perform a literature survey on this particular topic. Based on this survey, the student should write up a report in form of a review paper that not only summarizes, but also indicates the shortcomings of the approach and gives ideas on additional investigations or how to improve the particular technology. Besides the paper, the student has to prepare a presentation on the topic and present it in front of the class.