

## **EE513 Fiber Optic Sensors (3-0)**

**Wednesday: 9:45-12:30**

**Course coordinator:** Dr. Kıvılcım Yüksel Aldoğan

**Assistants:** Ertunga Burak KOÇAL, Şamil ŞİRİN

**Text Books:** **Rayleigh-based optical reflectometry**

M. Wuilpart

**An Introduction to Distributed optical fibre sensors**

Arthur H. Hartog

CRC Press

**Fiber Optic Sensors**

Ericc Udd, William B. Spillman

Wiley

**Fiber Optic Test and Measurement**

**Chapter 4:** Wavelength Meters

**Chapter 5:** High Resolution Optical Frequency Analysis

**Chapter 10:** Optical Reflectometry for Component Characterization

**Chapter 11:** OTDRs and Backscatter Measurements

D. Derickson

HP Company

Prentice Hall

### **Scientific articles:**

**An Overview of the Recent Advances in FBG-Assisted Phase-Sensitive OTDR Technique and its Applications**

K Yüksel, J Jason, EB Kocal, MLA Sainz, M Wuilpart

2020 22nd International Conference on Transparent Optical Networks (ICTON), 1-7

**A comprehensive study of optical fiber acoustic sensing**

Y. Wang et al.,

IEEE Access, 2017

10.1109/ACCESS.2019.2924736

**Distributed Fiber-optic sensors for vibration detection,**

Xin Liu,

Sensors 2016, 16, 1164

**Distributed fiber sensor and machine learning data analytics for pipeline protection against extrinsic intrusions and intrinsic corrosions**

Z.Peng et al., Optics Express, Vol.28,No.19, 2020.

**Recent progress in the performance enhancement of phase-sensitive OTDR vibration sensing systems,**

Romain Zinsou,

Sensors, 2019, 19, 1709

**Towards a Uniform Metrological Assessment of Grating-Based Optical Fiber Sensors: From Refractometers to Biosensors**

Francesco Chiavaioli et al.,

*Biosensors* **2017**, 7, 23; doi:10.3390/bios7020023

**A Simple All-Optical Water Level Monitoring System Based on Wavelength Division Multiplexing with an Arrayed Waveguide Grating**

*Sensors* **2019**, 19, 3095; doi:10.3390/s19143095

**Discrimination of chemicals via refractive index by EF-FLRD**

Alim Yolalmaz

Applied Physics B (2019) 125:156 <https://doi.org/10.1007/s00340-019-7261-5>

**Grading**

Project (Presentation and report) .....40 %

Simulation Homework .....20 %

Final Exam (written and oral) .....40 %

**Contents**

- 1) Introduction & course outline
- 2) Review of optical fiber technology
  - a. Optical fibers
  - b. Light sources
  - c. Optical detectors
  - d. Modulators
  - e. Passive devices
- 3) Intensity-based sensors
  - a. Water level measurement
  - b. Position detection
  - c. Point vibration sensor
- 4) Fiber Grating Sensors
  - a. Fabrication
  - b. Modelling of fiber grating sensors
  - c. Multi-parameter sensitivity problem
  - d. Applications
  - e. Future perspectives
- 5) Distributed FOS
  - a. Rayleigh backscatter
  - b. Principles of OTDR
  - c. Brillouin and Raman scattering
  - d. Polarisation concepts (review) and P-OTDR
  - e. Photon counting OTDR, Phase-OTDR
  - f. Optical Frequency Domain Reflectometry
  - g. Distributed vibration sensing (DAS) and its applications.

- 6) Interferometric FOS
  - a. Optical modulators for fiber optic sensors
  - b. Mach-Zehnder and Michelson interferometers
  - c. Fading issue
  - d. Sagnac interferometer and passive ring resonator
  - e. Introduction to Fiber-optic gyroscope
  - f. Faraday effect and current sensor
  
- 7) Multiplexing of FOS
  
- 8) Fiber Optic Biosensors (optional)
  - a. Sensor classes
  - b. Transducer mechanisms
  - c. Vital sign monitoring
  - d. Biochemical sensing
  - e. Plastic fiber optic endoscope
  - f. Fiber optic smart bed

**Course plan:**

Week-1	Course Outline REVIEW OF FIBER OPTIC TECHNOLOGY
Week-2	INTENSITY-BASED SENSORS
Week-3	FIBER GRATING SENSORS I (Fabrication, types, multi-parameter sensitivity)
Week-4	DISTRIBUTED FOS-I (Rayleigh scattering and classical OTDR)
Week-5	DISTRIBUTED FOS-II (OTDR trace analysis, Introduction to nonlinear effects in optical fiber)
Week-6	DISTRIBUTED FOS-III (Raman-, Brillouin-based reflectometry)
Week-7	DISTRIBUTED FOS-IV (Polarisation in optical fiber, P-OTDR, application in current sensors)- <i>by Şamil ŞİRİN</i>
Week-8	DISTRIBUTED FOS-V (Phase sensitive OTDR, FBG-assisted Phase-OTDR, crosstalk effects)- <i>by Ertunga B. KOÇAL</i>

Week-9	DISTRIBUTED FOS-VI (Optical frequency-domain reflectometry and its applications, challenges and perspectives of OFDR)
Week-10	FIBER GRATING SENSORS II (Applications)
Week-11	INTERFEROMETRIC FOS-I (principles)
Week-12	INTERFEROMETRIC FOS-II (state-of-the-art sensors)
Week-13	LAB SESSION
Week-14	ROUND-TABLE DISCUSSION, SIMULATION HOMEWORK PRESENTATION, FINAL PRESENTATION CORRECTIONS
Week-15	FINAL PRESENTATION (open to public)
Week-16	<b>FINAL EXAM (ORAL &amp; WRITTEN)</b>