Asian Photonics Association

# Learning Optics and Photonics with the Asian Photonics Association

**Welcome to learning Optoelectronics** with Dr. Muhammad Hassan Sayyad, Former Professor of Photonics and Dean, Faculty of Engineering Sciences (FES), GIK Institute, Topi, Pakistan.

This course is designed for senior undergraduate and graduate students doing or have done BS, MS and PhD in Electronics Engineering, Materials Science & Engineering, Optical Engineering, Photonics Engineering and Physics.

The course will comprise both the theory lectures, simulation & modeling and hands-on-fabrication of printed optoelectronic devices. The materials required for the fabrication of optoelectronic devices will be sent at the homes of the registered students. And students will be able to enjoy fabrication and study of the fabricated devices at thier homes. After completion of the course, the students will be able to submit 1-2 research articles on the simulation based design and characterization of optoelectronic and photonic devices.

Please fill out the following registration form to secure your spot in the course:

Registration Form

| **APA474 Optoelectronics (3 Credit Hours) – Spring 2024** | |
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| **Duration:** | 15 Weeks |
| **Cost:** | Free |
| **Instructor:** | Prof. Dr. Muhammad Hassan Sayyad, Former Professor of Photonics and Dean, Faculty of Engineering Sciences (FES), GIK Institute, Topi, Pakistan |
| **Contact us:** | For more information, please, contact us: asianphotonicsassociation@gmail.com |

| **Course Introduction** |
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| Optoelectronics, the alliance of optics and electronics is one of the most exciting and dynamic industries of the information age. The applications of optoelectronics extend throughout our |

everyday lives, including the fields of computing, communication, entertainment, education, electronic commerce, healthcare and transportation. Defense applications include military command and control functions, imaging, radar, aviation sensors, and optically guided weapons.

The course starts with an introduction to light and its propagation through anisotropic media. The theory and design aspects of the major components used in optical networks, including LEDs, Laser diodes, optical modulators, optical switching, optical amplifiers, and optical detectors are discussed. Finally, the organic optoelectronic materials and the optoelectronic devices based on organic conjugated materials are presented.

## Course Contents

- Polarization
- Light Propagation in an Anisotropic Medium
- Liquid Crystal Displays
- Electro-Optic Effects and Applications
- Integrated Optics
- Acousto-optic Effect and Applications
- Magneto-optic Effect and Applications
- Nonlinear Optics and Second Harmonic Generation
- Light-Emitting Diodes
- Laser Diodes
- Optical Amplifiers:
- Photodetectors
- Noise in Photodetectors
- Photovoltaic Devices: Solar Cells
- Organic Optoelectronics and Photonics

The above outlines serve only as a rough guideline of the course contents and may be changed as and when deemed necessary by the instructor. The Instructor is at a liberty to best distribute number of lectures to cover the entire course.

## Mapping of CLOs & PLOs

| CLOs | Course Learning Outcomes | PLOs | Blooms Taxonomy |
|---|---|---|---|
| **CLO1** | **Analyze** the design, working principle and characteristics operation principles, characteristics of optical detectors and modulators of light | PLO2<br>Problem Analysis | C4<br>Analysis |
| **CLO2** | **Analyze** the design, working principle and characteristics of LEDs, LDs, solar cells. | PLO2<br>Problem Analysis | C4<br>Analysis |
| **CLO3** | **Use** simulation tools for modeling and analysis of optoelectronic phenomena, devices and systems | PLO5<br>Modern Tool Usage | C4<br>Analysis |
| **CLO4** | **Describe** a relevant engineering application of optoelectronics devices which can be useful for the society. | PLO6<br>**The Engineer and Society** | C3<br>Applying |
| **CLO5** | **Active participation** on the part of the student. Formally present the results of an investigation/project related to Optoelectronics Applications | PLO10<br>**Communication** | C5<br>Evaluating |

## Text and Reference Books

**Textbooks:**

1. S. O. Kasap, "Optoelectronics and Photonics: Principles and Practices," 2nd Edition, Pearson, NJ, USA, 2013.
2. Adrian Kitai, "Principles of Solar Cells, LEDs and Diodes: The role of the PN junction", John Wiley, 2011.

**Reference books:**

1. B. E. A. Saleh and M. C. Teich, "Fundamentals of Photonics", John Wiley, 2nd ed. 2007.
2. J-M. Liu, "Photonic Devices", Cambridge University Press, 2009.
3. Khare, R. P., ed. Fiber optics and optoelectronics. Oxford University Press, USA, 2004.
4. Clifford Pollock, "Optoelectronics, Irwin, 1995.

Wilson and Hawkes, "Optoelectronics", Prentice Hall, 2nd ed.1995.

**Modern Tool Usage**

Students are taught the use of Software's for the simulation, modeling and analysis of optoelectronic phenomena, devices and systems.

## Lectures Breakdown

| Week | Topic |
|---|---|
| 1 | Optoelectronics: An Overview |
| | Polarization of Light |
| | Malus's Law |
| 2 | Birefringence |
| | Birefringent Optical Devices |
| | Optical Activity and Circular Birefringence |
| 3 | Liquid Crystal Displays |
| 4 | Electro-Optic Effects |
| 5 | Phase-Shift Modulation |
| | Longitudinal Electro-Optic Modulator |
| | Transverse Electro-Optic Modulator |
| 6 | Integrated Optics: An Introduction |
| | Waveguides and Integrated Optic Phase Shifter |
| | Integrated Optic Phase Shifter |
| | Integrated Mach-Zehnder Modulators, Coupled Waveguide Modulators and Modulated Directional Coupler |
| | Coupled Waveguide Modulators |

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| | Modulated Directional Coupler |
| 7 | Acousto-Optic Modulators and Photoelastic Effect |
| | Acousto-Optic Modulation Regime, Raman-Nath Regime, Bragg Regime |
| | Frequency Shift, Analog and Digital AO Modulators, SAW Based Waveguide AO Modulator |
| 8 | Faraday Rotation and Optical Isolators |
| | Nonlinear Optics and Second Harmonic Generation (SHG) |
| | Second Harmonic Generation (SHG) |
| | Second Harmonic Generation (SHG): The Photonic View |
| 9 | Light-Emitting Diodes: Principles |
| | LED Materials and Structures, LED Efficiencies and Luminous Flux |
| | Basic LED Characteristics, LEDs for Optical Fiber Communications, Phosphors and White LEDs, LED Electronics |
| 10 | Principle of the Laser Diode, Heterostructure Laser Diodes, Quantum Well Devices, Elementary Laser Diode Characteristics |
| | The Laser Diode Equation, Laser Diode Equation, Optical Gain Curve, Threshold, and Transparency Conditions |
| | Single Frequency Semiconductor Lasers (Distributed Bragg Reflector LDs, Distributed Feedback LDs) |
| 11 | Principle of the pn Junction Photodiode, Shockley–Ramo Theorem and External Photocurrent, Absorption Coefficient and Photodetector Materials |
| | Quantum Efficiency and Responsivity, The pin Photodiode, Avalanche Photodiode Principles and Device Structures, Heterojunction Photodiodes |
| | Schottky Junction Photodetector, Phototransistors, Photoconductive Detectors and Photoconductive Gain, Basic Photodiode Circuits |
| 12 | Noise in Photodetectors |
| | Noise in Photodetectors |
| | Photovoltaic Devices: Solar Cells, Basic Principles |
| 13 | Operating Current and Voltage and Fill Factor, Equivalent Circuit of a Solar Cell, Solar Cell Structures and Efficiencies. |
| | Optical MEMs |

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| | EDFAs |
| 14 | Raman Amplifiers, Semiconductor Amplifiers |
| | Organic Optoelectronics: An Overview |
| | Organic Semiconductors, Level Structure of Organic Semiconductors |
| 15 | UV-Vis Spectroscopy of Organic Semiconductors |
| | Organic Optoelectronic Devices: OLEDs, PLEDs, LDs |
| | Organic Optoelectronic Devices: Organic Solar Cells |

## Instructor Biography:

Prof. Dr. Muhammad Hassan Sayyad possesses wide multidisciplinary experience of (1) teaching physics, electronics, lasers, optics and Photonics at O-Level, A-Level, Intermediate, Bachelor, Master and PhD students, (2) research supervision to BS, MS/M.Phil and PhD students at the Dublin City University, Government College University Lahore and the GIK Institute of Engineering Science and Technology, He has written several books, published 100 plus research articles, supervised 100 plus BS, MS and PhD students in research.

He has been honored with the Pak-US and Pak-China research projects, focusing on advancing next-generation solar cell technologies, and has served as a visiting scientist in prestigious universities in the United States, China, and Malaysia.

## To see the Instructor CV, please click the following link:

https://sites.google.com/view/cvdrmuhammadhassansayyad/home