<u>Short Course Descriptions</u>

Instructor: Prof. Tom D. Milster
Optical Sciences Center
University of Arizona
Tucson, Arizona 85721
(520) 621-8280
(520) 621-4358
milster@arizona.edu

The following short courses have been taught at various locations around the world. Prof. Milster teaches some of the courses on a regular basis at conferences, but is also available to teach courses to sponsors and industry. The typical duration of the courses is four hours each, but they can be shortened or lengthened depending on the amount of material to be covered.

1.) Miniature optics for diode lasers and beam shaping

This course will provide an introduction to the design of present and future laser diode systems. Topics include (1) a review of laser diode optical properties; (2) collimation, focusing, circularization and astigmatism correction in laser diodes; (3) a topical overview of miniature optical components; and (4) an advanced design example.

BENEFITS/LEARNING OBJECTIVES

This course will enable you to:

- summarize the optical properties of laser diodes
- describe important characteristics of laser diodes
- optical systems including collimation, focusing, circularization and astigmatism correction
- list key features of each of the following miniature optic components molded optics, cylindrical lenses, microlens arrays, Fresnel lenses, and some future technologies
- combine miniature optic technologies and laser diodes through an application example geared toward coupling a laser diode to an optical fiber.

INTENDED AUDIENCE

This material is directed to those persons who work directly or peripherally with communication diode laser systems and/or miniature optics. It is suggested that attendees have a basic familiarity with optics as background.

2.) Near-field optical recording

Basic concepts and applications of near-field recording technology are reviewed. The course is divided into two sections. The first section covers aperture-type probes, which limit the size of the spot illuminating the recording layer by a physical aperture at the end of a waveguide. The second section covers solid immersion lens (SIL) probes, which reduce the size of the light spot by focusing with high numerical aperture into a lens with a high index of refraction. Both technologies require that the recording layer be in close proximity to the probe. We review theory, fabrication, and operation of the two near-field technologies. Students taking the course should have a basic understanding of optics and optical recording.

3.) Introduction to Laser Diode Optical Systems

This course is divided into three parts. The first part reviews the properties of miniature optical beams. Terms are defined that are particularly useful in describing these small beams, and common optical terms like stops and numerical aperture are interpreted for miniature laser systems. Properties of miniature laser beams, including both geometrical and wave optics considerations are described. Collimation, the Fresnel number, effects of hard and soft apertures, effects of aberrations, system performance metrics, and analysis and modeling tools are discussed. The second part of the course reviews several common types of semiconductor light sources. The importance of radiance is reviewed in the context of several types of diodes, like light-emitting diodes (LEDs), laser diodes, and vertical cavity laser diodes. Properties of edge-emitting laser diodes are reviewed in detail, including cavity structure, mode behavior, polarization, noise, divergence, and astigmatism. A summary of vertical cavity surface emitting lasers (VCSELs) is presented, and the basic properties of other types of diode lasers are reviewed. The third part of the course provides several design examples to illustrate important concepts from the material.

4.) Introduction to Ultra Violet Optical Systems

This course is designed to provide a basic understanding of ultraviolet (UV) optical systems. We start with a review of UV sources, which include wavelengths from the extreme ultraviolet (13 nm) to visible (365 nm). Physical properties, like index of refraction, absorption, fluorescence, resist exposure, and material damage will be addressed. Considerations for UV detectors will also be reviewed. Special considerations, like vacuum operation and biological hazards, will be discussed. We then review refractive and reflective optical systems used in the UV. Applications, such as biology, lithography, ablation, and data storage will be discussed.

BENEFITS

This course will enable you to:

- describe sources of UV radiation
- evaluate physical properties of UV radiation interacting with materials
- identify appropriate UV detectors
- understand some hazards associated with UV radiation
- describe properties of reflective and refractive UV optical systems
- discuss some applications of UV optical systems.

INTENDED AUDIENCE

Engineers, scientists and managers in either the physical or biological sciences who need a basic understanding of UV optics over a broad range of topics are encouraged to attend. A basic understanding of optics is helpful.

5.) Wave Optics (two-days to two weeks course duration)

This course is intended to serve as a foundation course in wave optics. The introduction is primarily a review of wave motion and the mathematical structure used to describe waves. Then, basic properties of point-source emitters are described. Two point sources are used to illustrate the phenomenon of interference. Concepts of coherence are described with combinations of point-source emitters and Young's double-pinhole interferometer. Both spatial and temporal coherence are described. The Michelson interferometer is reviewed in detail. The course then develops the foundations of diffraction theory, using Green's theorem to derive the integral theorem of Helholtz and Kirchoff. This theory is applied to various boundary conditions to describe diffraction from a plane screen. The Dirichelt boundary conditions are used to formulate the concept of Huygen's wavelets, which are then used to describe the point spread function and transfer function of free space. The angular spectrum is then introduced, and several examples of propagation using the angular spectrum are presented, like Talbot imaging. Fresnel zones, Babinet's principle, and zone plates are then discussed. Properties of converging and diverging wave fields through apertures are described, and the action of lenses used to image wave fields diffracted by apertures is presented. The final part of the course is a section on diffraction, including high-numerical aperture diffraction and vector diffraction.

6.) Basic Optics for Lithography (two-day course)

This course serves as an introduction to optics for personnel working with lithographic systems.

Basic concepts of aberrations, projection systems, illumination, and partial coherence are described from a conceptual point of view. A unique method for describing these effects with respect to lithographic systems enables those who only have a basic optics knowledge to understand complicated subjects with a minimum of mathematical rigor. The concepts of diffraction and interference are also described in this way. The final part of the course is centered on understanding how these concepts apply to lithographic systems.