Opti 475A/575A: Thin Film Optics and Photonics

Professor:
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Lectures: TBD

Office Hours: By appointment

Prerequisites: Undergraduate or Graduate Physical Optics Course (OPTI 330 or OPTI 505R)

Course Description:
Thin film optics are critical to a broad range of applications ranging from eye wear to lasers to lithography. The course will cover the optical properties of thin films, design of multilayer optical coatings, accurate calculation methods, physical mechanisms used for the growth of thin films, and critical optics and photonics applications of thin film coatings.

Course Objectives:

- Discuss the fundamental theory of thin film multilayers and of their design. Emphasis will be placed on techniques for understanding and prediction that supplement the calculation of performance that can be carried out with commercially available software such as Essential MacLeod.
- Provide an understanding of some of the significant physical mechanisms involved in the growth, structure and optical properties of thin films for use in the wavelength range ~1nm–10μm.
- Introduce students to a variety of different coatings including antireflection and high reflectance coatings, beam splitters, edge and dichroic filters, band-pass filters, polarizers, retarders, surface plasmon resonance devices, and coatings for ultrafast applications, among other topics.

Learning Outcomes:
Upon completion of this course, all students will be able to

- Analyze thin-film optical structures ranging from basic interfaces between two materials to multilayer thin-film optical coatings (Student Outcome 2);
- Design thin-film optical filters ranging from antireflection coatings to edge filters to dichroic mirrors (Student Outcome 5);
- Decide whether the optical application requirements are best met with metal coatings, dielectric coatings or a hybrid solution (Student Outcome 2);
- Choose among different thin-film deposition techniques for a specific optical thin-film application (Student Outcome 2);
- Assess the performance and quality of fabricated optical thin-films through techniques such as ellipsometry, profilometry and chemical analysis (Student Outcome 3);

- Explore advanced thin film topics such as surface plasmons, photonic crystals, metamaterials, and two-dimensional (2D) materials such as graphene (Student Outcome 2).

Graduate students (575A) will, in addition, learn to design an optical filter for a specific application relevant to their research through a final project (Student Outcomes 5 and 6).

Grading (OPTI 475A)

- Homework assignments - 30%
- Midterm exam – 30%
- Final exam – 40%

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E.

Grading (OPTI 575A)

- Homework assignments - 30%
- Midterm exam – 25%
- Final project - 15%
- Final exam – 30%

The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, below 60% = E.

Required Text

Thin-Film Optical Filters (5th Edition) by H. Angus Macleod (CRC Press, Boca Raton, FL, 2021)

Course Outline

1. **Fundamentals**
    a. Maxwell's equations
    b. Fresnel relations
2. **Thin Film Basics**
    a. Metals and dielectrics
    b. Matrix method
    c. Quarter wave rule
    d. Simple coatings
3. **Admitttance**
    a. Diagrams
    b. Antireflection coatings
    c. High reflectance coatings
4. **Oblique Incidence**
    a. Metal coatings
    b. Dielectric coatings
5. **Thin Film Growth and Characterization**
    a. Evaporation

b. Sputtering
c. Vapor-based techniques (CVD, PECVD)
d. In-situ thickness monitoring
e. Ellipsometry
f. Surface profilometry
g. Specifications of filters and coatings

6. **Advanced Coatings**
   a. Edge filters
   b. Narrowband filters
   c. Double-sided systems
   d. Surface plasmon resonant coatings
   e. Coatings for ultrafast applications
7. **Advanced Thin Film Topics**
   a. Nanocomposite materials
   b. Photonic crystals
   c. Metamaterials
   d. 2D materials

Exams: There will be two exams in the course, a mid-term and a final exam.

Equipment and software requirements: For this class you will need daily access to the following hardware: laptop or web-enabled device; regular access to reliable internet signal; ability to run the following software: web browser of choice, Adobe Acrobat, Matlab, Office 365 software and, if accessible, Essential Macleod.

Classroom attendance:

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.
- Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments.
  - Please communicate and coordinate any request directly with your instructor.
- If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.
- Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus.
- COVID-19 vaccine is available for all students at Campus Health.
- Visit the UArizona COVID-19 page for regular updates.

Academic advising: If you have questions about your academic progress this semester, please reach out to your academic advisor

(https://advising.arizona.edu/advisors/major). Contact the Advising Resource Center (https://advising.arizona.edu/) for all general advising questions and referral assistance. Call 520-626-8667 or email to advising@.arizona.edu

Life challenges: If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at (520) 621-2057 or DOS-deanofstudents@email.arizona.edu.

Physical and mental-health challenges: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Academic Integrity (http://web.arizona.edu/~studpubs/policies/cacaint.htm)
According to the Arizona Code of Academic Integrity "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student's submitted work must be the student's own." Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. Co-authored work of any kind is unacceptable. Misappropriation of exams before or after they are given will be considered academics misconduct.

Misconduct of any kind will be prosecuted and may result in any or all of the following:

- Reduction of grade
- Failing grade
- Referral to the Dean of Students for consideration of additional penalty, i.e. notation on a student's transcript re. academic integrity violation, etc.

Accessibility and Accommodations
At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu/) to establish reasonable accommodations.

The information contained in this syllabus, other than the grade policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.