OSE 6313 – Spring 2021

Materials for Optical Systems

College of Optics and Photonics, University of Central Florida

COURSE SYLLABUS

Instructor:	Kathleen Richardson	Term:	Spring 2021
Office:	CREOL A110	Class Meeting Days:	T, Th
Phone:	407-823-6815	Class Meeting Hours:	3:00-4:15pm
E-Mail:	kcr@creol.ucf.edu	Class Location:	ONLINE
Website:		Office Hours:	Following class, or by appt.

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Course Objectives: Understanding materials is integral to the design of modern optical systems. This course introduces students to the properties of engineered optical materials such as glasses, single-crystals, transparent ceramics and polymers. The course is taught from an 'engineering perspective' with specific discussion of applications (often, with industry-specific topic areas as examples) followed by the connection to the underlying science and engineering fundamentals required to critically evaluate the materials challenge involved. The relationship between material processing (melting, growth or deposition), manufacturing (optical fabrication) and resulting optical properties is reviewed. We will analyze the impact of these variables, and the role defects, impurities or tolerancing errors can make upon the optimal material selection choice for a target application. The role of processing method and thermal history, electronic and crystallographic-specific properties on the candidate material is discussed and examined as a potential detriment to the generation and propagation of light. Issues related to in-service performance are highlighted providing real world understanding of multi-material limitations within optical systems. The use of peer-reviewed literature will be exploited to highlight state of the art examples of key optical materials and their use.

Pre-requisites: College level basic Physics, Chemistry and Mathematics

Course Texts:

Recommended textbooks for this class are shown. Additional reading materials will include peer-reviewed journal articles from UCF's library.

***Transparent Ceramics: Materials, Engineering, and Applications**, Adrian Goldstein, Andreas Krell, Zeev Burshtein (2020), e-book available UCF library:*
https://go.openathens.net/redirector/ucf.edu?url=https%3A%2F%2Fonlinelibrary.wiley.com%2Fdoi%2Fbook%2F10.1002%2F9781119429524

***Handbook of Glass** (2019) e-book available, UCF library:*
https://go.openathens.net/redirector/ucf.edu?url=https%3A%2F%2Flink.springer.com%2Fbook%2F10.1007%252F978-3-319-93728-1

***Materials for Infrared Windows and Domes: Properties and Performance**, Daniel C. Harris, SPIE Press (1999) e-book available, UCF library:*
https://go.openathens.net/redirector/ucf.edu?url=https%3A%2F%2Fwww-spiedigitallibrary-org.eu1.proxy.openathens.net%2Febooks%2FPM%2FMaterials-for-Infrared-Windows-and-Domes-Properties-and-Performance%2FeISBN-9780819481016%2F10.1117%2F3.349896

Other useful references (optional):

- M. Fox, *Optical Properties of Solids*, Oxford Master Series in Condensed Matter Science, Oxford University Press (2010)
- J. Simmons, K.S. Potter, *Optical Materials*, Academic Press (1999)
- Key optical material literature – peer reviewed journal articles

COURSE OUTLINE (subject to further revision)

1. Introduction: Optical design and material selection criteria – working from a component 'print'
   - Spectral window (single band, dual band, broadband)
   - Environment of optics use (and impact on material choice)
   - Manufacturing methods (and impact on component cost)

2. Material basics
   - Silica (crystalline quartz and fused silica); key differences between Glasses, Crystals, Metals and Polymers
   - Chemical bonds, coordination number, structure (and impact on properties)
   - Band-structure
   - Linear optical properties (absorption, refractive index, dispersion and birefringence)
   - Non-linear polarizability and properties
   - Phonons
   - Thermo-optic properties
   - Thermo-mechanical properties
   - Opto-mechanical properties

3. Material design and fabrication methods:
   - Processing methods – growth, melting and deposition
   - Glasses and glass-ceramics
   - Single versus polycrystalline materials
   - Optical ceramics
   - Optical polymers and liquid crystals
   - Thin-films: bulk and thin film composition/structure/property variation, AR coatings

4. Defects, impurities and dopants:
   - Point defects, dislocations, grain-boundaries
   - Dopants, nanoparticles, glass-ceramics (controlled crystallization of secondary phase)
   - Color, crystal field, spectroscopy of transition ions and lanthanides
   - Laser damage

Examples in this class will cover a wide range of applications largely focusing on the infrared portion of the spectrum. Other examples may include nanophosphors for medical applications, optical coatings for high precision interferometers, glass, crystalline and ceramic laser gain media for high power and femtosecond generation, scintillator based nuclear detectors, transparent armors, and photo-engineered polymers for passive optics. The role of individual material optical performance within a multi-material optical system will be discussed.

GRADING POLICY

Homework assignments (3)	30 %
Midterm Exam	25 %
Group Project and participation	10%
Final Exam	35 %

Your grade will be based on your point total**:

900-1000 = A
800- 899 = B
700-799 = C
600-699 = D
below 600 = F

**borderline point totals will quality for a + or - grade*

HOMEWORK and GROUP PROJECT: Homework assignments will be a combination of reading assignments, problems from select textbooks, and the GROUP PROJECT (live/virtual and social distance-permitting) will involve critical thinking related to an actual industry-relevant materials problem.

EXAMS: The announced MIDTERM exam is worth 25% of your grade (250 pts) and the FINAL is 35% (350pts). It will be determined in advance (and you'll be notified) whether they are open book, closed book or a combination of **both,** and whether they will be completed during class time, or as **take home exams**. Most questions will be multiple choice, short answer, or short essay, based on classroom lectures and reading assignments. **You MUST be present to take/submit your exams.** In emergency situations – if you are sick, or have to be away for urgent reasons – you must notify me before the class and have documentation related to your absence. I will confirm receipt of this notification. **No make-up exams will be offered.**

HONOR CODE

All assignments and exams must be done on your own. All students at UCF are governed by the provisions of the Golden Rule Handbook. We take the honor code VERY SERIOUSLY and any violations will be reported and may result in dismissal from the class and/or other penalties.

SYLLABUS, WEBCOURSES and ADDITIONAL INFO

Modifications to the present syllabus can occur during the semester. Any change will be announced in class and posted online. Please check webcourses@ucf regularly where copies of all course notes/reading assignments will be posted. Assignments (and exams if appropriate) are expected to be submitted electronically to the instructor by 5pm on the due date (start of class). **No late submissions are allowed.** Double-sessions (or extra classes) may be scheduled if needed.

COVID-related INFO

Details of expectations for in-class, hybrid/flex schedules and other aspects of student and faculty behavior within the class are discussed below. Changes related to these policies may be made based on updates from University and/or State officials due to modification of campus regulations (version shown here is as of September 2020).

University-Wide Face Covering Policy for Common Spaces and Face-to-Face Classes

To protect members of our community, everyone is required to wear a facial covering inside all common spaces including classrooms, per policy here:

(https://policies.ucf.edu/documents/PolicyEmergencyCOVIDReturnPolicy.pdf.

Students who choose not to wear facial coverings will be asked to leave the classroom by the instructor. If they refuse to leave the classroom or put on a facial covering, they may be considered disruptive (please see the Golden Rule for student behavior expectations). Faculty have the right to cancel class if the safety and well-being of class members are in jeopardy. Students will be responsible for the material that would have been covered in class as provided by the instructor.

Notifications in Case of Changes to Course Modality
Depending on the course of the pandemic during the semester, the university may make changes to the way classes are offered. If that happens, please look for announcements or messages in Webcourses@UCF or Knights email about changes specific to this course.

COVID-19 and Illness Notification
Students who believe they may have a COVID-19 diagnosis should contact UCF Student Health Services (407-823-2509) so proper contact tracing procedures can take place.

Students should not come to campus if they are ill, are experiencing any symptoms of COVID-19, have tested positive for COVID, or if anyone living in their residence has tested positive or is sick with COVID-19 symptoms. CDC guidance for COVID-19 symptoms is located here: (https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html)

Students should contact their instructor(s) as soon as possible if they miss class for any illness reason to discuss reasonable adjustments that might need to be made. When possible, students should contact their instructor(s) before missing class.

In Case of Faculty Illness
If the instructor falls ill during the semester, there may be changes to this course, including having a backup instructor take over the course. Please look for announcements or mail in Webcourses@UCF or Knights email for any alterations to this course.

Course Accessibility and Disability COVID-19 Supplemental Statement
Accommodations may need to be added or adjusted should this course shift from an on-campus to a remote format. Students with disabilities should speak with their instructor and should contact sas@ucf.edu to discuss specific accommodations for this or other courses.