# OSE 6313 – Spring 2022

## Materials for Optical Systems

College of Optics and Photonics, University of Central Florida

## COURSE SYLLABUS

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| Instructor: | Kathleen Richardson | Term: | Spring 2022 |
| 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: | CREOL A214 and 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 and are largely available as e-books from the UCF library. Additional reading materials will be added and 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)
   - Linear optical properties (absorption, refractive index, dispersion and birefringence)
   - Non-linear polarizability and properties
   - Thermo-optic properties
   - Thermo-mechanical properties
   - Opto-mechanical properties
   - Crystals and Ceramics
   - Semiconductors

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**

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| Homework assignments (6-8) – 300 pts | 30 % |
| Midterm Exam – 200 pts | 20 % |
| FINAL Project and participation – 200 pts | 20 % |
| Final Exam – 300 pts | 30 % |

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 FINAL PROJECT:** Homework assignments will be a combination of reading assignments, problems from select textbooks, and the FINAL 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 20% of your grade (200 pts) and the FINAL is 30% (300pts). 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 (in a written exam) will be multiple choice, short answer, or short essay, based on classroom lectures and reading assignments.

**For in-class section students, you MUST be present to take/submit your exams.** Take home exams will be uploaded to WebCourses. 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 syllabus and course schedule may 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) unless another submission time is stated. **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 will be based on UCF defined policies and guidelines. Changes related to these policies may be made based on updates from University and/or State officials due to modification of campus regulations, as found at https://www.ucf.edu/coronavirus/ .