Special Topics: OSE 5313
Materials for Optical Systems
College of Optics and Photonics, University of Central Florida

COURSE SYLLABUS

Instructor:	Kathleen Richardson	Term:	Spring 2019
Office:	CREOL A110	Class Meeting Days:	T, Th
Phone:	407-823-6815	Class Meeting Hours:	4:30 - 5:45pm
E-Mail:	kcr@creol.ucf.edu	Class Location:	CREOL A214
Website:		Office Hours:	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. The use of peer-reviewed literature will be exploited to highlight state of the art examples of key materials and their use.

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

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

Materials for Infrared Windows and Domes: Properties and Performance, Daniel C. Harris, SPIE Press (1999) – available for $58.80 (new, based on deal with SPIE Press)

Optical Properties of Solids, M. Fox, Oxford Master Series in Condensed Matter Science, Oxford University Press (2010)

Other useful references (optional):

- J. Simmons, K.S. Potter, *Optical Materials*, Academic Press (1999)
- H. W. Jaffe, *Crystal Chemistry and refractivity*, Dover (1988)
- J.F. Nye, *Physical Properties of Crystals: Their Representation by Tensors and Matrices,* New York, (1986)
- M. Barsoum, *Fundamentals of Ceramics*, Cambridge, Mc-Graw Hill, (1996)

- G. Blasse, B.C. Grabmaier, *Luminescent materials*, Springer-Verlag, (1994)
- B. Henderson, G.F. Imbush, *Optical Spectroscopy of Inorganic Solids*, Oxford University Press, (2006)
- Key optical material literature – peer reviewed journal articles

COURSE OUTLINE

1. Introduction: Optical design and material selection – working from a component 'print': material selection
- 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)
- Chemical bonds, coordination number, structure (and impact on transmission)
- 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. Examples 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.

GRADING POLICY

Homework assignments (3)	30 %
Midterm Exam	25 %
Group project	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

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

EXAMS: The announced MIDTERM exam is worth 25% of your grade (250pts) 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. **<u>No make-up exams will be offered</u>.**

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.

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.