

ECE 570 – OPTOELECTRONIC SEMICONDUCTOR MATERIALS AND DEVICES

Instructor: Prof. Daniel Feezell
Office Location: CHTM 112B
Office Hours: by appointment
Class Meeting Day(s): MW
Class Location / Room: CHTM 103

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Course Credits: 3
Class Time: 11:00 am – 12:15 pm
Term / Semester: Spring 2023

Class Website:

<https://canvas.unm.edu/>

I will post the syllabus, homework assignments and solutions, lecture slides, and other course materials. The website requires you to login using your UNM NetID. A detailed course schedule is also available on the course website. This schedule includes the material to be covered, recommended sections of the book for reading, quiz dates, and HW assignments and due dates. Please note that the schedule is approximate.

Topics Covered:

Introduction to Semiconductor Materials (Ch. 1, 1 lecture) – common semiconductor materials and crystal structures, semiconductor growth techniques including MBE and MOCVD, lattice matching.

Basic Quantum Mechanics (Ch. 3, 2 lectures) – Schrodinger equation, bra-ket (Dirac) notation, operators, wavefunctions and basis representation, Hamiltonian, orthonormality, kronecker delta, probability density, infinite and finite barrier square potential wells.

Basic Semiconductor Physics (Ch. 2, 5 lectures) – continuity equations, Poisson's equation, drift/diffusion, electron/hole concentrations, Fermi-Dirac distribution, density of states, generation/recombination (SRH, radiative, Auger), ABC model, stimulated recombination, optical pumping, pn junctions and heterojunctions.

Optical Waveguides (Ch. 7, 2 lectures) – dielectric slab waveguide, graphical solution, cut-off condition, effective index, confinement factor, effective index method, lossy and gain media.

Optical Processes in Semiconductors (Ch. 9, 4 lectures) – Fermi's golden rule, optical absorption coefficient, spontaneous and stimulated emission, Einstein's coefficients, absorption/gain spectra, absorption and gain in bulk and quantum wells, optical matrix element, joint density of states, momentum matrix element.

Fundamentals of Semiconductor Lasers and LEDs (Ch. 10, 6 lectures) – threshold condition, transparency condition, light output power, differential efficiency, rate equations, LEDs and spontaneous emission, amplified spontaneous emission, gain-guided and index-guided lasers, quantum-well lasers, gain spectra, strained quantum-well lasers.

Advanced Semiconductor Lasers and Other Devices (Ch. 11, 2 lectures) – distributed feedback (DFB) lasers, vertical-cavity surface-emitting lasers (VCSELs).

Direct Modulation of Semiconductors Lasers (Ch. 12, 1 lectures) – modulation of semiconductor lasers, rate equations, small-signal response.

Photodetectors and Solar Cells (Ch.15 and Liu Ch. 14, 6 lectures) – photoconductors, noise in photodiodes, pn photodiodes, pin photodiodes, avalanche photodiodes, solar cells.

Required Text:

“Physics of Photonic Devices,” Shun Lien Chuang, John Wiley & Sons, 2nd edition (2009), ISBN-10: 0470293195; ISBN: 978-0470293195

**We will only have time to cover portions of the text in this one-semester course. The text is fairly comprehensive and will serve as a good reference in your future independent research activities. The text is also fairly advanced, so I suggest utilizing the reference texts below for additional perspective on difficult topics.*

Reference Texts:

“Optoelectronics and Photonics: Principles and Practices,” S. O. Kasap, Pearson, 2nd edition (2013), ISBN-13: 978-0-13-215149-8. *This is the standard undergraduate optoelectronics book that is used at UNM.*

“Fundamentals of Photonics,” B.E.A. Saleh and M.C Teich, Wiley, 2nd edition (2007), ISBN: 978-0-471-35832-9

“Diode Lasers and Photonic Integrated Circuits,” L. Coldren, S. Corzine, and Milan Masanovic, John Wiley & Sons Inc., 2nd edition (2012), ISBN: 0470484128.

“Photonic Devices, Part 2” Jia-Ming Liu, Cambridge University Press, (2005); ISBN 978-0-521-13578-8

Prerequisites:

ECE 371, 471, or 572 (required), undergraduate optoelectronics (strongly recommended), undergraduate electromagnetics (recommended)

Grading:

Homework (8 assignments)	30%
Quizzes (8 quizzes)	30%
Group Research Presentation (Week of May 9-13, times TBD)	30%
Class Participation	10%

Homework policy: There will be eight HW assignments throughout the semester. *The lowest homework score will be dropped before calculating grades.* The due dates for the homework assignments are noted on the detailed class schedule. Late homework assignments will typically not be accepted as I will post the solutions to the assignments right after you turn them in. Homework is due at the *beginning* of the class period on the due date. Homework should be neatly written, with each problem labeled and the pages stapled together. Show your work in a logical fashion in order to get maximum credit and ***please box your final answers!*** If the problem says “plot” you should use Excel, Matlab, or some other numerical tool, if the problem says draw or sketch, you can do it by hand.

Quizzes: There will be eight quizzes throughout the semester. *The lowest quiz score will be dropped before calculating grades.* Quizzes will be given on the due dates of the homework assignments and will cover material from the recent homework. Quizzes will be administered during the last ~20 minutes of the class period. Quiz format will vary and could include multiple choice, fill in the blank, short answer, and/or long answer questions.

Group Research Presentation: Instead of a final exam, students will give a group research presentation on a selected optoelectronic device topic (to be agreed upon with the instructor). Details of the requirements for the presentation and assessment of the presentation are posted on Canvas in a separate document. Groups will consist of 2-3 students.

Participation: The participation grade will be based on regular and punctual attendance, meaningful contribution to class discussion with other students and the instructor, and participation during the research presentations of other groups. Flexibility will be exercised with participation grading in the event a student is absent for COVID-related reasons.

COVID-19 Information: COVID-19 Health and Awareness. UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's Administrative Mandate on Required COVID-19 vaccination. If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the Centers for Disease Control (CDC) guidelines. If you do need to stay home, please communicate with me at dfeezell@unm.edu; I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. Please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

Student Health and Counseling (SHAC) at (505) 277-3136. If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID-19; OR If you recently tested positive and may need oral treatment, call SHAC.

LoboRESPECT Advocacy Center (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

Communication on change in modality: The President and Provost of UNM may direct that classes move to remote delivery at any time to preserve the health and safety of the students, instructor and community. The instructor will provide any updates about our class and please check <https://bringbackthepack.unm.edu> regularly for general UNM updates about COVID-19 and the health of our community.

Accommodation Statement: : In accordance with University Policy 2310 and the Americans with Disabilities Act (ADA), academic accommodations may be made for any student who notifies the instructor of the need for an accommodation. It is imperative that you take the initiative to bring such needs to the instructor's attention, as I am not legally permitted to inquire. Students who may require assistance in emergency evacuations should contact the instructor as to the most appropriate procedures to follow. Contact [Accessibility Resource Center](mailto:arcsrvs@unm.edu) at 277-3506 or arcsrvs@unm.edu for additional information. UNM is committed to providing courses that are

inclusive and accessible for all participants. As your instructor, it is my objective to facilitate an accessible classroom setting, in which students have full access and opportunity. If you are experiencing physical or academic barriers, or concerns related to mental health, physical health and/or COVID-19, please consult with me after class, via email/phone or during office hours. You are also encouraged to contact [Accessibility Resource Center](#) at arcsrvs@unm.edu or by phone 277-3506.

Academic Integrity: The University of New Mexico believes that academic honesty is a foundation principle for personal and academic development. All University policies regarding academic honesty apply to this course. Academic dishonesty includes, but is not limited to, cheating or copying, plagiarism (claiming credit for the words or works of another from any type of source such as print, Internet or electronic database, or failing to cite the source), fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. The University's full statement on academic honesty and the consequences for failure to comply is available in the college catalog and in the *Pathfinder*.

Title IX: Our classroom and our university should always be spaces of mutual respect, kindness, and support, without fear of discrimination, harassment, or violence. Should you ever need assistance or have concerns about incidents that violate this principle, please access the resources available to you on campus, especially the LoboRESPECT Advocacy Center and the support services listed on its website (<http://loborespect.unm.edu/>). Please note that, because UNM faculty, TAs, and GAs are considered "responsible employees" by the Department of Education, any disclosure of gender discrimination (including sexual harassment, sexual misconduct, and sexual violence) made to a faculty member, TA, or GA must be reported by that faculty member, TA, or GA to the university's Title IX coordinator at the [Office of Compliance, Ethics, and Equal Opportunity](#). For more information on the campus policy regarding sexual misconduct, please see: <https://policy.unm.edu/university-policies/2000/2740.html>.

LoboRESPECT Advocacy Center, the Women's Resource Center, and the LGBTQ Resource Center all offer confidential services.

Cell Phones and Technology: As a matter of courtesy, please turn off cell phones, pagers, and other communication and entertainment devices prior to the beginning of class. Notify me in advance if you are monitoring an emergency, for which cell phone ringers should be switched to vibrate.

Library and Tutorial Services: UNM-Main campus provides many library services and some tutorial services for distance students. For library services, go to <http://www.unm.edu/libraries/> to link to a specific library or to contact a librarian. For tutorial services, go to <http://caps.unm.edu/online> to explore UNM's online services.

Weather Policy: In the event of severe weather conditions UNM may close. Please call 277-SNOW to check UNM's status during questionable weather conditions.

Copyright Policy and Law: (*University Counsel's Office - Subject to Change Without Notice*)

The unauthorized distribution of copyrighted material, including through peer-to-peer file sharing, may subject a student to criminal and civil penalties. The laws that govern copyright are not specific to any one technology. Students can violate the rights of a copyright holder using many different types of technology. Both uploading and downloading of files can pose a violation of the copyright law. Students should be cautious when obtaining any copyrighted material. As a rule of thumb, before a student receives anything for free, they should research whether that source provides material licensed by the copyright owner. A group called EDUCAUSE has a list of legal file sharing alternatives at <http://www.educause.edu/legalcontent>.

Individuals who violate copyright law by illegally uploading and downloading copyrighted files may be subject to civil penalties of between \$750 and \$150,000 per song. These penalties are established by federal law. In the past, pre-litigation settlements offered by copyright owners have been in the \$3,000 to \$4,000 and up range while juries in some jurisdictions have issued verdicts of hundreds of thousands and up. In addition, a court may, in its discretion, grant the copyright owner reasonable attorney fees. Although criminal prosecution of students for file sharing is extremely rare, federal law lays out criminal penalties for intentional copyright infringement which can include fines and jail time. In addition to potentially violating the law, unauthorized distribution or receipt of copyrighted material is a violation of University Business Policies and Procedures Manual 2500. That policy states that: "Users shall respect all copyrights including software copyrights...Use of University computing services in violation of applicable laws or University policy may result in sanctions, including withdrawal of use privilege; disciplinary action, up to and including, expulsion from the University or discharge from a position; and legal prosecution under applicable federal and/or state law."