Engineering

ECE 802: Diamond Technology
Fall 2022 Syllabus (Semester starts Aug. 31, 2022)

Part 1: Course Information

Instructor Information
Instructor: Prof. Timothy Grotjohn
Office: Engineering Research C131
Office Hours: Timothy Grotjohn, grotjohn@egr.msu.edu,
Zoom Office Hours: Tuesday 3-4 pm and Friday 2-3 pm,
https://msu.zoom.us/j/7329335895
517-353-8906 (office)

The course instructor will answer questions by email and on-line by zoom. Other times can be arranged by appointment.
Please send me an email if you want to ask questions by phone so that I can call you.
E-mail: grotjohn@msu.edu In the subject line of the email put “ECE 802”. This helps me to avoid missing your email. My goal is to respond to email within 24 hours.

Course Description
Diamond has a host of outstanding properties including highest thermal conductivity, extreme hardness, wide bandgap, large electric field breakdown strength, high hole and electron mobility, high radiation hardness, good electrochemical performance, and good chemical inertness. Diamond has applications and potential applications in electronics, optics, sensors, MEMS, wear/cutting, quantum computing, and thermal management.
This course is intended to provide the student with a state-of-the-art knowledge of diamond properties, diamond devices/applications, and diamond growth/processing/manufacturing technology.

Prerequisite
Graduate student standing in Engineering, Physics, Chemistry (or permission of instructor)

Textbook & Course Materials
No textbook. Course materials to read will be posted on D2L.

Course Requirements
- Internet connection (DSL, LAN, or cable connection desirable)
- Access to Desire2Learn (D2L).
Course Structure
This course will be delivered online through the course management system and you will need your MSU NetID to login to the course from the D2L homepage (http://d2l.msu.edu).

In D2L, you will access online lessons, course materials, and additional resources. The course will consist of the 26 units. The pace of the course will be two units per week. The course material will consist of pre-recorded lectures, class notes and papers to read. This is an internet course so it can be completed on your time schedule each week. You are expected to complete two units each week. Material will be posted and work will be done in the D2L learning environment.

Technical Assistance
If you need technical assistance at any time during the course or to report a problem you can:

- Visit the Distance Learning Services Support Site
- Visit the Desire2Learn Help Site (http://help.d2l.msu.edu/)
- Or call Distance Learning Services: (800) 500-1554 or (517) 355-2345

Resource Persons with Disabilities (RCPD)

- To make an appointment with a specialist, contact: (517) 353-9642
  Or TTY: (517) 355-1293
- Web site for RCPD: http://MYProfile.rcpd.msu.edu
Part 2: Course Objectives

The primary learning objectives for this course are:

- Be able to list and describe the materials properties of diamond relative to other materials.
- Describe and understand the analytical technique for characterizing the properties of diamond.
- Describe and understand the technique for synthesis of diamond including high pressure, high temperature synthesis and chemical vapor deposition synthesis.
- Describe and understand how to quantify defects in diamond.
- Describe and be able to understand fabrication processes for diamond-based devices.
- Survey applications of diamond to electronics, quantum based sensors and information processing, electrochemistry, thermal management, optics and wear/cutting.

You will meet the objectives listed above through a combination of the following activities in this course:

- Reading papers from the journal literature and patent literature.
- Watching the recorded lectures and studying the associated lecture notes.
- Completing homework assignments on approximately a weekly basis.
- Preparing two papers (or one paper and one presentation) on diamond topics.
- Completing two exams.
Part 3: Course Outline/Schedule

Important Note: Refer to the course calendar for specific meeting dates and times. Activity and assignment details will be explained in detail within each week's corresponding learning module. If you have any questions, please contact your instructor.

Week 1 Review Syllabus (Aug. 31-Sept. 6)
   1. Diamond structure and properties
   2. Diamond application overview

Week 2 (Sept. 7-13)
   3. Making diamond: HPHT
   4. Making diamond: CVD-1

Week 3 (Sept. 14-20)
   5. Making diamond: CVD-2
   6. Characterizing diamond: Raman, PL, CL, XRD, Xray tomography, FTIR, birefringence, other

Week 4 (Sept. 21-27)
   7. Dislocation defects in diamond
   8. Point defects in diamond

Week 5 (Sept. 28-Oct. 4)
   9. Doping of diamond (Epitaxy)
   10. Doping of diamond (Implantation/Annealing)

Week 6 (Oct. 5-11)
   11. Laser cutting and polishing of diamond
   12. Etching of diamond

Week 7 (Oct 12-18) Midterm week
   13. Mechanical properties of diamond and applications

Week 8 (Oct. 19-25)
   Fall Break 10/24-25
   14. Diamond electronics (electrical properties and characterization)

Week 9 (Oct. 26-Nov. 1)
   15. Surface properties of diamond
   16. Metal contacts to diamond

Week 10 (Nov. 2-8)
   17. Diamond electronics (devices-1)
   18. Diamond electronics (devices-2)

Week 11 (Nov. 9-15)
   19. Diamond detectors (radiation hardness)
   20. NV centers in diamond and applications-1 (including sensors)

Week 12 (Nov. 16-22)
   21. NV centers in diamond and applications-2 (including quantum computing)
   22. Chemical and bio properties and applications

Week 13 (Nov. 23-29)
   23. Electrochemical diamond electrodes/Applications
      Thanksgiving break

Week 14 (Nov. 30-Dec. 6)
24. Optical properties of diamond (photonics, absorption)
25. Diamond optical windows & Raman lasers

Week 15
26. Heat sinks and thermal management
Part 4: Grading Policy

Graded Course Activities

The table below describes the graded course activities including points and activity description. The first column includes the points possible, and the second column includes a description for each activity.

<table>
<thead>
<tr>
<th>Points</th>
<th>Description</th>
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<tbody>
<tr>
<td>20%</td>
<td>Homework</td>
</tr>
<tr>
<td>20%</td>
<td>Paper #1</td>
</tr>
<tr>
<td>20%</td>
<td>Paper/Presentation #2</td>
</tr>
<tr>
<td>20%</td>
<td>Mid-Term</td>
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<tr>
<td>20%</td>
<td>Final Exam</td>
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<tr>
<td>100</td>
<td>Total Points Possible</td>
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</tbody>
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**Homework**: The course will have homework questions associated with each of the 26 units. One homework will be given out each week and will be due the following Tuesday (or Wednesday). The questions need to be completed and submitted. Homework accounts for 20% of the course grade. Doing the homework is important for learning the course material, to pass the course you must turn in at least 80% of the homework assignments.

**Two Papers or One Paper/One Presentation**: During the course students will write two short (5 page, single spaced, 12 point font) papers reviewing the state of the art of some aspect of diamond technology. Alternatively the second paper can be a presentation that you record. Paper 1 is on a topic in units 1-14, Paper 2 or a Presentation is on a topic in units 15-26. Each is worth 20% of the grade. For the presentation you will submit the recorded presentation along with the powerpoint slides.

**Mid-Term and Final Exam**: Each exam is worth 20% of the grade. It will test the topics covered in the class homework/lectures/readings. The exams will be a take-home exam type format.

**Late Work Policy**

Up to two HW assignments will be accepted late (up to 2 days late). After two late assignments a deduction will be taken for late assignments. The exam needs to be completed on time.

**Viewing Grades**

Your graded assignments will be on D2L. My goal is to grade assignments within a week of their turn-in date.
Part 5: Course Policies

Inform Your Instructor of Any Accommodations Needed

From the Resource Center for Persons with Disabilities (RCPD): Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued a Verified Individual Services Accommodation ("VISA") form. Please present this form to me at the start of the term and/or two weeks prior to the accommodation date (test, project, etc.). Requests received after this date may not be honored.

Understand When You May Drop This Course

Drops and Adds

Sept. 7, last date to add a course for FS22  
Sept. 23, last date to drop a class with tuition refund  
Oct. 18 last date to drop a class with no grade reported.

Commercialized Lecture Notes

Commercialization of lecture notes and university-provided course materials is not permitted in this course.*

*Note: The Code of Teaching Responsibility requires instructors who permit students to commercialize their class lecture notes to include a statement in their course syllabi that gives such permission. Absent such permission, students may not do so.

Complete Assignments

Assignments for this course will be submitted electronically through D2L unless otherwise instructed. Assignments must be submitted by the given deadline or special permission must be requested from instructor before the due date.