MSE 6402 – Structure and Defects

School of Materials Science and Engineering
Georgia Institute of Technology

Spring Semester 2021

Course Objective	To provide students with a fundamental understanding of structural features of crystalline materials, including point and space groups, representative crystal structures, point and linear defects, and the effect of symmetry and defects on materials properties
Mode of Instruction	This course will be delivered in the hybrid mode. Most lectures will be delivered remotely; however, there will be some in-class activities while observing social distancing, including **exams** and some planned homework or review sessions.
Lecture	**11:00 - 12:15pm** M W, **Love 183**
Instructors	Meilin Liu — Naresh Thadhani
Office	Love 258 — Love 286
Phone	894-6114 — 894-2651
E-mail	meilin.liu@mse.gatech.edu — naresh.thadhani@mse.gatech.edu
Office Hour	TuTh 4-5:00 pm or by appointment, also call or e-mail
Teaching Assistant and Office Hour	**Student A**: office hour time/location/e-mail/phone **Student B:** office hour time/location/e-mail/phone
Homework	Problems will be assigned periodically and solutions will be posted later. Homework may be collected but will not be graded.
Exam/grading	**4 Exams, 25% each** Exam 1 – Structure & symmetry of materials Exam 2 – Structure-property relationships Exam 3 – Point defects Exam 4 – Linear defects (dislocations)
Grading Basis	Scale >90% A guaranteed >80% B guaranteed >70% C guaranteed >60% D guaranteed

Learning Objectives:	Upon completion of this course, students will be able to: 1. Deduce point groups of simple crystal structures and geometric figures. 2. Understand space group notations and all symmetry elements associated with each space group. 3. Become familiar with structural features of crystalline materials. 4. Understand point defects and linear defects in crystalline solids. 5. Understand the inherent correlation between crystal structure, defects, and properties of materials.
Academic Integrity	Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at www.honor.gatech.edu. Academic dishonesty will not be tolerated, including cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code.
Learning Accommodations:	For students with documented disabilities, we will make classroom accommodations in accordance with the ADAPTS office (http://www.adapts.gatech.edu). However, this must be arranged in advance.
Electronic Devices	Silence all electronic devices (cell phones, smart watches, etc.) during class. The only electronic device that you may have out and available for use during an exam is a commercially available calculator.

References

1. **Lecture notes** – to be posted on **Canvas**
2. **Structure of Materials:** An Introduction to Crystallography, Diffraction and Symmetry, 2nd Edition, M. De Graef and M. E. McHenry, 2012, Cambridge University Press.
3. Physical Ceramics, Y. M. Chiang, D. Birnie, and W. D. Kinggery, Wiley, 1997.
4. Crystallography – An Introduction, 3rd ed., Walter Borchardt-Ott, Springer-Verlag, 2012
5. **Physical Properties of Crystals:** Their Representation by Tensors and Matrices, 3rd Edition, J.F. Nye, Oxford, 2001.
6. Defects in Solids, R.J.D. Tilley, Wiley, 2008, QD921.T53
7. Introduction of Dislocations, 4th Edition, D. Hull and D.J. Bacon, Pergamon Press
8. Elementary Dislocation Theory, 1992 Edition, Johannes Weertman and Julia R. Weetman, Oxford University Press

MSE 6402: Topical Outline

# of Lectures	Date	Topics	Ref
		Crystal Structure and Symmetry	**1,2,3,4**
7	Jan-20 to Feb-10 **Feb-22**	Overview of the course; Geometric principles: Representative structures of important materials: metals, alloys, semiconductors, and ceramics (AX, AX_2, ABX_3, AB_2X_4 compounds: Fluorite, Perovskite, Spinel, Garnet, etc.); Pauling rules Crystal Symmetry: Symmetry operations; Crystallographic point groups; Magnetic (color) point groups; Space groups; **Exam 1: Crystal Structure and Symmetry (25%)**	
		Structure-property relationships	**1,2,5**
6	Feb-15 to Mar-8 **Mar 15**	Non-crystallographic point groups: Curie (limiting) groups (symmetry of force fields and physical properties) Introduction to anisotropy and tensors Effect of crystal symmetry on properties of materials: Neumann's principles; Formulation of physical interactions Number of independent components of tensor properties in different crystals; Ferro-electricity, Ferrimagnetism, and other physical interactions **Exam 2: Structure-property relationships (25%)**	
		Point Defects	**1,3,6**
6	Mar10 to Mar 31 **April 5**	Defect Notations Equilibrium Defect Concentrations Defect Reactions Mass-Action Law/Electroneutrality approximation Ionic and Electronic Disorders in materials Brouwer's Approximation Non-stoichiometry: Solid-Gas Interactions Effect of Doping: Donors and acceptors Temperature Effect Charged Surfaces & Space Charge Region, Complex Defects **Exam 3: Point Defects (25%)**	
		Dislocations – N. Thadhani	**1,7,8**
6	Apr 7 to Apr 26	Line Defects and their Characteristics Movement of Dislocations Elastic Strain and Stress fields of Dislocations Strain Energy of a Dislocation Forces on Dislocations Dislocations reaction in FCC Systems Jogs and Interactions of Dislocations Origin and Multiplication of Dislocations	
Final Period	**May 5**	**Exam 4: Dislocations (25%); 11:20 AM – 12:50 PM**	

Requirements and Guidelines Specific to Spring 2021

The spring semester 2021 is still challenging due to the Covid-19 pandemic and a growing awareness of racial inequities. The following information relates to specific services and guidelines for courses during this semester. The most up-to-date information on Covid-19 is on the TECH Moving Forward website and in the Academic Restart Frequently Asked Questions.

Expectations and Guidelines

Each of us has a responsibility to ourselves and our fellow Yellow Jackets; please be mindful of our shared commitment.

- We are all required to wear a face covering while inside any campus facilities/buildings, including during in-person classes, and to adhere to social distancing of at least 6 feet. If an individual forgets to bring a face covering to class or into any indoor space, there will be a clearly marked supply of these in each building. If a student fails to follow Georgia Tech's policies on social distancing and face coverings, they will initially be reminded of the policy and if necessary, asked to leave the class, meeting, or space. If they still fail to follow the policy, they may be referred to the Office of the Dean of Students. Information on the Institute's policy on face coverings.
- Students are expected to sit in assigned seats and to come to class only on days that are assigned to them.
- Papers, projects, tests, homework, and other assignments will only be accepted in **electronic form** unless the assignment is a physical artifact.

Additional information is available in the Student Guidebook.

Instructor Illness or Exposure to Covid-19

During the semester, some faculty members may be required to quarantine due to exposure or isolate due to a Covid-19 diagnosis. Some disruption to classes or services is inevitable, but Georgia Tech is making every effort to ensure continuity of operations. As is the case in any semester, faculty may cancel a class if they have an illness or emergency situation and cover any missed material at their own discretion. If an instructor needs to cancel a class, they should notify students as early as possible.

Faculty who are staying home due to symptoms should monitor their health closely and consult with their school chair to determine if remote instruction or substitute instruction is most appropriate for the course. If they need to cancel a class repeatedly, a backup will be supplied in the form of a temporary substitute instructor or asynchronous work. No course will be canceled after the first class has occurred.

If you have not tested positive but are ill or have been exposed to someone who is ill, please follow the Covid-19 Exposure Decision Tree for reporting your illness.

Student Illness or Exposure to Covid-19

During the semester, you may be required to quarantine or self-isolate to avoid the risk of infection to others. Quarantine is the separation of those who have been exposed to someone with Covid-19 but who are not ill; isolation is the separation of those who have tested positive for Covid-19 or been diagnosed with Covid-19 by symptoms.

If you have not tested positive but are ill or have been exposed to someone who is ill, please follow the Covid-19 Exposure Decision Tree for reporting your illness.

During the quarantine or isolation period you may feel completely well, ill but able to work as usual, or too ill to work until you recover.

Remote courses and remote class sessions during hybrid courses. Unless you are too ill to work, you should be able to complete your remote work while in quarantine or isolation.

In-person courses and in-person class sessions during hybrid courses. When in isolation or quarantine you will be unable to attend in-person course sessions but your instructor may require you either to participate in the course remotely, complete some complementary work that parallels what you are missing in class, or make up some class work when you return.

If you are ill and unable to do course work this will be treated similarly to any student illness. The Dean of Students will have been contacted when you report your positive test or are told that it is necessary to quarantine and will notify your instructor that you may be unable to attend class events or finish your work as the result of a health issue. Your instructor will not be told the reason. We have asked all faculty to be lenient and understanding when setting work deadlines or expecting students to finish work, and so you should be able to catch up with any work that you miss while in quarantine or isolation. Your instructor may make available any video recordings of classes or slides that have been used while you are absent, and may prepare some complementary asynchronous assignments that compensate for your inability to participate in class sessions. Ask your instructor for the details.

CARE Center, Counseling Center, Stamps Health Services, and the Student Center

These uncertain times can be difficult, and many students may need help in dealing with stress and mental health. The **CARE Center** and the **Counseling Center**, and **Stamps Health Services** will offer both in-person and virtual appointments. Face-to-face appointments will require wearing a face covering and social distancing, with exceptions for medical examinations. Student Center services and operations are available on the **Student Center** website. For more information on these and other student services, contact the Vice President and Dean of Students or the **Division of Student Life**.

Accommodations for Students at Higher Risk for Severe Illness with Covid-19

Students may request an accommodation through the Office of Disability Services (ODS) due to 1) presence of a condition as defined by the Americans with Disabilities Act (ADA), or 2) identification as an individual of higher risk for Covid-19, as defined by the Centers for Disease Control (CDC). Registering with ODS is a 3-step process that includes completing an application, uploading documentation related to the accommodation request, and scheduling an appointment for an "intake meeting" (either in person or via phone or video conference) with a disability coordinator.

If you have been approved by ODS for an accommodation, I will work closely with you to understand your needs and make a good faith effort to investigate whether or not requested accommodations are possible for this course. If the accommodation request results in a fundamental alteration of the stated learning outcome of this course, ODS, academic advisors, and the school offering the course will work with you to find a suitable alternative that as far as possible preserves your progress toward graduation.

Course Homeworks/Assignments/Papers

All course assignments will be submitted electronically via Canvas.

Exam Proctoring

Exams will be given preferentially in class if at all possible (depending on availability of a large classroom). If an exam has to be given remotely, Honorlock will be used for digital proctoring. To get prepared for remote exams, the following are required of students:

- Include important Honorlock technical requirements
- Students must have a broadband internet connection
- Students must have a webcam and microphone
- Students must have a secure private location to take an exam
- Students will be asked to provide a picture ID and take a picture of themselves via a webcam as part of the exam process
- Honorlock is not compatible with Linux OS, Virtual Machines, tablets, or smartphones
- Honorlock requires the installation of Google Chrome and the Honorlock Chrome extension

---

HELP CREATE RESISTANCE TO SEXUAL HARASSMENT https://www.mse.gatech.edu/values/crsh

MSE is committed to a community that actively resists sexual and gender harassment. If you see or experience any of the following: sexual harassment, domestic and dating violence, sexual assault and stalking, resources are available:

- **Confidential VOICE Advocates** can provide support 24/7 and explore resources and options, some of which are time sensitive. Call GTPD dispatcher at 404-894-2500 and ask to speak to the On-Call VOICE Advocate. You do not need to make a report or provide any information other than your phone number for a VOICE advocate to contact you.
- Sexual violence or harassment can be reported directly to Georgia Tech's **Title IX Coordinator**, Marcia Bull Stadeker, (404) 385-5583, marcia.stadeker@gatech.edu.

Faculty, Staff and TAs are mandatory reporters and are required to inform the Title IX Coordinator should they become aware that you or any student has experienced sexual violence or sexual harassment.