

## MSE 6412 – Structure of Materials

School of Materials Science and Engineering  
Georgia Institute of Technology

Fall Semester 2019

<b>Course Objective</b>	To provide students with a fundamental understanding of structural features of materials, including point and space groups, representative crystal structures, quasi-crystals, amorphous and rubbery states, liquid crystals, colloids, solutions, and effect of symmetry on materials properties
<b>Lecture</b>	<b>4:30 - 5:45pm</b> Tu Th, <b>Instr Center 111</b>
<b>Instructors</b>	<b>Meilin Liu</b> <b>Natalie Stingelin</b>
<b>Office</b>	Love 258                              MoSE 2278
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<b>Office Hour</b>	Tu Th 5:45-6:45pm or by appointment, also call or e-mail
<b>Teaching Assistant and Office Hour</b>	<b>Hansol Lee:</b> 3-4pm on Tuesday/Thursday <b>Zheyu Luo:</b> 11-12 on Wednesday/Friday, <b>Location:</b> 4 <sup>th</sup> floor lobby in MoSE
<b>Homework</b>	Problems will be assigned periodically and solutions will be posted later. Homework may be collected but will not be graded.
<b>Exam/grading</b>	<b>4 Exams, 25% each</b> Exam 1 – Macromolecular matter: basic structure Exam 2 – Semicrystalline vs. amorphous polymers Exam 3 – Structure & symmetry of materials Exam 4 – Structure-property relationships
<b>Grading Basis</b>	Scale >90% A guaranteed >80% B guaranteed >70% C guaranteed >60% D guaranteed

<b>Learning Objectives:</b>	<p>Upon completion of this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Deduce point groups of simple crystal structures and geometric figures.</li> <li>2. Understand space group notations and all symmetry elements associated with each space group.</li> <li>3. Understand relationships between mass, shape and size of polymers and other nanostructures.</li> <li>4. Become familiar with structural features of all classes of materials, including hard and soft materials.</li> <li>5. Understand the inherent correlation between structure and properties of materials.</li> </ol>
<b>Academic Integrity</b>	<p>Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at <a href="http://www.honor.gatech.edu">www.honor.gatech.edu</a>. Academic dishonesty will not be tolerated, including cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code.</p>
<b>Learning Accommodations:</b>	<p>For students with documented disabilities, we will make classroom accommodations in accordance with the ADAPTS office (<a href="http://www.adapts.gatech.edu">http://www.adapts.gatech.edu</a>). However, this must be arranged in advance.</p>
<b>Electronic Devices</b>	<p>Silence cell phones during class. Surfing OK during class, not during exams. Calculator (not one on an internet-connected device!) is OK during exam, but you should not need it much.</p>

## References

1. **Lecture notes** – to be posted on T-Square, **Canvas** or Dropbox
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. Kingery, Wiley, 1997.
4. **Crystallography – An Introduction**, 3<sup>rd</sup> ed., Walter Borchardt-Ott, Springer-Verlag, 2012
5. **Physical Properties of Crystals: Their Representation by Tensors and Matrices**, 3<sup>rd</sup> Edition, J.F. Nye, Oxford, 2001.
6. **Soft Matter Physics**, Masao Doi, 2015, Oxford.
7. **Polymer Chemistry**, 2nd Edition, P.C. Hiemenz and T. P. Lodge, 2007, CRC.
8. **Colloid Science: Principles, Methods and Applications**, Terence Cosgrove, 2010, Wiley.
9. **Structured Fluids: Polymers, Colloids, Surfactants**, Thomas A. Witten, 2010, Oxford.

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### Topical Outline

Week	Date	Topic	Comment
1	8/20	Overview of the course, structural features of materials/materials classes, and their impact on properties	
	8/22	Polymer solids: review of macromolecules and their structures	<b>Last day to drop w/o "W" August 23</b>
2	8/27	How can polymers crystallize? Influence of chemical structure	
	8/29	Morphology and structure of macromolecular matter: solidification from dilute solutions I	
3	9/3	Morphology and structure of macromolecular matter: solidification from dilute solutions II	
	9/5	Solidification from concentrated solutions/melt I	
4	9/10	Solidification from concentrated solutions/melt II	
	9/12	Recap: Polymer structure formation to guide processing	
5	<b>9/17</b>	<b>Exam 1: Polymer structure formation</b>	
	9/19	Polymer crystal unit cell and crystal modulus // Effect of non-ambient conditions on polymer structure	
6	9/24	Crystallinity and measuring crystallinity in soft matter	
	9/26	Polymer melting I	
7	10/1	Polymer melting II	
	10/3	Polymer phase diagrams to establish structure property relation	
8	10/8	Amorphous polymers	
	10/10	Representative crystal structures (& unique properties) of metals, alloys, intermetallics, superlattices	

9	10/15	Holiday	Fall Recess: Oct. 14/15
	10/17	Exam 2: Structure/property relations in soft matter	
10	10/22	Ceramics/Ionic crystals: AX, AX <sub>2</sub> , ABX <sub>3</sub> , AB <sub>2</sub> X <sub>4</sub> compounds: e.g., Fluorite, Perovskite	
	10/24	Spinel, Garnet, etc.; Pauling rules; <i>molecular</i> crystals (soft materials)	Last Day to Withdraw (Oct 26 @ 4 pm)
11	10/29 (→ 10/28)	Transformation of coordinate systems; Symmetry operations: rotations, inversion, reflection, translation, etc.	
	10/31	Introduction to groups, crystallographic point groups (2D and 3D)	
12	11/5	Magnetic symmetry: time reversal; Magnetic (color) point groups (color, charge, & time reversal); Space groups	
	11/7 (→11/4)	Non-crystallographic point groups: Curie (limiting) groups (symmetry of force fields, physical properties)	
13	11/12	Exam 1: Structure & symmetry of materials	
	11/14	Introduction to anisotropy and tensors	
14	11/19	Effect of crystal symmetry on properties of materials: Neumann's principles	
	11/21	Formulation of physical interactions	
15	11/26	Number of independent components of tensor properties in different crystals	
	11/28	Holiday	Thanksgiving Holiday
16	12/3 (→11/25)	Ferro-electricity, Ferrimagnetism, and other physical interactions	Final Class
	12/5	No Class	Reading Period
	12/9	Time to be announced Exam 4: Structure-property relationships	