

# MSE 6412 – Structure of Materials

School of Materials Science and Engineering  
Georgia Institute of Technology

Fall Semester 2018

Course Objective	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	
Lecture	<b>4:30 - 5:45pm</b> Tu Th, <b>Instr Center 111</b>	
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Office Hour	TuTh 5:45-6:45pm or by appointment, also call or e-mail	
Teaching Assistant and Office Hour	<b>Steven Zhang:</b> 1:30-2:30 MW in IPST 280; e-mail: <a href="mailto:stlzhang@gatech.edu">stlzhang@gatech.edu</a> ; Phone: 408-223-5157 <b>Hansol Lee:</b> 3:00-4:00 pm TuTh, MoSE 4 <sup>th</sup> floor lobby; office: MoSE 4243; e-mail: <a href="mailto:hlee641@gatech.edu">hlee641@gatech.edu</a> ; Phone: 404-205-9612	
Homework	Problems will be assigned periodically and solutions will be posted later. Homework may be collected but will not be graded.	
Exam/grading	<b>4 Exams, 25% each</b> Exam 1 – Structure & symmetry of materials Exam 2 – Structure-property relationships Exam 3 – Amorphous States Exam 4 – Liquid crystals, colloids, and solutions	
Grading Basis	Scale >90% A guaranteed >80% B guaranteed >70% C guaranteed >60% D guaranteed	

Learning Objectives:	<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>
Academic Integrity	<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>
Learning Accommodations:	<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>
Electronic Devices	<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 shouldn't 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	8/21	Overview of the course, structural features of materials and their impact on properties; Geometric arrangement of atoms: Lattice and unit cells	
	8/23	Representative crystal structures (& unique properties) of metals, alloys, intermetallics, superlattices	Last day to drop w/o "W"
2	8/28	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	
	8/30	Spinel, Garnet, etc.; Pauling rules; <i>molecular</i> crystals (soft materials)	
3	9/4	Transformation of coordinate systems; Symmetry operations: rotations, inversion, reflection, translation, etc.	
	9/6	Introduction to groups, crystallographic point groups (2D and 3D)	
4	9/11	Magnetic symmetry: time reversal; Magnetic (color) point groups (color, charge, & time reversal; Space groups	
	9/13	Non-crystallographic point groups: Curie (limiting) groups (symmetry of force fields, physical properties)	
5	<b>9/18</b>	<b>Exam 1: Structure &amp; symmetry of materials</b>	
	9/20	Introduction to anisotropy and tensors	
6	9/25	Effect of crystal symmetry on properties of materials: Neumann's principles	
	9/27	Formulation of physical	

		interactions	
7	10/2	Number of independent components of tensor properties in different crystals	
	10/4	Ferro-electricity, Ferrimagnetism, and other physical interactions	
8	10/9	Holiday	Fall Recess: Oct. 8-9
	<b>10/11</b>	<b>Exam 2: Structure-property relationships</b>	
9	10/16	Soft Materials Components: macromolecules (synthetic & natural), surfactants, mesogens	
	10/18	Crystals from polymers, colloids and proteins: same as Part 1 only bigger and softer.	
10	10/23	Distributions: it's a mess.	
	10/25	Dimensions and Stiffness	Last Day to Withdraw (Oct 26 @ 4 pm)
11	10/30	Scattering: X-ray, Neutron, Light	
	11/1	Even structure & function are controlled by thermodynamics	
12	<b>11/6</b>	<b>Exam 3: Soft components and basics</b>	
	11/8	Copolymers and blends	
13	11/13	Glasses, rubbers, gels and melts.	
	11/15	Rubber elasticity	
14	11/20	Flow and deformation	
	11/22	Holiday	Thanksgiving Holiday
15	11/27	Surfaces, surfactants	
	11/29	Emulsions & Vesicles	
16	12/4	Liquid Crystals & Rods	Last Day of Class
	12/6	No Class	Reading Period
	<b>12/11</b>	<b>Dec 11 (Tuesday) 2:40 - 5:30 pm</b> <b>Exam 4: Soft systems</b>	