

## EM 566X/ME566 XE: Phase Transformations in Elastic Materials

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### Course Description:

Thermodynamics and kinetics of temperature- and stress-induced phase transformations and main approaches to modeling of phase transformation and microstructure evolution and nano- and micro- scales.

### Student Learning Outcomes/Objectives

By completion of the course, students should be able to understand and analyze existing publications, as well as perform research projects that involve:

1. Main mechanical phenomena that involve martensitic phase transformations, including shape memory effect, pseudoelasticity, pseudoplasticity, and transformation-induced plasticity.
2. Continuum thermodynamics and kinetics approaches to phase transformations.
3. Phase field approach to martensitic transformations, twinning, and melting/solidifications at the nanoscale.
4. Micromechanical and phase field approaches to martensitic phase transformations and twinning at the microscale.
5. Crystallography of stress-induced martensitic transformations.
6. Phase field approach to surface-induced phenomena and interface stresses.

### Prerequisites

EM510 Continuum Mechanics or EM516 Mechanics of Deformable Solids, or EM514 Advanced Strength of Materials, or graduate Elasticity, or consent of instructor.

### Textbook

1. Levitas V.I. Phase transformations in elastic materials. Lecture notes, 2012.
2. Some original journal papers.
3. Pieces from some textbooks for background information.

All required materials will be provided.

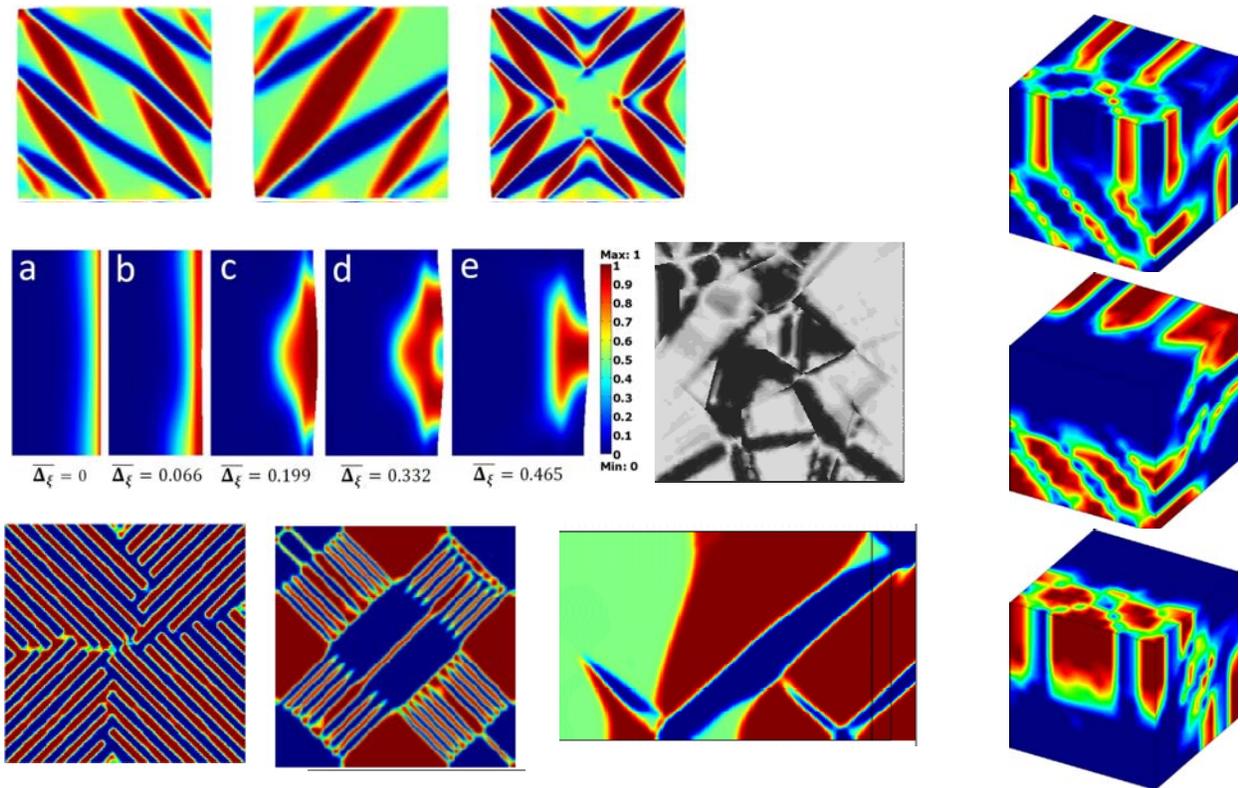
Homework assignments will be related to derivation of equations. It is expected that students will work with notes and suggested reading material. Each student will work on a project, which would require literature review, analytical and computational efforts.

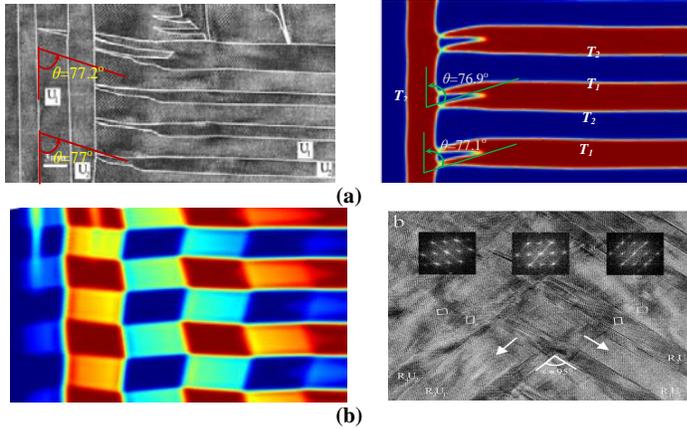
The main focus of this course is related to the effect of stresses on PT in elastic materials. The course is heavily filled with equations and requires intensive analytical work. It is recommended for students who do, or plan to do, research on phase transformations that involves mechanics.

This will be updated and improved version of a course that has been taught in 2012. Updates will be based on results obtained after 2012. At least nine students from class 2012 have published papers on phase transformations in leading mechanical and physical journals.

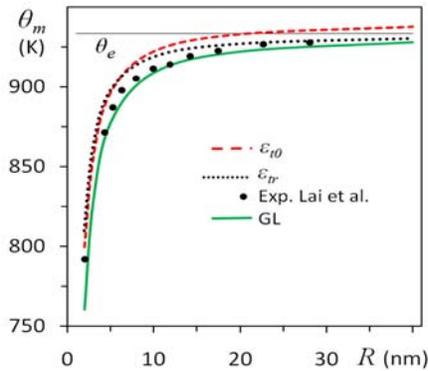
Phase transformations are phenomena that are very widespread in nature, physical experiments, and modern technologies. The practical significance of phase transformations is connected to such technologies as the heat treatment of metals, melting/solidification, utilization of smart materials (in particular, shape memory alloys), and high pressure synthesis of diamonds and other superhard materials. Phase transformations play an important role in such phenomena as transformation-induced plasticity, pseudoelasticity, pseudoplasticity, transformation toughening, and shape memory effect. Knowledge gained in this course is of fundamental importance for engineering applications and research in a wide variety of disciplines (mechanics, material science, physics, material synthesis, and geophysics).

**Examples of nano- and microstructures obtained using phase field approaches**

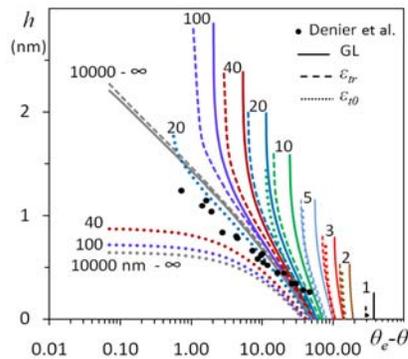




**Melting temperature of Al vs. particle radius**



**Thickness of molten surface layer vs. temperature**



## Grading Policy

Percentage	Description
30%	Homeworks
70%	Project

Letter Grade	Percentage	Performance
A	92-100%	Excellent Work
A-	89-91.99%	Nearly Excellent Work
B+	86-88.99%	Very Good Work
B	81-85.99%	Good Work
B-	79-80.99%	Mostly Good Work
C+	76-78.99%	Above Average Work
C	71-75.99%	Average Work
C-	69-70.99%	Mostly Average Work

D+	66-68.99%	Below Average Work
D	61-65.99%	Poor Work
F	0-60.99%	Failing Work

## Academic Dishonesty

The class will follow Iowa State University's policy on academic dishonesty. Anyone suspected of academic dishonesty will be reported to the Dean of Students Office.

<http://www.dso.iastate.edu/ja/academic/misconduct.html>

## Disability Accommodation

Iowa State University complies with the Americans with Disabilities Act and Sect 504 of the Rehabilitation Act. If you have a disability and anticipate needing accommodations in this course, please contact (instructor name) to set up a meeting within the first two weeks of the semester or as soon as you become aware of your need. Before meeting with (instructor name), you will need to obtain a SAAR form with recommendations for accommodations from the Disability Resources Office, located in Room 1076 on the main floor of the Student Services Building. Their telephone number is 515-294-7220 or email [disabilityresources@iastate.edu](mailto:disabilityresources@iastate.edu) . Retroactive requests for accommodations will not be honored.

## Dead Week

This class follows the Iowa State University Dead Week policy as noted in section 10.6.4 of the Faculty Handbook

<http://www.provost.iastate.edu/resources/faculty-handbook> .

## Harassment and Discrimination

Iowa State University strives to maintain our campus as a place of work and study for faculty, staff, and students that is free of all forms of prohibited discrimination and harassment based upon race, ethnicity, sex (including sexual assault), pregnancy, color, religion, national origin, physical or mental disability, age, marital status, sexual orientation, gender identity, genetic information, or status as a U.S. veteran. Any student who has concerns about such behavior should contact his/her instructor, Student Assistance at 515-294-1020 or email [dso-sas@iastate.edu](mailto:dso-sas@iastate.edu), or the Office of Equal Opportunity and Compliance at 515-294-7612.

## **Religious Accommodation**

If an academic or work requirement conflicts with your religious practices and/or observances, you may request reasonable accommodations. Your request must be in writing, and your instructor or supervisor will review the request. You or your instructor may also seek assistance from the Dean of Students Office or the Office of Equal Opportunity and Compliance.

## **Academic Issues**

If you are experiencing, or have experienced, a problem with any of the above issues, email [academicissues@iastate.edu](mailto:academicissues@iastate.edu).