MSE1063: Phase Transformations and Evolution of Microstructure
Course Syllabus Spring 2021

Catalog Description

Phase equilibria and kinetic phenomena relevant to the origins and stability of microstructure in metallic, ceramic, and polymeric systems. Lecture topics include: application of thermodynamics to the understanding of stable and metastable phase equilibria; interfaces and their effects on stability; defects and diffusion; empirical rate equations for transformation kinetics; driving forces and kinetics of transformations; diffusional and diffusionless phase transformations.

This course will have a deeper discussion on thermodynamics, kinetics, mechanisms and microstructure of solid state phase transformations. Specific studies are directed towards diffusional transformations such as precipitation transformations in alloys, ferrite, pearlite and bainite transformations in steels. Martensitic transformations in steel and shape memory alloys are also included. (3 credits)

Schedule: Wednesday 13:50 - 16:25PM @ Zone 3 - 102
Approx.17 weeks for 55 Class of 2018 MSE seniors.

Instructor **Prof. Charles Hua** charleshua@scu.edu.cn
17760422493, Room Zone 4 -226
Teaching Assistant **Luo Zhou** 周楞 2019223020063@stu.scu.edu.cn

When emailing the instructors or TA, include "MSE1063" in the subject field of your message. Use your university email account (student_ID_number@stu.scu.edu.cn); mail from other accounts might be stopped by the SCU spam filter.

Q/A Office Hours Wednesday morning 9-11:30am, Room Zone 4 -226.
If you don't understand something, and talking to your classmates doesn't help, then you should be seeking help from the instructor or teaching assistant.

Office hours are times we have specifically set aside to be available to students. During office hours, you can come to our office; you don't need an appointment. We are also available at other times; please email to schedule a time.

Textbook

"Phase Transformations in Metals and Alloys", D.A. Porter, K.E. Easterling and M.Y. Sherif, 3rd Ed., CRC Press, Boca Raton, FL, 2009.

Reference books

1. Robert E. Reed-Hill and Reza Abbaschian, Physical Metallurgy Principles, 3rd Edition, PWS Publishing Co., 1994.

2. J. W. Christian, The Theory of Transformation in Metals and Alloys, Part I and Part II, Pergamon, 2002.
3. R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, 1992.
4. M. Ferry, Direct Strip Casting of Metals and Alloys, CRC Press, 2006.
5. R.E. Smallman, Modern Physical Metallurgy, 1985.
6. I.J. Polmear, Light Alloys: 3rd edition. Edward Arnold, 1995.
7. R.W.K. Honeycombe and H.K.D.H. Bhadeshia, Steels – Microstructure and Properties, Edward Arnold, 1995.

Prerequisite and Co-requisite:

- You *must* have taken:
  - Materials Structure and Properties (Or equivalent, or consent of instructor)

- You *should* have taken:
  - MSE 1053 – Crystal Structures and Diffraction
- It is assumed that the student has a basic working knowledge of:
  - **Phase diagrams:** reading and understanding the diagrams, identifying phases and eutectics, solubility and relative composition of phases
  - **Basic kinetics:** equilibrium cooling (i.e. through a phase boundary) and time-temperature-transformation diagrams
  - **Microstructure:** Phases, eutectics, lamellae, connection to phase diagrams and kinetics

If these terms are fuzzy to you, review your course notes. If they are totally unfamiliar, beware…

Web Site https://learn.scupi.cn/

There you will find the course syllabus, homework assignments, and other materials. Current announcements and assignments will be posted on the home page. All assignments will be uploaded through the Blackboard system. Please check the class page frequently.

Class Format

This course is taught using a combined lecture, reading, review and discussion format. The class in the afternoon begins with two session lecture to review material in the literature and introduce new concepts. In the third session, the lecturer may ask questions to as many students as possible and encouraging critical reading of published papers in related field.

It is imperative that you come to class prepared. This will generally involve reading all posted literature and viewing tutorial videos. This is a three credit hour class, which means you should expect to devote at least 9 to 12 hours of effort outside the scheduled class time every week.

Homework Assignments

Homework problems will be assigned every three week and posted on Blackboard. These are to be completed and turned in by **Tuesday 1:30 PM** the following week. You may work with other people on homework, but all writeups must be individual efforts. Homework will be graded on a 0-100 point scale.

All work will be submitted electronically through the Blackboard system. Late homework will not be accepted.

Unless specifically requested, emailed homework will not be accepted.

Please adhere to these homework guidelines:

- Your assignment must be typeset using Word and submitted electronically through Blackboard. Handwritten assignments will not be accepted.
- Put your name, ID number (last four digits), and class section at the top of the first page.
- List the names of other people you've worked with on the assignment or report.

All of the homework scores will be used in your grade computation. Unless otherwise indicated, you can work with your fellow classmates in the class, but you must submit a distinct and independent write-up to receive credit.

If you're sick, or have a compelling emergency that prevents you from turning in the homework on time, email Prof. Charles Hua.

If you believe an error has been made in the grading of an assignment, bring it to the attention of your TA within ONE WEEK of its return.

Grading

Your grade will be based on the in-class Q/A (20%) and homework (20%), mid-term (30) and final exam (30%).

Course Goals

1. Obtain a sound understanding of the thermodynamic and kinetic factors affecting the origins and stability of microstructures.
2. An ability to predict the temporal and thermal stabilities of microstructure by applying the principles of kinetics and phase equilibria.
3. An ability to interpret and discuss the effects of compositional change and thermal history on the stability of microstructure and kinetics of phase transformations in material systems.
4. An ability to solve engineering-related materials problems involving kinetic phenomena and phase equilibria.

After this lecture session the students will be able to…

1. Phase equilibria in unary, binary and ternary systems (70%)
2. Departures from phase equilibria (70%)
3. Microstructure evolution during cooling or heating (70%)
4. Source and influence of interfacial energies (70%)
5. Diffusion in metals and ceramics (70%)
6. Diffusion-controlled phase transformations (70%)
7. Diffusionless phase transformations (70%)

Course topics and lecture hours devoted to each topic:

1. **Phase Equilibria (~12 hrs):** Thermodynamics of condensed systems and criteria for equilibrium; phase rule; Gibbs free-energy diagrams and their relation to binary and ternary phase equilibrium diagrams; departures from equilibrium.
2. **Interfaces (~9 hrs):** Thermodynamics of interfaces; grain boundary and interphase interfaces in solids; effects of interfacial energy on second-phase shape; effects of interfaces on phase stability; interface migration phenomena (*e.g.* recrystallization and grain growth).
3. **Defects and Diffusion (~9 hrs):** Phenomenological and atomistic treatments; interstitial and substitutional diffusion; Kirkendall effect; defects, defect reactions, and diffusion in ionic compounds; activation energies for diffusion; diffusion couples; boundary conditions and applied solutions to the diffusion equation.
4. **Phase Transformations (12 hrs):** Solidification: Homogeneous and heterogeneous Nucleation and growth; Hypo-eutectics and Eutectic alloy solidification; Scheil Equations; Diffusional transformations: Homogeneous and heterogeneous nucleation; kinetics of nucleation; effect of temperature on nucleation; spinodal decomposition; precipitate growth and coarsening; Johnson-Mehl-Avrami equation and transformation diagrams.

Contribution of course to meeting the requirements of criterion 5:	Engineering Science:	1.5 Credits
	Engineering Design:	0.0 Credit
	College Level Mathematics:	0 Credits
	Basic Science:	1.5 Credits
	Realistic Constraints:	none
	Engineering Standards:	none

Mechanical Engineering and Materials Science Program outcomes addressed:

Item	How Addressed		
a.	Not addressed	g.	Not addressed.
b.	Not addressed	h.	Not addressed.
c.	Not addressed.	i.	Not addressed.
d.	Not addressed.	j.	Not addressed.
e.	Not addressed.	k.	Not addressed.
f.	Not addressed.		

Prepared by: Mingjian (Charles) Hua Feb. 14, 2019 Updated on March 4, 2021

Appendix 1 Class Photo Roster

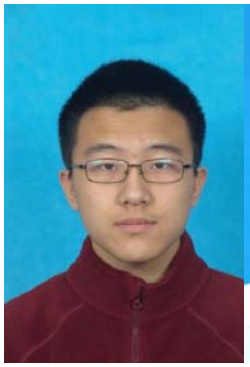
张桓硕
2015141522030

田佳
2017141522024

曹涛
2018141521014

盛淑伟
2018141522005

孙怡然
2018141522006



杜禹豪
2018141522007

刘嘉洋
2018141522010

施舒羽
2018141522011

张祎晴
2018141522013

陈宣任
2018141522014

邓宇轩
2018141522015

彭桢楠
2018141522016

吴哲宇
2018141522018

邹义嘉
2018141522020

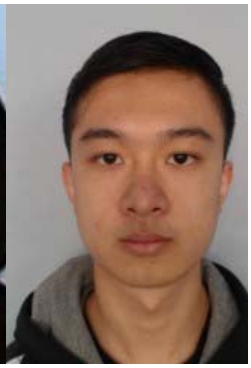
陈笑晨
2018141522022

马广汐
2018141522023

方艺蒙
2018141522026

李晨曦
2018141522027

姚修齐
2018141522028



李泰赫
2018141522030

刘睿智
2018141522031

逄浩然
2018141522032

张家铭
2018141522036

苟书淳
2018141522040

李鑫诚
2018141522041

权友力
2018141522044

孙睿达
2018141522046

王俊淇
2018141522048

王雨辰
2018141522049

李婧鸣
2018141522053

张偌涵
2018141522055

李论
2018141522056

杜阳
2018141522063

郑子渝洋
2018141522065

陈睿
2018141522066

罗伊雯
2018141522067

钟子昊
2018141523018

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Appendix 2 School Calendar

2020—2021 学年（春季学期）校历

周次		星期 日	一	二	三	四	五	六	月份	备注
						25	26	27	2月	1. 2月25-26日为在校本科生报到注册时间。 2. 2月26-28日为本科生补缓考时间。 3. 第一周起正式行课。 4. 清明节4月4日。 5. 端午节6月14日。 6. 红色是节假日，停课一般不补。 7. 政治学习、党团组织生活统一安排在双周星期五下午进行，上半段为政治学习时间，下半段为党团组织生活时间。 8. 实践及国际课程周安排劳动教育、实践环节、短期课程、国内外短期访学交流等。
1	教学周	28	1	2	3	4	5	6	3月	
2		7	8	9	10	11	12	13		
3		14	15	16	17	18	19	20		
4		21	22	23	24	25	26	27		
5		28	29	30	31	1	2	3	4月	
6		4	5	6	7	8	9	10		
7		11	12	13	14	15	16	17		
8		18	19	20	21	22	23	24		
9		25	26	27	28	29	30	1	5月	
10		2	3	4	5	6	7	8		
11		9	10	11	12	13	14	15		
12		16	17	18	19	20	21	22		
13		23	24	25	26	27	28	29		
14		30	31	1	2	3	4	5	6月	
15		6	7	8	9	10	11	12		
16		13	14	15	16	17	18	19		
17		20	21	22	23	24	25	26		
18		27	28	29	30	1	2	3	7月	
19	实践及国际课程周	4	5	6	7	8	9	10		
20		11	12	13	14	15	16	17		
21	暑假	18	19	20	21	22	23	24		
22		25	26	27	28	29	30	31		
23		1	2	3	4	5	6	7	8月	
24		8	9	10	11	12	13	14		
25		15	16	17	18	19	20	21		
26		22	23	24	25	26	27	28		