2017 Spring

"Calculation and Applications Phase Equilibria"

Principles *of* Solidification

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Introduction

- **Web lecture assistance: http://etl.snu.ac.kr**
  - All materials will be posted at the webpage.
  - text message will be sent for the important and urgent notice.
- **Hand out copied materials or scanned materials in website**

Text: **"Principles of Solidification",**
BRUCE CHALMERS, John & Sons, Inc (1964)

References: 1) **"Solidification Processing,"** MERTON C. FLEMINGS, McGraw-Hill Book Company, INC (1974)
2) **"Fundamentals of Solidification,"** W. KURZ, TRANS TECH PUBLICATION (1984)
3) **"Solidification and Casting,"** G.J. DAVIES, JOHN WILEY & SONS (1973)

Additional reading materials will be provided.

Course Goals

This course provides a critical review of the state of knowledge and understanding of the process of solidification, defined for this purpose as the discontinuous change of state from liquid to crystalline solid. In particular, this course is intended to provide an understanding of the physical processes that relate to solidification and to show how these processes combine to produce the phenomena observed in practical situations. An essential aim of many solidification processes is to obtain optimum properties in the resultant material. This course can provide a working knowledge of how the solidification principles can be utilized to produce structures with improved mechanical or physical properties, which then can be used to solve problems involving materials and process design. By the end of the semester, you will be able to understand key concepts, experimental techniques, and open questions in the solidification phenomena of various materials.

Contents in Phase Transformation

Background to understand phase transformation

- (Ch1) Thermodynamics and Phase Diagrams
- (Ch2) Diffusion: Kinetics
- (Ch3) Crystal Interface and Microstructure

Representative Phase transformation

- (Ch4) Solidification: Liquid → Solid
- (Ch5) Diffusional Transformations in Solid: Solid → Solid
- (Ch6) Diffusionless Transformations: Solid → Solid

Schedule

week 1 Brief introduction : the relevant thermodynamic laws, properties, and relationships

week 2 Solidification as an Atomic Process I

week 3 Solidification as an Atomic Process II

week 4 Nucleation I

week 5 Nucleation II

week 6 Microscopic Heat Flow Consideration I

week 7 Microscopic Heat Flow Consideration II

week 8 Reduction of Solute during solidification I

week 9 Reduction of Solute during solidification II

week 10 Polyphase Solidification I

week 11 Polyphase Solidification II

week 12 Macroscopic Heat Flow and Fluid Flow I

week 13 Macroscopic Heat Flow and Fluid Flow II

week 14 The Structure of Cast Metals I

week 15 The Structure of Cast Metals II

Components of Your Grade:

1) Exams (midterm: 30% + final: 35%)

There will be two exams, each of which will take 2-3 hours. I will not use class time for the exams and instead will reserve separate time slots. The exams will be conceptual and difficult.

2) Reports and Presentation (15%)

Assignments handed in after the start of class lose credit depending on the timing. If you wish, you may work together on homework assignments. But, you must hand in your own work, in your own words.

3) Quizzes (15%) and Attendance (5%)

There will be a few short quizzes between the major exams. These will take place in class, at the beginning of class and will last for 20 minutes.

Remarks: The weight of each grade component may change up to 5% depending on the student's achievement.

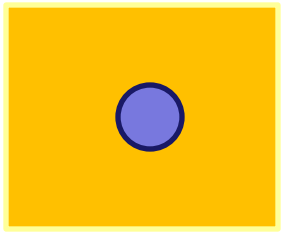
Policies and Procedures

- ***All homework are due by the start of class on the stated deadline.***
  - Late assignments go to my office. If I'm not around, slide it under my door and leave me an email so that I know when you turned it in.
  - You lose 20% of the full assignment value per day late. Since homework are due on **Wednesday,** you can get 80% credit if you turn it in on **Friday,** 50% on next **Wednesday**, nothing thereafter.
- ***If you wish, you may work together on homework assignments. BUT, you must hand in your own work, in your own words.***
- **IMPORTANT***: you MUST reference your sources appropriately, including texts, journals web sites, etc.*
  - Article authors, title, journal, volume, year, pages
  - Book authors, title, publisher, year, pages
  - Web address
  - etc.

Chapter 1 Introduction of Solidification

Melting and Crystallization are Thermodynamic Transitions

Solidification: Liquid → Solid



<Thermodynamic>

- Interfacial energy ⇨ ΔT_N

Liquid | T_m Undercooled Liquid | Solid

No superheating required!

- Interfacial energy ⇨ No ΔT_N

$$\gamma_{SL} + \gamma_{LV} < \gamma_{SV}$$

vapor

Melting: Liquid ← Solid

Incentive Homework 1:
Example of Superheating (PPT 3 pages)