

Colorado School of Mines
Dept. of Metallurgical and Materials Engineering
MTGN 557 Solidification Processing
Fall 2007

Instructors: Dr. Stephen Liu (HH 254, X3796, sliu@mines.edu)

Time: TBA

Room: TBA

Textbooks & Reference:

- M.C. Fleming, "Solidification Processing", McGraw-Hill Series in Materials Science and Engineering, 1974.
- B. Chalmers, "Principles of Solidification", Robert Krieger Publishing Company, John Wiley & Sons, 1964.
- W. Kurz and D.J. Fisher, "Fundamentals of Solidification", 3rd Edition, - Trans Tech Publications, 1992.
- P. Shewmon, "Transformations in Metals", McGraw-Hill, 1969.
- D.A. Porter and K.E. Easterling, "Phase Transformations in Metals and Alloys", Van Nostrand Reinhold, 1972.
- R. Cahn and P. Haasen, "Physical Metallurgy Vol. I and II", North-Holland Physics Publishing, 3rd Edition, 1983.
- J. Christian, "The Theory of Transformations in Metals and Alloys", 2nd Edition, Pergamon Press, 2002.

Recent publications or classical papers in the phase transformations literature will also be used.

Course Outline:

1. Heat Flow in Solidification
 - a) Removal of Latent Heat
 - b) Extraction of Latent Heat by Conduction into the Solid
 - c) Conduction of Latent Heat into the Liquid
 - d) Rate of Solidification

2. Fluid Flow in Solidification
 - a) Convection in the Bulk Liquid

- b) Interdendritic Fluid Flow
 - c) Macrosegregation
 - d) Movement of Liquid plus Solid
3. Thermodynamics of Solidification
- a) Pure Materials
 - b) Binary Alloys
 - c) Partition Coefficient
 - d) Composition at the Liquid-Solid Interface
 - e) Equilibrium Shapes of Phases
 - f) Liquid-Solid Surface Energy
4. Nucleation and Interface Kinetics
- a) Homogeneous Nucleation
 - b) Heterogeneous Nucleation
 - c) Grain Refinement
 - d) Growth
 - e) Lateral Growth
 - f) Growth Morphology
5. Interface Stability Theory
- Interface Stability
- a) Plane Front Solidification of Single Phase Alloys
 - i)* Equilibrium Solidification
 - ii)* No Solid Diffusion
 - iii)* Limited Liquid Diffusion, No Convection
 - iv)* Effect of Convection
 - v)* Czochralski Growth
 - vi)* Zone Melting
 - vii)* Diffusion in the Solid
 - b) Cellular Solidification
 - i)* Constitutional Supercooling
 - ii)* Cell Structure
 - iii)* Dendrite Formation
 - iv)* Solute Redistribution
 - v)* Cell Spacing
 - vi)* Dendrite Arm Spacing
6. Plane Front Solidification of Polyphase Alloys
- a) Lamellar Eutectic Growth
 - b) Rod Eutectic Growth

7. Solidification of Castings and Ingots
 - a) Grain Structure
 - b) Columnar Structure
 - c) Microsegregation in Columnar Structures
 - d) Solidification of Undercooled Melts
 - e) Temperature and Fraction Solid
8. Solidification of Polyphase Alloys
 - a) Peritectic Solidification
 - b) Eutectic Solidification
 - c) Solute Distribution in Ternary Alloys
 - d) Inclusion Formation
 - e) Dissolved Gases
 - f) Gas Removal by Bubble Formation
 - g) Porosity Formation on Solidification

Course Format

Lecture and Seminar Format
Student (assigned) Presentation
Q&A
Discussion
Group Participation

Grading System

6 Take Home Exams