Department of Materials Science and Engineering  
University of Maryland, College Park, Maryland

ENMA 461: Thermodynamics of Materials (Required) – 3 credits

Class Schedule: Lectures, Tuesday and Thursday, 11:00AM-12:15PM

Instructor: Prof. Alexander Roytburd

Textbooks:

Catalog Description: Thermodynamics of Materials is a basic theoretical material science and engineering course. It is devoted to analysis of fundamental material properties and processes for near equilibrium conditions.

Course Description: Thermodynamics of materials is a basic theoretical material science and engineering course. It is devoted to analysis of fundamental material properties and processes for near equilibrium conditions. Principal concepts and applications of the thermodynamics are used to understand the thermal properties of materials in the first two parts of the course. The statistics-mechanical approach is used to introduce the concepts of entropy and temperature. A harmonic crystal with point defects and a polymer chain are used as models to formulate basic thermodynamics concepts and the principles. This approach is more effective and better understood by material engineering students than the traditional approach through the model of an ideal gas. Phase equilibrium and phase transformations in single and multi-component systems are then considered. The phase diagrams, their construction and applications are considered for several materials. Concluding lectures are devoted to thermodynamic analysis of examples of processing, synthesis and engineering of materials.

Prerequisites: calculus and physics

Course Goals: The main objectives are to teach students fundamentals of the thermodynamics and to develop their skills in applying the thermodynamics to material problems. After successful completion of the course, students should demonstrate:
1. The ability to formulate analytically fundamental concepts and principles of thermodynamics, to understand the interconnections between them;
2. The understanding of thermodynamic background of thermal properties of material and the ability to interpret the experimental results on this basis;
3. The ability to use phase diagrams for analysis phases, compositions and microstructures of materials;
4. The ability to discuss thermodynamic aspects of synthesizing, processing and engineering of materials.
**Student Outcomes Covered by the Course:**
ABET A: Ability to apply mathematics, science and engineering principles;
ABET E: Ability to identify, formulate and solve engineering problems.
ABET K: Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

**Topics Covered:**
I. Introduction
   Thermodynamic aspects in design, processing and properties of materials, thermodynamics vs. kinetics

II. Principle concepts of thermodynamics
1. Models: Einstein’s crystal, crystals with point defects
2. Energy, work, heat; 1st law of thermodynamics
3. Entropy and temperature; 2nd law and 3rd law
4. Adiabatic and isothermal processes, heat capacity
5. Internal and free energies

III. Thermal properties of crystals and polymers
1. Heat capacity of crystals (Einstein’s model)
2. Elasticity of crystals and polymers, enthalpy vs. energy

IV. Phase equilibria in single component system
1. Vapor-liquid-solid equilibria
2. Polymorphic and martensitic transformations
3. Concept of smart materials

V. Surface and interfaces
1. Thermodynamics of nanocrystalline materials
2. Nucleation

VI. Equilibria in multicomponent materials
1. Thermodynamics of solutions; chemical potential
2. Equilibrium of solution, phase rule
3. Phase diagrams of binary alloys
4. Chemical reactions