Diffusion in solids - Web course

COURSE OUTLINE

Many physical and mechanical properties in the solid state are controlled by the diffusion process. Fundamental knowledge in this area is very important to understand the performance of many products in applications such as in aero engines, electronic packaging etc. Even many components are manufactured using the diffusion process such as intermetallic superconductors, laminate structures, bond coats on the superalloys in turbine blades, carburized steels, doping of Si, nanotubes etc.

In this course, I have started with thermodynamics to understand the driving force for diffusion and then discussed Fick's laws of diffusion, atomic mechanism of diffusion, different kinds of diffusion parameters used depending on the conditions. Multicomponent diffusion is introduced. The recent developments in this area are also discussed. This course can be used by the advanced level undergraduate as well as at the initial stage of postgraduate students.

COURSE DETAIL

Module	Sl. No. and Topic	Hours
Module 1	**Thermodynamics and defects in solids** • Lecture 1: Concept of free energy, enthalpy and entropy • Lecture 2: Gibb's free energy change with temperature in a single component system • Lecture 3: Thermodynamic parameters in a binary system • Lecture 4: Thermodynamics and phase diagrams • Lecture 5: Concept of the	9

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Metallurgy and Material Science

Pre-requisites:

- Very basic knowledge in the area of materials science including basic crystal structures.

Coordinators:

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	chemical potential and the activity of elements • Lecture 6: Point defects: Equilibrium vacancy concentration in a pure element. • Lecture 7: Equilibrium concentration of interstitial atoms • Lecture 8: Defects in the ordered phases • Lecture 9: Calculation of thermodynamic parameters	
Module 2	**Fick's laws** • Lecture 10: Fick's laws of diffusion and thin film solution • Lecture 11: Solution in sem-infinite diffusion couples (error function analysis) • Lecture 12: Solution for homogeneization (separation of variables)	3
Module 3	**Diffusion under chemical potential gradient, the composition profiles in an interdiffusion zone and diffusion as a tool to make products** • Lecture 13: Diffusion under the thermodynamic driving forces • Lecture 14: Driving force for diffusion and Fick's laws of diffusion Lecture 15: Product phase formations because of diffusion in real systems • Lecture 16: Diffusion process as a tool to make products • Lecture 17: Definition and description of different diffusion terms	5
Module 4	**Atomic mechanism of diffusion**	6

	• Lecture 18: Interstitial diffusion • Lecture 19: Concept of random walk • Lecture 20: Substitutional diffusion • Lecture 21: Activation energy for diffusion • Lecture 22: Orientation dependence • Lecture 23: Diffusion in the ordered phases		
Module 5	**Determination of different kinds of diffusion parameters** • Lecture 24: Matano-Boltzmann analysis • Lecture 25: Calculation of diffusion parameters using the Matano-Boltzmann analysis • Lecture 26: Den Broeder and Wagner's approach • Lecture 27: Problem of finding the initial contact plane • Lecture 28: Effect of molar volume in a hypothetical diffusion couple • Lecture 29: The Kirkendall effect • Lecture 30: The intrinsic diffusion coefficients: Darken analysis and the van Loo relation • Lecture 31: Integrated diffusion coefficient • Lecture 32: Calculations of the integrated diffusion coefficients • Lecture 33: Tracer diffusion coefficient and the vacancy wind effect • Lecture 34: Recent developments on the Kirkendall effect	13	

	• Lecture 35: Physico-chemical approach • Lecture 36: Grain boundary diffusion	
Module 6	**Phase diagram and diffusion in ternary and multicomponent systems** • Lecture 37: Ternary phase diagrams • Lecture 38: Ternary and multicomponent diffusion • Lecture 39: Intrinsic, integrated and the average diffusion coefficients • Lecture 40: Phase diagram determination by the diffusion couple technique	4
	Total	**40**

References:

1. Porter and Easterling, Phase Transformations in Metals and Alloys
2. P. Shewmon, Diffusion in Solids
3. J. Philibert, Atom movements: Diffusion and mass transports in solids
4. Aloke Paul, Ph.D Thesis (2004), The Kirkendall effect in the solid state, http://alexandria.tue.nl/extra2/200412361.pdf