MICROSTRUCTURAL EVOLUTION IN MATERIALS SCIENCE

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In this lecture series, we will review the basic materials science that underpins microstructural evolution. These topics include Nucleation, Grain Growth, Grain-Boundary Properties, Precipitation, Ostwald Ripening, Zener Pinning (of interfaces), and Transformation Kinetics. The emphasis will be on mesoscopic approaches to these phenomena that permit the development of microstructure to be understood. The practical exercises associated with this lecture series will be use of the Potts model for grain growth. This is the simplest model that simulates curvature-driven coarsening and yet captures much of the complexity of the phenomenon, permits efficient simulation of particle pinning, abnormal grain growth and solute drag. This will be accomplished with the aid of the MMSP software package, which can be found at (and freely downloaded from) http://matforge.org/cmu/. Students are encouraged to obtain Paraview, which is a highly capable 3D viewer and is freely available from http://www.paraview.org/.

Lecture 1a. Homogeneous and Heterogeneous Nucleation.
Lecture 1b. Growth of Precipitates; Ostwald Ripening.
Lecture 2a. (Zener-Smith) Pinning of Interfaces by Particles.
Lecture 2b. Transformation Kinetics and the KJMA Equation.
Lecture 3a. Grain Boundary Properties.
Lecture 3b. Grain Growth and Recrystallization.
Lecture 4. Demonstration of Potts model with the MMSP package.

References

Phase transformations in metals and alloys, D.A. Porter, & K.E. Easterling, Chapman & Hall.
Stability of Microstructure in Metallic Systems, J.W. Martin, R.D. Doherty and B. Cantor, Cambridge Univ. Press.
Interfaces in Crystalline Materials, Sutton & Balluffi, Oxford U.P., 1998.
Interfaces in Materials, J. Howe, Wiley, 1999.
Grain Boundary Migration in Metals, G. Gottstein and L. Shvindlerman, CRC Press, 1999.
Materials Interfaces: Atomic-Level Structure & Properties, D. Wolf & S. Yip, Chapman & Hall, 1992.
Grain Boundary Migration in Metals, G. Gottstein and L.S. Shvindlerman, CRC Press (1999).
See also mimp.materials.cmu.edu (Publications) for recent papers on grain boundary energy by researchers connected with the Mesoscale Interface Mapping Project (“MIMP”).