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“3-D Studies of Microstructures in Structural and Magnetic Materials”

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Abstract

The past decade has seen a dramatic increase in the use of automated characterization tools for the study of material microstructures in 3-D. In this presentation, we will describe a few basic approaches, such as focused ion beam serial sectioning, robot-controlled serial sectioning, electron tomography, and vector field electron tomography. We will begin with an overview of the instrumentation used to obtain these 3-D data sets, as well as the methodologies needed to subsequently convert the individual images into a high quality 3-D stack. Segmentation, i.e., partitioning of the data set into disjoint regions, continues to be a major stumbling block in our attempts to streamline the data acquisition and reconstruction processes. We will draw examples from the study of structural materials, such as nickel-based super alloys used in jet engines and land-based turbines; we will also apply our approach to biological samples (in this case the cotyledon of the Arabidopsis Thaliana plant) with images acquired by laser confocal scanning microscopy. We will conclude the presentation with an overview of Lorentz microscopy, which is used to determine the magnetic domain structure of magnetic materials. We will illustrate how this technique can be combined with tomographic approaches, to reconstruct, in 3-D, the magnetic vector potential in and around the sample.

Biography

Professor De Graef received his BS and MS degrees in physics from the University of Antwerp (Belgium) in 1983, and his Ph.D. in physics from the Catholic University of Leuven (Belgium) in 1989, with a thesis on copper-based shape memory alloys. He then spent three and a half years as a post-doctoral researcher in the Materials Department at the University of California at Santa Barbara before joining Carnegie Mellon in 1993 as an assistant professor. He is currently full professor and co-director of the J. Earle and Mary Roberts Materials Characterization Laboratory.

Professor De Graef's research interests lie in the area of microstructural characterization of structural intermetallics and magnetic materials. His current focus is on the development of experimental and modeling techniques for the quantitative study of magnetic domain configurations in a variety of materials, including ferromagnetic shape memory alloys, magnetic thin films, and patterned structures. This study includes a theoretical analysis of the use of shape functions in the computation of shape-dependent material properties. A second research focus is on the acquisition and representation of the three-dimensional character of microstructures. Work in this area includes development of experimental and numerical techniques to extract quantitative 3-D data from serial sectioning experiments using a focused ion beam or the recently acquired RoboMet.3D automated metallography instrument.