Carnegie Mellon

Materials Science and Engineering Seminar Series

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"Direct Visualization of the Behavior of Defects"

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11:00 A.M. Seminar in Baker Hall 136A

Traditionally, transmission electron microscopes are used for microstructural and microchemical characterization of materials. As no insight is provided about reaction pathways, this usage requires that we make educated guesses about how these structures and chemistries evolved and how they might impact macroscopic properties. However, the electron microscope can be used to investigation reaction mechanisms and rates provided a means for stimulating the material can be incorporated within the limited volume available in the objective pole-piece. In addition to being able to observe the micromechanisms activated, we would like to be able to correlate them with changes in a macroscopic property – that is, we want to determine the structure-property relationship at the microscopic and even the atomistic level. This type of experiment has been possible to some extent through modifications of sample holders, the objective pole-piece or both. The applications and accessibility have been limited by the restrictions the available volume places on the functionality that can be incorporated. The progress in microlithographic techniques and microelectromechanical machines has made it feasible to design and fabricate a functional laboratory that can operate within the electron microscope. These laboratories may be intended for single use as the sample under investigation can be fabricated as an integral component of the device. This approach to incorporating probes and sensors provides exciting new opportunities for conducting dynamic experiments in the electron microscope and for directly correlating changes in macroscopic properties with microscopic mechanisms. In this talk, I will demonstrate this approach, show examples of possible experimental laboratories, demonstrate how this approach can be used to discover atomic scale processes controlling grain growth, creep, phase transformations and mechanical properties, and show how this insight can be used to develop physically-based predictive models of material properties.

Ian Robertson joined the Metallurgy and Mining Engineering Department at the University of Illinois in 1982, after receiving his D. Phil. (Metallurgy) from the University of Oxford. In 2004 he was appointed as Head of the Department of Materials Science and Engineering at the University of Illinois. His research focuses on the use of the electron microscope as an experimental laboratory in which dynamic experiments can be conducted to reveal the atomistic processes responsible for the macroscopic response of a material. He has applied this technique to enhance our understanding of the reaction pathways and kinetics that occur during deformation, phase transformation, irradiation and hydrogen embrittlement of metallic materials. His insight to the mechanisms responsible for hydrogen embrittlement of metals was recognized by the Department of Energy in 1984 when he, along with Howard Birnbaum, received the DOE prize for Outstanding Scientific Accomplishment in Metallurgy and Ceramics. He has been a Principal Editor for the Journal of Materials Research since 1995 and a Key Reader for Metallurgical Transactions since 1994. Recently, he was awarded a Donald B. Willett Professorship by the College of Engineering, which is the highest honor a faculty member can receive from the College.