

STEM-Based Characterization of Defects and Precipitates in Metals

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With the advent of probe-corrected STEM, it is now possible to resolve the lattice spacings in the metallic matrices along multiple zone axes. The importance of this capability in discerning fine-scale precipitate structure and coherency will be demonstrated with the use of high angle annular dark field and bright field imaging to discern the structure of nanoscale clusters in certain ferritic steels. These mechanically alloyed, oxide-dispersion-strengthened (ODS) ferritic steels represent a class of nano-structured alloys that can display high resistances to neutron radiation and creep deformation. The challenging task of determining the structure and chemistry of these nanoclusters embedded in their ferromagnetic matrices using probe-corrected STEM imaging and electron energy loss spectroscopy (EELS) will be described. Through-focal imaging indicates that the nanoclusters have faceted interfaces consistent with low index planes of the Fe matrix. In addition, the attractive interaction of dislocations with the nanoclusters has also been studied using bright-field and dark field STEM imaging. In light of these observations, a model of the creep response using a modified Kocks-Argon-Ashby approach will be introduced.

Diffraction contrast STEM imaging has demonstrated significant advantages over conventional TEM imaging modes for discerning the fine-structure of dislocations due to the ability to determine fine dislocation features even in relatively thick foils. In several commercial alloys. For instance, this technique has provided important new insights into the rich variety of deformation processes that control deformation in Ni-based superalloys. At intermediate temperatures, the deformation mechanisms involve shearing by $\langle 112 \rangle$ type partials, and include microtwinning, $a[112]$ dislocation ribbons, superlattice intrinsic and extrinsic stacking faults and anti-phase boundary coupled matrix dislocations. Examples will be provided where novel STEM imaging and spectroscopy techniques have been instrumental in developing this fundamental understanding in these commercially important alloys.

Bio. . .

Professor Mills earned his PhD degree in Materials Science and Engineering at Stanford University in 1985. He joined the Department of Materials Science and Engineering at the Ohio State University in 1994 as Associate Professor with tenure after a two-year research associate appointment at the Ecole Polytechnique Federale-Lausanne, Switzerland, and a six-year appointment as Senior Member of Technical Staff at Sandia National Laboratories, Livermore, CA. Mills was promoted to Professor in 2000 and was appointed as the McDougal Professor of Engineering in 2004. He also served as Interim Chair of the Department of Materials Science and Engineering at OSU from 2014-2015.

Professor Mills' primary research interests are the relationship between microstructure and properties of materials, with special emphasis on transmission electron microscopy techniques which make it possible to study the structure and chemistry of materials down to atomic dimensions. Mills and his group are developing new insights into the mechanical behavior of several important metallurgical systems. This understanding forms the foundation for models of

behavior that have significant basic science content and are also of keen interest with respect to industrial applications through the development of Integrated Computational Materials Engineering (ICME) tools. Recent research has included studies of creep and deformation in commercial titanium and zirconium alloys, strengthening mechanisms in aluminum alloys and novel ferritic steels, and dislocation processes and microstructure development in nickel-based superalloys. He has authored or co-authored with members of his group over 180 journal articles and is a Fellow of the American Society for Metals. He was Chairman of the 2013 Gordon Research Conference on Physical Metallurgy, and has served on the Program and Organizing Committees for Superalloys 2012 and 2015. He was inducted as Fellow of TMS in 2015.