Quantitative Electron Microscopy of Individual Nanometer-sized Defects

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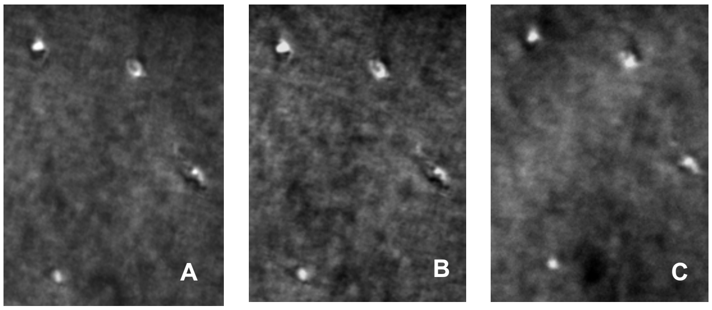
CONTRIBUTIONS OF INELASTICALLY SCATTERED ELECTRONS TO DEFECT IMAGES



Defect images in ion irradiated Au, energy-unfiltered (A), energy-filtered on zero-loss peak with 10 eV slit (B), and energy-filtered on plasmon-loss electrons with 10-40 eV window (C). Note the great similarity in image resolution and contrast for the first two, and some loss of resolution for the image formed by plasmon-loss electrons only. Integrated intensity measurements on four of the defects and neighboring backgrounds showed between 15 and 20% of the total contrast to come from inelastically scattered electrons, and about one third of that could be assigned to plasmon-loss electrons.

SIMULATIONS OF IMAGES OF DEFECTS UNDER WEAK-BEAM DIFFRACTION CONDITIONS

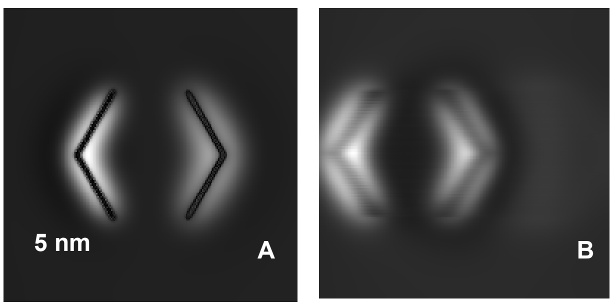
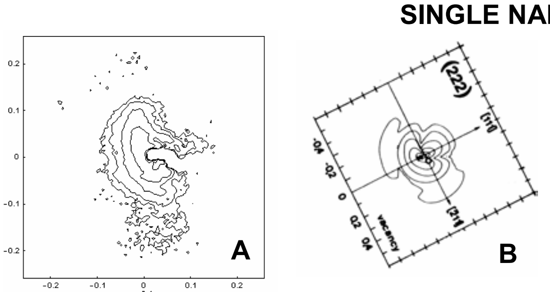


Image simulation utilizing the full three-dimensional multibeam dynamical diffraction theory presented by Howie and Basinski with column approximation (A), without column approximation (B). Notable results without invoking the column approximation in the simulations is the observed scattering between columns, the overall displacement of the image in the direction of the diffraction vector, and the simulation and observation of g.bxu=0.

MEASUREMENT OF DIFFUSE ELECTRON SCATTERING FROM SINGLE NANOMETER-SIZED DEFECTS



Small coherent electron beam is placed on 4 nm defect in Au foil to produce elastic diffuse scattering quantitatively measured in diffraction plane and displayed as intensity contours (A) and compared with calculated diffuse scattering (B) for a particular defect. The close similarity determines the defect geometry (Frank dislocation loop on 111 plane) and nature (vacancy).

The technique described here for measuring elastic electron scattering in the image and diffraction planes from individual nanometer-sized defects, when combined with both atomic modeling of defects in more complex materials and calculated electron scattering from such models, will be a powerful addition to the techniques for full defect characterization by TEM.

References: Kirk, M. A., et al, 2002, Microscopy and Microanalysis 8, suppl.2, 622CD.
Kirk, M. A. et al, to be published in Phil. Mag. 2003.

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