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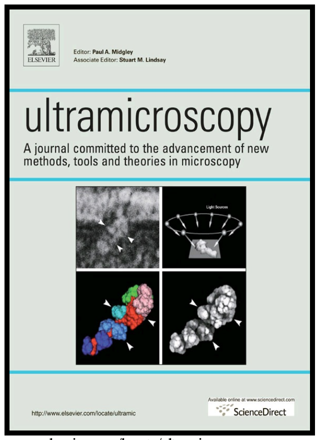

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Three-Dimensional Imaging of Individual Point Defects Using Selective Detection Angles in Annular Dark Field Scanning Transmission Electron Microscopy

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Abstract:

We propose a new scanning transmission electron microscopy (STEM) technique that can realize the three-dimensional (3D) characterization of vacancies, lighter and heavier dopants with high precision. Using multislice STEM imaging and diffraction simulations of β-Ga_2O_3 and $SrTiO_3$, we show that selecting a small range of low scattering angles can make the contrast of the defect-containing atomic columns substantially more depth-dependent. The origin of the depth-dependence is the de-channeling of electrons due to the existence of a point defect in the atomic column, which creates extra “ripples” at low scattering angles. The highest contrast of the point defect can be achieved when the de-channeling signal is captured using the 20-40 mrad detection angle range. The effect of sample thickness, crystal orientation, local strain, probe convergence angle, and experimental uncertainty to the depth-dependent contrast of the point defect will also be discussed. The proposed technique therefore opens new possibilities for highly precise 3D structural characterization of individual point defects in functional materials.