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HIGH RESOLUTION IMAGING IN BRIGHT AND DARK FIELD AT HIGH VOLTAGES

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The weak beam dark field(1) and high order bright field imaging(2) methods are powerful means for improving the resolution of images detected by diffraction contrast. However, at high voltages, many beam interactions become important as more interband transitions occur between different Bloch waves. At the exact Bragg condition, for any order reflection, usually more than two interband transitions are important for both weak beam and bright field images, and complicated images result(3,4).

Extensive many beam contrast calculations for loops and dipoles of different size and separation, and depth for various reflecting conditions and accelerating voltages have shown that the visibility of the defect $\{ V = (I_{\max} - I_{\min}) / (I_{\max} + I_{\min}) \}$ is higher at the exact Bragg condition ($s=0$) than for $s \neq 0$. However, the image width and image separation of the two sides of a dipole or loop are not appreciably altered. Consequently, images may be obtained with high visibility and high resolution at the exact Bragg condition using high order reflections both in BF and DF. At the exact lg Bragg condition, however, complicated images result.

Fig. 1 shows the plot of visibility vs. reflection conditions around various order Bragg condition $\{ng, (n+0.05)g$ for $n=2,4\}$ for different sizes of dislocation loops for the weak beam case. The calculations show that the contrast decreases, sometimes rapidly, for $s \neq 0$ compared with that at the exact Bragg condition ($s=0$).

Experimental confirmation is shown in Fig. 2. The circled loop in the micrographs shows good contrast at the exact Bragg condition for both bright field and weak beam dark field at $s=0$, the loop contrast becomes extremely low or even invisible. The depth dependence for the image contrast of a 60Å diameter loop, has been checked. The visibility values V are always higher than 0.88 compared with those obtained for the 2.05g reflecting condition. This shows that the contrast depends more upon the diffracting conditions than upon its position in the foil.

Although in some cases multiple peaks occur, for closely spaced dislocations or small loops, the exact high order Bragg condition (ng $s=0$) may be the most useful as far as visibility and resolution are concerned.

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Fig. 1. Calculated results of visibility vs reflecting conditions for different sizes of perfect prismatic loops.

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Fig. 2. High order bright field (a) $s < 0$ (c) $s = 0$ (e) $s > 0$ and weak beam bright field (b) $s < 0$ (d) $s = 0$ (f) $s > 0$ for $3g$ reflection $g = [111]$.

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