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Publication Date

1974-03-01

Presented at the 32nd Annual Meeting of
the Electron Microscopy Society of America,
St. Louis, MO, August 13 - 16, 1974

LBL-2711

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Prepared for the U. S. Energy Research and
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SOME APPLICATIONS OF THE BERKELEY 650 kV HVEM IN MATERIALS SCIENCE

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The applications of high voltage electron microscopy in materials science stem principally from the well known advantages of improved penetration, resolution, and benefits derived from multiple diffraction effects (e.g. critical voltage).

The principal disadvantages are the high costs, somewhat poorer resolution compared to the latest breed of 100 to 125 kV microscopes and for crystals it is necessary to operate at voltages below those which cause primary knock-on damage, unless in situ studies of such damage are required. (See refs 1-4 for recent reviews). Some examples of current work at Berkeley include the following:

1. Contrast and Resolution (5) - Applications of the many beam dynamical theory to systematic diffracting conditions have provided several advantages. Bright field imaging using the fifth order reflection of the $\langle 111 \rangle$ systematic set in silicon is sufficient to resolve partial dislocations e.g. at shear loops. From the measured separation of the partials ($\approx 75\text{\AA}$) the stacking fault energy has been computed to be 45 ergs/cm^2 (isotropic elasticity theory). Dark field imaging in the first order reflection (1g) when the second order (2g) is exactly satisfied has also been shown to be a useful new method for determining the intrinsic or extrinsic nature of stacking faults. This is based upon the fact that independently of foil thickness, this dark field image gives higher contrast when the phase factor $\alpha = 2\pi \mathbf{g} \cdot \mathbf{R}$ is negative than when it is positive.
2. Ceramics and Minerals - The HVEM is particularly useful for materials which are difficult to thin especially since the perfection of ion bombardment. Current programs include studies of ceramics (6) and minerals (7,8). Figure 1 shows an example of the $\{110\}$ cation faults observed in lithium ferrite (LiFe_5O_8). Since the displacement vectors are $a/4\langle 110 \rangle$ normal to the fault planes (6) these faults cannot be shear faults. TaC is another ceramic in which considerable faulting occurs. Recent studies (9) have proved the existence of intrinsic and extrinsic faults on $\{111\}$ and by examining thick areas in the HVEM (Fig. 2) faults have been found on planes other than $\{111\}$, probably on $\{112\}$. These are thought to be due to growth faults associated with non-stoichiometry.
3. Diffraction applications; Ordered Alloys - Diffraction advantages of HVEM include the increased accuracy of selected area diffraction, more diffraction data due to the flatter Ewald sphere, and less diffuse scattering due to chromatic aberration. Very recently we have built a new 1000°C biaxial tilting hot stage for the study of diffuse scattering associated with short range order to utilize these advantages. (10) Figs. 3,4 show examples obtained at temperatures above and below the critical temperature ($\approx 280^\circ\text{C}$) in off-stoichiometric Cu_3Au using the new stage.

Other applications being carried out in Professor J. Washburn's group include knock-on radiation damage and swelling studies in metals for possible nuclear reactor applications, and ion implantation in semiconductors.

We thank the U.S. Atomic Energy Commission and the National Science Foundation for support of these research programs.

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3. Proc. EMSA Symp. on HVEM, 1973, Ed. B. Siegel, J. Wiley & Sons, N.Y. (In Press).

4. See the EMSA Proc. (Claitors Publishers, Baton Rouge, La).
5. Chen, L. J. and G. Thomas, submitted to Phys. Stat. Sol. (LBL-1893).
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7. Joint programs with Prof. H.-R. Wenk, Geology Dept., UCB (see Refs. 2 and 4).
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9. Rowcliffe, D. J. and G. Thomas, submitted to J. Mat. Sci. & Engr. (LBL-2588).
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XBL 746-3700

Fig. 1. $\{110\}$ cation faults in LiFe_5O_8 .

XBB 743-1388.

Fig. 2. $\{111\}$ and (112) faults in TaC_{0.78}.

XBB 745-3148

Fig. 3. [011] Cu_3Au 80°C above T_c . Fig. 4. As Fig. 3 but 50°C below T_c .

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