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ELECTRON DIFFRACTION CONTRAST OF SLIP TRACES AND SLIP BANDS

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When dislocations are moved in thin foils by stresses due to the electron beam or during deformation experiments the remaining electron diffraction contrast consists of pairs of black-white lines (slip traces) or bright and dark bands (slip bands). The slip traces which can mostly be seen for a short time only are the places where the slip plane cuts the surfaces.

The contrast of slip traces can be well explained on the assumption that a surface layer of oxide, carbon or chemical deposit exists which fixes the slip step caused by the moving dislocation /A.Howie, M.J.Whelan, Proc. Roy. Soc. A267, 206 (1962)/. This slip step can be represented by a long dislocation left in or just below the surface layer plus an image dislocation (Fig. 1a), where the separation of the dislocations in each dipole is about $0.1\,\xi_g$ (bright-field curves 1 and 2).

Fig. 2 shows an example of slip band contrast in aluminium /F.Appel, U.Messerschmidt, phys.stat.sol.(a)34,175(1976)/. It can be assumed that the surface layer consists of Al_2O_3 which is the cause of the strong slip band contrast.

For the explanation of the slip band contrast the model using two dislocation dipoles must be extended to an infinite series of image dislocations for a correct consideration of the surface layer /A.K.Head,Phil.Mag.44,92(1953)/. Already two image dislocations (Fig. 1b, bright-field curves 3 and 4) give a sufficient interpretation of the contrast of the whole slip band /K.Scheerschmidt, Proc.15.Czech.Conf. Electron Micr., Prag 1977,p.619 and Proc.9.Conf.Electron Micr., Dresden, 1978, p. 43/.

For each slip system the analysis of the imaging conditions of Fig.2 gives six different possibilities to characterize the slip trace model with two image dislocations. If only reflexes of $\langle 200 \rangle$ and $\langle 220 \rangle$ type are considered, then 15 different diffraction conditions exist for which in Fig.3 the bright-field contrast profiles are calculated. Hence it follows that the slip bands are dark if $n>0$, bright if $n<0$ and in the case $n=0$ they are determined from the parameter m. Using this result it should be possible to determine the slip system and the slipped dislocation by taking two experimental pictures with orthogonal reflexes.

Fig. 4 shows the dependence of the calculated slip band contrast on the diffraction parameters and on the parameters describing the surface layer. The dotted curve is equivalent to the curve n=1 (iii) of Fig.3. The parameters d and z_o influence the contrast of the slip traces and do not change the slip band brightness. The parameters w and $\varkappa$ determine the visibility of the slip bands, good contrast of the slip bands should be expected near the Bragg-orientation ($w \lesssim 0$) and if a great difference of shear modulus of substrate and surface layer is obtained ($|\varkappa| \gg 0$).

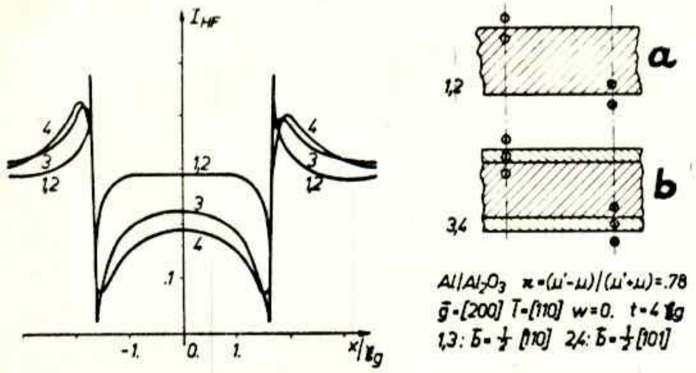

Fig.1: Computed bright-field slip trace contrast assuming the model of a dislocation at either surface of the foil just below the surface layer:
a) one image dislocation
b) two image dislocations

- μ, μ' shear moduli
- $\vec{g}$ diffraction vector
- $\vec{I}$ dislocation direction
- w deviation parameter
- t foil thickness
- $\vec{b}$ Burgers-vector
- ξ_g extinction distance

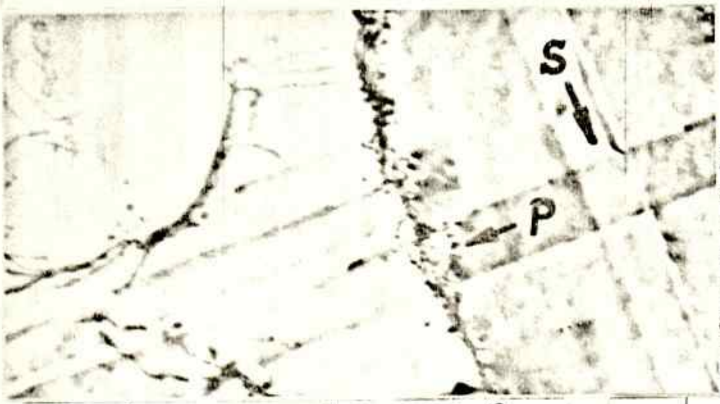

Fig.2: Slip bands in aluminium: primary slip system P, secondary slip system S, slip trace orientation ⟨110⟩, tensile axis ⟨15 4 0⟩, foil plane {100}, slip system {111}⟨110⟩

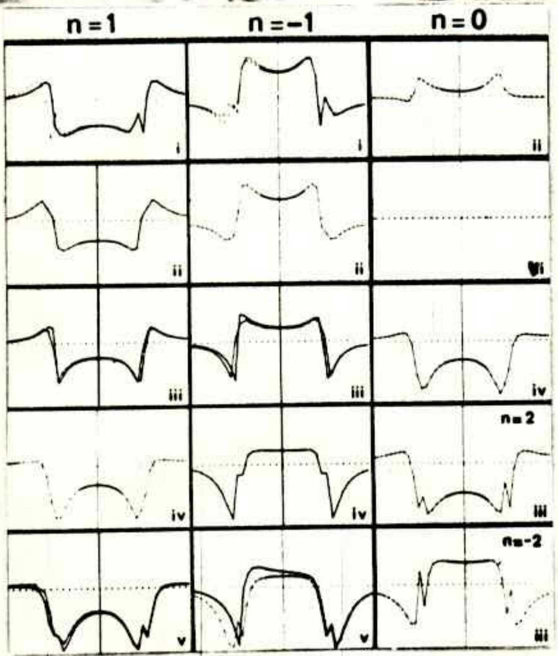

Fig.3: Bright-field contrast of slip bands in different diffraction situations $n=\vec{g}\vec{b}$, $m=\vec{g}(\vec{b}\times\vec{I})/8$, $p=\vec{g}\vec{b}_e/\vec{g}\vec{b}$

i:m=-.1775 p=1., ii:m=-.0885 p=.5
iii:m=0. p=0., iv:m=.0885 p=.5
v:m=.1775 p=1., vi:m=0. p=1.

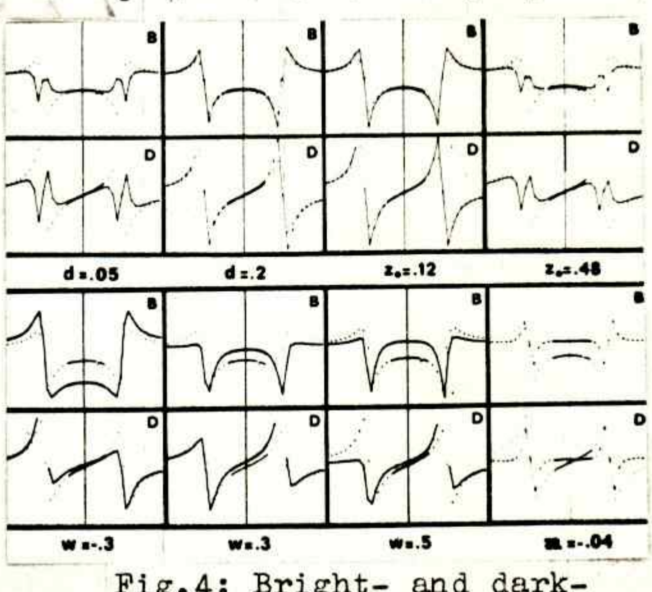

Fig.4: Bright- and dark-field contrast, B and D resp., of slip bands under different calculation conditions:
- d thickness of the surface layer assumed
- z_o depth of the dislocation representing the slip trace below surface layer (the equilibrium value is determined by d and $\varkappa$)