The Study of LACBED Patterns for a Dislocation Pair in Aluminum

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Introduction: The LACBED (Large Angle Convergent Beam Electron Diffraction) technique has been proven to be a powerful tool for investigating strain fields or the nature of dislocations[1,2]. Cherns and Preston[1] have devised a simple rule to determine the Burgers vector, b, of a dislocation from its LACBED patterns. The purpose of this work is to examine in detail the practical applicability of the LACBED technique for the identifying of the nature of dislocations.

Observations: The dislocations in a thin foil of aluminum were observed with J2010 (200 kv) microscope. Fig. 1 is the strong bright field image of g(-200) reflection, showing the dislocations pair at A. Figs 2 ~5 show a series of LACBED patterns taken moving around the dislocation pair at the A, to see the splits of several diffraction lines. Fig. 2 shows clearly the 2-fringe split of the g(- 400) diffraction line. When the pair dislocations were moved up, the g(-600) diffraction line split into 3 fringes as shown in Fig. 3a. But when the dislocations were a little further moved up, only the one side dislocation of the pair made the diffraction line split as in Fig. 3b. As the dislocations moving up continually, the g(551) diffraction line split due to the one dislocation of the pair as in Fig. 4a. In this case the number of fringes of the split could be estimated as 5 (fig. 4b) at the dislocation position intersecting with g(-800) diffraction line or 3(Fig. 4b) off the position a little. When further moved up, the g(6-20) diffraction line split into 3-fringes clearly as shown in Fig. 5a and b.

Analysis: When the data that the 2-fringe split of the (-400) diffraction line, the 3-fringe split of the (551), and the 3-fringe split of the (6 -2 0) is collected, the Burger vector of the dislocation pair can be estimated with Cherns and Prestonrule[1] as b= [$\frac{1}{2}$0 $\frac{1}{2}$] and -b respectively.

Calculations: The computer simulations of the observed LACBED patterns were done to see in detail the nature of the dislocations pair, as shown in Figs. 6~9. In the calculations the formulation of the dynamical theory for the contrast of dislocations developed by the author[3] was used. The analyzed data given in simulations was follows: the thickness of the specimen is about 220 nm; the orientation of specimen to the beam, near the(01-5); the convergent angle of the beam, 0.906º´2 and the specimen height from the convergent point, 0.0212 mm. The direction of the dislocation lines is about [6-15] or [4-15] which is inclined to the beam direction by the angle about 50°. These directions are close to the b-direction, which mean a screw type of dislocations.

Discussion: Generally one can see very good agreements between the images of observations and their theoretical calculations, as shown in the figures. It can be noted in Figs. 3b and 7b that the splitting of g-diffraction lines with n-fringes by the dislocation near the specimen surface, become faded away. Thus Cherns and Prestons rule could not be applicable to this situation. Finally the simulation failed to identify the slip plane of the dislocation pair, and also to obtain 5-fringes of the g(551) diffraction line split matching with Fig. 4b. This point will be further investigated.

References

[1] C.T. Chou, A.R. Preston and J.W. Steeds, Phil. Mag. A, 65, 863-888(1992).

[2] M. Tanaka, M. Terauchi and K. Tsuda, Convergent Beam Electron Diffraction III, JEOL Ltd., 156-177(1994).

[3] H.S. Kim, Microsc. Microanal. 8 (Suppl. 2), 2002.

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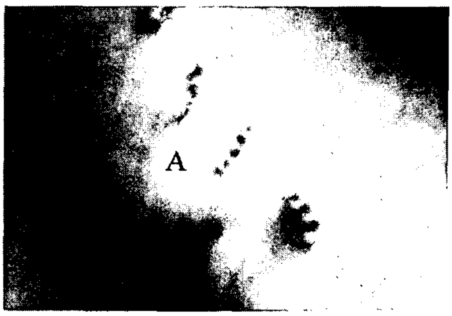


Fig. 1. The strong bright field(BF) image of the g(-200) diffraction for the dislocation pair at A. The separation of the pair is about 150 nm.

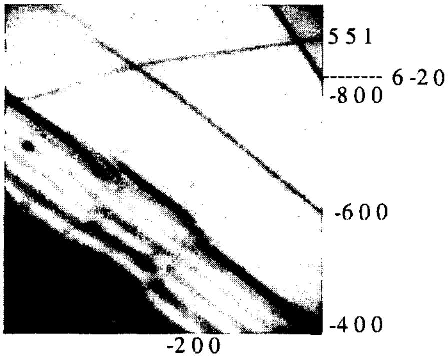


Fig. 2. The bright field(BF) LACBED pattern for the dislocation pair near g(-400) line.

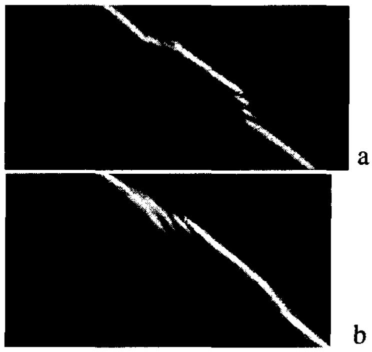


Fig. 3. The dark field LACBED pattern of g(-600) diffraction line.

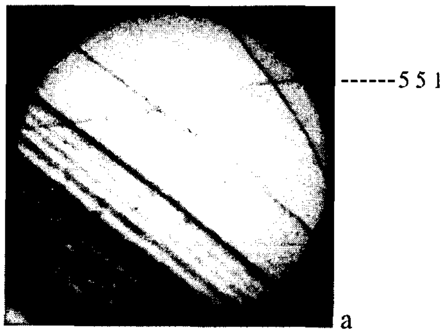
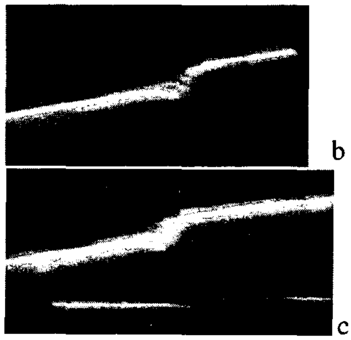


Fig. 4a. The BF LACBED pattern showing g(551) diffraction line split.



b) and c). The DF LACBED pattern of g(551) diffraction line.

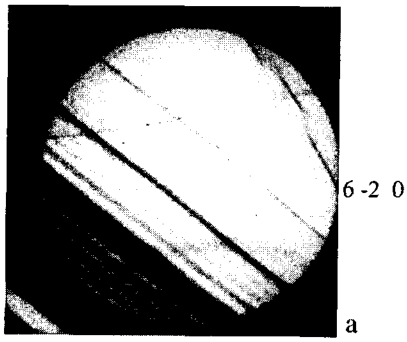
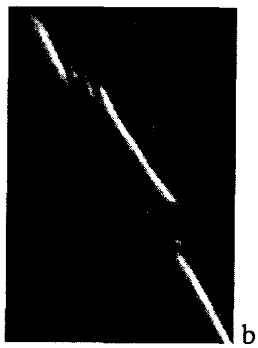


Fig. 5a. The BF LACBED pattern showing the spli of g(6-20) diffraction line.



b). The DF LACBED pattern of g(6-20) showing 3-fringes splitting.

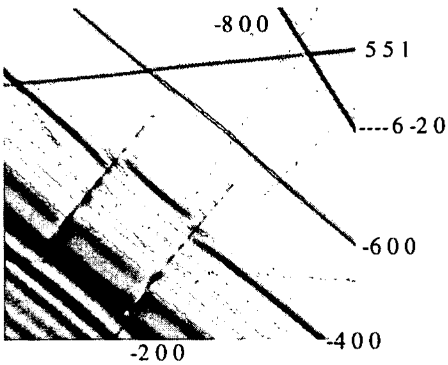


Fig. 6. The calculated BF LACBED pattern corresponding to Fig. 2.

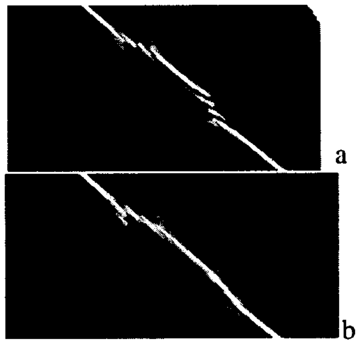


Fig. 7. The calculated DF LACBED pattern corresponding to Fig. 3.

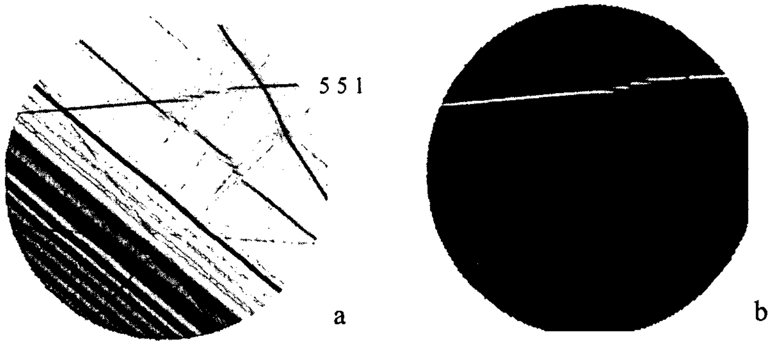


Fig. 8. The calculated BF(a) anf DF(b) LACBED patterns corresponding to Fig. 5 and b respectively.

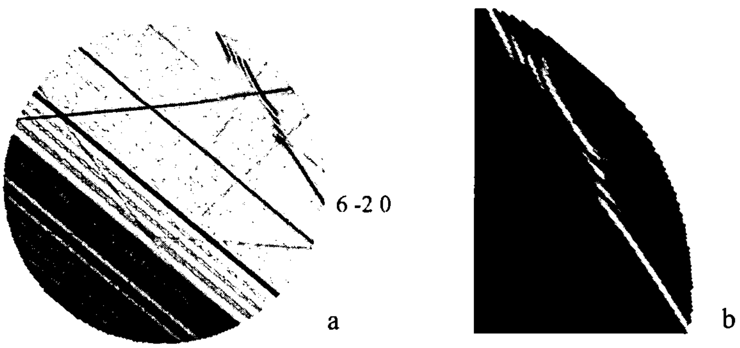


Fig. 9. The calculated BF(a) and DF(b) LACBED patterns corresponding to Fig. 4 and b respectively.