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Author

Ranganathan, S.

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University of California

Ernest O. Lawrence
Radiation Laboratory

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S. Ranganathan

February 1966

COMMENTS ON 'FIELD ION MICROSCOPE OBSERVATIONS OF
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S. Ranganathan

Inorganic Materials Research Division
Lawrence Radiation Laboratory
Berkeley, California

In a recent article Ryan and Suiter¹ have discussed the observation of a dislocation effect in tungsten in a study with the field ion microscope and presented their interpretation on the basis of a stacking fault on a {111} plane. They have also referred briefly to the author's conflicting view-point.² The latter is elaborated here with additional comments on the interpretation of dislocation effect in field ion micrographs.

OBSERVATIONS

The defect structure in question is well defined and easily recognized (Fig. 1). There is no extra-half-plane. The net planes are seen to be drawn inwards. Similar micrographs have appeared in earlier work on tungsten (Ranganathan³) and on platinum (Muller⁴). Ryan and Suiter¹ have added the further remarkable observation that the effect disappeared over a hundred layers and then appeared again in the same place. This observation has been confirmed by the author,² who also observed that the effect could reappear in a different place. Also in between such effects there was a residual contrast: in a particular case a single (011) plane was found to exhibit a closure failure.

DISCUSSION

The contrast to be expected from dislocation and stacking faults is still not well-understood in field-ion microscopy, and the main unknown quantity in this regard is the effect of the field on the imperfections concerned. A paper by Ranganathan et al⁵ has shown the need for the exercise of caution in the interpretation of stacking faults.

In the model proposed by Ryan and Suiter, an edge dislocation lying on a (112) plane prefers to dissociate on a (110) plane and then the partials spread out on a (111) plane. This sequence appears highly improbable on energy considerations. Besides there is no evidence for the presence of the partial dislocations with the given Burgers vectors. The reason for preferring the particular mode of dislocation dissociation appears to be that two of the partial dislocations could move on a (111) plane - the fault plane demanded by observation. The author has observed similar structures on both (111) and (100) planes. Hence a more general explanation appeared desirable.

It may be pointed out that Ryan and Suiter make an error in arguing "that the total dislocation must be pure edge, for if it had a screw component, a spiral step would occur on the surface and the edge of the (011) planes would appear as a spiral on the micrograph". What is important is the angle the Burger vector makes with the plane normal. For $\frac{a}{2} [\bar{1}\bar{1}\bar{1}]$ and (011), the angle is 90° and hence a helicoid based on the plane will not occur, no matter what the character of the dislocation is. This point, however, does not invalidate the other details raised by their paper.

The regular and repeated occurrence of the defect seems to favour an interpretation on the basis of a dislocation network (Fig. 2). In the case of tungsten, such a network can be formed by the reaction

$$\frac{a}{2} [111] + \frac{a}{2} [\bar{1}\bar{1}\bar{1}] \rightarrow a [010]$$

The locking in of the dislocation might explain their stability in the presence of the field. On this interpretation, the disturbed structure would correspond to the asymmetrical three-fold node formed by this reaction. Nets of this type observed in iron have been analyzed in detail by Carrington et al.⁶ In tungsten, also, such networks have been noted and a feature of many of these networks is the close spacing ($\sim 100\text{\AA}$) of the dislocations (F. O. Jones⁷). This answers one of the objections raised by Ryan and Suiter against the present model.

On the basis of the network theory, away from the node, one should expect contrast from three dislocations with Burgers vectors $\frac{a}{2} [111]$, $\frac{a}{2} [\bar{1}\bar{1}\bar{1}]$ and $a[010]$. When these dislocations intersect the (011) plane, $\frac{a}{2} [111]$ and $a[010]$ dislocations should give rise to spirals on the (011) planes, while the $\frac{a}{2} [\bar{1}\bar{1}\bar{1}]$ dislocation will not give rise to a spiral regardless of its edge and screw components. The author believes that it is possible to associate the closure failure of the (011) plane with this dislocation. The spirals from the other two dislocations were not observed. Further observations are necessary to check whether these dislocations with the associated spirals occur.

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