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ABSTRACT

Dislocations in a field-ion specimen under specified conditions give rise to a spiral contrast in field ion-micrographs. The nature of the spirals can be used to draw information concerning the Burgers vector of the dislocation. Such an analysis is applied here to the case of the two-leaved spirals from hexagonal close packed structures.

In a recent paper, Melmed and Klein (1966) have presented the first field-ion micrographs from ruthenium, establishing that this h.c.p. metal along with rhenium is amenable for field-ion microscopic observations at 77°K. A number of spiral structures have been observed in some of these micrographs and they are analyzed here following a method due to Ranganathan (1966).

The contrast for the case of a dislocation running at an angle to a plane, i.e., $\bar{n} \cdot \bar{g} \neq 0$ where $\bar{n}$ is the direction of the dislocation and $\bar{g}$ is the direction normal to the plane is considered. $\bar{b}$ is the Burgers vector of the dislocation. Then the dot product $\bar{g} \cdot \bar{b}$ determines the nature of contrast (Ranganathan, 1966). If $\bar{g} \cdot \bar{b} = 0$, the dislocation is effectively invisible. The net plane rings then remain closed and the displacements are confined to a plane. In close packed planes where good resolution is available only near the edges, such displacements may be difficult to discern. If $\bar{g} \cdot \bar{b} = N$, an integer, the net plane rings do not close on themselves but form a continuous spiral. The spiral is due to the component of the Burgers vector normal to the plane. When N = 1, a simple spiral arises. If N = 2, a two-leaved spiral will occur and so on. The nature of the spiral allows the vertical component of the Burgers vector to be determined. Further characterization can be done only in cases where the direction of the dislocation line is such that it intersects different crystal planes on field evaporation.

In the cubic system the dot product for the plane $(hk\ell)$ and the Burgers vector [uvw] is given by $\bar{g} \cdot \bar{b} = hu + kv + \ell w = N$. This formula can be extended to the hexagonal case. For $\bar{g} = [hki\ell]$ and $\bar{b} = [HKIL]$,

$$\bar{g} \cdot \bar{b} = hH + kK + iI + \ell L$$

In the hexagonal close packed structure this will not necessarily be equal to the number of leaves in the spiral. In the hcp metals there are two classes of atoms. Therefore there are two possible surfaces (J. F. Nicholas, 1965) whenever $2h + 4k + 3\ell$ is not a multiple of 6. For these planes and perfect dislocations the dot product must be multiplied by 2. It follows that for a perfect dislocation intersecting such planes, only even-leaved spirals are possible (i.e., 2,4,6, leaved).

Figure 1 shows a two-leaved spiral occurring on $(10\bar{1}0)$ in ruthenium. This is caused by a dislocation forming part of a low angle boundary. On field evaporation the intersection of the boundary moved and the dislocation was seen to intersect $(10\bar{1}2)$ where again a two-leaved spiral was observed. This fact can be used to rule out a number of possible Burgers vectors. From the information given below in tabular form, it can be seen that $\frac{1}{3}[2\bar{1}\bar{1}0]$, $\frac{1}{3}[\bar{1}\bar{1}20]$, $\frac{1}{3}[\bar{1}\bar{1}23]$, and $\frac{1}{3}[\bar{2}113]$ are possible Burgers vectors.

Nature and Expectancy of Spiral in h.c.p.

Type	$\vec{b}$	$N_{10\bar{1}0}$	$N_{10\bar{1}2}$
a	$\frac{1}{3}[2\bar{1}\bar{1}0]$	2	2
	$\frac{1}{3}[\bar{1}2\bar{1}0]$	0	0
	$\frac{1}{3}[\bar{1}\bar{1}20]$	2	2
c	$[0001]$	0	4
c + a	$\frac{1}{3}[11\bar{2}3]$	2	6
	$\frac{1}{3}[\bar{1}\bar{1}23]$	2	2
	$\frac{1}{3}[2\bar{1}\bar{1}3]$	2	6
	$\frac{1}{3}[\bar{2}113]$	2	2
	$\frac{1}{3}[1\bar{2}13]$	0	4
	$\frac{1}{3}[\bar{1}2\bar{1}3]$	0	4

References

A. J. Melmed and R. Klein, 1966, J. Less Common Metals, 10, 225.

J. F. Nicholas, 1965, "An Atlas of Models of Crystal Surfaces", Gordon and Breach, Science Publishers, Inc., New York.

S. Ranganathan, 1966, submitted for publication.

Figure Caption:

Fig. 1. Two-leaved spiral structure on central $(10\bar{1}0)$ plane of Ruthenium. Helium field-ion micrograph at 77°K and 10.6 KV.

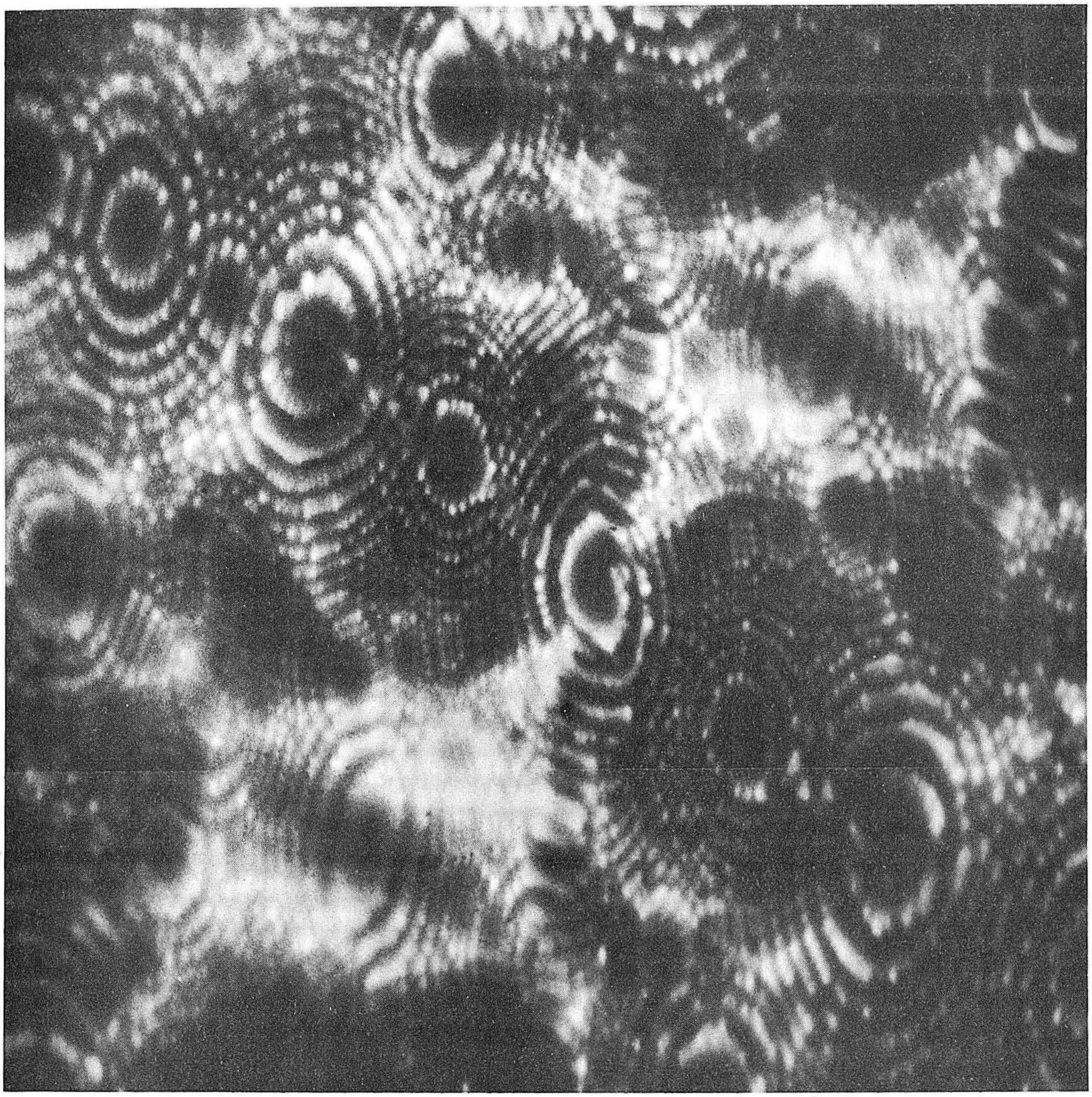

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Fig. 1