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Twinning and slip in α-uranium. By R. W. Cahn, *Atomic Energy Research Establishment, Harwell, Berks, England*

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A study has been made of the crystallographic elements of twinning and slip in the orthorhombic (low-temperature) form of uranium. The experiments were carried out with coarse-grained metal made by recrystallization after a small extension; it was not possible to obtain reasonably sized single crystals which were also of strictly uniform orientation. A special precision back-reflexion X-ray camera was used, by means of which it was possible to obtain Laue patterns from grains previously selected under a polarizing microscope. The metal was twinned by small applied deformations. It was also possible to twin it by heating and cooling, on account of the great anisotropy of thermal expansion. The twinning elements were the same in either case, and the twin lamellae were always very thin (rarely thicker than 5μ). Slip lines could also be generated either mechanically or thermally. Many of the slip markings were accompanied by *cross-slip* (Cahn, 1951). Grains which had undergone slip often contained, in addition, lamellar *kink bands*; these are regions in which the lattice is rotated a few degrees only from the parent orientation (Hess & Barrett, 1950).

The composition planes K_1 of the twins were determined from the directions of their traces on polished surfaces. The other elements, K_2, η_1 and η_2 (for an explanation of these symbols see Schmid & Boas (1950, p. 71)) were determined primarily by an examination of intersecting pairs of twins. If a twin A passes through a twin B, then the direction and magnitude of shear must be the same, or almost the same, in A and in that portion of B through which A is passing. (This portion has of course an orientation differing from the orientations of A and B.) The findings were checked by optical goniometric measurements of the surface tilt accompanying twinning. Another check was achieved by measuring the deflexion of slip lines in passing through a twin lamella, on a specimen which had become twinned after slipping.

Slip planes were determined in the same way as twin composition planes. One slip direction was deduced from the appearance of cross-slip and kink-band markings on differently oriented grains, since all cross-slip planes must include the slip direction, and kink-band lamellae are approximately normal to this direction. The elements thus determined are listed in Tables 1 and 2. For indexing, axes were assigned as follows:

$$a = 2{\cdot}852, \quad b = 5{\cdot}865, \quad c = 4{\cdot}945\,\text{A}.$$

There are thus four distinct families of twins. Types 2 and 4 are formed by a *shear of the first kind*, i.e. K_1 and η_2 are rational elements, while K_2 and η_1 are not. Type 3 is of the *second kind* (K_2 and η_1 rational, K_1 and η_2 not). Type 1 is of both kinds combined, resembling in this the twins occurring in all other metals investigated up to now. It is interesting to note that types 2 and 3 are *reciprocal* with respect to each other, i.e. K_1 and η_2 of type 2 have the same indices as K_2 and η_1, respectively, of type 3. Such reciprocal relationships are common among non-metallic materials capable of twinning (Tertsch, 1949, p. 67).

Table 1. *Twinning elements*

Twinning type	K_1	K_2	η_1	η_2	Magnitude of shear
1	(130)	$(1\bar{1}0)$	$[3\bar{1}0]$	[110]	0·299
2	(112)	Irrational	Irrational	[312]	0·213
3	Irrational	(112)	[312]	Irrational	0·213
4	(121)	Irrational	Irrational	[113]	—

Table 2. *Slip elements*

Slip type	T	t	Remarks
1 (predominating)	(010)	[100]	Cross-slip on (011), (013) and some other planes
2 (rare and faint)	(110)	?	No cross-slip

The probable atomic motions for twinning of types 1 and 3 have been examined graphically; in neither case will a pure shear generate the twin orientation exactly. If the main lattice is considered to contain covalent bonds between certain neighbours, as suggested by Tucker (1950), then most of these bonds are broken by the twinning process and re-established between new neighbours. According to Tucker, the structure of uranium consists of giant corrugated sheets, with covalent bonds joining the atoms *within* each sheet. These sheets are parallel to (010), which is the principal slip plane. The slip direction [100], besides being the closest-packed direction, is also parallel to the corrugations of the sheets.

Full details of these experiments, and of the X-ray camera, will be published later. This note is published by kind permission of the Director, Atomic Energy Research Establishment.

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X-ray diffraction study of several branched-chain fatty acids. By G. L. Clark and Chia-Chen Chu, *Department of Chemistry, University of Illinois, Urbana, Illinois, U.S.A.*

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The branched-chain fatty acids are of increasingly evident chemical and physiological importance. For example, they occur in bile acids and in lipoids of tubercle bacilli; they are produced by oxidation of branched-chain hydro-