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ON THE OCCURRENCE OF URANIUM METAL PARTICLES IN FUSED UO_2

by

R. COLOMBO and G. FRIGERIO (FIAT)

1963

Euratom/United States Agreement for Cooperation
Work done by FIAT, Sezione Energia Nucleare, Torino,
under the Euratom contract No. 013-60-5 RDI

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ON THE OCCURRENCE OF URANIUM METAL PARTICLES IN FUSED UO_2

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Received 13 September 1961

The fused uranium dioxide powder is made up of particles of different sizes, with varying appearances. It has already been shown [1]) that many of these particles are single crystals or aggregates of very few single crystals, and some of their properties have been described. Moreover, the microscopical examination – both optical and electronic – reveals the presence of inclusions of a light, soft phase at the grain boundaries and inside the UO_2 matrix, the shape of the inclusions being surprisingly geometric in the second case.

Our specimens were supplied by the Spencer Chemical Co., Kansas City, Mo (U.S.A.); a typical spectrographic analysis follows:

Silver	0.1 ppm	Magnesium	30 ppm
Aluminum	25 ppm	Manganese	20 ppm
Boron	1 ppm	Molybdenum	2 ppm
Cadmium	1 ppm	Nickel	10 ppm
Chromium	10 ppm	Phosphorus	50 ppm
Copper	5 ppm	Lead	20 ppm
Iron	150 ppm	Silicon	50 ppm
Tin	1 ppm		

The O/U ratio measured by the oxidation to U_3O_8 method was 1.995 $\pm$ 0.004, i.e. the material is very slightly understoichiometric.

Figs. 1 and 2 show the distribution of the light phase respectively within the matrix and at the boundary between two grains; in the first case a subgrain pattern is quite visible. The shape of the inclusions is apparent in figs. 3 and 4, the latter photomicrograph was obtained with polarized light. Figs. 5 and 6 are electron photomicrographs obtained from single-stage collodion replicas with platinum-palladium shad-

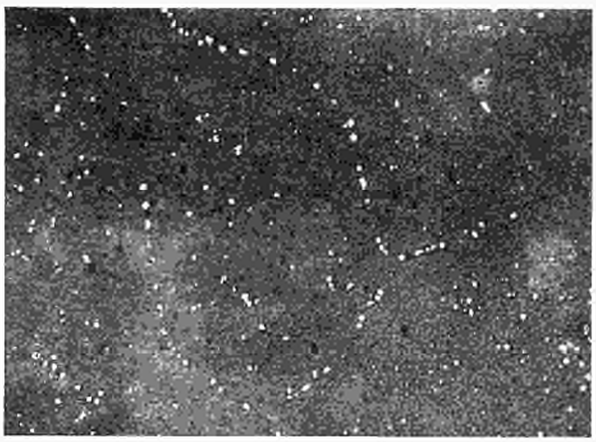

Fig. 1. Fused uranium dioxide. Unetched. × 375.

Fig. 2. Fused uranium dioxide. Unetched. × 150.

† Work done under Euratom-USAEC Contract No. 013–60–5 RDI.

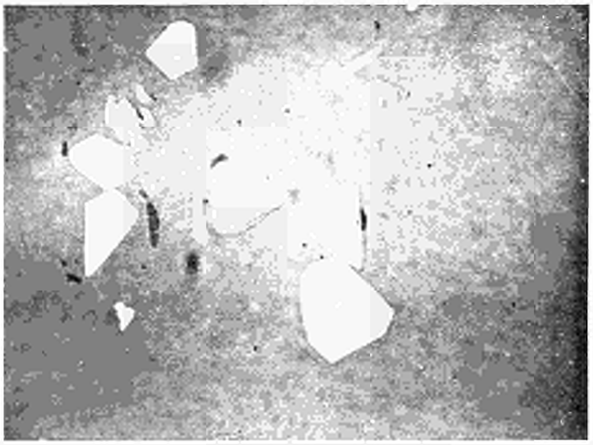

Fig. 3. Fused uranium dioxide. Unetched. × 750.

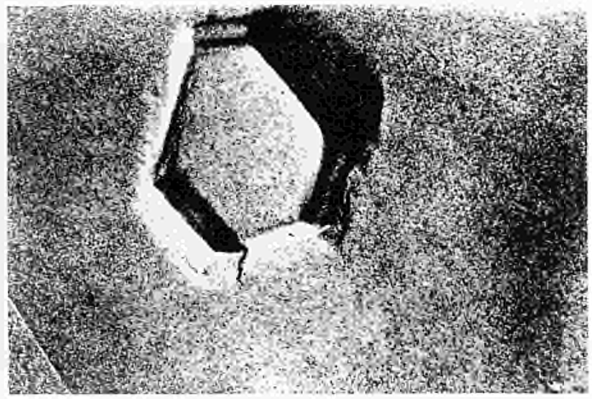

Fig. 6. Fused uranium dioxide. Electron photomicrograph. × 11.000.

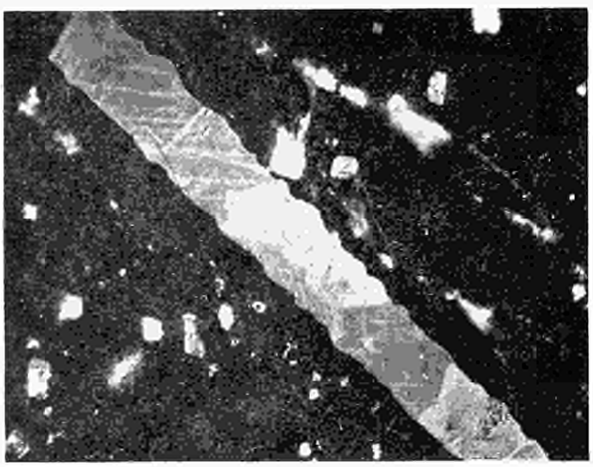

Fig. 4. Fused uranium dioxide. Unetched. Polarized light. × 750.

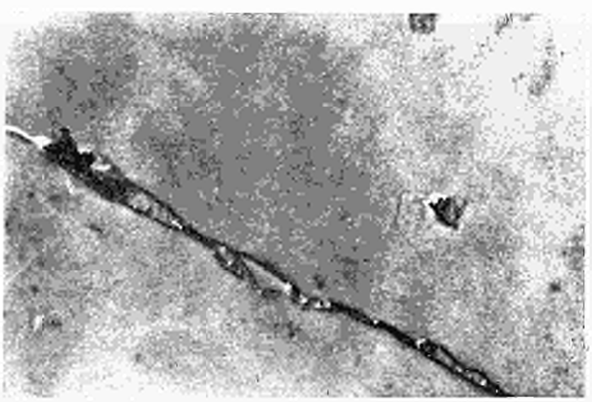

Fig. 5. Fused uranium dioxide. Electron photomicrograph. × 5000.

owing: the occasional uplifting and warping of the replica does not prevent the confirmation of the geometric habit of the light phase within the matrix, as seen in the optical micrographs.

Microhardness was measured on the UO_2 matrix and on the light phase inclusions, both within the matrix and at the grain boundaries, using a Vickers pyramid indenter and loads from 6 to 12 g; the results were the following:

	UO_2 matrix	Light phase	
		within the matrix	at the grains boundaries
V.P.N.	610 + 810	220 + 290	250 + 335

Actually the hardness of the light phase is somewhat higher than that of the uranium metal [2]), but the difference may be easily explained in terms of work-hardening during the mechanical polishing. The microscopical appearance, specially in polarized light, and the high purity of the specimens also are in favour of this explanation. The uranium metal would segregate during solidification along the easy growth planes of the matrix and at the grain boundaries, owing to variations of the stable or metastable solubility of oxygen in UO_2

Mrs. A. Moioni, of the Istituto Elettrotecnico Nazionale "Galileo Ferraris", is to be thanked for taking the electron photomicrographs.

After this work was done, we learned that the presence of uranium metal in fused UO_2 single-crystals (relatively impure) obtained by a commercial producer was observed at the Battelle Memorial Institute, Columbus, Ohio (USA), though no evidence of the discovery was given at that time [3]).

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1) R. Colombo, J. C. Danko, H. M. Ferrari, submitted for publication to J. Nucl. Science
2) C. J. Smithells, Metals Reference Book, Vol. II (Butterworth, 1955) p. 803
3) J. Melehan *et al.*, Battelle Memorial Institute, Report, BMI-1324 (1959) 33

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Bericht

Bladzijde 6, Paragraafteken 1.1.

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