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LETTERS TO THE EDITORS – LETTRES AUX REDACTEURS

MEASUREMENTS ABOUT THE EFFECT OF GRAIN BOUNDARIES ON THE ELECTRICAL RESISTIVITY OF URANIUM DIOXIDE

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One of the reasons for the scattering in electrical resistivity data of UO_2 (up to 4 orders of magnitude at room temperature [1])) may be the difference in grain size. To find out to what extent grain boundaries can affect the UO_2 electrical resistivity the following measurements have been made. Two types of UO_2 specimens having different grain sizes have been used, the chemical analysis and stoichiometry of which were very similar (UO ratios: 1.96 for coarser grain; 1.98 for finer grain). Starting with the same powder, the compacts have been prepared by extrusion ($\varrho = 10.69$ g/cm$^3 \simeq 97.6\%$ TD). Different heat treatments led to the different microstructures shown in fig. 1. A rough stereometric analysis using Tomkeiff's

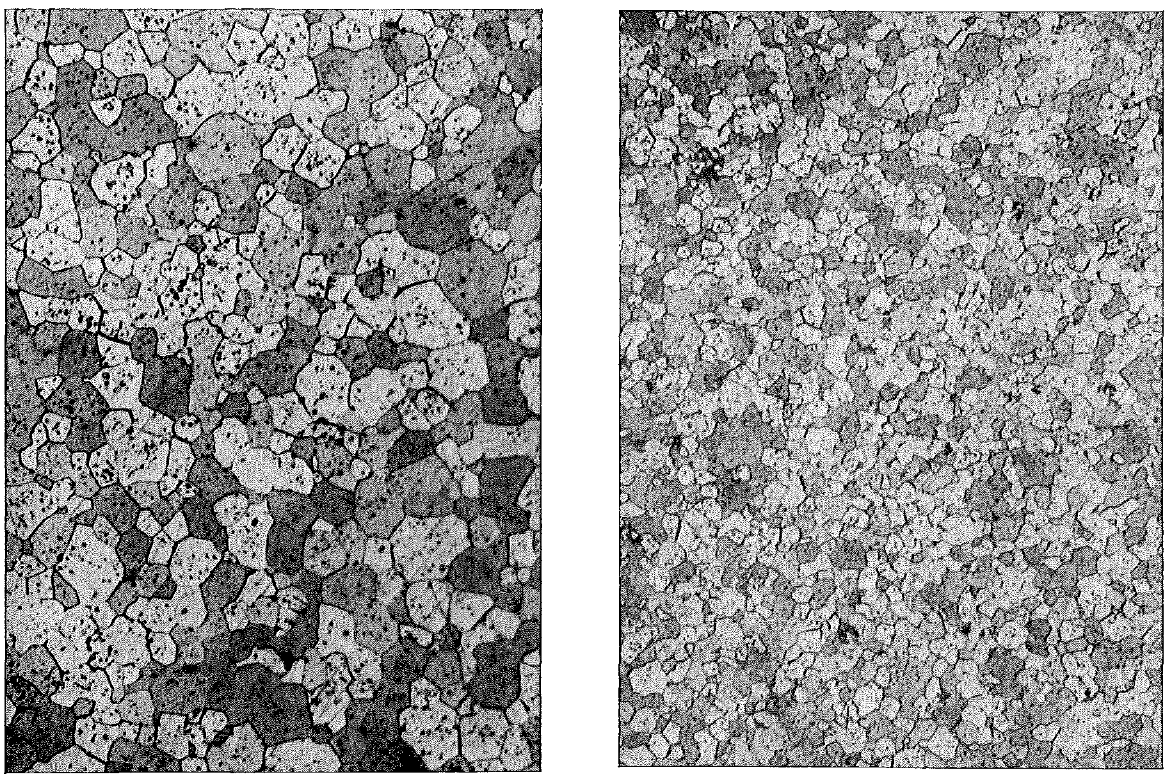

Fig. 1. Microstructure of coextruded UO_2 with different grain size; etchant: $HCL + HNO_3$ (1:1). ×450

equation [2])

$$S_V = \frac{2}{\bar{L}}$$

($\bar{L}$ = measured mean intercept length) shows that the total internal surface (grain boundary area) per unit test volume of UO_2 (S_V) is approximately twice as large in the fine grained UO_2 as in the coarser one (fig. 1). Three specimens of each type of microstructure have been used for measuring the temperature dependence of the electrical resistivity. The resulting curves are shown in fig. 2 demonstrating that the electrical resistivity of the coarser grained UO_2 is approximately one order of magnitude higher than that of the finer grained UO_2 at all temperatures in the measured range.

Due to the different heat treatments of the specimens they should also have different amounts of lattice defects. This – as well as the different microstructure – could be the reason for the difference in the electrical resistivity. Lattice defects, however, would create an effect opposite to that shown in fig. 2: the finer grained material should have the higher resistivity because of the higher concentration of lattice defects. Consequently, one can assume that the difference in the electrical resistivity shown here comes from the different grain size. Because of the high electrical resistivity of the UO_2 crystallites the conductivity of the bulk material is improved by the grain boundaries. These results were observed for polycrystalline NaCl [ref. [3])] as well as for Al_2O_3 [ref. [4])], although in the latter case of Al_2O_3 other workers [5]) have reported low grain boundary conductivity. Both results, higher as well as lower grain boundary conductivity, can be explained in terms of "binder material" in the grain boundaries of Al_2O_3 changing the electron affinity between the grain boundary and the crystal [6, 7]). No conclusion can be drawn from the present results as to whether this effect occurs in UO_2. In spite of the clear results here, it cannot be

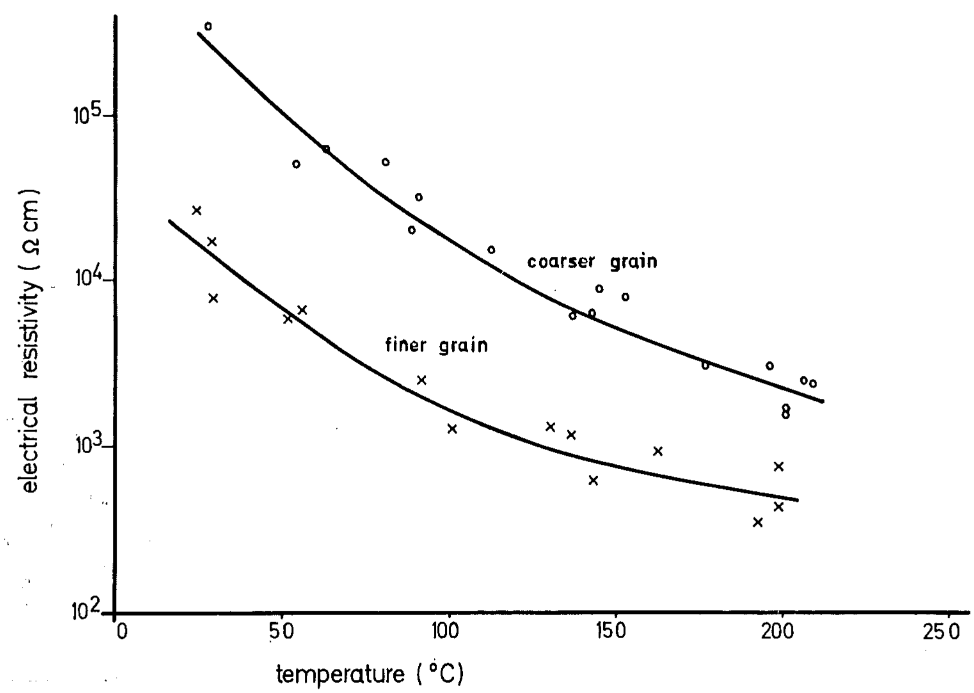

Fig. 2. Electrical resistivity of UO_2 specimens with different grain size.

stated generally, that the grain boundary conductivity of UO_2 at lower temperatures is always higher than that of the crystals.

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