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PREFERRED ORIENTATION IN ROLLED AND IN RECRYSTALLIZED
HIGH-PURITY URANIUM ROD

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ABSTRACT

The preferred orientation of a relatively small piece of high-purity uranium rod, rolled to an 85% reduction at 300° C, has been determined in the as-rolled and in the recrystallized conditions. The 12 different charts obtained indicated that the as-rolled texture could be described as a duplex (041) and (352) with the (041) being the major component and with considerable spread about each component. The recrystallized rod showed approximate (041) and (392) components with considerable spread. These texture components for both the as-rolled and the recrystallized rods are not too different from those previously reported for reactor-grade uranium rod. However, it was noted that the texture appeared to be quite sharp for the reduction used, and the maximum intensity on an inverse pole figure was considerably displaced from the periphery of an (001) standard projection for both the rolled and recrystallized rods.

I. INTRODUCTION

Intensity data obtained for a few common pole charts, such as (020), (110), (200) and (002), from a small piece of high-purity uranium rod had indicated that the texture seemed to be quite sharp for the amount of reduction. In addition, the texture components seemed to be described best in terms of components away from the periphery of an (001) standard projection, for example, an (041) instead of an (010).⁽¹⁾ Since this condition was suspected previously from some of the work on reactor-grade uranium,⁽²⁾ it was decided to make a more extensive study of the preferred orientation in both as-rolled and recrystallized high-purity uranium rods.

II. MATERIAL STUDIED AND SPECIMEN PREPARATION

The rolled uranium rods used for this study were fabricated from high-purity ingot B-260, which was liquated for 8 hr at 1200°C and quenched. The chemical analysis is given in Table I.

Table ICHEMICAL ANALYSIS* OF
CASTING B-260

Element	Top	Bottom
C		54, 45
O	29, 1, 9	16, 10, 19
Fe		3
Si		7
Al		10
Cu		2
Mn		1

The ingot was reduced at 300°C to a rod 0.337 in. in diameter with hand round rolls, which amounted to a reduction of 85%. Three different sections of the rod described above were used to obtain sufficient pole-intensity data by the Schulz reflection technique for the construction of pole charts. The three sections were cut from the rod so that the plane surfaces of the cross, 45° and longitudinal sections could be said to be formed by rotating a plane surface about an axis perpendicular to the rolling direction and passing through the center of the rod. As shown previously⁽³⁾ the sections were cut in this way to minimize the effect of asymmetry which might be produced by roll pass design.

After cutting each specimen with a cutoff wheel to the correct angle, approximately 0.010 in. was removed from the plane surface by hand polishing on fine paper. Several thousandths of an inch were then removed by electropolishing in order to remove the last trace of cold work.

Since only a short rod of this high-purity material was available, the same three sections were used for both the as-rolled and recrystallized studies. After obtaining the data for the as-rolled study, the three pieces were annealed in vacuum for 1 hr at 475°C, lightly polished, and then used in determining the recrystallization texture.

III. INSTRUMENT AND METHOD FOR STUDYING PREFERRED ORIENTATION

The data for the pole charts were obtained with an X-ray diffractometer, using a Geiger counter and the modified Schulz device previously described.⁽⁴⁾ Each of the three specimen sections was mounted and aligned on a scanning table - the cross section on the rotating scanning table and the other two sections on the oscillating table. Intensity data were then

*All results are given in ppm.

obtained from each section for the various reflections. The cross section of the rod was used to obtain intensity data from 0° to 30° from the rolling direction, a 45° section for the 15° to 65° positions, and a longitudinal section for the 60° to 90° positions. This scheme, as previously used,^(2,5) provided considerable overlap between sections.

The intensity data minus background were then plotted in the form of pole charts, shown in Figs. 1 through 12, in which the intensity is plotted versus degrees from the rolling direction, ϕ . The intensity at each individual point is not shown because of the large amount of data; however, there was very little difficulty encountered in drawing smooth curves through the plotted points.

It has been recognized for some time that the intensity data obtained for pole charts should be corrected as a function of the angle. Although a rigorous method of correction has not been found, it has been suggested^(5,6) that pole charts be plotted in terms of $I \sin \phi$ versus ϕ . The $\sin \phi$ correction appears to be quite good for ϕ angles greater than approximately 20° ; however, for angles less than 20° the procedure becomes inaccurate, since the intensity goes to zero for a ϕ angle of 0° .

All pole charts obtained on both the as-rolled and the recrystallized materials were plotted with uncorrected and $\sin \phi$ corrected intensity versus degrees from the rolling direction. The calculated locations of high-intensity areas for certain texture components are indicated on the pole charts by heavy arrows together with their respective components.

In order to show a composite of the preferred orientation indicated by all pole charts, a very rough inverse pole figure has been drawn (Fig. 13). It has been constructed primarily to show the type and kind of pole concentration in the rolling direction rather than the relative amount, since sufficient data were not taken for this latter purpose. We have shown only a relatively few pole locations on this inverse pole figure, since we primarily wish to show the pole concentration with respect to the periphery of an (001) standard projection and in relation to the (010) and (110) poles.

IV. EXPERIMENTAL RESULTS AND DISCUSSION - AS-ROLLED RODS

The (020) and (110) pole charts (Figs. 1 and 2) have their major intensities for the as-rolled material at 15° to 20° from the rolling direction. The (200) pole chart (Fig. 3) has relatively high intensity near 35° and near 90° for the as-rolled material, with some intensity in between those two positions. Referring to the (002) pole chart (Fig. 4), the major portion of the as-rolled intensity occurs in a broad band approximately 70° to 80° from the rolling direction, with an appreciable amount extending out to 90° from the rolling direction.

The inverse pole figure (Fig. 13), which is a result of these four reflections, indicates a band of high intensity from the (041) pole to about the (352) pole, with a lesser but appreciable amount running from the (010) pole to about the (110) pole. These results also appear to be consistent with the other eight pole charts, shown in Figs. 5 through 12.

On the basis of the above results, the as-rolled material could then be said to have (041) and (352) texture components with the (041) predominating and with considerable spread. It was also noted that the texture seemed to be quite sharp for the amount of reduction.

Although earlier work,^(5,7) on preferred orientation in uranium rods had described rod texture in terms of (010) and (110) components, later work by Jetter and McHargue⁽⁸⁾ on extruded rods and work by Mueller, Knott, Chernock and Beck⁽²⁾ on rolled rods had indicated that the texture components, as described in terms of the location of the maximum pole concentration, could best be expressed in terms of poles somewhat displaced from the (010) and (110) poles. In the case of the (010) pole, the displacement seems to be generally towards the (001) to approximately the (041), and in the case of the (110) the displacement may be towards both the (001) and the (010) poles. Experience with a number of rolled uranium rods indicated that the amount of displacement may vary for different samples taken from the same rod as well as different rods. Hence it would appear that the texture observed in the present high-purity uranium rod is in agreement with the previously reported texture for uranium rods; however, it may be somewhat sharper for the given reduction and may also be displaced slightly more from the (010) and (110) components than usual.

V. EXPERIMENTAL RESULTS AND DISCUSSION - RECRYSTALLIZED RODS

Referring again to the (020), (110), (200) and (002) pole charts (Figs. 1 through 4, respectively) for the recrystallized rods, a slight change is observed from the peak intensity positions in the as-rolled state. The (020) pole chart has its strongest intensity near 30° from the rolling direction, but spread from 0° to 60°. The (110) has considerable intensity from 30° to 90°, with the highest intensity near 30° and 60°. The (200) has its highest intensity near 50° and 90°, with some intensity between those positions. The intensity distribution on the (002) pole chart is similar to that for the as-rolled rod except that the peak intensity is not as sharp and spreads more towards the 90° position.

The composite result of these four poles (Fig. 13) shows a band of high intensity from the (041) pole to about the (392) pole, with a band of only slightly less intensity from the (010) pole to perhaps the (120) pole.

The other eight pole charts shown in Figs. 5 through 12 also indicate the same general results. On the basis of the above results, the recrystallized rod may be said to have major texture components near the (041) and the (392). The high-intensity area covered by the recrystallized material on a standard projection appears to be less than that of the as-rolled material. This more even distribution of intensity for the recrystallized rod may be explained on the basis that in going from the as-rolled condition to the recrystallized state there is a shift of intensity from near the (352) to the (392), with high intensity remaining near the (041). As indicated in Fig. 13, there is a smaller angular distance between the (392) - (041) than between (352) - (041), which results in a more uniform intensity for recrystallized rod.

The texture reported here for the recrystallized high-purity uranium rod is in essential agreement with previously reported results for recrystallized reactor-grade rolled rod⁽²⁾ and recrystallized extruded rod.⁽⁸⁾ These previous investigations have indicated, in addition to a near (041) or (010) component, another component near (140) or (131); however, these latter components are not very far displaced from the near (392) component which was used to describe the texture in this recrystallized high-purity rod.

VI. CONCLUSIONS

The as-rolled texture for the high-purity rods could be described in terms of (041) and (352) components and the recrystallized texture in terms of (041) and (392) components. These texture components are similar to those previously reported for less pure uranium rods. However, the texture developed in the high-purity rod may be somewhat sharper for the given amount of reduction. Additional work on high-purity rods would be necessary to determine if the displacement of the maximum from the periphery of an inverse pole figure is greater for high-purity material, since displacements have been observed for less pure material.

Fig. 1 (020) POLE CHART

Fig. 2. (110) POLE CHART

Fig. 3. (200) POLE CHART

Fig. 4. (002) POLE CHART

Fig. 9. (041) POLE CHART

Fig. 10. (113) POLE CHART

Fig. 11. (133) POLE CHART

Fig. 12. (152) POLE CHART

Fig. 13. INVERSE POLE FIGURE OF HIGH PURITY URANIUM ROD
LEFT: AS ROLLED RIGHT: RECRYSTALLIZED

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