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TRANSLATION

RECRYSTALLIZATION OF COLD DEFORMED TUNGSTEN

By V. A. Lavrenko and I. Ye. Shiyanovskaya

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In literature we have data concerning the recrystallization of tungsten, deformed by filing. We studied compact metal-ceramic tungsten of high purity (99.989% W; 0.0034% O; 0.001% Cu; 0.001% Fe; 0.0008% Al) deformed by a method developed by B. D. Grozin (2).

The tungsten was subjected to deformation during close irregular compression in steel rings under a pressure of 300 kg/mm^2. The height of undeformed test pieces was 8 mm, the diameter 5 mm. As a result of compression, the height was decreased to 4.8 mm and the rest piece took on a barrel-shaped form.

Electronic microphotographs of the undeformed and deformed tungsten[1] are shown in Figure 1* see inset. A set deformation is characteristic for this metal.

Deformed test pieces are subjected to tempering for two (2) hours at 800 - 1650 degrees in the VVPS oven in a vacuum of 10^{-3}mm of mercury column. The temperature was maintained with an accuracy of 10 degrees.

The processes of recovering and recrystallizing tungsten were studied in relation to the annealing temperature by measuring the hardness magnitude of the granules and microdistortions.

As a result of cold hardening, the hardness of the tungsten increased from 20.5 to 33R. Annealing at 800 - 1300 degrees brings about an insignificant decrease in hardness, which is characteristic of the recovery process (Figure 2). At 1300 - 1400 degrees, sudden softening

[1]Electronic microphotographs by A. N. Pilyankevich

*Translator's note: Figure 1 must have been in previous text.

Figure 2.

The Dependence of the Hardness of Cold Hardened Tungsten on the Annealing Temperature.

of the tungsten is observed, which indicates recrystallization. A further increase of temperature has no effect on the change of hardness. Thus it might be assumed that the temperature of the recrystallization threshold of tungsten studied by us is approximately 1350 degrees.

Figure 3.

The Dependence of the Size of Granules on the Annealing Temperature.

The results obtained by a method of hardness are confirmed by the investigation of the growth of granules (Figure 3).

At the same time we were conducting X-ray diffraction studies of non-deformed, deformed and annealed test pieces, obtained by means of reverse exposure, the relation of the broadening of the spectral line (321) to the annealing temperature was established.

Controlled measurements of deformed and non-deformed test pieces were carried out parallely to clarify the nature of line broadening on the URS-501 apparatus. The measurements pointed out that the broadening effect was caused mainly by the emergence of second-class stresses in tungsten test pieces, inasmuch as the value $\Delta \frac{d}{d}$, calculated for different angles of reflect ion remains practically constant. This conclusion agrees with results obtained by V. Ya. Pines and N. G. Bereznyak (3), who conducted harmonic analysis of the curve of true line broadening of a tungsten wire, deformed by broaching between tempered steel plates.

Figure 4.

The Dependence of Microdistortions on the Annealing Temperature.

The results of the calculation (Figure 4) indicate that the elimination of microdistortions is being observed already in the relaxation process of deformed tungsten. During a transition into the area of recrystallization, no sudden decrease in the value $\frac{d}{d'}$ of tungsten is observed which agrees with data obtained earlier (4). The changes of line broadening and hardness with annealing temperature in a function do not coincide, but the relative distortions of the lattice depend linearly on the temperature.

Consequently, stresses brought about by blurring of the line are not the cause of the hardening of tungsten during strain. If we assume that the modulus of elasticity for tungsten is $E = 4.1 \times 10^4$ kg/mm^2, (5), then the maximum second-class stresses of deformed non-annealed test pieces have a value of approximately 32 kg/mm^2.

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