THE LATTICE PARAMETER AND DENSITY OF PURE TUNGSTEN

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Abstract

Because of the importance of knowing the values of these constants as accurately as possible, x-ray diffraction patterns were made for several samples differently treated as follows, (1) W plus 10 parts flour in comparison with NaCl in the other end of specimen tube; (2) the same in comparison with Au plus 10 parts flour, and (3) W plus 10 parts NaCl. The results agree within the reproducibility of the results, .001 to .003A, with the values previously obtained for *lattice parameter* ($a = 3.155 \pm .001$) and *density* ($D = 19.32 \pm .02$).

THE most accurate determinations of the diameters of fine wires are made in terms of their length and weight. All calculations of efficiency of light emission and of thermionic emission of W wires depend therefore upon a knowledge of their density. Experiment shows[1] that, within the experimental error, these W wires have the same lattice parameter as pure annealed W powder, so that the density of both must be identical. It therefore seemed desirable to attempt to check the value of the lattice parameter of pure W (99.999 percent) which was published recently.[1] That value was obtained in terms of the lattice parameter of NaCl. The W powder, diluted with ten times its volume of wheat flour so as to reduce its opacity to the x-rays, was inserted in one end of a specimen tube. NaCl diluted with its own volume of flour was in the other end. In this way the two diffraction patterns were obtained side by side on the same photographic film.

There was a possibility that the W had not been sufficiently diluted, so that the equivalent centers of the W and NaCl might not have been in the same straight line. This would have made the lattice parameter of W come out too small, thus giving too high a value for the density. A portion of the same lot of W was therefore mixed directly with ten times its volume of NaCl, so that the two diffraction patterns were superimposed.[2] In this way the equivalent centers of the W and of the NaCl were necessarily identical. Measurements of the lattice parameter of W made in this way were therefore free from any possible objection which might have been raised against the previous measurement. Pure Au furnishes a second check. The parameter of 99.999 percent Au previously

[1] Davey, Phys. Rev. **25**, 753 (1925).

[2] Havighurst, Mack and Blake, J. Amer. Chem. Soc. **46**, 2368 (1924).

published[1] gives a density which agrees within the error of experiment with the highest density found for Au by the ordinary methods.[3] Since the admixture of any impurities in gold must necessarily lower the density, this was taken to mean that the published parameter for pure Au was correct. A portion of the same sample of Au was mixed with ten times its volume of flour and inserted in one end of a specimen tube as a calibration standard. A portion of the original lot of W was mixed with ten times its volume of flour and inserted in the other end. The two diffraction patterns were thus obtained side by side. The two metals were both of such high atomic number that any error caused by differences in the equivalent centers of the two must have been negligible.

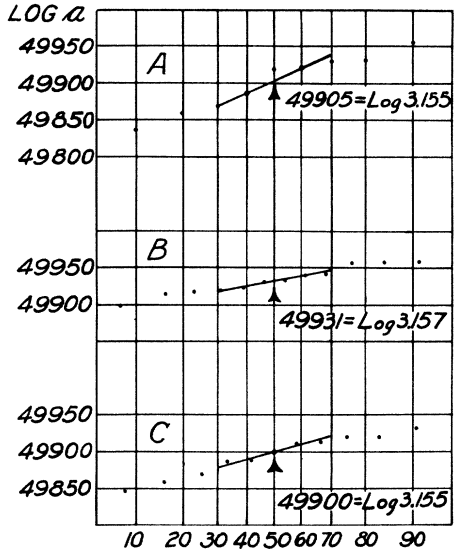

FIG. 1. Probability curves for the lattice parameter of tungsten.
A. W plus 10 parts flour; NaCl plus 1 flour at other end of specimen tube.
B. W plus 10 NaCl; calibration in terms of NaCl.
C. W plus 10 flour; Au plus 10 flour at other end of specimen tube.

Every line in the W diffraction pattern corresponding to an interplanar distance of less than 2.00A was corrected in terms of the calibration pattern on the same film, and each of these corrected readings was made to give a value of the lattice parameter. These results were then plotted on probability paper as previously described[4] to find the most probable values of the parameter. The reproducibility of such a result is ± 0.1 percent for ordinary diffraction patterns. For the data originally pub-

[3] Averkieff, Zeits. anorg. Chem. **35**, 329 (1903).
[4] Davey, Phys. Rev. **19**, 538 (1922).

lished the lines were so fine that the reproducibility was considered to be ± 0.03 percent. The probability curves for films from all three methods are given in Fig. I. It is interesting to note that, in every case, if the curve is lifted or lowered to the level of the point which lies furthest off the curve, the value of the lattice parameter a is not changed by more than 0.001A.

The three methods give for the value of the lattice parameter of W, $3.155 \pm .001$A, $3.157 \pm .003$A, and $3.155 \pm .003$A, where $\pm$ refers to the degree of reproducibility of the data. It therefore seems justifiable to retain the original value 3.155A. The close agreement between the results given by the two methods of using the NaCl for calibration is at first sight surprising. It must mean that when W is mixed with as much as ten times its volume of flour, the dilution is sufficient to provide direct paths through the specimen through which the x-ray beams may travel to and from each particle of W with little or no absorption. Such a result was hardly to have been expected.

This parameter gives a density of $19.32 \pm .02$. As was pointed out in the original paper this is much higher than the values published in Van Nostrand's Chemical Annual and in Groth's Chemische Krystallographie. It is, however, consistent with the value 19.3 published by Fink[5] for rods 3.75 mm in diameter.

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[5] Fink, Trans. Amer. Electrochem. Soc. **17**, 229 (1910).