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Measurement of Stacking Faults in Cold Worked Alpha Brass

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Measurements of Stacking Faults in Cold Worked Alpha Brass*

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Barrett[1] has suggested that stacking faults on the (111) planes should contribute to the broadening of the x-ray reflections from a cold worked face centered cubic metal. Paterson's[2] recent treatment of this problem predicts peak shifts as a result of stacking faults, and hence gives a method for uniquely proving their existence and measuring the probability of occurrence. The (111) reflection moves toward large angle and the (200) reflection toward small angle, so that the separation of these two peaks decreases as a result of stacking faults. For the (222)-(400) pair the opposite effect is predicted.

Filings of 70-30 Brass were pressed into flat briquets and the reflections recorded on a Norelco spectrometer using CoKα. To minimize positioning errors of the sample, all peaks were recorded on a single run, and measurements were made only of the distance between the centers of gravity of the neighboring lines (111)-(200) and (222)-(400). Figure 1 shows the measured peak separations for a cold worked sample given subsequent one hour anneals at various temperatures. The left hand side corresponds to the cold worked filings, and the right hand side to well annealed material. The effect of cold work in the sample is to decrease the (111)-(200) separation by 0.15° and to increase the (222)-(400) separation by about 0.34°.

From Paterson's theory, stacking faults produce a peak shift $\Delta h_3 = \pm\, 3\sqrt{3}\,\alpha/4\pi$ where α is the stacking fault probability. In spectrometer coordinates, the shift in degrees is

$$\Delta(2\theta)^{\circ} = \pm \frac{\tan\theta \cos^2\varphi \, 270\sqrt{3}\,\alpha}{h_3\,\pi^2} \qquad (1)$$

where φ is the angle between the normal to the diffracting planes and the normal to the 111 planes on which the stacking faults exist. Allowing for the fact that stacking faults on a particular set of (111) planes will produce shifts on only 3/4 of the (111) powder pattern reflections, the change in the

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(111) - (200) peak separation for 70-30 brass and CoKα is given by $\Delta(2\theta)_{(111)-(200)} = 6.0\alpha$. For the cold worked brass filings represented by Fig. 1, the reciprocal of the stacking fault probability is then $1/\alpha = 6.0/0.15 = 40$. On the average there is a stacking fault once every 40 (111) planes.

Using log plots[3] of the Fourier coefficients to separate particle size and distortion broadening, average particle size dimensions of about $\langle L_{100} \rangle = 80A$ and $\langle L_{111} \rangle = 180A$ are obtained. It turns out that most of this apparent particle size broadening results directly from the stacking faults, and there is very little true particle size or fragmentation broadening. In cold worked brass there is both particle size and distortion broadening, but the major part of the particle size broadening results from stacking faults. For the high angle reflections the broadening is due mostly to distortion (a root mean square strain $(\langle \epsilon^2 \rangle)^{1/2} = 0.008$), and for the low angle reflections it is due mostly to stacking faults. If slip occurs on (111) by a series of half dislocations, an odd number produces a stacking fault and an even number leaves the proper sequence of planes. If the probabilities are equal, a stacking fault on the average every 40 (111) planes means slip on the average every 20 planes.

References

1. C. S. Barrett, "Imperfections in Nearly Perfect Crystals" (John Wiley and Sons, Inc, New York, 1952) Chap. III.

2. M. S. Paterson, Jour. Appl. Phys., 23, 805 (1952).

3. B. E. Warren and B. L. Averbach, Jour. Appl. Phys. 23, 497 (1952).

Figure Caption

Fig. 1 Peak separations (111)-(200) and (222) - (400) for cold worked 70-30 Brass filings given subsequent 1 hour anneals at various temperatures until well annealed. Radiation CoKα.

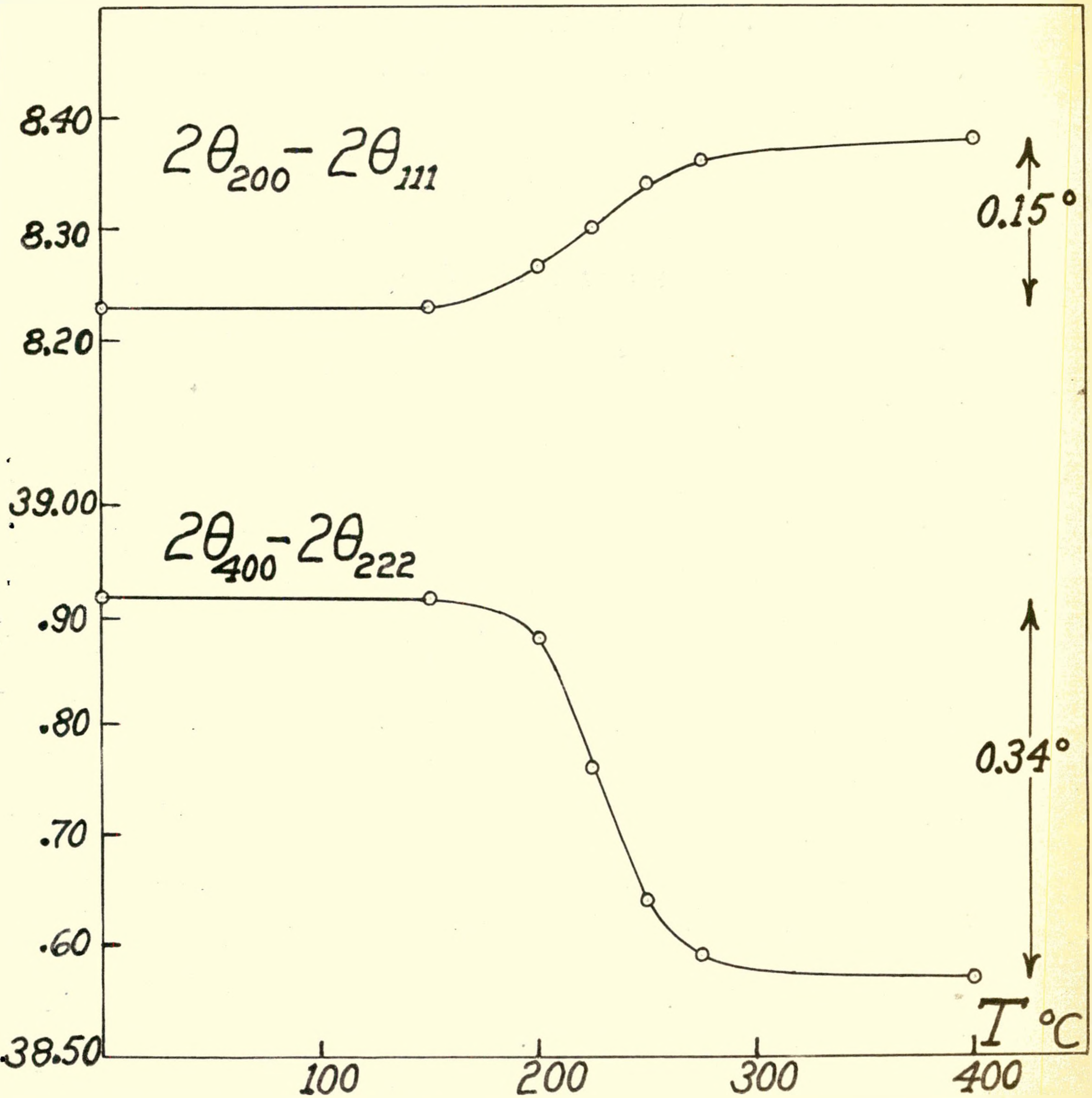
8.40
8.30
8.20
$2\theta_{200} - 2\theta_{111}$
0.15°
39.00
.90
.80
.70
.60
38.50
$2\theta_{400} - 2\theta_{222}$
0.34°
T °C
100
200
300
400

Fig 1.