01 Jan 1990

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Recommended Citation

H. P. Leighly, "Comments On The Papers By Kê And Su," *Scripta Metallurgica et Materiala*, vol. 24, no. 6, pp. 1167 - 1168, Elsevier, Jan 1990.
The definitive version is available at https://doi.org/10.1016/0956-716X(90)90319-C

Scripta METALLURGICA
et MATERIALIA
Vol. 24, pp. 1167-1168, 1990
Printed in the U.S.A.
Pergamon Press plc

COMMENTS ON THE PAPERS BY Kê AND SU

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(Received February 19, 1990)
(Revised March 5, 1990)

Several years ago, Baik and Raj (1) studied the internal friction in an aluminum-5 wt % magnesium alloy containing 90ppm copper. The specimens were heated in air or in vacuum up to the temperature of 550 K. From these experiments, these authors obtained Debye peaks at temperatures of about 520 K for specimens heated in air and about 490 K for specimens heated in vacuum. These results were found to be reversible in that the Debye peaks obtained while heating in vacuum could be shifted to a higher temperature by heating in air and then returned to the original value by reheating in vacuum. The explanation attributed the effect observed after heating in air to the internal oxidation of copper. The authors contended that subsequent heating in vacuum reduced the internally oxidized copper to elemental copper.

Leighly (2) has been able to demonstrate thermodynamically that copper in solid solution in aluminum cannot be internally oxidized. To explain the results obtained by Baik and Raj (1), Leighly (2) pointed out that aluminum heated in air will react with the water vapor present to produce elemental hydrogen according to the reaction:

$$2Al + 3H_2O \rightarrow Al_2O_3 + 6H.$$

The monatomic hydrogen thus created can enter the aluminum very easily when it is annealed at high temperature. Subsequent heating of aluminum containing hydrogen in vacuum will reduce the hydrogen content to a very low level. This explains the results obtained by Baik and Raj (1). These authors agreed with this model (3).

Recently, Su and Kê (4,5), studied the internal friction in well-annealed aluminum single crystals and in similar specimens having a bamboo structure. The effect of plastic deformation introduced by twisting or stretching followed by annealing at 873 K was also studied. They stated, "the effect of gaseous impurities introduced in the process of annealing in air can be neglected" (6). These authors were referring to oxygen and nitrogen but they failed to consider the presence of water vapor in air.

The internal friction as a function of temperature for a well annealed specimen as recorded by Su and Kê (4) is shown in Figure 1, curve 1, and should be compared with the data obtained by Baik and Raj (1) shown in Figure 2. Curve 1, Figure 1 and curves b and c, Figure 2, show two weak peaks. These peaks occur in specimens heated in air. Twisting of the specimens followed by annealing introduces large numbers of dislocations. This is associated with the gradual diminution of the two weak peaks which are replaced by one rather intense peak. This is the result of the preferential trapping of hydrogen in dislocations rather than vacancies. Similarly, from Figure 1, the heating under vacuum removes the hydrogen, with the two weak peaks being replaced by a single strong peak. This means that the removal of the hydrogen from vacancies, either by vacuum annealing or by providing alternative trapping sites in the dislocations, causes the replacement of the two weak peaks by a single strong peak.

In aluminum, the possible presence of hydrogen must be taken into account in any experiments involving point defects.

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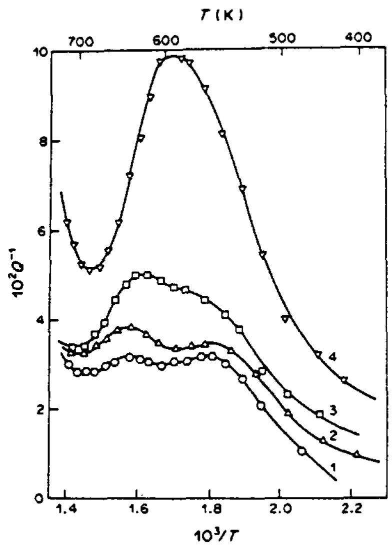

Figure 1, curve 1, Internal friction for a specimen annealed at 858 K for two hours in air. Other curves for similar specimens twisted prior to annealing at 858 K for two hours in air. (After Su and Kê [7]).

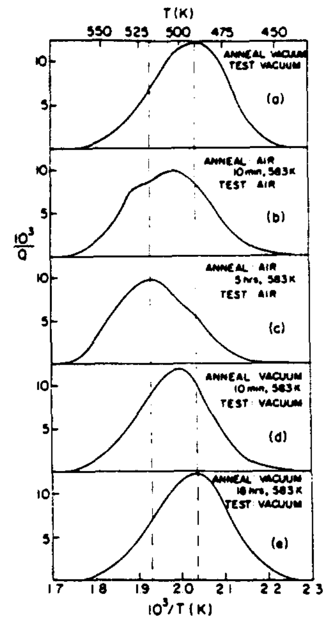

Figure 2, Internal friction of well-annealed specimens of Al-5 wt Mg heated in air and vacuum to 583 K. (After Baik and Raj [8]).

References

(1) S. Baik and R. Raj, Acta Met 30, 499 (1982).
(2) H. P. Leighly, Jr., Scripta Met, 17, 681 (1983).
(3) See addendum to reference 2.
(4) C. M. Su and T. S. Kê, Acta Met 37, 79 (1989).
(5) T. S. Kê and C. M. Su, Ibid 2953.
(6) Reference 5, p. 80 left column, lines 7 and 8 from the bottom of the page.
(7) Reference 5, Figure 1.
(8) Reference 1, Figure 3.