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Effect of Pressure on Creep in Tin*

K. L. DEVRIES, G. S. BAKER, AND P. GIBBS†
University of Utah, Salt Lake City, Utah
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Bending creep of tin is reported with activation volume approximately 8.5×10^{-24} cm³, essentially independent of temperature between 0° and 50°C and pressures to 8 kbar. The pressure dependence of the output of resistance-type strain gauges is given.

INTRODUCTION

HIGH-PRESSURE phenomena in solids have been discussed.[1-3] Christy[4] found the activation volume for creep in single crystal zinc bromide to be $6.3\pm0.5\times10^{-23}$ cm³, slightly less than the $7-7.6\times10^{-23}$ cm³ for diffusion as determined by Seitz,[2] Shewmon,[5] Butcher and Ruoff[6] and DeVries, Baker, and Gibbs.[7] Gibbs[7] found the activation volume for creep in lead (fcc) to be approximately the atomic volume. This is nearly equal to that for self diffusion in lead as determined by Nachtrieb, Resing, and Rice.[8] Tin has a tetragonal structure.

SAMPLE PREPARATION AND EXPERIMENTAL PROCEDURE

Samples were prepared from three grades of tin. The first was of unknown origin, but marked 99.99+%. The second was 99.9+% tin purchased from Morris P. Kirk and Son, Inc. 99.999% tin was purchased from the Cominco Chemical Corporation. An ingot of the tin was rolled to approximately 0.35-cm thickness, after which samples were cut and filed to finished size: 2.4 cm long, 0.275 cm wide, and 0.25 to 0.35 cm thick. Specimens spontaneously recrystallized completely between preparation and use, with final average grain size of approximately 0.1 mm.

The tin samples were loaded under 3-point loading as described for lead.[7] The distance between end supports was 2.1 cm and the center load of approximately 1 kg was applied by weighing.

Two methods were employed to measure sample deformation. A differential transformer and resistance-type strain gauges. The differential transformer was basically the same as that described for use on lead. It had a linear region of approximately 1-cm length and an output of approximately 5 V/cm.

The resistance strain gauges (BLH AB-7 and ABF-32) were bonded directly to the sample with Eastman 910, and so measured directly the strain at the tension surface of the sample. The effect of pressure on strain-gauge output was determined by attaching the strain gauge to a spring steel beam which was bent about a form of known radius of curvature. The beam was secured in this position by a brass wire that was broken at various pressures allowing the beam to straighten out. Noting the strain indication at various pressures gave an indication of the effect of pressure on strain-gauge output. The results of these tests are shown in Fig. 1.

A large transient output of the gauge upon any pressure change was encountered with resistance type gauges. Upon initial application of pressure, the gauges indicated an apparent shortening of the samples, the rate of which decreased approximately exponentially with time. Soft metals such as tin, showed very large effects (apparent transient strains of 0.1 to 0.2% at 10 kbar). The effect was considerably less on brass and very small for steel. The time required for the transient to disappear was often as long as 12 h for tin at 10 kbar and only a few minutes when the gauge was attached to steel under the same conditions. These transients made pressure changes and subsequent rapid strain readings difficult. As an alternative method,

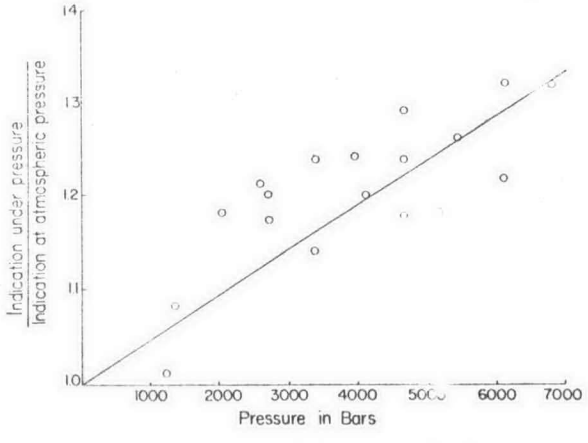

FIG. 1. Pressure dependence of the output of resistance strain gauges (BLH type AB-7 and type ABF-32).

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† Present address: Aerojet General, Sacramento, California.
‡ Address for 1963: Depto. De Fisica, Escola de Engenharia de Sao Carlos, Sao Carlos, Est. Sao Paulo, Brazil.
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