Letters

Surface tension of liquid Pb-Sn alloys

The contact angle and surface tension of lead-tin alloys on fused silica substrates were measured using the sessile drop technique. The apparatus consisted essentially of an evacuated horizontal fused silica tube with a resistance heating furnace on the outside. The working pressure was kept lower than 10^{-5} mm Hg. To reduce the O_2 partial pressure in the silica tube, flushing with purified N_2 was adopted. Degassing of the metal and alloy drops was accomplished by holding in vacuum for 3 h at a temperature just below the melting point before heating to the working temperature. The profile of the drop was photographed through a cathetometer tube on a 35 mm film and measurements were taken from enlarged photographs.

High purity lead and tin metals (better than 99.999%) were used to prepare the metals and alloys for the sessile drops (pure lead, pure tin, alloys containing 30, 50 and 61.9 wt % tin). The substrate was ground and polished commercial fused silica plates. All surfaces were cleaned by degreasing in acetone followed by ether. The metals and alloys used for the drop were in the form of rods about 5 mm long and 2 mm in diameter.

The surface tension of the liquid alloys (γ) was calculated from measurements of the drop

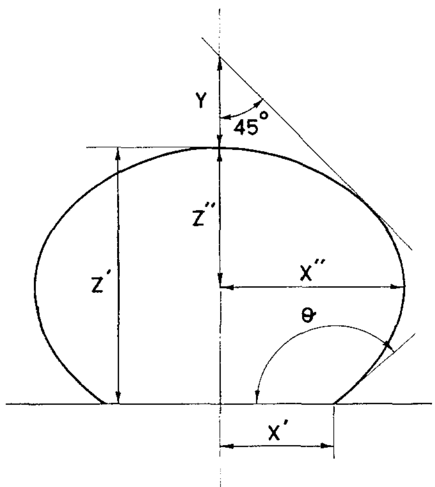

Figure 1 Drop parameters used in calculations.

dimensions shown in Fig. 1 and using Dorseys empirical formula [1]

$$\gamma = g\rho\,(x'')^2 \left[\frac{0.052}{f} - 0.1227 + 0.0481\,f\right]$$

where f is defined as $f = (y/x'') - 0.4142$; g is the acceleration due to gravity; ρ is the density of liquid drop.

Several tests were carried out to check the reproducibility of the measurements and it was found that a scatter of about $\pm$ 5% is obtained in most cases.

The variation of the contact angle with the composition is shown in Fig. 2 for different test temperatures. The pure lead and tin exhibited the usual decrease of contact angle with increasing temperature, but the 61.9 wt % tin eutectic composition and 50 wt % tin alloys showed very little variation.

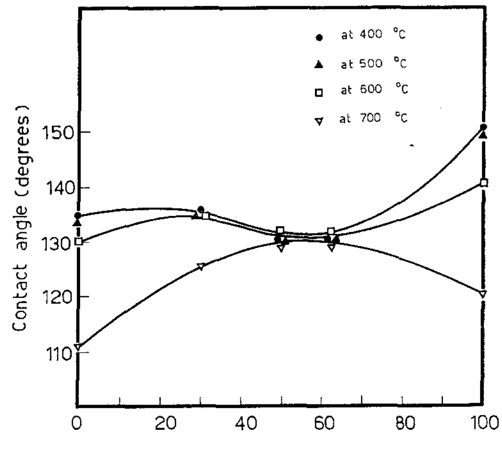

Figure 2 Effect of composition and temperature on the contact angle of (Pb-Sn) alloys.

The surface tension values obtained in this work for pure (Pb) and pure (Sn) vary from (386 to 415) and (657 to 695) dyn cm^{-1} respectively. The results are compared with those reported in the literature [1-4] in Table I. The differences observed are primarily due to the variety of experimental conditions adopted, the nature of the substrates studied, the purity of the metals investigated and the possibility of contamination.

TABLE I Comparison of surface tension values of Pb and Sn-units in dyn cm^{-1}.

	Temperature								Reference
	232	250	327	350	400	500	600	700	
Pb	—	—	—	386	390	400	395	—	present work
	—	—	444	442	438	431	—	—	[3]
	—	—	451	441	443	—	426	—	[2]
	—	—	480	—	463	438	423	—	[4]
	—	695	—	—	670	680	675	657	present work
Sn	531	—	—	522	518	510	—	—	[3]
	621	—	—	556	545	—	526	—	[2]
	566	—	—	—	555	550	540	—	[4]

Fig. 3 shows the variation of surface tension with the composition of the alloys at different test temperatures while Fig. 4 gives a comparison of surface tension of the alloys at the same equivalent temperature above liquidus line. Both figures show a non-linear variation of the surface tension with composition which is indicative of preferential adsorption of one of the components at the surface [5]. The results of Figs. 3 and 4 also show that the surface tension of the eutectic alloy is lower than the surface tension of either the pure metals. Similar results were obtained by Olsen and Johnson [6] for the (Hg-Tl) amalgams where the eutectic alloy showed a minimum surface tension value. At the present, there does not seem to be a satisfactory explanation for this phenomenon and more work is needed in this area.

References

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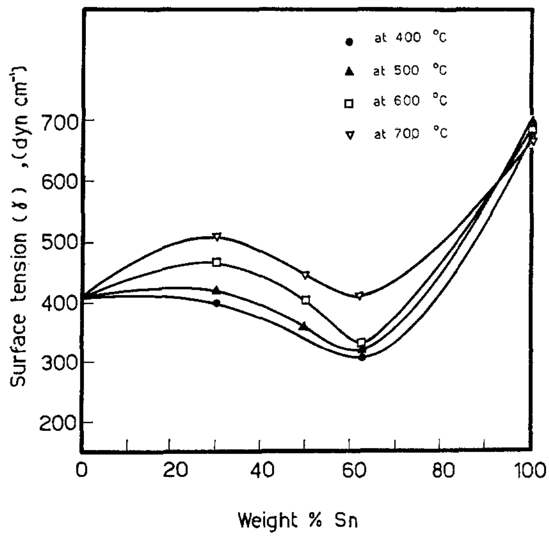

Figure 3 Effect of composition and temperature on the surface tension of (Pb-Sn) alloys.

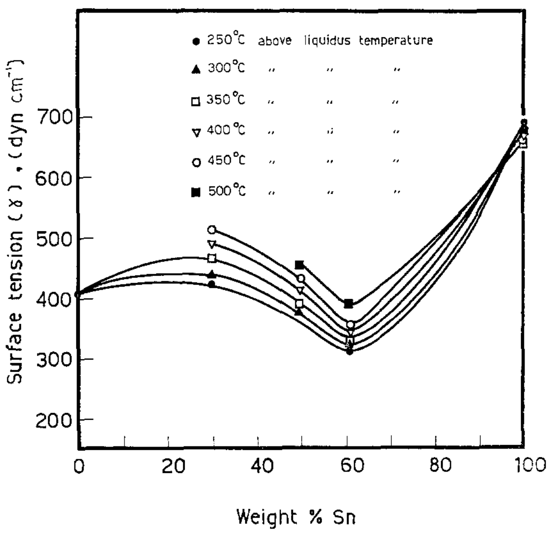

Figure 4 Comparison of surface tension of alloys at the same equivalent temperature above the liquidus line.

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The effect of annealing on fracture toughness, strength and microstructure of hot-pressed alumina

The effect of microstructure on fracture toughness of ceramics is not firmly established in spite of numerous investigations of the influence of both grain size [1-3] and porosity [3, 4]. In particular, reports on porosity are contradictory. Coppola and Bradt [4], using the work-of-fracture method of testing [5], found that up to 10% porosity did not affect toughness of hot-pressed alumina. Simpson [3] using cold-pressed and sintered alumina and a fracture mechanics technique (analytical notched beam test [6]), found that connected porosity reduced the fracture toughness. Only connected porosity was studied because the sintering process did not yield closed porosity until porosity levels dropped below 4%. In addition, the porosity distribution was frequently non-uniform. The work-of-fracture method was also used but some doubt was raised concerning the accuracy of this method when applied to high strength ceramics. Hence, in this work, an analytical technique has been used to determine the effect of closed porosity on fracture toughness of hot-pressed alumina.

Alcoa XA-16 alumina* powder was hot-pressed in graphite dies in vacuum at a pressure of 35 MN m^{-2} for 1 h at temperatures ranging from 1300 to 1450° C, yielding slabs about 30 × 25 × 6 mm^3. About 75% of the powder was treated with isopropyl alcohol prior to hot-pressing to remove surface adsorbed water carefully following the procedure outlined by Rossi and Fulrath [7]. Hot-pressing yielded final densities as shown in Fig. 1.

The hot-pressed slabs were cut into bars 25 × 6 × 3 mm^3 and either tested as-hot-pressed or after annealing in groups of two or three for 3 h at temperatures ranging from 1500 to 1750° C.

When the high density (> 96% T.D.), as-hot-pressed material was annealed, a reduction in density occurred accompanied by an increase in the porosity. The degree of this density reduction increased with annealing temperature and in some extreme cases caused blistering of the material due to the growth of a few very large pores. This increase in porosity did not occur when low density as-hot-pressed material was annealed; instead, a dense (98 to 99% T.D.) body was produced. Immersion of the as-hot-pressed material in dye penetrant indicated that the material whose density increased upon annealing had connected porosity in the as-hot-pressed

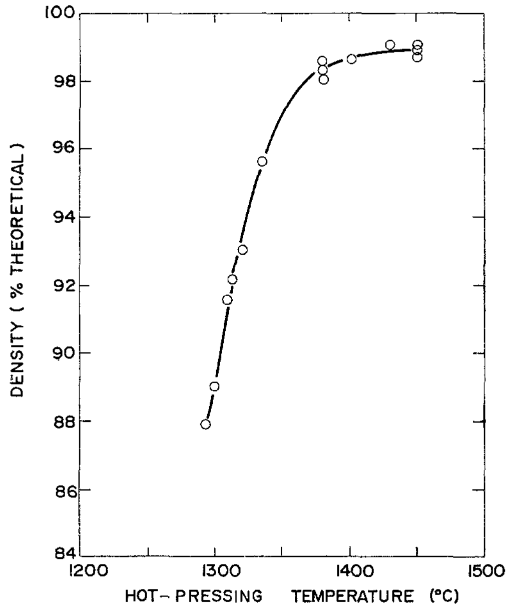

Figure 1 Final density as a function of hot-pressing temperature.

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