

Thermoelectric Power of the Liquid Tin-Lead Eutectic Alloy

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We have measured the Seebeck coefficient of the $\text{Sn}_{0.74}\text{Pb}_{0.26}$ liquid alloy, in the temperature range 190°C – 700°C . The results were compared with those predicted by the Faber-Ziman theory.

The absolute thermoelectric power of the $\text{Sn}_{0.74}\text{Pb}_{0.26}$ liquid alloy (eutectic composition) was measured in the temperature range $190^\circ\text{C} \leq T \leq 700^\circ\text{C}$.

Two couples of Cr-Al leads were used as electrodes, with one pair at each end of the sample [1], which was contained in an alumina boat. The Seebeck e.m.f. was measured by a potentiometer method, either between the Cr or the Al leads. The absolute thermoelectric power (Seebeck coefficient S_x) of the liquid sample is given by

$$S_x = S_1(T) + [\Delta E_1/(\Delta E_1 - \Delta E_2)] \cdot [S_2(T) - S_1(T)]$$

where S_i ($i=1, 2$) is the absolute thermoelectric power of the electrodes, E_i is the Seebeck e.m.f. between them and T is the mean temperature. This relation strictly holds only when ΔT is infinitesimal, but practically it still remains valid up to $\Delta T \sim 10^\circ\text{C}$. In our case $2^\circ\text{C} \leq \Delta T \leq 9^\circ\text{C}$. The advantages of this method are that it avoids temperature measurements which are an important source of errors, and that due to the small gradient, the thermodiffusion process is negligible [2]. To keep a constant concentration, all the experiments were performed under Ar overpressure ($\sim 2 \text{ kg cm}^{-2}$). As it has been remarked [3], little inhomogeneities of the wire can produce spurious e.m.f.s, of about a few microvolts which could invalidate the results. In order to avoid this effect we have changed ΔT , keeping the mean temperature constant. By plotting ΔE_1 against $\Delta E_1 - \Delta E_2$ one can calculate the slope $\Delta E_1/\Delta E_1 - \Delta E_2$. The intercept on the ΔE_1

axis represents these spurious e.m.f.s. It depends on temperature and varies between $-3 \mu\text{V} \leq \Delta E_1 \leq 4 \mu\text{V}$. The reproducibility of the measurements was good. The experimental results are shown in Figure 1.

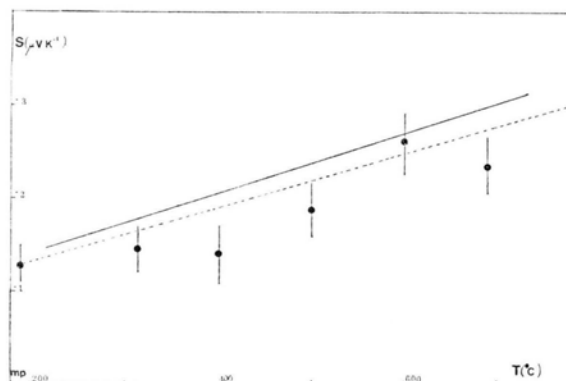


Fig. 1. Thermoelectric power of liquid $\text{Sn}_{0.74}\text{Pb}_{0.26}$ as a function of temperature. ● ● ● Experimental points, — Srivastava model, ---- Nordheim-Gorter rule.

We compared the results with the predictions of the Faber-Ziman theory for liquid alloys [4]. We have assumed that the pseudopotentials are energy independent [5]. We have chosen two different ways to account for the lack of experimental partial interference functions. The first is to apply the substitutional model, choosing the only structure factor equal to the experimental one corresponding to pure tin. The second is to use theoretical structure factors taken from the hard-sphere solution of the Percus-Yevick equation [7]. We tried several

Table 1. Thermopower of the $\text{Sn}_{0.74}\text{Pb}_{0.26}$ liquid alloy at 350°C (in $\mu\text{V K}^{-1}$).

Model	S_s	S_{H-s}	Experimental values
Ashcroft	−0.52	−0.37	−1.5 (this paper)
Heine-Abarenkov	−3.25	−2.75	−1.15
Srivastava (non-parametric) [11]	−3.85	−2.69	(Tougas [12])
Srivastava model potential [10]	−1.93	−1.93	

S_s : Substitutional model; S_{H-s} : Hard-Sphere model.

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model pseudopotentials, due to Ashcroft and Langreth [8], Heine and Abarenkov [9] and Srivastava [10], [11]. The results are reported in Table 1. It is seen that Srivastava's model pseudopotential gives the best fit in this case. This result may be expected in view that the calculation of resistivity and

thermopower of pure Sn and Pb using this model are in excellent agreement with the experimental values, while the other models are not so accurate simultaneously in both quantities. The theoretical results are displayed together with our experimental values in Figure 1.

- [1] C. C. Bradley, *Phil. Mag.* **7**, 1337 [1962].
- [2] N. E. Cusack and S. A. Cusack, *Phys. Chem. Liquids* **5**, 12 [1976].
- [3] J. C. Valiant and T. E. Faber, *Phil. Mag.* **29**, 571 [1974].
- [4] T. E. Faber and J. M. Ziman, *Phil. Mag.* **11**, 153 [1965].
- [5] J. E. Enderby, J. B. van Zytveld, R. A. Howe, and A. J. Mian, *Phys. Lett.* **28A**, 144 [1968].
- [6] V. P. Kazimirov, G. I. Batalin, A. V. Romanova, Ye. L. Ziskind, and V. N. Isay, *Fiz. Metal, Metalloved.* **42**, 501, 1976.
- [7] N. W. Ashcroft and D. C. Langreth, *Phys. Rev.* **156**, 685 [1967].
- [8] N. W. Ashcroft and D. C. Langreth, *Phys. Rev.* **159**, 500 [1967].
- [9] A. O. E. Animalu and V. Heine, *Phil. Mag.* **11**, 1249 [1965].
- [10] S. K. Srivastava, *Phys. Stat. Sol. (b)* **61**, 731 [1974].
- [11] S. K. Srivastava, *Phys. Stat. Sol. (b)* **66**, 93 [1974].
- [12] R. Tougas, *Phys. Chem. Liquids* **2**, 13 [1970].