LIQUIDUS TEMPERATURES OF Hg-RICH Hg-Cd-Te ALLOYS*

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The liquidus temperatures have been measured for ten $(Hg_{1-x}Cd_x)_yTe_{1-y}$ compositions with $0.091 < x < 0.401$ and $0.544 < y < 0.952$. For metal-rich melts with the same x-value, the liquidus temperature increases with y for $0.5 < y < 0.7$. This behavior is attributed to a higher degree of association between Cd and Te than between Hg and Te in the melts.

Key Words: Mercury cadmium telluride, phase diagram, associated solutions.

The liquidus temperatures have been determined by differential thermal analysis (DTA) for the ten $(Hg_{1-x}Cd_x)_yTe_{1-y}$ compositions listed in Table I. The experimental apparatus and procedure were similar to those used previously,[1] except for two modifications; type S (Pt/Pt-10% Rh) thermocouples were used instead of type K (chromel-alumel) thermocouples, and the triple-point-of-water cell and x-y recorder used previously were replaced by a data logger with isothermal, thermally-compensated junctions and a microcomputer to store

TABLE I. LIQUIDUS TEMPERATURES FOR Hg-RICH $(Hg_{1-x}Cd_x)_yTe_{1-y}$ ALLOYS. THE PSEUDOBINARY LIQUIDUS VALUES ARE FROM REFERENCE 1.

Overall x	Overall y	Observed liquidus (°C)	Free volume inside ampule (%)	Mass of Hg (g)	Mass of Cd (g)	Mass of Te (g)
0.100	0.5	733 ± 4				
0.100	0.550	751 ± 3	20	10.344	0.644	5.986
0.100	0.591	773 ± 4	19	10.206	0.636	5.000
0.091	0.648	788 ± 4	22	11.532	0.649	4.380
0.200	0.5	792 ± 3				
0.200	0.544	823 ± 3	23	8.809	1.233	5.862
0.200	0.554	819 ± 3	33	8.724	1.222	5.580
0.200	0.601	849 ± 4	17	9.384	1.311	4.943
0.200	0.952	806 ± 5	32	14.394	2.018	0.581
0.302	0.5	841 ± 3				
0.299	0.544	868 ± 4	19	7.701	1.836	5.847
0.299	0.589	895 ± 4	17	8.094	1.938	5.120
0.404	0.5	884 ± 4				
0.401	0.545	907 ± 4	30	6.465	2.423	5.727

the data. As in Ref. 1, the melting point of antimony
(630.74°C) was used as the temperature calibration point
during each experimental run. A typical DTA curve is shown
in Fig. 1. The measured liquidus temperatures, elemental
masses, and free volumes inside the ampules are included
in Table I. Additional experimental details are given in
Ref. 2.

Because the partial vapor pressures of Hg over the
alloy melts are expected to be much larger than the partial
pressures of Cd and Te,(3,4) the preferential evaporation
of mercury into the ampule free volume alters both the
Te/metal and Cd/Hg fractions. Hence, the actual melt com-
positions at the liquidus are somewhat higher in x and
somewhat lower in y than the values listed in Table I.
The precise melt compositions cannot be calculated from the
masses of the elements and the free volume in an ampule
because of the lack of vapor pressure data for metal-rich
melts. However, based on the composition dependence of
the vapor pressures over the Hg-Te binary melts, the
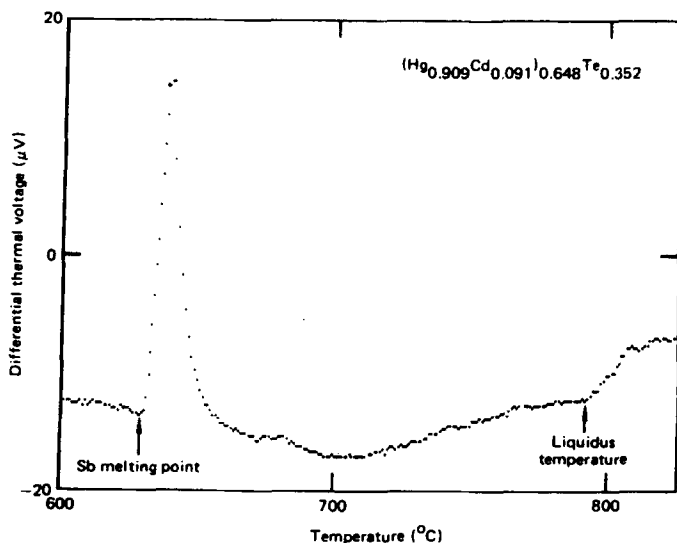corrections to x and y are estimated to be less than

The plot shows differential thermal voltage (μV) on the y-axis (from -20 to 20, with 0 marked) versus Temperature (°C) on the x-axis (from 600 to 800). The sample is labeled $(Hg_{0.909}Cd_{0.091})_{0.648}Te_{0.352}$. Arrows mark the "Sb melting point" near 630°C and the "Liquidus temperature" near 790°C.

Figure 1. Typical differential-thermal-analysis record

-0.005 and +0.006, respectively, for nine of the samples. For the x=0.401, y=0.545 sample, the corrections may be as large as -0.014 and +0.009, respectively, because of the combination of the relatively high temperature and 30% free volume in the ampule.

The major recognized sources of error in the liquidus temperatures are the uncertainty in the temperature measurements and the subjectivity in selecting the proper liquidus points from the DTA curves. Estimates of the un-certainties associated with the temperature measurements were obtained from calibration runs using an ampule con-taining silver as a DTA sample. The calibration runs indicated a maximum discrepancy of 1.5°C between the actual melting temperature of silver (961.93°C) and the value measured relative to the melting temperature of Sb in the DTA apparatus. The DTA signals were recorded at 1°C intervals, which implies an additional inherent uncertainty of $\pm 0.5^{\circ}$C. Thus, the uncertainties arising from temperature measurements ranged from about $\pm 0.5^{\circ}$C at the melting point of Sb to about $\pm 2^{\circ}$C at the melting point of Ag.

In contrast to the behavior of the Hg_yTe_{1-y}(5) and Cd_yTe_{1-y}(6) binary systems, for a given x-value between 0.1 and 0.4, the liquidus temperature of the metal-rich melts increases with decreasing Te-fraction in the range $0.5<y<0.7$. In some cases, the liquidus temperatures are larger by more than 50°C than the corresponding pseudobinary values. This interesting behavior was first noted in Ref. 7. We believe that this behavior is a direct consequence of a higher degree of association between Cd and Te than between Hg and Te in the melts, as suggested by the respective $Cd + Te \rightleftarrows CdTe$ and $Hg + Te \rightleftarrows HgTe$ equilibrium constants.(8-10) That is, the preferential affinity of Te for Cd causes the alloys to become more like CdTe in character as the Te fraction is decreased. Recent calculated values of the liquidus isotherms by Tung et al.(10) are in fair to good agreement with our experimental results. Liquidus temper-atures as high as 500°C have been observed for compositions with less than 1 at. % Cd.(11, 12) A more quantitative analysis of the results in terms of a generalized associated solution model(9) for the ternary system is in progress.

REFERENCES

1. F. R. Szofran and S. L. Lehoczky, J. Electron. Mater.
    10, 1131 (1981).

2. S. L. Lehoczky, F. R. Szofran, and B. G. Martin,
    "Advanced Methods for Preparation and Characterization
    of Infrared Detector Materials," McDonnell Douglas
    Report MDC Q0717, NASA Contract NAS8-33107 (July 1980).

3. J. Steininger, J. Electron. Mater. 5, 299 (1976).

4. J. P. Schwartz, Tse Tung, and R. F. Brebrick, J.
    Electrochem Soc. 128, 438 (1982) and Tse Tung, L.
    Golonka and R. F. Brebrick, J. Electrochem Soc. 128,
    451 (1982).

5. A. J. Strauss, MIT Lincoln Laboratory, Private
    communication, and R. F. Brebrick and A. J. Strauss, J.
    Phys. Chem. Solids, 26, 989 (1965).

6. J. Steininger, A. J. Strauss, and R. F. Brebrick, J.
    Electrochem. Soc. 117, 1305 (1970), and M. R. Lorenz,
    J. Phys. Chem. Solids 23, 939 (1962).

7. S. L. Lehoczky and F. R. Szofran, "Advanced Methods
    for Preparation and Characterization of Infrared
    Detector Materials," McDonnell Douglas Report MDC
    Q0744, NASA Contract NAS8-33107 (September 1981).

8. R. F. Brebrick, T. Tung, C-H. Su, and P-K. Liao, J.
    Electrochem Soc. 128, 1595 (1981).

9. J. D. Kelley, B. G. Martin, F. R. Szofran, and S. L.
    Lehoczky, J. Electrochem. Soc. 129, 2360 (1982).

10. T. Tung, C.-H. Su, P.-K. Liao and R. F. Brebrick, J.
    Vac. Sci. Technol. 21, 117 (1982).

11. A. V. Vanyukov, I. I. Krotov, and A. I. Ermakov, Izv.
    Akad. Nauk SSSR, Neorg. Mater. 13, 815 (1977).

12. K. J. Riley, P. E. Herning, P. R. Bratt, W. H. Konkel,
    G. G. Silvestri, G. L. Whiteman, and A. H. Lockwood,
    Proc. IRIS Detector Conference, 1980, p. 183
    (January, 1981).