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The pressure–temperature phase diagrams of the HgTe and $\mathrm{Hg_{1-x}Cd_xTe}$ systems

The use of $\mathrm{Hg_{1-x}Cd_xTe}$ alloys to produce solid state devices capable of detecting radiation in the infrared ranges is well established. In the production of material which is suitable for device manufacture it has been found necessary to anneal some of the as-grown crystals in suitable Hg-rich atmospheres to achieve the correct electrical properties [1]. Thus, for photoconductive devices which will operate in the 10 to 14 μm range at 77 K, n-type material with carrier concentrations of $5 \times 10^{14}\,\mathrm{cm^{-3}}$ and Hall mobilities of $2 \times 10^{5}\,\mathrm{cm^2\,V^{-1}\,sec^{-1}}$ are required, whereas photovoltaic detectors require a p-type substrate with carrier concentrations of $\sim 10^{17}\,\mathrm{cm^{-3}}$.

Although several workers [2, 3, 7] have studied the closely similar pressure–temperature diagrams for both the binary and ternary systems, there still appears to be considerable disagreement concerning the position of the p ⇌ n intrinsic–extrinsic lines for these materials. It is, therefore, essential to define this transition more closely in order to obtain the correct electrical properties reproducibly.

In an attempt to clarify this situation a series of single and two temperature annealing experiments have been carried out with as-grown materials obtained from both the Bridgman and cast-recrystallization growth techniques. The results of these studies together with a summary of the earlier work on these materials is presented in Fig. 1.

In the case of the binary HgTe system, it would appear that the original intrinsic–extrinsic line proposed by Rodot [4] is still generally valid, although its position at high mercury pressures is somewhat uncertain as the results of Strauss and Brebrick [2] suggest that p-type material can be obtained at temperatures lower than those predicted by Rodot.

The results for the pseudo-binary $\mathrm{Hg_{1-x}Cd_xTe}$ system in the range x Cd 0.12 to 0.22 suggest that the original proposition by Schmit and Speerschneider [3] needs some modification. The present results taken with the earlier ones do not allow us to define the intrinsic–extrinsic line exactly and it is best represented by a band as indicated in Fig. 1. It should be noted that the line proposed by Schmit and Speerschneider represents a high-temperature boundary to the band.

Considering the range of existence of p- and n-type materials, it is apparent that $\mathrm{Hg_{1-x}Cd_xTe}$ $(0.12 < x < 0.22)$ is n-type below 400 to 450° C and 260 to 280° C on the mercury and tellurium saturated solidii, respectively.

Although the precise values of the carrier concentrations will depend upon the exact thermal and crystallographic histories of the specimens, an indication of the mean values which can be expected is given for materials which have been annealed at the temperatures–pressure combinations shown in Fig. 1.

An exact defect model is still needed to explain these intrinsic to extrinsic changes in the binary and ternary systems; however, the present authors suspect that the instabilities which may occur in the sphalerite structure in the ternary system [10] will contribute to the nature of the defects at higher temperatures and mercury pressures.

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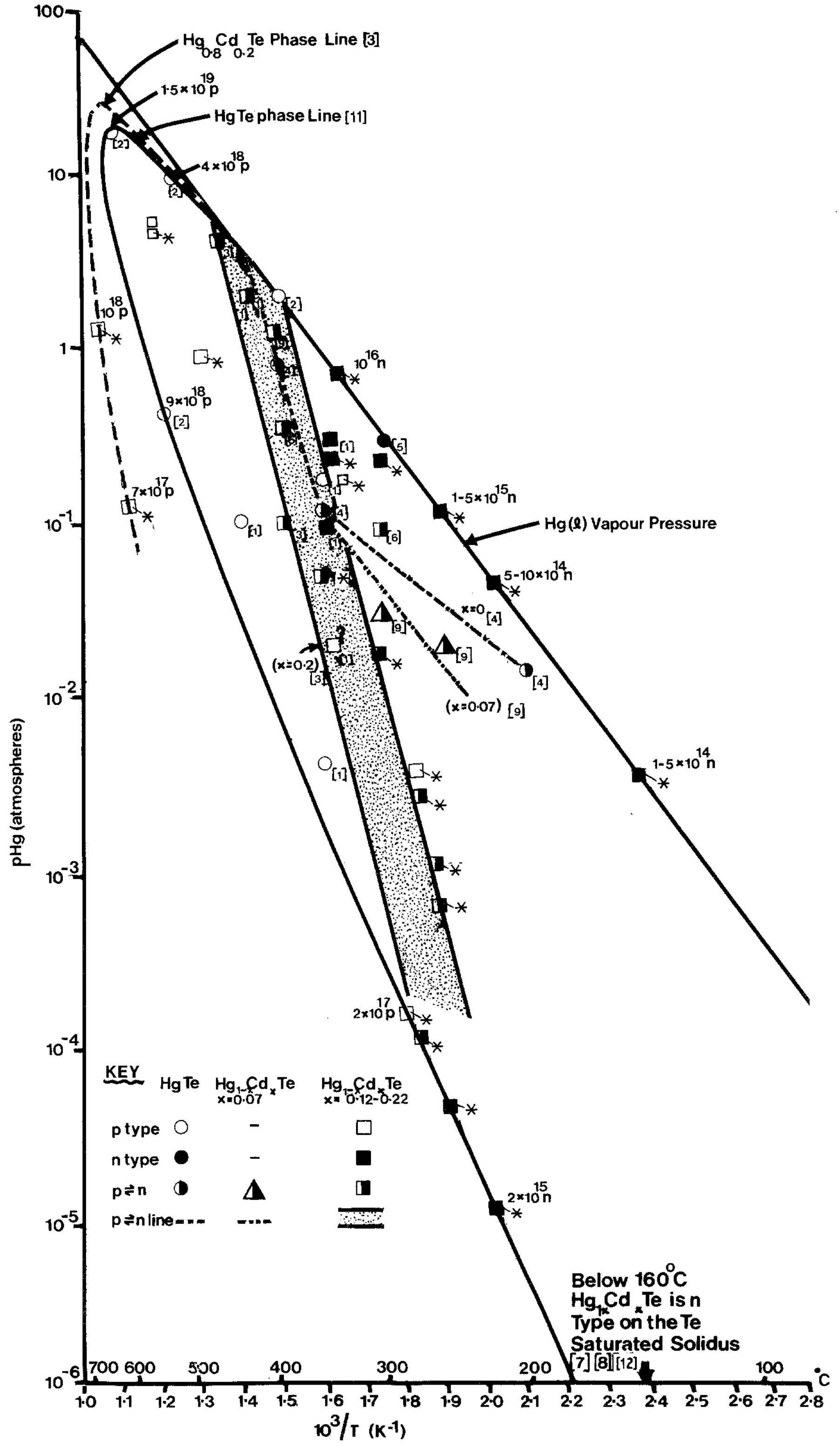

Figure 1 Pressure–temperature diagram for the $Cd_xHg_{1-x}Te$ $(0 < x < 0.3)$ system, showing regions of n- and p-type conduction. $*$: Present results.

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High temperature thermal expansion of ThO_2, MgO and Y_2O_3 by X-ray diffraction

There is an increasing need for knowledge of the physical properties of various oxides at high temperatures because of their importance as refractory materials. As limited data exist in the literature on the high temperature thermal expansion of these materials, the purpose of this note is to report some X-ray diffraction measurements of the thermal expansion of ThO_2, MgO and Y_2O_3 between 500 and 1800° C.

The diffractometer, high temperature furnace chamber, and high temperature cell used in this work have been described previously [1]. The sample powder materials were purchased from Mitsuwa Chemical Company and Wakoh Chemical Company and were of nominal purity: ThO_2, 99.99%; MgO, 99.8%; Y_2O_3, 99.8%. All data were obtained using copper radiation, and a graphite monochromator in the diffracted beam was also used. The chamber was evacuated with rotary and

TABLE I Lattice parameters of ThO_2, MgO and Y_2O_3 at various temperatures

Run no.	ThO_2		MgO		Y_2O_2	
	Temp. (° C)	Lattice parameter (Å)	Temp. (° C)	Lattice parameter (Å)	Temp. (° C)	Lattice parameter (Å)
1	25	5.592	25	4.203	25	10.607
2	614	5.621	603	4.240	619	10.655
3	806	5.636	807	4.253	814	10.671
4	1009	5.649	996	4.262	1007	10.689
5	1211	5.659	1209	4.276	1225	10.710
6	1407	5.670	1416	4.287	1408	10.731
7	1603	5.687	1601	4.299	1601	10.757
8	1782	5.698	1739	4.308	1764	10.773
9	25	5.601	25	4.216	25	10.608
10	508	5.619	502	4.234	543	10.645
11	714	5.633	715	4.245	704	10.664
12	905	5.641	906	4.259	917	10.681
13	1096	5.653	1108	4.271	1092	10.697
14	1323	5.664	1317	4.281	1303	10.722
15	1504	5.681	1525	4.296	1511	10.743
16	1711	5.693	1704	4.304	1685	10.767
17	1769	5.698	1765	4.308	1757	10.772