Melting Point and Transformation of Pure Chromium

by D. S. Bloom, J. W. Putman, and N. J. Grant

SEVERAL recent determinations of the melting point of pure chromium have been reported which give values of 1845°C,[1] 1892°C,[2] 1930°C,[3] 1860°C,[4] and 1890°C.[5] Because of this wide spread of values, it appeared desirable to make one additional attempt to obtain a more accurate, reliable figure. Bloom and Grant[3] recently reported a phase transformation in chromium; it was desired to check this, too, in the course of checking the melting point.

To accomplish this, a much higher purity chromium was required. Electrolytic chromium containing about 0.5 pct O was crushed to a finer size and was then annealed in highly purified, dried hydrogen at 1375°C for 100 hr. This treatment produced chromium with about 0.008 pct O, 0.002 pct N, and negligible carbon. The balance of the impurities was 0.3 pct Fe, 0.03 pct Si, 0.004 pct S, and less than 0.001 pct Mo. This chromium was melted in a stabilized zirconia crucible under prepurified argon, using induction heating. Temperature measurements were made with annealed wolfram-molybdenum thermocouples and a Leeds and Northrup Speedomax Recording Potentiometer. The thermocouples were annealed for 1 min in hydrogen at a temperature of about 2400°C.

Each leg of the thermocouple was immersed in an ice-water mixture using mechanical connectors to the lead wires. The thermocouple tip was immersed in the molten chromium in a zirconia protection tube which introduces an error of about 3°C as a temperature drop through the walls of the tube. The weight of chromium was about 183 g. The dimensions of the melt in the crucible were about 1.25 in. diam x 2 in. high. The tip of the thermocouple was held about ½ in. from the bottom of the crucible. Two new thermocouples were used with the above set-up giving the results shown in Table I.

Since this chromium is purer than that used by Greenaway, Johnstone and McQuillan,[1] by Carlile et al.,[4] and other investigators,[2, 3] it is believed to be the more accurate. Thermocouple aging effects which are believed responsible for the high value of 1930°C[3] were avoided in this work. This value of 1903°C is correct to about ±10°C.

The right hand column lists the temperature of the $\alpha \rightarrow \beta$ transformation on heating and the $\beta \rightarrow \alpha$ on cooling.[3] A sample curve is shown in Fig. 1. The value so determined is 1840°C ± 15°C. Fig. 1 gives adequate evidence that there is a transformation in chromium at high temperatures.[3]

Table I. Melting and Transformation Temperature Data

Thermocouple	Melting Point		α (b.c.c.) $\leftrightarrows$ β (f.c.c.) Transformation	
	Emf (mv)	Temperature, °C	Emf (mv)	Temperature, °C
No. 1	4.65 (c) *	1886		
	4.77 (h) †	1903	4.38	1848
	4.70 (c)	1894	4.15	1815
	4.80 (h)	1908	4.30	1836
No. 2	4.77 (c)	1903		
	4.83 (h)	1912		
	4.80 (c)	1908	4.43	1855
	4.82 (h)	1911	4.38	1848
Average	4.77	1903	4.33	1840

* (c) = cooling.
† (h) = heating.

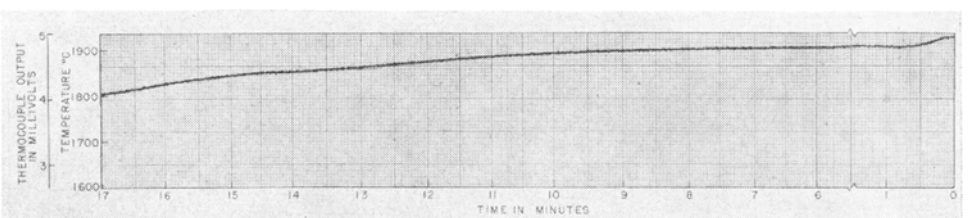

Fig. 1—Cooling curve of chromium indicating solidification at 4.80 mv (1908°C) and transformation at about 4.43 mv (1855°C). Note deletion of 4 min of the curve during solidification period.

References

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[2] J. W. Putman, R. D. Potter, and N. J. Grant: The Ternary System Chromium-Molybdenum-Iron. *Trans.* A.S.M. (1951) **43**, p. 824.

[3] D. S. Bloom and N. J. Grant: Chromium-Nickel Phase Diagram. *Trans.* AIME (1951) **191**, p. 1009; JOURNAL OF METALS (November 1951).

[4] S. J. Carlile, J. W. Christian, and W. Hume-Rothery: The Equilibrium Diagram of the System Chromium-Manganese. *Journal* Inst. Metals (1949) **76**, p. 169.

[5] G. Grube and R. Knabe: *Ztsch. Elektrochemie* (1936) **42**, p. 793.

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