Antiferromagnetism of Manganese

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Measurements of resistance and thermoelectric power of Mn show anomalies near the Néel temperature. A thermocouple of degassed Mn and nondegassed Mn gives evidence of a Mn transition at 100°K.

SHULL and Wilkinson[1] have reported a transition in Mn from an antiferromagnetic to a paramagnetic state at 100°K. This temperature is known as the Néel temperature. One would expect changes in the electrical properties in the neighborhood of this transition, but no measurements of resistance or thermoelectric power have been reported for this temperature range. Because α-Mn is brittle, it cannot be obtained in wire form, and precise electrical measurements are difficult, but it is possible to soft-solder Cu wires to electrolytic chips, and this permits rough measurements to be made. Chemical analysis of the electrolytic chips showed a purity of over 99.9 percent, and the samples were degassed by heating for 3 hours at 450°C in a vacuum.

The measurements showed a broad resistance minimum at about 90°K, and at liquid nitrogen temperature (77°K) the temperature coefficient of resistance was still negative. The thermoelectric power of Mn against Cu changed sign at about 93°K. When a Mn specimen was used which had not been degassed, this change of sign occurred at about 85°K. The progressive increase of this temperature was also observed on a single specimen as the specimen was subjected to successively higher degassing temperatures between 100° and 300°C. The lower reversal of sign of the thermoelectric power of the nondegassed specimen suggests that it may have a lower Néel temperature. Potter and Huber[2] made measurements of the Mn lattice parameter as a function of H_2 content, and found that the parameter increased as much as 0.2 percent on absorption of H_2. With the increased lattice parameter one would expect a lower Néel temperature, since there is evidence that with a large enough increase in lattice parameter Mn would become ferromagnetic.[3]

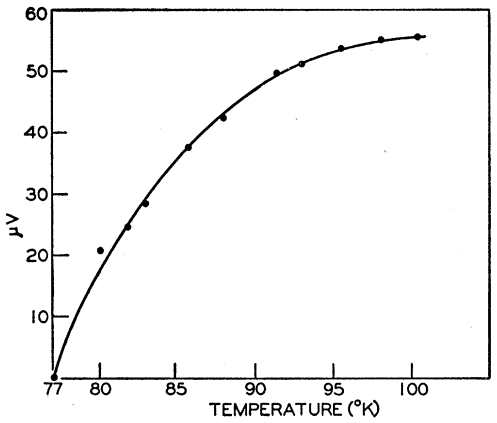

FIG. 1. Emf plotted against hot junction temperature for a thermocouple of degassed Mn *vs* nondegassed Mn with cold junction held at 77°K.

The change of sign of the thermoelectric power in the Mn-Cu couple depends on the properties of Cu as well as those of Mn, so it cannot be used as an indication of the Néel temperature. There is no reason to identify the broad resistance minimum with the Néel temperature either. However, the use of a thermocouple made of degassed Mn and nondegassed Mn seems much more promising. The assumption is made that there is a thermoelectric power at liquid nitrogen temperature because the degassed Mn is in a more highly ordered state, being farther from its transition temperature. Then with the cold junction held in liquid nitrogen one would expect the emf measured on warming the other junction to become constant after reaching the higher Néel temperature (that of the degassed specimen). Above this temperature the *effective* hot junction must move along the specimen so that it remains at the transition temperature. This behavior is found experimentally, as can be seen in Fig. 1, which shows that the emf levels off at about 55 microvolts near 100°K. This temperature is in good agreement with that of Shull and Wilkinson, which was also obtained with a degassed sample.

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[1] C. G. Shull and M. K. Wilkinson, Revs. Modern Phys. **25**, 100 (1953).

[2] E. Vernon Potter and Ralph W. Huber, Phys. Rev. **68**, 24 (1945).

[3] R. M. Bozorth, *Ferromagnetism* (D. Van Nostrand Company, Inc., New York, 1951), p. 341.