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Technical Note

Effect of Cold Work and Annealing on the Thermoelectric Power Of Molybdenum

by J. Howard Kittel

THE properties of the metal molybdenum have been the subject of recent investigations[1, 2] which have included studies of the changes that occur in the metal when it is annealed after having been cold worked. Most of the data which have been reported have pertained to only one aspect of annealing, that is, the conditions under which recrystallization has been observed. The process of recovery which may precede recrystallization does not appear to have been investigated, and it is the purpose of this note to report observations on the recovery process in cold-worked molybdenum as determined by changes in the thermoelectric power which occur as the metal is annealed.

The measurements were made on commercially pure molybdenum wires which, after annealing at 1035°C in dried hydrogen for 1 hr, were swaged to give a series of reductions up to a maximum of 84.5 pct. The variously cold-worked wires were then annealed in dried hydrogen for periods of 16 hr at progressively higher temperatures from 200° to 1000°C, with a final annealing treatment of 70 hr at 1100°C. After each annealing treatment the thermal emf's were determined against a length of original unworked material that had received the initial hydrogen annealing treatment. The difference in temperature between the hot and cold junctions was maintained at about 75°C, and the thermal emf's were measured with a potentiometer that could be read to 0.01 microvolt.

Fig. 1 shows the thermoelectric power (dE/dT) in microvolts per °C between annealed and cold-worked molybdenum as a function of the degree of cold work. The effect of annealing is shown in Fig. 2. The general shape of the curves in both figures is similar to results which have been obtained for copper.[3] It was observed that after annealing at temperatures as low as 200°C recovery was well under way. The rapid changes in thermoelectric power observed near 900°C are probably associated with recrystallization, since such a relation has been observed with copper.[3] Beyond 900°C the thermal emf's changed in polarity, indicating that from this point on the specimens were more highly annealed than the standard. Annealing treatments could not be given at temperatures higher than 1100°C due to limitations of the furnace, and it is evident that, since equilibrium values of thermoelectric powers were far from having been attained, temperatures considerably higher are required to fully anneal molybdenum.

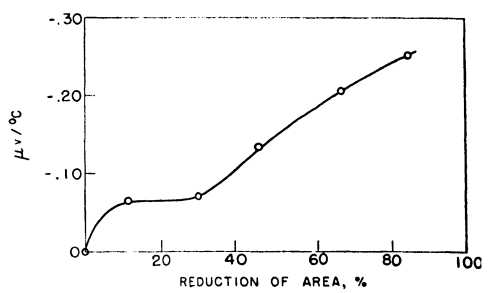

Fig. 1—Effect of cold work on the thermoelectric power of molybdenum.

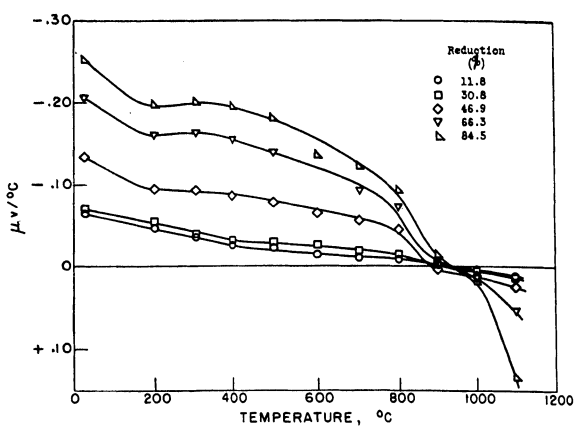

Fig. 2—Effect of annealing on the thermoelectric power of cold-worked molybdenum.

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