# Diffusion in Platinum-clad Molybdenum

## LIMITATIONS ON HIGH-TEMPERATURE APPLICATIONS

Platinum-clad molybdenum has for long been of interest in the glass industry and, in a rather more restricted field, as a material of construction for the grids of thermionic valves. In the glass industry, platinum coatings are found to impart limited but useful protection from oxidation to molybdenum stirrer rods, electrodes and mandrels, and thus make it possible to take advantage of the high strength of molybdenum at temperatures up to 1300°C or more. In thermionic valves, the platinum coatings provide, on the strong grid supports, a surface having a high electron work function.

In both these applications, the useful life at high temperatures may be limited as a result of diffusion between the platinum and the molybdenum. An X-ray study of the phases present in the alloy layer formed during diffusion was reported in an anonymous article by the staff of the General Electric Company in 1959 (1), but this appears to have received little attention and is not quoted in a more recent metallographic study by K. Kirner, of the Max-Planck Institute for Metal Research, Stuttgart (2).

The earlier work was restricted to relatively short heating periods at temperatures up to 1300°C. Kirner has heated specimens for periods up to 500 hours at 1400°C and claims to have observed a previously unknown phase in alloys in the molybdenum-rich part of the system. This phase is only stable over 1400°C and is termed the $\eta$ phase. It is very hard, the Reichert microhardness instrument recording a value of 1000 kg/mm² $HV_{25}$ on the phase formed in argon-arc melted alloys annealed for 100 hours at 1400°C. The phase decomposes after annealing at 1200°C for 30 hours. These results indicate that earlier work by Raub and others on the equilibrium diagram is incomplete and further theoretical work would thus be welcome.

Kirner includes in his paper a large number of microhardness traces across diffusion bonds, both in molybdenum rods sprayed with platinum coatings and in pressure-welded cylinders. The total width of the diffused zone was found to grow according to a $\sqrt{t}$ law.

The sprayed-on coatings, applied by an argon-plasma spray, formed a good joint after vacuum annealing and were dense, with only very few visible inclusions. Adhesion, however, was poor before annealing. They afforded good protection at temperatures up to 1200°C, but above 1400°C the brittle $\eta$ phase which is formed tended to cause coatings to peel. The formation of this phase might, however, be inhibited by interposing a layer of stable refractory, such as alumina, between the two metals.

A new approach, found to be suitable for electronic applications, has recently been suggested by the Brown Boveri company (3). This is to apply an electrodeposited coating of rhenium to the molybdenum to act as a barrier layer, adhesion of the rhenium to the molybdenum being accomplished by annealing in hydrogen or in vacuum at a high temperature. It is implied that no alloying occurs between rhenium, which melts at 3167°C, and platinum at temperatures below the melting point of platinum.

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### References


1 Anon. .. *GEC Journal*, 1959, **26**, (1/2), 82

2 K. Kirner *Metall*, 1962, **16**, (7), 672

3 M. Deák *Brown Boveri Rev.*, 1961, **48**, (7), 394