EVAP-4 Technical Note

Evaporation of Tungsten in the Evap-4 mini e-beam evaporator

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Introduction

The Evap series mini electron evaporators offer an economical and compact alternative to larger electron beam hearths for evaporating metals. For moderate melting point (<2000°C) such as gold, silver and chromium, the evaporant can be loaded in a Mo crucible. For materials with higher melting point (>2,500°C) such as tungsten, molybdenum and niobium the higher temperature conditions required for evaporation is achieved by evaporating from a rod. The Evap Series enable evaporation from 2mm and 4mm diameter rods. For tungsten, W the combination of high melting point (3410°C) and low vapour pressure makes this material particularly challenging to evaporate. In this tech note we present details of the evaporation of tungsten using the EVAP-4 with a specially designed filament and shaped rod design which maximises heating at the tip.

Experiment

In order to increase the power density and thus the temperature of the tungsten rod, a shaped rod design with a narrowed tip is used. The standard 4mm diameter and 28mm long rod was shaped according to the dimensions in table 1 and the photo in Figure 1. The rod was then fitted into the Mo collar inside the HV pocket and secured with a grub screw to the EVAP-4 body.

	Diameter (± 0.5)	Length (± 1)
Top section	1.9 mm	10mm
Middle section	1.4mm	6mm
Bottom section	4.0mm (as supplied)	12mm

Table 1 Dimensions of the shaped W rod

Figure 1 Shaped Tungsten rod (left) and standard Tungsten rod (right)

To increase the electron current and thus the power transferred to the tungsten rod a circular filament which surrounds the rod is employed (shown in Figure 2). The circular filament should be positioned so that the filament wire is aligned level or just below the tip of the rod then secured using the grub screw. The EVAP-4 was then mounted on an upward facing port of a HV chamber and pumped down.

Figure 3 Evap-4 mounted on a 30deg angle port

Figure 2 Evap-4 Pocket 2 loaded with the W rod and circular filament

Results

The deposition rate was measured using a quartz crystal microbalance at a working distance of 70mm for the shaped W rod using the circular filament. Figure 4 shows the stable evaporation of W with rates up to 0.07Å/s in both power control and ion flux control mode. The operating power is limited to 160W by the filament current limit, which is a pre-set hard limit (of 1.3A) programmed into the power supply to protect the filament from burnout. There is good agreement between the Rate vs Power relationship in both power control and flux control modes above~ 135W. There is some discrepancy between the control modes for very low deposition rate <0.02A/s, which corresponds to powers < 140W. Therefore, it is recommended that flux control is suitable for control of W evaporation but only for powers >140W. It should be noted that relationship between flux and deposition rate will vary with the rod diameter, so should be tested for each new rod variation.

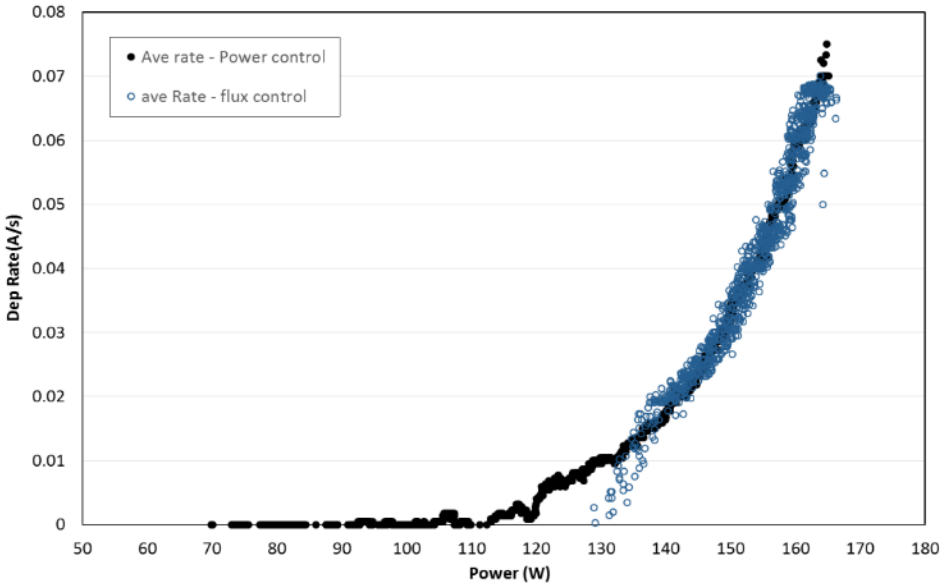

Figure 4 Deposition Rate vs power for shaped W rod in the Evap-4

Conclusions

Evaporation of tungsten is possible using the circular filament in the EVAP-4 using a shaped rod with a reduced tip diameter (in this case 1.9mm) to increase the power density in the rod. The 4mm diameter rod base is retained to allow the rod to fit easily into the HV pocket. The evaporation rate is low reaching a maximum of 0.075A/s at 160W at a working distance of 70mm but could be increased by reducing the working distance. Flux control has been shown to be a stable means to control the W evaporation.

This work shows that evaporation of high melting point materials can be achieved in a compact low power mini evaporator.