PO1052

Sn Thin Film Deposition using a Hot Refractory Anode Vacuum Arc

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A Hot Refractory Anode Vacuum Arc (HRAVA) starts as cathodic arc, in which the plasma jets and macroparticles (MPs) generated by cathode spots are deposited on the anode, which is heat by the arc. When the anode is hot, all material is re-evaporated from the anode forming a plasma plume which expands radially from the arc gap and which has little MP contamination. The HRAVA was sustained between a water-cooled Sn cathode and a graphite or W anode, with a gap h of 10 or 15mm, for times up to 180s, and arc current I=60–175A. The cathodes were 10mm in height (in Cu shielded cup) and either diameter D=60mm (and were used with a W anode with D=60mm and height 10mm) or D=30mm (and used with a D=32mm and height 9 or 15mm graphite anode). A mechanical shutter controlled the deposition onset and exposure duration (15s). The distance from the arc axis to the substrate (L) was 80, 110, or 125mm. Film thickness was measured with a profilometer. MPs on the coating surface were examined by optical microscopy.
For L=110mm, I=175A, h=9mm and D=30mm cathode, the deposition rate V_{dep} increased with time to a peak of ~0.84μm/min, and then decreased to a steady state of ~0.69μm/min. This peak was observed for all I≥80A and was earlier and higher for larger I and thinner anodes. The peak was explained by MPs deposited early on the cold anode surface and their subsequent evaporation when the anode was sufficiently hot. When a balance was achieved between material impingement and evaporation at the hot anode the deposition rate approached its steady-state level. The peak didn't appear with D=60mm cathodes—in that case with I=175A, V_{dep} monotonically increased with time from ~0.5 to ~3.0μm/min. The MP density decreased with current, e.g. with a D=30mm cathode from 37mm^{-2} at I=80A to ~17mm^{-2} at I=175A. These MP densities were larger than that measured with Cu cathodes (~1-2 mm^{-2} at I=175A with a W anode). Presumably this is because Sn is a low melting temperature material with a large cathode spot MP generation rate.

Keywords
Vacuum arc
refractory anode
film deposition