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SIMULTANEOUS MEASUREMENTS OF MICROCRATER EMISSIONS OF CURRENT AND COPPER LIGHT AT THE CATHODE OF A MOVING ARC

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INTRODUCTION

Numerous data have been published in the past pertaining to the erosion rate of various metal in an arc and the energies of the erosion products^{1,2}. The size of the arc footprints or the motion of the arc spots have been studied using photographic techniques, and the size of the craters has been used to estimate the current per crater and the current density^{3,4}; the micro-arc current has also been measured directly⁵. However, the mechanism of erosion is still unknown. In particular does the erosion result from a continuous evaporation during the life of the emitting site or does it result from an explosion of the site?

We present, here, simultaneous measurements at the cathode surface, of the fluctuations of the cathode current resulting from the initiation and extinction of the current from individual emitting sites and of the fluctuations of the light associated with the deexcitation of the erosion products; these results should contribute to a better understanding of the emission/erosion phenomenon at the cathode.

EXPERIMENT

The experimental arrangement is shown on Fig. 1. The 200 A arc is driven, in air at atmospheric pressure, by a transverse magnetic field between two parallel electrodes. The electrodes are separated by 2 mm; they are made of aluminium. The wire probe, made of copper, is embedded in the cathode. It is 0.3 mm in diameter. It is insulat-

Fig. 1 Experimental arrangement.

ed from the electrode except at its end where it is soldered to it as shown on Fig. 1. It is terminated in the form of a loop so as to inductively couple the element of arc current incident on the probe surface to a small secondary coil⁵. The light emitted during the passage of the arc at the surface of the probe and corresponding to neutral and ion copper transitions is monitored using a microscope reflecting objective and a spectrometer.

RESULTS AND DISCUSSION

A typical result is reproduced on Fig. 2. The probe signal, dI/dt , gives the rate of change of the total current emitted by the copper wire probe surface⁵. The PM signal corresponds to the fluctuations, at the copper wire probe surface, of the light associated with a transition of the copper ion, Cu I 2193 Å.

As both the anode and cathode rail-electrodes are made of aluminium all the copper light emission comes from the probe surface and we may compare it

with the dI/dt signal from the probe. In fact the two signals are very similar both in duration and structure. Both the increases and decreases in the emission of light are simultaneous with those of the probe current; furthermore the high frequency fluctuations in the current associated with the initiation and extinction of individual emitting sites is also a characteristic of the light emission indicating that the emission of light is indeed associated with individual sites on the surface and not with the bulk of the plasma above the surface. Correlation of the two signals using a Biomation recorder and a PDP 11 computer has been carried out. Preliminary results indicate that the two signals are simultaneous within a μs . Correlation with a better time resolution is necessary in order to determine if the emission of light is associated with a continuous evaporation of copper during the life of the emitting site or results from an explosion of the site at the time of extinction of the current.

It is also of interest to note, on Fig. 2, the small current precursor labelled (a), 5 μs in duration, which precedes the high increase of arc current. We propose that this current may be asso-

Fig. 2 Time evolution of the light emitted from the copper probe surface (Cu I, 2193 Å) and of dI/dt , the rate of change of the probe current.

ciated with the electrical polarization³ of the dielectric oxide surface by ions from the discharge as illustrated on Fig. 3. Such a polarization is necessary to induce field emission from the cathode surface³. In our case, the total charge, Fig. 2, would be approximately 10^{-7} coulomb for a probe

Fig. 3 Ion deposition on the oxide layer inducing the current precursor.

surface of 10^{-3} cm^2 . If this interpretation is correct, then the sharp increase in current, following this 5 μs field build-up across the oxide layer, would correspond to a breakdown through the layer and the emission of copper light would originate from the evaporation or explosion products. A small emission of copper light is also observed, on Fig. 2, simultaneously with the current-precursor. It may be associated with the existence at the cathode surface of a copper vapor layer which, according to Leycuras⁶, would be responsible for the high current-density injection of electron in the plasma.

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