Characterization of the liquid surface deformation resulting from a pin-water discharge using free-surface synthetic Schlieren

F.Dyson[1], E. Moreau[1], T. Orriere[1]

[1] *Institut PPrime, Université de Poitiers, ISAE ENSMA, CNRS, UPR 3346, Poitiers, France*
mél: fredric.dyson@univ-poitiers.fr

This study deals with a three-dimensional measurement of the water surface during pin-water plasma interaction. Different discharge regimes are studied, from onset corona to stable glow by applying a slow triangle waveform. The effect of different liquid conductivities on the deformation of the liquid electrode is also studied.

Plasma discharges in contact with liquids generate reactive species which drive a wide range of useful chemistries for relatively low energy input. Thus, plasma-liquid interactions have gathered a lot of attention in many areas of research [1]. The reactive species created in the gas phase must react with the liquid phase before they recombine and no longer contribute to the desired chemistry. Understanding the interface could provide useful insight for optimizing this. The liquid electrode in many configurations is deformed, by the electric field, ionic wind or other phenomena, which will modify the electric field and the discharge. Few papers have studied experimentally the shape of the interface. Using the free-surface synthetic Schlieren (FS-SS) method detailed in [2], it is possible to measure the shape of the liquid electrode in three dimensions.

Our reactor consists of a tungsten needle (r = 100 µm) placed 2 mm above the centre of the water contained in a cubic glass cuvette ($30x30x30 \, mm^3$). A platinum wire is placed in the water for grounding and a slow triangular wave is applied to the pin. The conductivity of the solution is varied from 0.2 to 10.0 $mS.cm^{-1}$ by adding KCl. For the FS-SS measurements, light is shone through a motif situated above the water and reaches the lens of the camera placed below the cuvette. Shown in figure 1 is the height of the free-surface with a conductivity of 1 $mS.cm^{-1}$ at 1.7 kV.

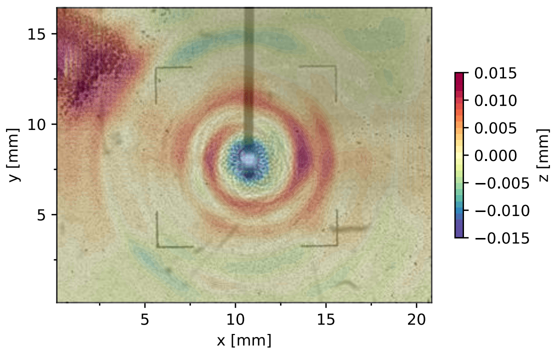

Figure 1: Height map of the water surface during unstable glow of 1 mS.cm−1 at 1.7 kV and 2.5 mA.

Capillary waves originate from the centre and propagate outwards with a wavelength of approximately 1.8 mm. In the top left corner, bubbles formed from electrolysis perturb the measurement. Omitting this, the surface reaches a maximum height of 13 µm and a minimum of 12 µm. During the positive half cycle, a Taylor cone appears at onset voltage, but soon after the surface is pushed inwards due to the presence of ionic wind. During the negative half cycle, the surface is pushed down with a wider depression than during positive voltage.

[1] Bruggeman, P. J. et al. Plasma Sources Sci. Technol., **25**, 053002 (2016).
[2] Moisy, F., Rabaud, M. & Salsac, K. Exp Fluids, **46**, 1021–1036 (2009).

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