LOW VOLTAGE MICROPLASMA GENERATION IN CONDUCTING LIQUIDS AND THEIR MEDICAL APPLICATON

Lucas Schaper, Mark Muir, Fred. J. Currell and William G. Graham
Centre for Plasma Physics, Queen's University Belfast, Belfast, BT7 1NN, Northern Ireland, UK

Plasma production in liquids has been investigated using a wide range of experimental setups and different kinds of liquids. Among those, discharges operating in water have drawn considerable interest[1]. The predominant setup in this environment is a pin to plate discharge created with pulsed applied voltages of between 10 and 100 kV in low conductivity water. This leads to multiple micro-channel breakdown plasmas, similar to the corona discharges in high pressure gas plasmas. Disease treatment in vivo gave rise to the exploration of plasmas in conducting liquids. It has been found that those have the ability to ablate tissue in electrosurgical operations[2] and, when operated at the right conditions, do not cause nerve stimulus.

Here studies on the formation of a micro-plasma in a 0.9%w/v saline solution are presented. Single voltage pulses of negative polarity and magnitudes of up to 350V are applied to a coaxial electrode setup with a cylindrical centre electrode of 0.5mm diameter. It is observed that the electrical signals show different phases within an applied pulse. Immediately after voltage increase an electrical double layer is formed around the centre electrode followed by ohmic heating which leads to a phase transition of the liquid surrounding electrode and forms a vapour layer. The initial formation phases are highly reproducible while evolution of this vapour layer as well as subsequent plasma formation within this layer show shot to shot variation. Analysis is performed by using current-voltage waveforms and time dependant emission measurements. Shadowgraphy, in combination with an ultra fast ICCD camera, allows for exploration of the behaviour during and after the discharges.

The plasma production results in a highly reactive environment containing a number of species, e.g. radicals and UV radiation, which are significant for applications in medicine. A study of the influence of those species on cells in comparison to established treatment methods, especially x-ray radiation, is on-going..

1. M. A. Malik, A. Ghaffar, and S. A. Malik, “Water purification by electrical discharges,” Plasma Sources Sci. Technol., vol. 10, pp. 82–91, 2001
2. K. R. Stalder, D. F. McMillen and J. Woloszko, „Electrosurgical plasmas“, J. Phys. D: Appl. Phys., vol. 38, pp. 1728-1738, 2005