Characterization of plasma discharge in single gas bubbles in water

Patrick Vanraes

Supervisor: Christophe Leys

I. Introduction

Electrical discharge in the gas phase has been intensively studied and applied in industry. The last decade, also interest in applications of electrical discharge plasma in or in contact with liquids has been growing. Experiments show that interaction of plasma with water leads to the production of UV-radiation, shock waves, reactive radicals, ions and molecules. Many chemical reactions can be initiated this way [1]. Therefore, water treatment has been proposed as one of the possible applications of plasma discharge in or in contact with water. A common choice for the setup is a pin-to-plate electrode system submerged in water. The high voltage applied to the electrodes can be DC-, AC- or pulsed voltage.

In spite of the increased research in this area of plasma physics, few is known about the initiating mechanism and development of plasma discharge in pure water. One proposed theory is that plasma is created in the water by means of bubble generation due to heating of the water [1]. Beside this, an alternative approach is to introduce gas or vapor bubbles in between the electrodes submerged in water in order to generate a plasma inside the bubbles. The mechanism of this so-called bubble discharge is poorly understood as well. The presented research wants to fill this gap in understanding by the investigation of pulsed plasma discharge in single gas bubbles in water.

II. Method

Pulsed voltage from -12 kV down to -18 kV with a rise time below 10 ns was used. Argon or helium bubbles were produced by a constant gas flow through a capillary underneath the pin-to-plate electrode system. In the first setup, the vertical position of the bubble during electrical discharge is not controlled. The waveforms of the voltage and current during discharge were measured to investigate the time dependency of the discharge. The spectrum of the light emitted during the bubble discharge was measured to identify the different generated species.

III. Results

The current and voltage waveforms showed two types of bubble discharge were possible: direct spark discharge and delayed spark discharge. The occurrence of each type of discharge is believed to be dependent on the vertical position of the bubble during discharge. The spectrum was dominated by spectral lines of zinc and copper. Both metals originate from the brass electrodes.

IV. Conclusion

In order to understand the two types of bubble discharge, the bubble position during discharge needs to be controlled. Corrosion of the electrodes seems to play an important role during discharge. Further research is required to see the influence in plasma chemistry of more inert electrodes.

References

[1] Shih, K.-Y. and Locke, B. R., *Chemical and Physical Characteristics of Pulsed Electrical Discharge Within Gas Bubbles in Aqueous Solutions*, Plasma Chemistry and Plasma Processing 30(1): 1-20, 2010.