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Electric and Dielectric Properties of Dielectric Barrier Discharge (DBD) Plasmas in Water by using Silicon Diodes for Alternating Current (SIDAC)

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1. Introduction

In this study, DBD plasma has been generated directly in water using a cylindrical reactor submerged in water and an inexpensive circuit with ten devices called Silicon Diode for Alternating Current (SIDAC). The SIDACs were used as a voltage trigger. When applied voltage meets or exceeds breakover voltage of the series connecting SIDACs, these SIDACs will switch from a blocking state to a conducting state. Then, a step change in voltage are created, as the bubble formed an electrical breakdown instantaneously takes place within the bubble. Conventionally, charge accumulation on dielectric layers induces the choking effect and then terminates the discharges [1]. On the other hand, SIDACs switching characteristics could also cause discharge termination but it can differ from those in the conventional DBD [2]. Thus, the characteristic of such DBD should be studied sufficiently when the characteristic is governed by two switches: the SIDACs and the dielectric layers, and also governed by synchronization of the bubble formation time and switching time of SIDAC. In this study firstly the electrical characteristic of the DBD plasma was investigated, then the progress and reactivity of the DBD plasma in bubbles in water were observed using an ICCD camera.

2. Silicon Diodes for Alternating Current (SIDAC)

SIDAC or Silicon Diodes for Alternating Current is a bidirectional switching device designed for direct interface with the power line. When applied voltage meets or exceeds its breakover voltage (V_{BO}), the SIDAC will switch from blocking state to conducting state. The conducting state will continue until the main terminal current drops below the holding current (I_H). If the number of SIDACs in series connection is N, the breakover voltage of this connection will be increased to N times, but the holding current (I_H) is kept the same as single.
In this study, we used ten SIDACs (Model No. K1V38 (W), Shindengen Electric Mfg.Co.Ltd). The breakover voltage of this series connection is increased up to 3600 ~ 4000 V. When this connection is switched on, a sharp change of up to 4000 V in applied voltage with a rise time of several hundred nanoseconds will be generated [3].

3. Experimental setup and result

The experimental setup for DBD bubble plasma in water is shown in figure 1. A cylindrical copper electrode filled by ultra-pure water was located inside a tiny inner quartz tube. This electrode works as a high voltage electrode. These were located concentrically inside an outer quartz tube. There is a number of 0.5 mm diameter holes on the wall of the outer tube. When working gas is blown into tap water through these holes, a number of bubbles are formed. A wire with PTFE insulator set on the bottom of a water tank and water will work as grounded electrode. The discharge gap is the area between inner tube and outer tube and inside the bubbles surrounded by water.
The experimental result (figure 2) shows that DBD have been efficiently generated corresponding to every switching time of SIDACs.

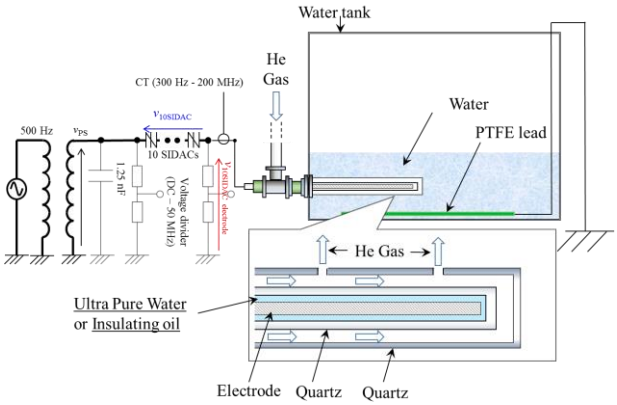

Fig. 1 Experimental setup for DBD plasma in water

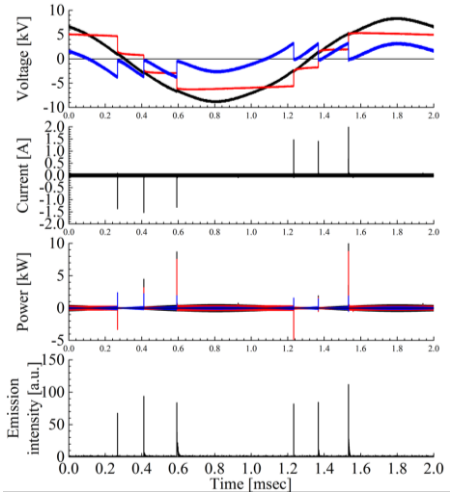

Fig. 2 Discharge waveform in one cycle of applied voltage

4. References

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