Topic number

Influence of water temperature on stability of three dimensional atmospheric plasma using water-dielectric multi layer electrode

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In this study, the development of discharge method using water dielectric multi layer electrode were carried out in order to improve the stability of three dimensional atmospheric discharge plasma. This electrode is composed of the glass container which include the pure water as an insulator put on the metal electrode. By the interaction between temperature dependency of the dielectric constant of the water and electric discharge, it is possible to easily generate the atmospheric pressure Ar plasma of three dimensional shape. The structure and dynamics of discharge structure of atmospheric plasma was drastically change with the increase of water temperature. This plasma is suitable for plasma treatment of three dimensional shaped objects, fruit and agricultural products.

1. Introduction

The atmospheric discharge technique using the water dielectric multi layer electrode [1] can generate three dimensional shaped atmospheric plasma to which be useful for various application. In this technique, the water temperature has the important role for the phenomena of discharge (Fig.1(a)-(c)). This electrode is composed of metal electrode and glass container which involve the water. The localization of atmospheric discharge arises by un-uniformity of the electric field around the electrode surface. Then, the water around the localized discharge in the container is heated by the strong electric field, and the dielectric constant of same place decreases in comparison with neighbour area. As a result, the localized discharge is moved to the neighbour area, where the dielectric constant is larger than previous discharge place and it is easy to discharge. According to the above effect, it seems to be possible to stably generate the atmospheric plasma in the complicated shaped electrode like the flask shape (Fig.1(d)) [2]. In order to clarify the role of water temperature on atmospheric plasma generated by water dielectric multi layer electrode, the dependence of water temperature on the atmospheric discharge condition using water dielectric multi layer electrode was observed.

2. Experimental setup and discussion

The experiment was carried out using coaxial water dielectric multi layer electrode using strait shaped cooling pipe with constant temperature system. The water temperature was controlled from several to 70 °C. The Ar gas (1 atm in pressure and 3 L/min in flow rate) and ac high voltage (10kHz, 9kVp-p) was applied between inner and outer electrodes. The pattern of the electric discharge along inside surface of inner glass tube was observed by exposure photographing using digital camera. The pattern of discharge changed with increase of water temperature shown in Fig.2. In the case of 1.5 °C, filamentary discharge structure was generated on the inner surface of glass tube (Fig.2(a)). With the increase of water temperature, the uniform atmospheric discharge was generated (Fig.2(b)-(d)). In the case of 70 °C, it was observed that the filamentary discharge structure moves at high speed in the inner glass tube by the high shutter speed observation of 1 [ms], and moving speed was 200-500 [mm/s].

3. References

[1] Tatsuya Misawa, Nobuya Hayashi, Japan patent JP6083093B, PCT/JP2012/079297.

[2] Tatsuya Misawa, et al., Frontier of Applied Plasma Technology, Vol.6, No.1, pp.1-5(2013) (ISSN: 1883-5589).

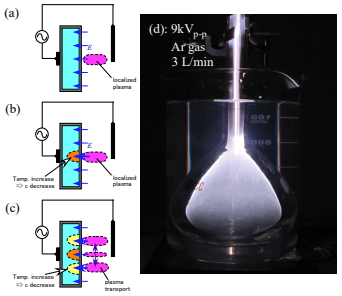

Fig.1 Schematic and typical discharge of water dielectric multi layer electrode

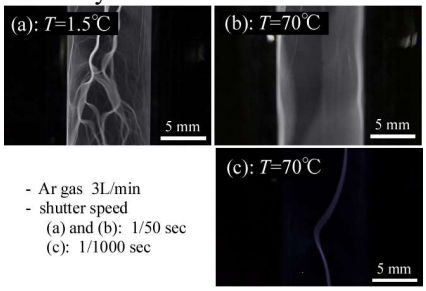

Fig.2 Dependence of water temperature on discharge. (a): T=1.5°C, (b): T=70°C, (c): T=70°C and 1 msec.