2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Development of Large-Area, Wide Gap Dielectric Barrier Discharges with Pre-Ionization Electrodes for Uniform Material Processing

Kazuya Sugiyama[1], Akihisa Ogino[1], Naohisa Kawamura[2], Masaaki Nagatsu[1,3]
[1]Graduate School of Integrated Science and Technology, Shizuoka University,
[2] Kumeta Manufacturing Co. Ltd.
[3]Research Institute of Electronics, Shizuoka University
sugiyama.kazuya.17@shizuoka.ac.jp

1. Introduction

Recently, the atmospheric pressure plasmas attract attention in various industrial fields. Especially, atmospheric pressure non-equilibrium plasma can supply various active species by the collision of a high energy electron with neutral particles under low temperature environment without any pumping system. Generally, the non-equilibrium plasmas generated under atmospheric pressure, such as atmospheric pressure plasma jet (APPJ) and dielectric barrier discharge (DBD) were widely used. For large area treatment, the parallel plate electrode type DBD is desirable. However, uniformity of plasma discharge is a big issue for practical application. In this study, we developed the large-area, wide gap parallel plate electrode type DBD device with pre-ionization method[1)] and presented experimental result of the spatial uniformity of large-area DBD plasmas.

2. Experiment Methods

Figure 1 shows a schematic diagram of DBD apparatus, which consists of four Cu wire electrodes covered with quartz tubes for the pre-ionization and two parallel plate electrodes for main discharge, where the edge of electrodes was curved to avoid any local discharge between two main electrodes. The flat surface area of parallel plate electrodes was 182 x 32 mm^2, and the distance between the parallel electrodes was varied from 5 to 10 mm. The surface of lower plate electrode was covered with a polytetrafluoroethylene (PTFE) sheet with a thickness of 1 mm, which plays a dielectric barrier sheet between main discharge electrodes. Uniform pre-ionization DBD plasma was first ignited around four pre-ionization electrodes by applying a high voltage V_{pre} between the Cu wire electrodes and lower plate electrode. Then, the main DBD can be generated between main discharge electrodes by applying out-of-phase high voltage V_{main} between the Cu wire electrodes and upper electrodes. The applied voltages of V_{main} and V_{pre} were rectangular or sinusoidal wave at the frequency of 1 kHz. The waveforms of applied voltage and current were measured with a high-voltage probe Tektronix P6015A and Pearson current monitor. In addition, the uniformity evaluation of the discharge was carried out using heat sensitive paper (see Fig. 1).

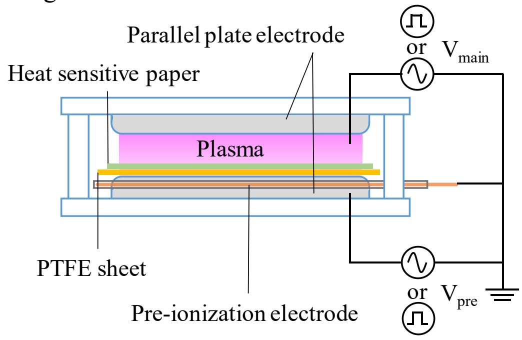

Fig.1. Schematic diagram of DBD apparatus.

3. Result and Discussion

Figure 2 shows typical discharge patterns of DBD plasmas taken by putting the heat sensitive papers on the PTFE sheet above the lower electrode. We compared the discharge patterns of DBDs for 90 s by applying high voltages sinusoidal and rectangular waves at the same frequency of 1 kHz and the same applied voltages of V_{pre} =9 kV$_{p-p}$ for pre-ionization discharge and V_{main} =19 kV$_{p-p}$ for main discharge. It is clearly seen that the discharge pattern in the case of sinusoidal wave looks like dot-pattern along 4 pre-ionization electrodes, which means filament-like discharges. On the other hand, it looks very uniform pattern over the entire electrode surface in the case of rectangular wave. The difference of discharge patterns was mainly attributed to the timing between the pre-ionization and main DBDs with sinusoidal and rectangular applied voltages.

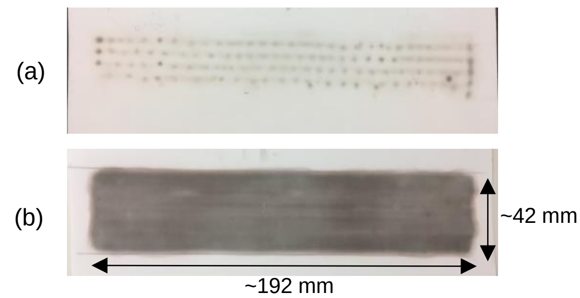

Fig. 2. Discharge patterns of DBD plasmas ignited by (a)sinusoidal and (b)rectangular applied voltages, respectively.

Acknowledgement

This work was supported in part by Grant-in-Aid for Scientific Research (No. 17H02804) from JSPS and collaborative research with Kumeta Manufacturing Co. Ltd.

References

[1] M. Nagatsu, K. Sugiyama, I. Motrescu, et al., *J. Photopolym. Sci. Technol.* (2018) in press.