Self-Rotating Discharge using a Pattered Dielectric Area in Ambient Air and Potential Application in Materials Surface Modification

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I. SUMMARY

In this work, in order to produce the self-rotated plasma regularly and stably in ambient air, we have proposed novel atmospheric pressure (AP) plasma devices with a dielectric pattern, that is, the metal plate surrounded by a dielectric layer. The effects of dielectric on the edge of the electrode on the behavior of self-rotation discharge were examined using a high-speed camera. Furthermore, we exhibit that the proposed AP air plasma reactor can uniformly treat large areas of material surfaces by employing linearly patterned dielectric. In order to confirm the effect of the self-rotating plasma for water treatment, conventional representative plasma treatment methods such as atmospheric pressure plasma jet and pin-to-liquid discharge were also compared.

II. EXPERIMENTAL SETUP

Fig. 1 shows the schematic diagram of the proposed AP air plasma reactor and experimental setup employed in this study. In the plasma reactor, a powered electrode consists of a conductor area of a copper disk with a diameter of 20 mm and a dielectric area coated on the edge of the copper disk. A sinusoidal voltage with a peak voltage of 10 kV and a frequency of 27 kHz was applied to this electrode. Indium tin oxide (ITO) glass was used as the counter electrode in an electrically floating ground state, and the distance between the powered and counter electrodes was fixed at 6 mm.

III. EXPERIMENTAL RESULTS

The self-rotating plasma behaviors in ambient air controlled by the patterned dielectric area at the edges of planar electrodes have been investigated for application in large-area surface treatment. To verify the effect of the dielectric pattern on the movement of plasma, a small area containing the dielectric pattern in the powered electrode was monitored using a high-speed camera.

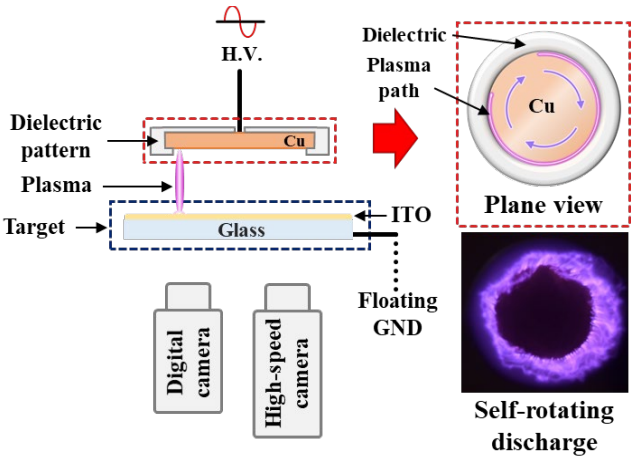

Figure 1: Schematic diagram of the experimental setup and optical images of self-rotating discharge according to the dielectric patterns.

As a result, the plasma was observed to be repeatedly generated at one location instead of moving continuously. Based on the experimental observation, the detailed mechanisms of self-rotating streamer discharge are under study and will be discussed in detail.

Furthermore, we demonstrated that the proposed AP air plasma reactor using linear patterned dielectric could be used to treat large areas uniformly of materials surfaces such as ITO glass, fluorine-doped tin oxide glass, semiconductor, and water surfaces. The detailed characterizations of surface treatment by the proposed self-rotating discharge method using water contact angle, scanning electron microscope, atomic force microscope, UV-vis spectrophotometer, conductivity meter, and hydrogen ion exponent meter are under study and will be discussed in detail.

REFERENCES

1. H.-S. Tae, C.-S. Park, G.T. Bae, H.-K. Lee, D.Y. Kim, “Atmospheric pressure plasma device,” U.S. Patent 11 011 352, May 18, 2021.