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Development of Low-Temperature Dielectric Barrier Discharge (DBD) System for Cost-Effective Atmospheric Pressure Plasma Treatment

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Various low-temperature plasma-systems have become an effective tool and reliable key technique in improving properties and performances of materials for numerous applications. Primarily, the plasma treatment of materials focuses on surface modification[1], disinfection and food decontamination[2], and seed performance and crop yield[3] for modern vegetables and fruit farming. In this report, the low-cost custom-built DBD system was characterized to explore on its potential as a cost-effective system that is designed to investigate the effects of plasma-material interactions for various types of materials, particularly solids, thin films, and liquids.

The custom-built DBD system in this report was made of two identical watch glasses with a diameter and thickness of 10-cm and 5-mm, respectively. A 3-D printed PLA-based frame was installed between the glasses to maintain a minimum working distance of ~1-mm. The thickness of the frame can be varied to manipulate the working distance in the future. The ambient air and the nitrogen gas was used to facilitate plasma ignition.

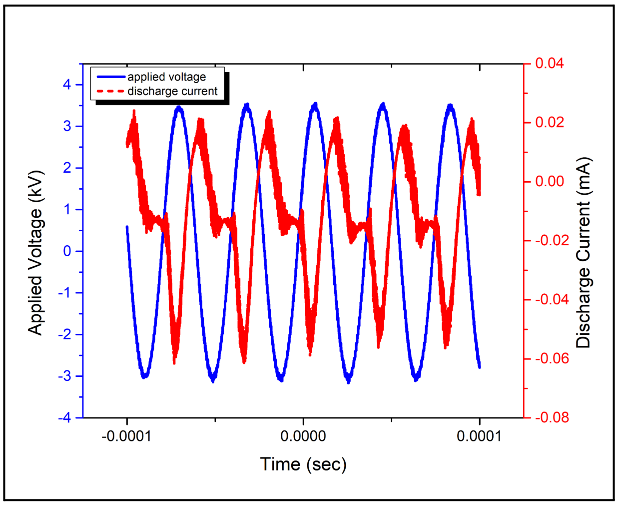

Figure 1. Current-voltage waveform of the plasma in the custom-built DBD system

Electrical characterization of the system's plasma discharge was employed using the oscilloscope. The depicted waveform in figure 1 is typically observable in DBD systems[4]. It can also be regarded that the system has a capacitive behavior.

The voltage and current igniting the plasma were also measured at ±3.5kV and 0.02mA, respectively.

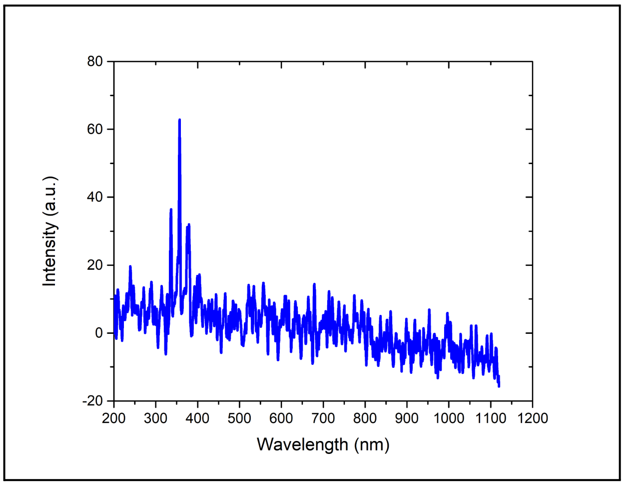

Figure 2. OES spectra of the DBD system in air and N2 atmospheric pressure.

The optical emission profile of the plasma discharge was characterized by an optical emission spectrometer (OES). Several O2 and N2 species were noticeable as the appearance of the high-intensity peaks depicted between 200 to 400 nm. In particular, distinct peaks at 340 nm and 380 nm are associated with N2 species while 309nm and 357nm are associated with OH and O2 species, respectively[5]. After plasma species diagnosis, initial application of plasma-material interactions on 98% Al films were initially conducted. A notable change in characteristic in the surface energy was observed; further optical characterization of the treated films were employed.

References

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