Influence of oxygen content on the characteristics of DBD plasma actuator

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The aerodynamic performance of an *AC* powered dielectric barrier discharge (DBD) plasma actuator immersed in pure oxygen and also in O_2 + noble gas mixtures is presented in terms of actuator's discharge structure and momentum coupling to the surrounding gas. At various gas pressures the impulse imparted to the freely-moving actuator body and its transient motion as a function of the applied voltage from 8-24 kV at f = 200 Hz is determined using laser interferometry. The present *E/N* results show that with increase of oxygen content the momentum coupling is better, especially in the negative species dominated forward discharge phase.

Understanding of plasma chemistry and collision dynamics of species in non-thermal plasmas produced in a DBD plasma actuator under the influence of time-varying applied voltages has been the focus in recent years for optimizing the actuator's performance at various geometries and operating regimes for aerodynamic flow-control [1]. The natural presence of electronegative O_2 in the ambient air forms negative ions, and also forms positive ions more easily than the N_2 in the discharge. We have investigated the actuator's performance by varying O_2 content in the mixture of O_2 + noble gas, and using 25 μm diameter wire exposed electrode (see Fig. 1) instead of conventional flat electrode [2]. As shown in Fig. 2, discharge is produced twice and quenched twice per AC cycle applied between asymmetrically placed wire electrode exposed to the surrounding gas and an encapsulated electrode.

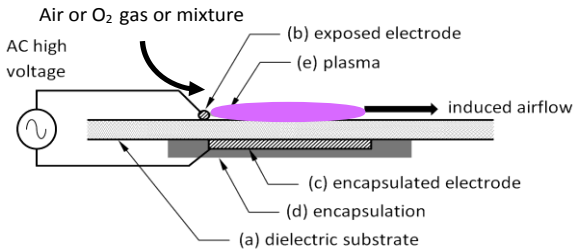

Figure 1. (Top) A schematic of a DBD plasma actuator with highly asymmetric electrodes set-up.

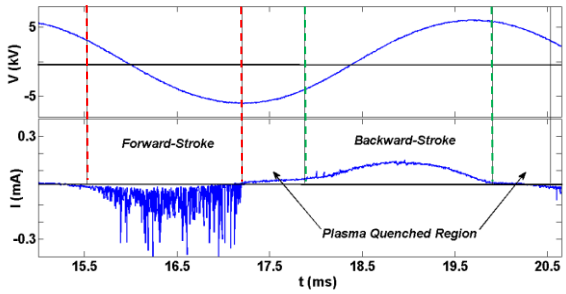

Figure 2. Voltage and current profiles of a DBD discharge with 25 μm diameter exposed-electrode at 6 kV of $V_{AC}(t)$ for the above geometry.

The use of wire exposed electrode shows improvement in the uniformity of discharge, especially during the positive going voltage half cycle as shown in Fig. 2, and in the momentum coupling compared to the conventional flat electrode [2]. We present the DBD plasma actuator body velocity (v), determined using laser interferometry, with respect to the discharge during each *AC*-half-cycle as a function of applied voltage. The plasma exerted force is followed by the negative force due to drag from surrounding gas on the actuator surface during plasma quenched phase are shown in Fig. 3. Most importantly the negative oxygen ions are a key element in producing plasma actuator's unidirectional net aerodynamic force even though the actuator is inherently AC device with no net charge transfer in either direction due to the presence of the dielectric barrier.

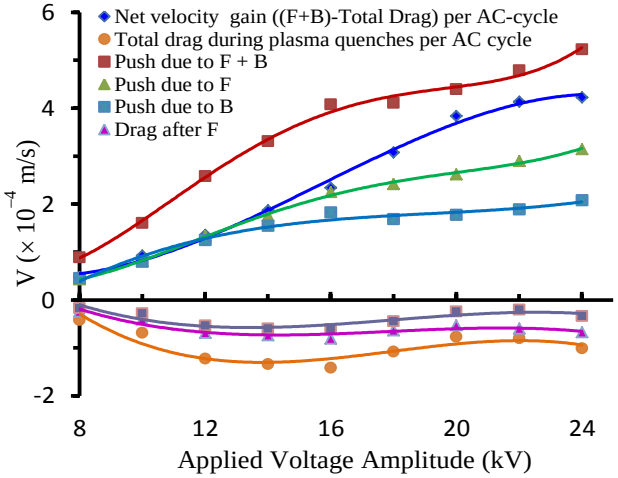

Figure 3. DBD plasma actuator velocity as a result of forward (F) and backward (B) discharges and drag during plasma-quenched phase in oxygen at atmospheric pressure as function of applied voltage.

References

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