LDA electric wind velocity measurements behind single dielectric barrier, multi dielectric barrier and sliding discharge plasma actuators

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For plasma separation flow control applications on mini unmanned aerial vehicles (UAVs) it was envisioned to develop easy to built and effective plasma actuators for use with highly miniaturized plasma generators restricted to 12.5kVpp AC, 20.0kV DC and an overall power consumption of 30.0W for long time operations. For this purpose, we first aimed to compare the steady and unsteady wall jet velocities of three plasma actuator types with standard Kapton dielectrics and sinusoidal excitation: 1. SDBD, 2. MDBD (two unphased SDBDs) and 3. sliding discharge plasma actuators [1, 2, 3]. The main focus was on high unsteady wall jet velocities to attain as much flow control authority as possible at low Reynolds numbers relevant for small UAVs as discussed in [1].

The electric wind velocities were measured on different locations of a flat plate inside a smoke filled box using a 2-component LDA system in quiescent air (u=0 m/s). Fig. 1a and Fig. 1b show the steady wall jet velocities measured 5 mm downstream of the serrated last electrode on power. A sliding discharge actuator with moderate 8.0kVpp AC, 10.0kV DC and 30.4W can already induce peak velocities of 3.5 m/s. Two 30W generators powering a MDBD at 12.5kVpp can even induce velocities up to 5.5 m/s. This is quite effective and comparable to the results in [2, 3, 4].

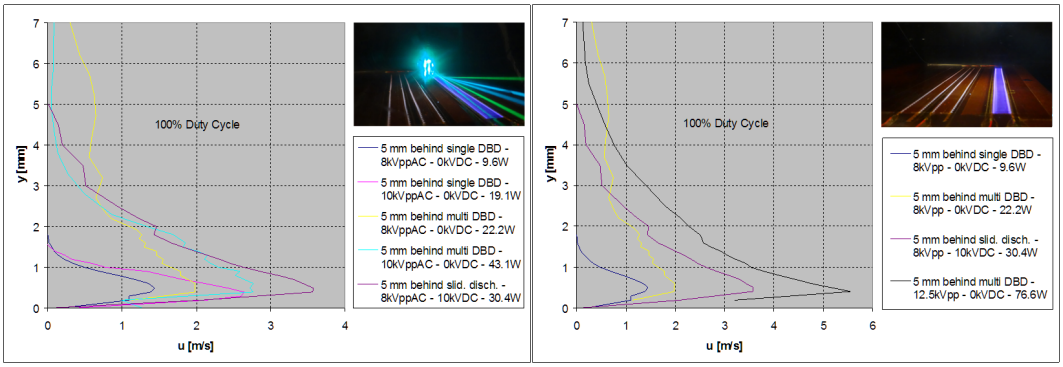

Figure 1a, b: Wall jet velocities 5 mm downstream of actuators with 100% steady duty cycle.

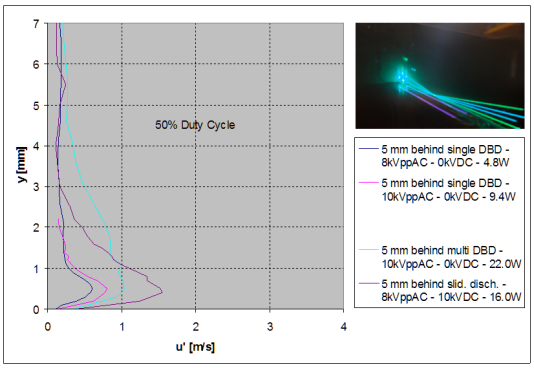

Figure 2: Wall jet velocities with 50% duty cycle.

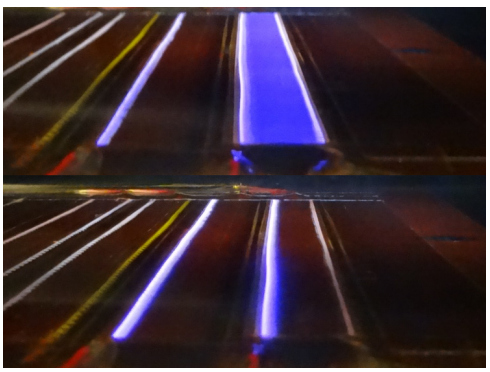
Figure 3: Serrated plasma actuators in series.

Fig. 2 shows the unsteady velocities reached at a duty cycle of 50%. As already expected from the steady velocity distributions, the highest mean unsteady velocities are achieved by DBDs in series and sliding discharge plasma actuator. Shown are only the unsteady velocities for 50% duty cycle. Usually the peak unsteady momentum is reached at a duty cycle of approximately 10% [1].

MDBD plasma actuators [5] with moderate voltages of 8-12kV AC and sliding discharge actuators with voltages up to 20kV DC can be combined to further increase the control authority (Fig. 3) and thus efffectiveness of the plasma actuators to be used on small UAVs like the Plasma Flyer UAS of Electrofluidsystems with more sophisticated, doped flexible dielectric barrier materials (Fig. 4).

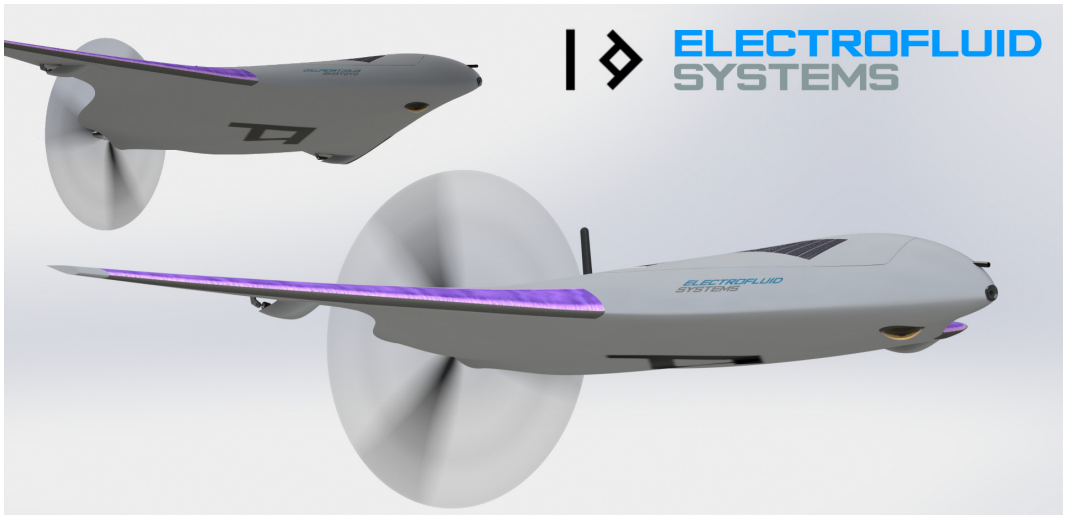

Fig. 4: Electrofluidsystems Plasma Flyer UAS with advanced sliding discharge plasma actuators.

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