Abstract Submitted
for the GEC06 Meeting of
The American Physical Society

Modeling of Asymmetric Dielectric Barrier Discharge Plasma Actuators for Flow Control SERGEY MACHERET, ALEXANDER LIKHANSKII, MIKHAIL SHNEIDER, RICHARD MILES, Princeton University — Asymmetric dielectric barrier discharge (DBD) plasma actuators have been demonstrated to be effective in low-speed flow control. However, understanding of their physics is currently insufficient. We have developed a comprehensive kinetic model for asymmetric DBD actuators in air. Modeling showed that charging of the dielectric during the avalanche ionization lasts a small fraction of the cycle but plays crucial role. The tangential force on the gas is shown to be directed downstream in both cathode and anode half-cycles, with critical role of negative ions in the cathode half-cycle and of positive ions in the anode half-cycle. The motion of positive ions toward the exposed electrode in the cathode half-cycle considerably decreases the integrated downstream force. Based on the detailed understanding of DBD actuator operation, an optimal voltage waveform is proposed, consisting in high repetition rate nanosecond pulses of negative voltage in combination with positive dc bias applied to the exposed electrode. Computations show that repetitive-pulse waveform can induce gas velocities similar to those in conventional sine-voltage DBD actuators at considerably lower voltages and smaller plasma sizes. Application of repetitive-pulse waveform with several kilovolt peak voltages is predicted to generate wall jet velocities at least an order of magnitude higher than those in conventional DBD actuators.

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Date submitted: 16 Jun 2006 Electronic form version 1.4