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Numerical Simulation of a Nanosecond-Pulse Discharge for High-Speed Flow Control JONATHAN POGGIE, Air Force Research Laboratory, IGOR ADAMOVICH, The Ohio State University — Numerical calculations were carried out to examine the physics of the operation of a nanosecond-pulse, single dielectric barrier discharge in a configuration with planar symmetry. This simplified configuration was chosen as a vehicle to develop a physics based nanosecond discharge model, including realistic air plasma chemistry and compressible bulk gas flow. First, a reduced plasma kinetic model was developed by carrying out a sensitivity analysis of zero-dimensional plasma computations with an extended chemical kinetic model. Transient, one- dimensional discharge computations were then carried out using the reduced kinetic model, incorporating a drift-diffusion formulation for each species, a self-consistent computation of the electric potential using the Poisson equation, and a mass-averaged gas dynamic formulation for the bulk gas motion. Discharge parameters (temperature, pressure, and input waveform) were selected to be representative of recent experiments on bow shock control with a nanosecond discharge in a Mach 5 cylinder flow. The computational results qualitatively reproduce many of the features observed in the experiments, including the rapid thermalization of the input electrical energy and the consequent formation of a weak shock wave. At breakdown, input electrical energy is rapidly transformed (over roughly 1 ns) into ionization products, dissociation products, and electronically excited particles, with subsequent thermalization over a relatively longer time-scale (roughly 10 μs).

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