RATE OF PLASMA THERMALIZATION OF PULSED NANOSECOND SURFACE DIELECTRIC BARRIER DISCHARGE

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The paper presents a detailed explanation of the physical mechanism of the nanosecond pulsed surface dielectric barrier discharge (SDBD) effect on the flow. Actuator-induced gas velocities show near-zero values for nanosecond pulses. The measurements performed show overheating in the discharge region at fast ($\tau \sim 1$ μs) thermalization of the plasma inputed energy. The mean values of such heating of the plasma layer can reach 70, 200, and even 400 K for 7-, 12-, and 50-ns pulse durations, respectively. The emerging shock wave together with the secondary vortex flows disturbs the main flow. The resulting pulsed-periodic disturbance causes an efficient transversal momentum transfer into the boundary layer and further flow attachment to the airfoil surface. Thus, for periodic pulsed nanosecond dielectric barrier discharge DBD, the main mechanism of impact is the energy transfer to and heating of the near-surface gas layer. The following pulse-periodic vortex movement stimulates redistribution of the main flow momentum. Analysis of the experimental results of fast nonequilibrium plasma thermalization has been performed. It was shown that significant part of energy deposited into the non-equilibrium plasma at high electric field converts to translational degrees of freedom during plasma recombination.

Summarizing the results of temperature measurements in atmospheric pressure SDBD we estimated the energy release into translational degrees of freedom during first microsecond of atmospheric pressure air plasma recombination as 55-65% for investigated range of parameters. Reduced electric field measured for these conditions was E/n = 800-900 Td and slightly increased with a pressure decrease.

Kinetic model of fast plasma thermalization at high and ultra-high electric field has been proposed. This model is able to explain existing experimental data and broadens the theory range to strong electric field region up to the electrons run-away threshold.

The analysis of the model showed that, under the conditions studied, ion-ion and dissociative electron-ion recombination made the major contribution into fast gas heating; ion recombination provided a 24 % contribution at *nef* = 10^{14} cm^3 and a 14 % contribution at *nef* = 10^{15} cm^{-3}, whereas the contribution of electron ion recombination was, respectively, 5 and 12 % in these cases.

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