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CURRENT AND EMISSIVE PROPERTIES OF NANOSECOND SURFACE SLIDING DISCHARGE IN SUPERSONIC AIRFLOWS IN A CHANNEL *)

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The characteristics of discharge in a high-speed flow are interesting from the standpoint of practical implementation of controlled energy deposition. In plasma aerodynamics, this is essential for optimizing the performance of plasma actuators [1]. The aim of the study was to analyze the current dynamics and emission of a sliding surface discharge in a supersonic flow with an oblique shock wave generated when flowing around an obstacle within the shock tube channel.

In the discharge chamber of a shock tube [2], a sliding surface discharge was initiated under a single-pulse voltage of 25 kV applied to a discharge gap 30 mm wide and 100 mm in length along the flow direction. The current was recorded using a low-inductance shunt, while the discharge emission was captured with photo cameras and ICCD cameras. Measurements were conducted in flows with Mach numbers ranging from 1.30 to 1.60 and in stationary air at densities between 0.02 and 0.25 kg/m^3. In uniform air, the discharge developed in the form of parallel channels - diffuse and of increased intensity, forming a plasma sheet with an area of 30 × 100 mm^2 [2]. The current waveforms exhibited oscillations with an attenuation decrement that increased with the air density. The duration of the current pulse ranged from 500 to 800 ns.

Following the diffraction of a flat shock wave, a supersonic flow around the obstacle was established. The interaction of the oblique shock wave with the boundary layer resulted in the formation of a low-density zone [2]. When a pulsed electric field was applied to this zone, an increased value of the reduced electric field (E/N) was achieved. Consequently, the discharge current is concentrated in a single, straight current channel, whose radiation was marked by high intensity and a duration of up to 6 μs [2]. ICCD recording revealed that the decay time of the discharge emission in flows was significantly longer than that in uniform air, reaching 1300 ns.

Current waveforms obtained in flows with an oblique shock wave at various time intervals of the flow (160–400 μs after the supersonic flow had fully developed) show close similarities. The dynamics of the current in the flows are characterized by higher peak values and smaller attenuation decrements of oscillations relative to the measurements in uniform air. The increased conductivity is likely due to a higher electron concentration within the localized current channel.

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References

[1]. Komuro A., Takashima K., Suzuki K. et.al. Influence of discharge energy on the lift and drag forces induced by a nanosecond-pulse-driven plasma actuator. Plasma Sources Sci. Technol., 2019. V. 28. 065006. DOI 10.1088/1361-6595/ab1daf.

[2]. Mursenkova I.V., Ivanov I.E., Liao Yu., and Ziganshin A.F. The Study of Surface Sliding Discharge Interacting with an Oblique Shock Wave. Plasma Physics Reports, 2023. V. 49. No. 6, P. 795. DOI: 10.1134/S1063780X22601468.

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