COMBINED LASER-MICROWAVE DISCHARGE IN SUPERSONIC FLOWS

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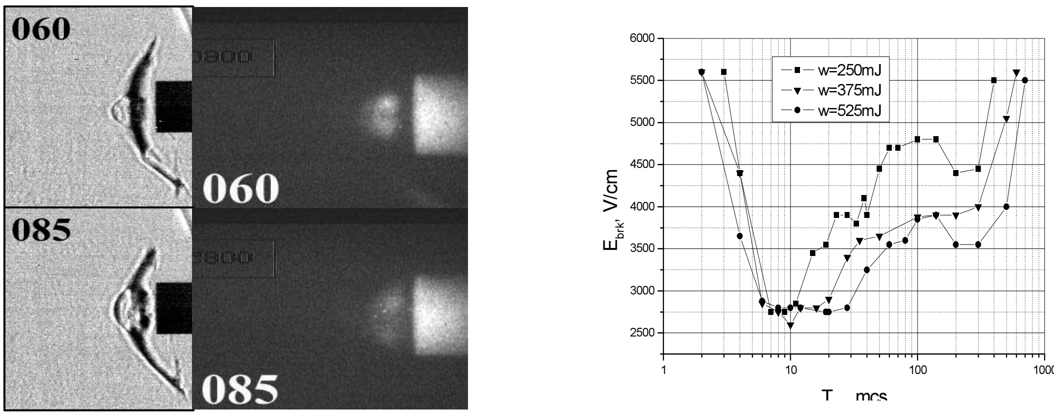
The theoretical and experimental researches performed the last years, have shown that drag of a blunt body can be diminished by means of energy deposition in the supersonic flow. Interaction of heated by microwave discharge gas domain with shock layer significantly changes streamlining of the body. Analysis of the problem shows that effectiveness of energy deposition in supersonic flow depends of heated domain shape, its temperature and grows with flow Mach number increases [1,2]. These effects have been investigated on experimental setup described in [3]. Flow Mach number was 2,1, static pressures 20-70 Torr. The output power of MW generator was 250 kW, pulse duration 1,5 µs, electric field strength in focus area – 4,5-5,5 kV/cm. The results of heated domain – bow shack interaction for different delays of MW-pulse and Schlieren and weak luminescence images (60 and 85 µs) shown on the Fig.1.a. The long leave vortex structure, arising under the shock layer is clearly seen.



(a) (b)

Figure1: Interaction of MW heated domain with bow shack (a) and threshold characteristics of laser-spark initiated MW discharge and different energies of laser pulses (b)

Unfortunately several problems are arising in its practical applications, especially in pressure range 100-760 Torr. The most important of them - the difficulty of focusing MW radiation for getting the focus area with breakdown level of electric field. The next problem is connected with great difficulties in managing of MW plasmoids shape. For example, for some plasmadynamic applications the spatial-elongated kind of plasmoids (air spike) is needed [4]. One of the possible ways for solving these problems may be the using of laser spark as initiator. The process of the laser spark assisted initiation of microwave discharge in quiescent air has been experimentally studied in [5,6]. It is established that, at the preset MW field intensity, the maximum time when the laser spark retains its initiating ability increases with the laser pulse energy. In the interval of air pressures of 150–750 Torr, a significant decrease in the MW discharge initiation threshold and the period of retained initiating ability of laser spark are determined by laser spark induced gasdynamic perturbations. Figure 1b shows the experimental results obtained in air at atmospheric pressure. On the whole, as the laser spark intensity grows, there is a general tendency of decrease of the breakdown threshold and an increase of the period of time for which the spark retains its initiating ability. However, there is a time interval at about 10 µs, where the breakdown threshold is at minimum and remains virtually the same in the entire range of laser pulse energies. An increase in the laser energy most significantly influences the MW discharge formation for time delays from several dozen microseconds up to several milliseconds and more. As the air pressure is decreases, the time for which the spark retains its initiating ability increases to several dozen milliseconds and up to about a hundred of milliseconds.

Thus, the results of our experimental investigation revealed factors that influence the initiation of MW discharge in the free space in air by laser spark at all stages of its decay. An important parameter that determines the threshold of MW discharge depending on the delay of the MW pulse relative to the laser pulse is the laser pulse energy. At a preset MW field intensity, the maximum time for which the laser spark retains its initiating ability increases with the laser pulse energy. At both atmospheric and reduced air pressure, a significant decrease in the MW discharge initiation threshold and the period of retained initiating ability of laser spark are determined by laser spark induced gasdynamic perturbations. The developing technique may become a promising way for creating of spatially compact MW discharges with predictable shape and position for plasmadynamic applications.

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