STUDY OF NEAR-electrode processes in pulse discharge in a diode with a point cathode in a wide range of pressures BY the methods OF laser PROBING

1,2Parkevich Е.V., 2Tkachenko S.I., 1,3Agafonov А.V., 1Mingaleev А. R., 1Romanova V.M., 1Shelkovenko Т.А., and 1Pikuz S.А.

1Lebedev Physical Institute, Russian Academy of Sciences, Moscow, Russia
2Moscow Institute of Physics and Technology, Dolgoprudnyi, Moscow oblast, Russia,
 parkevich@phystech.edu
3Moscow Engineering Physics Institute, Moscow, Russia

The study of pulse discharges in gases and in vacuum is both fundamental and topical task for many applications. The paper focuses on the study of pre-breakdown stage (before the formation of plasma channel between the electrodes), because the processes that take place at this stage, determine the rate of discharge, and that is important including for rapid operation of discharger. Due to the difficulty of diagnosing of fast processes with high spatial (microns) and the temporal (nanoseconds or less) resolution it is observed the lack of information about the plasma formed at various stages of discharge. To overcome these difficulties we use the laser probing methods.

To study of a pulse discharge in a wide pressure range (from 10-5 Torr to 1 atm) was create small-sized facility with rigid synchronization of picosecond Nd: YAG LS-2151 laser (pulse width at half height is 70 ps, the pulse energy to 40 mJ, two harmonics, λ = 1064 and 532 nm) with the voltage pulse (synchronization accuracy of the voltage pulse and the probe beam ~1 ns). Installation allows us to get the voltage pulse with amplitude up to 10 kV and duration of 150 ns with rise time of 20 ns, the maximum current is about 1.5 kA. Used optical scheme allows us to get three frames per shot with simultaneous recording in each channel interference-, shadow- and Schlieren-images; the exposure is determined by the duration of the laser pulse, and it is 70 ps. It was found that in the case of a discharge in a gas of atmospheric pressure, the initial breakdown stage is accompanied by an appearance of the dense cloud of plasma on the tip of the cathode with an electron density of about 5·1019 cm–3 at the spatial scale of a few tens of microns.

It was found that typical velocities of the plasma expansion are ~25 km/s in the longitudinal and ~5 km/s in the transverse direction. These values are essentially independent of the emitter material and have not changed from shot to shot (study was only conducted at a voltage of 10 kV). The formation of a similar plasma cloud at the anode begins only after the appearance of the cathode clouds and its little movement toward the anode.