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MODELING WAVEGUIDE FORMATION IN LASER-ASSISTED CAPILLARY DISCHARGES*

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A plasma-based acceleration scheme for particle acceleration by space charge wave was proposed by Y. Fainberg in 1956 [1]. Later on, plasma-based accelerators (PBA) were considered as an alternative for the conventional ones. PBAs use either intense laser pulses in the case of laser wake-field acceleration (LWFA) or charged particle beams passing through plasma in the case of plasma wake-field acceleration (PWFA). These acceleration approaches allow overcoming the most significant limitation in conventional accelerators - limited electric field gradient in radio frequency accelerating structures. Extreme LWFA accelerating gradients, demonstrated experimentally by different teams, offer a path towards a compact PBA needed in a broad variety of applications, including free-electron lasers (FEL). Comprehensive model of processes in a discharge capillary is required in order to obtain nominal parameters of a preformed plasma channel suitable for the laser wake-field acceleration [2]. We present 3D magnetohydrodynamics simulations of a hydrogen gas filling process and discharge plasma formation in a short square shape capillary with gas supply channels. Time evolution of the gas pressure and the plasma density in the capillary channel for a chosen discharge current profile is analyzed. Performed simulations provide distributions of the electric current, the magnetic field and the electron density along the whole channel, taking into account gas supply areas as well as areas outside of the capillary. Obtained results show that presence of gas supplies leads to the inhomogeneous plasma density distribution along the capillary channel which have to be taken into account for generating optimal laser-driven electron beam.

The computations were carried out using supercomputers K60 and K100 at KIAM RAS.

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