Optimization of Femtosecond Laser-induced Plasma for Initiation of Nuclear Reactions

Annotation

The graduation work is dedicated to the diagnostics of plasma generated by a high-intensity femtosecond laser radiation onto the surface of solid target. It was demonstrated that the preplasm, formed by the prepulses, affects significantly on the acceleration of hot electrons and the generation of hard X-rays. In our experiments the plasma was generated by pulse generated by Ti:Sa laser system (40 fs, 800 nm, $I > 10^{18}$ W/cm^2). In our research solid-state targets (Fe, Pb, W) were used. A solid-state laser Nd:YAG (6 ns, 532 nm, $I > 10^{11}$ W/cm^2) was used to generate the preplasma.

It was shown that at a sharp plasma-vacuum interface ($L/\lambda < 1$), for the intensity of the heating pulse above 10^{18} W/cm^2, the energy of hot electrons reaches a few hundreds keV and is determined basically by the ponderomotive potential. The growth of the preplasma layer up to a few tens of wavelengths by the action of the prepulse, leads to appreciable increase of hot electron energy and of hard X-ray yield. At laser intnsity of 2×10^{18} W/cm^2, the mean energy of the hot electrons raised from 300 keV to 2.5 MeV. The conversion efficiency of the laser pulse energy into X-rays with energy above 1 MeV increased by 2 orders of magnitude. The observed results may be connected with the relativistic mechanisms of electron acceleration: growth of parametric instabilities, excitation of a plasma wave etc.

The calculations and theoretical estimations proton- and photon-nuclear reactions excitation by the laser-driven plasma products were made. It was demonstrated that it is possible to initiate the reactions D(d,n)He^3, $^9Be(\gamma; n+2\alpha)$ with the efficiency of a few processes per a laser shot.