Relativistic laser-plasma interaction with prepulse generated liquid metal microjets

D.S.Uryupina, K.A.Ivanov, A.B.Savel'ev
Physics Faculty and International Laser Center of M.V. Lomonosov Moscow State University, Leninskie gory, Moscow, 119991, Russia
A.V.Brantov, V.Y.Bychenkov
Lebedev Physical Institute of the Russian Academy of Sciences, Leninski pr., 53, Moscow, 119991, Russia
e-mail: dasha_uruypina@mail.ru

Efficient control of plasma properties using targets with microstructured surface was recently demonstrated at moderate intensities below 10^{17}W/cm^2. In particular huge enhancement in hard x-ray yield and temperature of hot electrons was achieved. At much higher, relativistic intensities this approach failed predominantly due to microstructure destroying by the pre-pulse. We introduce the new approach where melted metal surface is irradiated by the sequence of two femtosecond laser pulses separated by 12 ns. Due to the action of the leading weak pulse (intensity below 10^{15}W/cm^2) liquid microjets are ejected from the metal surface, thus the main intense pulse interacts with those microjets.

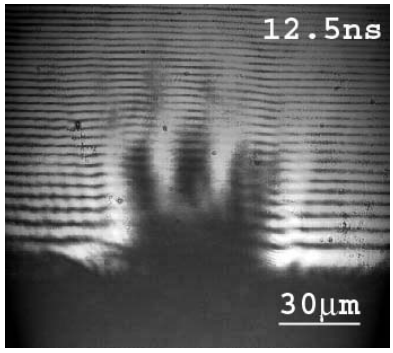

Fig.1 Shadowgraph of the plasma plume after the action of laser pulse with energy of 200uJ.

In the talk we discuss our experimental results about hard x-ray yield increasing under the action of femtosecond laser pulse sub-relativistic intensity (Ti:Sa laser system, τ_p=55 fs, E=1 mJ, λ=805 nm, I~10^{17} W/cm^2) with advancing prepulse onto the gallium melted target. It was observed that if prepulse energy is 50 times less than that of the main pulse 60 times magnification of x-ray yield and almost fourfold growth of hot electron mean energy in plasma (from 20 keV to 75 keV) occur, comparing to the prepulse free case.

To clarify how nanosecond pre-pulse influence on interaction of the main pulse with plasma we carried out optical pump-probe visualization of plume created by the pre-pulse. Fig.1 shows plume images obtained at time delay 12.5 ns after pulse action. We observed formation of long microjets (~20-30 μm long and less than 10 μm thick). Jets are more or less stochastically directed inside the cone with opening of ~90^o.

We also discuss the possible reasons which can lead to x-ray yield increasing for the target with micro-size jets and laser pulse with intensity from sub-relativistic to relativistic based on the 3D PIC simulations. Numerical results well reproduce experimental data.

We also present simulations showing promising advantages of our approach at much higher intensities well above relativistic one.