formation of collimated Fast electron beam under interaction of 100-ns UV laser pulses with targets

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Fast superthermal electrons with energies of a few keV, which considerably exceeds average electron energy in laser plasma, are generated due to a development of parametric instabilities in plasma corona [1]. Such process constrains maximal intensity of nanosecond pulses intended for a direct compression of thermonuclear targets in the ICF by values 1014−1015 W/сm2 [2]. Opposite case is a fast-ignition ICF sheme where collimated electron beam accelerated up to 1-MeV energy must deliver for ~ 20 ps into a preliminary compressed target ~ 20 kJ of energy, that requires very high intensity ~1019 W/сm2 and peak power of a short laser pulse up to several petawatts.

In our experiments a collimated beam of MeV-energy electrons was produced in the forward direction by laser radiation of rather moderate intensity of 1012−1013 W/сm2.

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| Рис.1_eng.jpg | When narrow-bandwidth UV radiation of KrF laser (λ = 248 nm, Δλ ~ 10-3 nm) with a pulse energy up to 100 J and duration of 100 ns was focused in a spot of ~ 100-m diameter onto a target of polymethyl methacrylate (plexiglas), conditions for a two-dimensional hydrodynamic flow arose: an ablation front moved inside the target with a supersound velocity of 4−5 km/s (sound velocity in a plexiglas is 2.7 km/s) and it produced cone-like Mach shock wave [3]. Due to a radial squeezing out of the matter a deep (~ 1 mm) conical crater grew in the target (see an upper picture). |

Interesting and not yet described feature of such interaction regime is a very narrow (of 40-m diameter) and extended channel going from the crater tip along ~ 1-mm length (see a bottom picture). An origin of this channel cannot be explained by a self-focusing of UV radiation in a plexiglas, as its penetration length is of a few microns. Most likely, the channel represents a track produced by a collimated electron beam, which was formed due to an effective development of parametric plasma instabilities along an extended nonlinear interaction length of narrow-bandwidth laser radiation with erosion plasma in the deep crater. A typical behavior of electron beam break-up is also observed in the picture. Electron energy as high as 0.4 MeV is estimated based on the found range of electrons, being many orders of magnitude higher than electron temperature ~100 eV in plasma corona [3].

References

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