Efficient generation of fast particles and X-ray radiation from nanostructured targets irradiated by ultra short, intense laser pulses

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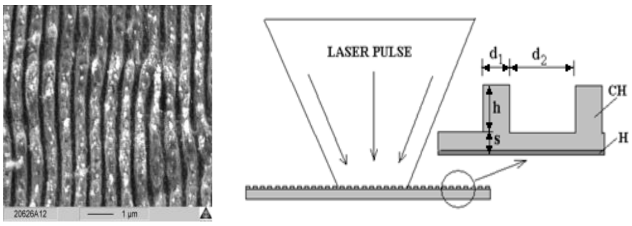
Abstract

The interaction of ultra-short high intensity laser pulses with different types of nano-structured targets has been considered. The optimal parameters of structure to maximise energy and number of fast particles were obtained.

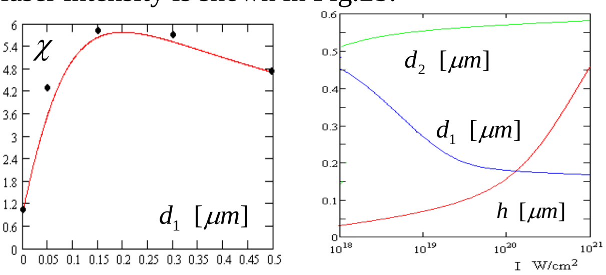
Interaction of an ultra-short and intense laser pulse with nano-structured targets is considered. One example of such target is shown in Fig.1a. Maximum energy of fast particles, conversion efficiency of laser energy to energetic particles and the divergence of particle beams are compared for various types of targets.



a) b)

Fig.1 a) Laser made "grating" target; b) Schematic of the nanostructure target,

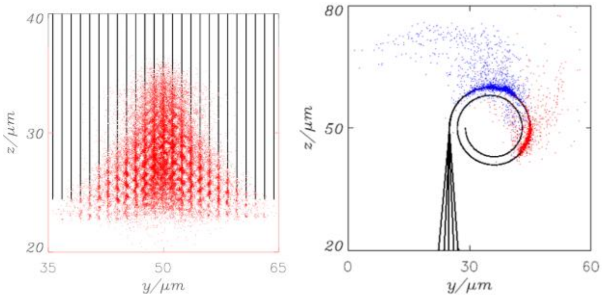
The optimal targets have maximal absorption (see Fig.2a) and the dependence of its parameters on laser intensity is shown in Fig.2b.



a) b)

Fig.2 a) Absorption in the units of the plane 300 nm foil. $C^{+6}H^{+1}$; $I_L=10^{20}$ W/cm^2, t_L=15 fs, d_L=3 μm; h = 0.4 μm; d_2 = 0.35 μm; s = 0.3 μm; b) Dependence of the optimal target parameters on laser intensity [1].

Another variant of efficient target consist of a bunch of parallel or tapered carbon nano-wires (see Fig.3a). Such targets generate effectively a big current of relativistic electrons, propagating along the wires and following their curvature (see Fig.3b). It was found that the optimal wire thickness should be of several length of the laser field skin depth and has to be in the order of magnitude of tens of nanometers. The distance between the wires can vary between several Debye radiuses up to values of a few laser wavelengths. Collecting all wires in only one (see Fig.3b) allows to reduce the transverse size of fast electron cloud.



a) b)

Fig.3 a) Electron density shown by red and black lines are ion density of wire target; b) Electron density distribution in red at *t* = 277 fs, in cone and dented wire target; laser hit targets from the bottom.

The density of the energy flux of the hot electrons in such bunch, propagating along one nano-wire exceeds several times the intensity of the laser pulse. The absorption of laser energy in optimal nanostructure targets is about 100%. The factor of conversion of laser energy in energy of fast ions for such target can come approximately to tens percents. Efficient conversion of fundamental laser radiation into characteristic sub-femtosecond X-ray radiation and generation of tunable up-converted radiation are considered. The results of the simulations were compared with the experimental data and have shown a good coexistence.

References

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