Laser electron and ion acceleration, neutron generation from Innovative Nano-Forest targets

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A majority of modern studies on generation of high-energy electrons and ions by relativistic laser pulses considers either rare (gaseous) plasmas or plane targets of solid density. At the same time, use of innovative micro- and nano-targets available with modern technologies (low-density nano-structured foils of high homogeneity, "nano-forest" targets with controllable ordering, microwires with tailored cross-section, etc.) allows to increase conversion efficiency of laser energy to accelerated particles and improve their characteristics, as well as achieve more efficient gain of secondary electromagnetic radiation of wide wavelength range and radioactive products, including application for neutron source of high brightness [1]. This problem is of high priority for radiation applications utilizing powerful lasers. We mention that such targets have been fabricated recently in Lebedev Physical Institute [2].

In this work the interaction of ultrashort relativistically intense laser pulse at normal incidence with target surface containing microwires covering has been studied with the help of 3D PIC simulation and analytical model of adiabatic plasma expansion. It was assumed that distance between nanowires was less than the laser wave length and their diameter approximately equals a half of the laser wave length. In such target the effective volume heating of laser energy happens. In the process of interaction electrons were heated in forming standing wave in the direction of laser pulse propagation as well as the transverse direction. The character of electron heating is close to stochastic one. Effective absorption of laser energy finally leads to generation of accelerated ions (primarily deuterons and tritons). For determining of plasma spectral characteristics the model of adiabatic expansion [3] and spectra from PIC simulations have been used. Neutron yield in D-T reaction was calculated with the help of overlapping integral. Our calculations demonstrated that for effective nuclear reaction the high laser intensities were not necessary as the reaction rate reached a maximum for temperature (mean energy) of accelerated deuterons being of order of 100 keV for 1018 W/cm2. The results show that for 1 PW laser pulse yield of neutrons can reach value 108-109 per 1J of laser energy.

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References

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