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Exploring potential of 3D printed structures in PW laser driven ion acceleration experiments

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Laser-produced ion beams from 1 um laser-plasma interactions have been a focus of high-energy density physics studies for several decades. Traditionally, these beams have been accelerated via the target normal sheath acceleration (TNSA) mechanism, which has a rootlike scaling of the maximum kinetic energy of protons Ep∞√I, where I is the laser intensity. To enhance TNSA via increase in coupling efficiency of radiation into hot electrons, beyond the ponderomotive potential of the laser, the current trend is to utilize very thin ~100-200 nm foils. Here, as was shown experimentally in a PW laser-plasma interactions, a relativistic induced transparency and associated flux of super-thermal electrons can result in increase in proton energy to near-100 MeV with a particle yield of ~10e9 (MeVxSr)-1. However, survival of such an ultrathin target irradiated by picosecond prepulse becomes a true limiting factor in wide usage of this approach. To develop a robust platform for ion acceleration in PW laser-solid target interactions, we explore a novel target design, laser-printed 2PP structures with and without regular organization of elements. Use of a relatively thick low-density target (~10-50l, where l is the laser wavelength) can improve the absorption of the laser energy, substantially drop requirements for the pulse contrast and facilitate generation of a relativistic plasma with electron temperature, Te≥1MeV in which different mechanisms of ion acceleration both in the bulk and boundary parts may play a role.

In the experiments, a 0.7 PW OMEGA EP laser beam was focused to an average intensity of ~5x1020 W/cm2 onto a 3D printed log-pile or stochastic target made of ~1 μm size wires. We tested both 10 and 50 μm thick structures with and without foils at the exit side. For a shorter log-pile target, protons with energies up to ~80 MeV were measured by the RCF stack and that correlated well with the Thomson spectrometer data, which detected both protons and C6+ ions. 2D PIC modeling revealed that the laser interacts with a family of microstructured overdense plasmas and sheath acceleration is the dominant mechanism. The results and future activities will be discussed.

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