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High-energy proton beams generated from PW laser-irradiated 3D printed microstructures

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In a series of experiments at OMEGA EP facility, we explore potential of petawatt 1-um laser-driven ion acceleration in two-photon polymerization 3D laser printed microstructures. We tested two types of accelerators made of acrylic log-pile organized wire and stochastic non-periodic wire microstructures. We find that enhanced target normal sheath acceleration mechanism is responsible for detected ~80-110 MeV protons with a high conversion efficiency reaching ≥8%. The key advantage of a relatively thick 10-50 um log-pile (stochastic) wire structure is efficient coupling of the laser into a flux of hot electrons in the target's front and formation of an overdense, wire-related, microplasma surrounded in voids by a low-density plasma sustaining sheath field at the back on a few picoseconds time scale. Additional electron heating in such a hybrid plasma resulted in generation of a stream of hot electrons in forward direction with an electron temperature, Thot≥20MeV and with the maximum electron energy about 150 MeV much above the ponderomotive energy. We observed no difference in proton beam laminarity and energy between a free-standing log-pile structure and the same structure printed in front of the 2 um flat foil. 3D printed multilayer microstructures represent a robust platform for reproducible ion acceleration relatively immune to the picosecond and nanosecond laser prepulses. It may become a viable alternative to nanofoils in generation of energetic ion beams that doesn't require high-contrast laser pulses. Modeling reveals that such designer accelerators are promising for production of 60-200 MeV proton beams with a high-peak-current for advanced radiotherapy application.

Working group

WG2 : Laser-driven plasma acceleration of ions

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