Towards manipulating relativistic laser-plasma interaction with micro-structured targets

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Efficient coupling of intense laser pulses to solid-density matter is critical to many applications including ion acceleration for cancer therapy. At relativistic intensities, the focus has been mainly on investigating various laser beams irradiating initially overdense flat interfaces with little or no control over the interaction. With recent development on pulse cleaning technique, such as XPW and the use of plasma mirror, we now propose a novel approach that leverages advancements in 3D nano-fabrication of materials and high contrast lasers to manipulate the laser-matter interactions on the micro-scales. The advanced technique can produce repeatable structures with at a resolution as high as 100 nm. Based on 3D PIC simulations, we explored two typical structures, the micro-cylinder and micro-tube targets. The former serves to enhance and control laser-electron acceleration and the latter is dedicated to manipulate relativistic light intensity. First principle-of-proof experiments were carried out in the SCARLET laser facility located in the Ohio State University and confirmed some of our predictions on enhancing direct laser acceleration of electrons. We believe that the use of the micro-structured elements provides another degree of freedom in LPI and these results will open new paths towards micro-engineering interaction process that will benefit high field science, laser-based proton therapy, near-QED physics, and relativistic nonlinear optics.

References

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