Suitability and robustness of triangular nanostructured targets for proton acceleration

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Proton acceleration via the target normal sheath acceleration (TNSA) mechanism has became a promising tool for future and current technologies where accelerated ions with energies in the MeV range are needed. The possibility of achieving these energies with table-top femtosecond laser sources and thin foils makes this technology cheaper for some applications than the traditional particle acceleration methods.

A current challenge for TNSA is to improve the properties of the proton beam without increasing the laser peak power. To that end several proposals for target engineering have been made, such as manipulating the target thickness, growing a low density foam on top of the target, nanostructuring the rear surface or the front surface of the target. The latter has proven to be a very efficient method to enhance the laser energy absorption and thus the transfer of energy from the laser to the electrons, having as a product more energetic protons in the accelerated beam. This method to increase the energy of the protons has demonstrated to be extremely efficient for triangular nanostructures, where nearly a 100% of the laser energy can absorbed by the plasma if the proper conditions are met [1].

In this contribution we present the results from realistic three-dimensional particle-in-cell (PIC) simulations of triangular nanostructured targets, in order to give a realistic estimate of the outcome of such an experiment, and be able to estimate the expected number and corresponding energies of the accelerated protons. We also address the robustness of this acceleration method by analyzing how the laser energy absorption is affected by deviations of the setup from the assumed ideal situation, such as changes in the laser peak intensity, changes in the ion species, the existence of irregularities in the nanostructures, or the existence of a pre-plasma at the target front surface. Our findings demonstrate, on one hand, that the very high absorption percentages achieved are robust with respect to non-ideal target manufacturing, but on the other hand, that very high contrast laser pulses are needed to preclude the formation of a pre-plasma region.

References

[1] M. Blanco, M.T. Flores-Arias, C. Ruiz and M. Vranic, New J. Phys **19**, 033004 (2017)