TOWARDS COMPACT LASER-DRIVEN ACCELERATORS : EXPLORING THE POTENTIAL OF ADVANCED DOUBLE-LAYER TARGETS

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The interest towards compact, cost-effective and versatile hadron accelerators is increasing for many applications of great societal relevance, ranging from nuclear medicine to agriculture, pollution control and cultural heritage analysis and conservation. In this context superintense laser-driven ion acceleration represents a promising alternative to conventional accelerators, addressing some of their limitations such as limited flexibility in terms of particle energy and nature, radioprotection issues, high costs, high energy consumption and non-portable size [1]. Among the different laser-based ion acceleration mechanisms that have been proposed in the last two decades, the so-called target normal sheath acceleration (TNSA) is arguably the most studied and understood acceleration scheme. In TNSA ultra- short (pulse duration < 100 fs), ultra-intense ($I > 10^{18}$ W cm^{-2}) laser pulses irradiate a μm- thick solid target, generating a hot electron population which expand at relativistic energies towards the back side. The resulting charge separation give rise to a very strong sheath electric field (few MV μm^{-1}) which is responsible for the acceleration of bunches of light ions (around 10^9 protons per shot) up to energies of tens of MeV per nucleon [1].

The great potential of laser-driven ion acceleration has stimulated different research approaches aimed at the enhancement of the acceleration performances, especially in terms of energy and number of accelerated ions. A widely investigated strategy relies on the continuous progress in laser technology, which can ensure an improvement of the relevant laser parameters (pulse energy, intensity, repetiton rate) and hence of the overall acceleration performance. This approach is of primary importance for the advancement of fundamental research and the study of novel laser-plasma interaction regimes; however, since it ultimately relies on the availability of a limited number of top-class, state-of-the-art laser facilities, it cannot find a widespread diffusion in developing countires and will hardly lead to a practical compact and cost-effective alternative to conventional accelerators in the near future. A complementary approach focuses on the optimization of the laser-target coupling, since a more efficient laser absorption results in an enhancement of ion current and energy with reduced requirement on the laser side. Among the advanced target concepts that have been explored, one appealing option is given by double-layer targets, where a very low-density layer, which acts as the enhanced absorbers, is attached to a micrometic solid foil [2,3].

In this contribution we present and review the most recent result we obtained in the field of laser-driven ion acceleration with advanced double-layer targets [2,3], with a specific focus on the applications of relevant societal interest like non-destructive material characterization [4], neutron generation [5] and medical radioisotope production. We believe that our results could prove critical toward the development of compact, smart and cost-effective laser-driven accelerators, which could be available to a much broader pool of potential users (including hospitals and high-tech enterprises) compared with present-day conventional accelerators. Moreover, a new community of scientists (especially from emerging and developing countries) could be empowered with a research capability that today is only accessible within large-scale facilities.

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