In Situ Characterisation of Thin Free-Standing Targets: Alpha Particle Energy Loss Measurement & Point Confocal Microscopy

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The knowledge of geometrical parameters that precisely characterize target dimensions and surface properties is one key to successful experiments in high energy density physics. Target shape and surface texture can greatly influence accessible physical phenomena during the interaction between an energetic particle beam or intense laser pulse and target matter. In situ characterisation during the experiment just shortly before the interaction becomes inevitable for substrates that can only be fabricated in situ, like cryogenic targets or are intentionally fabricated online e.g. to avoid contamination during storage. Although high precision target metrology during an experimental campaign with limited space and time to set up equipment under vacuum conditions does pose many difficulties, it is worthwhile to develop suitable diagnostic tools and procedures.

With the recent availability of large temporal contrast ratios at high power laser facilities the use of ever-thinner targets becomes desirable. Depending on the target material and actual laser prepulses, targets as thin as a few nanometers can be successfully utilised in ion acceleration experiments. Simulations of new laser-driven particle acceleration regimes exploiting these very thin targets, e.g. radiation pressure acceleration (RPA) [1] and laser breakout afterburner (BOA) [2]) predict particle energies in the GeV range in contrast to tens of MeV achievable in present target normal sheath acceleration (TNSA) schemes.

Suitable targets that are solid at ambient temperature like plastic foils, e.g. Polymethylpentene or Parylene, and carbon targets (DLC), can be fabricated with thicknesses that allow for the BOA acceleration mechanism and these targets are used to explore the BOA regime and characterise the contrast ratio of a laser system. Nevertheless, these targets always deliver multiple ion species – namely carbon and hydrogen – from the bulk material and also suffer from additional contaminants that get adsorbed on the target surfaces from the residual gas inside the vacuum chamber.

In terms of the best charge to mass ratio for the acceleration process and maximum ion velocity a pure hydrogen target at solid density is ideal as no driver energy is used to accelerate heavier ions. Depending on the parameters of the laser system, BOA works best for a certain line density, which allows for a relatively “thick” hydrogen target of some micrometers in comparison to sub-micrometer CH-targets that performed best in previous experiments at the *Phelix* laser facility at GSI, Germany.

This presentation will give a short overview on the growth procedure and experimental setup that allow for the fabrication of a thin, freestanding hydrogen membrane target and its in situ characterisation. Two experimental techniques will be depicted, alpha particle energy loss measurement and point confocal microscopy, which are suitable to determine surface mass density and geometrical target thickness respectively.

Possible applications of a high energy proton beam, that can be generated from such a thin, free standing hydrogen target at solid density, include proton driven fast ignition [3] and the production of secondary particle beams such as neutrons [4].

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[4] M. Roth et al., *Bright Laser-Driven Neutron Source Based on the Relativistic Transparency of Solids*, Phys. Rev. Lett. 110, Vol. 4, 044802 (2013)