8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Ion acceleration from aluminium foil embedded with gold nanolayer irradiated by ultrashort laser pulses.

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Enhancement of proton energy has always been a key aspect addressed via laser-driven proton acceleration [1]. As the target normal sheath acceleration, protons are driven by the electric field produced at the target rear surface. The presence of a gold nanolayer on the surface of the target foil will enhance the energy of accelerated ion beams [2]. In this study, we investigated the impact of gold nanolayer coated on aluminum foil on the proton acceleration. While previous research by various groups has shown that having a nanolayer on the target's front side enhances laser absorption, consequently boosting proton energy [3-4]. However, our study has revealed that coating gold nanolayer on the rear side of the target shows much better performance in terms of energy enhancement. When a 2 μm thick aluminum target coated with a layer of 10–20 nm gold was irradiated with femtosecond laser pulse at an intensity of $3x10^{20}$ W/cm^2, we observed proton energy of 16MeV when the gold layer was on the front side and 19MeV when it was on the rear side of the target, as shown in Fig.1 and Fig.2.

The presence of electron-rich species at the target's rear side results in the release of more electrons into the vacuum, leading to a greater positive charge formation on the rear surface in contrast to the gold nanolayer present at the front side (Au–Al). This variation contributes to the formation of a higher electric field in the Al–Au configuration compared to the Au–Al configuration. Here, "Al–Au" denotes gold nanolayer coated on the rear side of the aluminium foil, and "Au–Al" denotes gold nanolayer coated on the front surface of the aluminium foil. Our experimental results demonstrated better performance of the target in terms of proton energy when the gold nanolayer were on the rear end of the target. To further validate our experimental observations, we performed numerical simulations using the EPOCH 2D PIC code, which provided a better understanding of the role played by the positioning of gold nanolayer on the target.

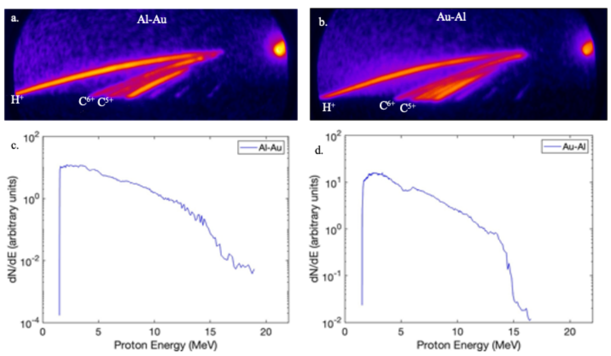

Fig. 1. Energy spectra of the proton obtained from Thomson parabola spectrometer (TPS). (a) and (b) Image of proton and carbon ion traces for Al–Au and Au–Al tar- gets, respectively. (c) and (d) Proton energy spectrum for Al–Au and Au–Al, respec- tively, extracted from TPIS

Reference:
[1] A. Macchi et al, Rev. Mod. Phys. 85, 751–793 (2013).
[2] A. Maksimchuk et al. Phys. Rev. Lett. 84, 4108–4111 (2000).
[3] L. Torrisi et al. Phys. Scr. 90, 015603 (2015)
[4] S. Link et al J. Phys. Chem. B 103, 4212–4217 (1999)

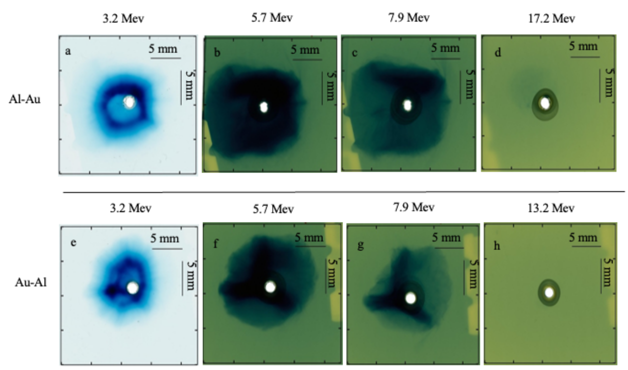

Fig. 2. Proton beam profiles, (a) to (d) correspond to the Al–Au target with energies 3.2, 5.7, 7.9, and 17.2 MeV, respectively; (e) to (h) correspond to the Au–Al target with energies 3.2, 5.7, 7.9, and 13.2 MeV, respectively. The white hole drilled at the centre is for the ions to be detected on the Thomson parabola spectrometer.