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Study on Electron Injection in Laser Wakefield Acceleration with Plasma Structures of Metal-Layered Target

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Laser wakefield acceleration (LWFA) is a method for accelerating electrons injected into a cavity created by the ponderomotive force resulting from the interaction between a femtosecond laser and low-density plasma. Significant research has been conducted on plasma generation for this purpose, and LWFA using metal ablation targets stands out for achieving high vacuum and high repetition rates due to the small size of the generated plasma plume. Furthermore, the large quantity of injected electrons enables the production of high-flux electron beams.

Among the metals studied as targets, titanium is producing many ionized electrons near the optical axis of the main beam, resulting in high-flux electron bunches. However, due to the incomplete formation of the acceleration cavity, these electron bunches are not accelerated. To address this limitation, we propose a structured target using titanium and aluminum to increase the number of injected electrons and produce a monoenergetic electron beam.

When using a structured aluminum target with a thin titanium layer, electron acceleration was achieved at lower laser conditions than aluminum, resulting in high charge monoenergetic electron beams. Moreover, the thickness and position of the titanium layer were used to control the electron beam properties.

In this study, we used the CFD code FLASH to analyze the plasma density trends of the structured target, and further investigated laser wakefield acceleration in various structured plasma targets using the PIC code Smilei.

In the titanium-layer structure with lower-density titanium plasma, the charge amount was approximately 50% of that in the high-density titanium-layer structure. However, the energy spread remained similar at around 5.5%, and the beam was sustained for a longer

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