Abstract—Issues in laser ion accelerator include an energy efficiency from laser to ions, ion beam collimation, ion energy spectrum control, ion beam bunching and ion particle energy control. In this study each component is designed to control the ion beam quality. The energy efficiency from the laser to ions is improved by using a solid target with a fine sub-wavelength structure or a near-critical density gas plasma. The ion beam collimation is performed by holes behind the solid target or a multi-layered solid target. The control of the ion energy spectrum and the ion particle energy, and the ion beam bunching are successfully realized by a multi-stage laser-target interaction.

Key words—laser ion acceleration; ion beam control; laser plasma interaction

I. INTRODUCTION

The present paper shows a concept for a future laser ion accelerator, which should have an ion source, ion beam collimators, ion beam bunchers and ion post acceleration devices [1]. Based on the laser ion accelerator components, the ion particle energy and the ion energy spectrum are controlled, and a future compact laser ion accelerator could be designed and realized for ion cancer therapy or for ion material treatment.

In the post acceleration, a higher ion particle energy and an energy spectrum control are realized in a laser plasma interaction; a few hundreds of MeV of the proton beam energy is successfully achieved by several times of the ion post-accelerations in the laser-plasma interaction. In addition, a mono-energetic proton beam is also produced.

II. LASER ION ACCELERATOR CONCEPT

Figure 1 shows a concept proposed for a future laser ion accelerator. In an intense laser interaction with a target, initially ions are generated at an ion source device. The laser ion accelerator would need post-acceleration devices to enhance the ion energy and collimators to suppress the ion divergence, as well as beam bunchers to compress the ion beam longitudinally.

The laser ion accelerator would consist of an ion source [2], ion beam collimators, ion beam bunchers and post-accelerators depending on the requirements for the ion particle energy, the ion energy spectrum, the beam radius and the ion beam pulse length. Each realistic component is also proposed and studied in this work. The acceleration field gradient is rather large (>10GV/m) compared with that (<100MV/m) of the conventional accelerator. Each component and combinations of the components provide a high controllability of the ion beam quality generated by the laser ion accelerator to meet variable requirements for laser ion accelerator [1].

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