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Development and testing of a pulsed helium ion source for probing materials and warm dense matter studies*

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Pulsed ion beams can be used to for isochoric heating of target materials for high energy density physics experiments and warm dense matter (WDM) studies. The Neutralized Drift Compression Experiment (NDCX-II) was designed and commissioned as a pulsed, linear induction accelerator to drive thin foils to WDM states with peak temperatures of ~ 1 eV using intense, short pulses (~ 1ns) of 1.2 MeV lithium ions[1]. At that kinetic energy, heating a thin target foil near the Bragg peak energy using He^+ ions is a better match than Li^+ ions [2]. We also expect a higher current density of helium ions form a plasma source compared to the Li^+ ions from a hot plate type ion source [3].

The He^+ ion source developed for NDCX-II is a filament-driven multi-aperture plasma ion source [4] with an overall beam diameter of 7 cm. This diameter allows for favorable beam optics in the existing 150 kV injector column, while relaxing the current density requirements that would otherwise be demanded from a smaller ion beam diameter. At 1700W of arc power, the measured He^+ ion current density on axis reached as high as 80 mA/cm^2. Both filament and arc power supplies are pulsed to reduce the heat load and we are exploring pulsing the helium gas supply to reduce the base pressure within the system. The repetition rate of the linear induction accelerator is 0.03 Hz. A plasma extension chamber surrounded by 28 permanent magnets was attached the ion source to contain helium plasma within a larger chamber, resulting in an increased uniform region from 3.5 cm to approximately 6-7 cm in diameter. A grid assembly of hundreds of 1-mm-diameter apertures with more than 50% transparency was used to extract helium ions. The measured pulsed He^+ ion beam reached more than the objective 160 mA at peak current within a 4 μs pulse width. With such a He^+ ion source, we anticipate achieving ~50 to 80 nC of charge in a 1 ns pulse on target after neutralized drift compression and focusing to ~1 mm^2 diameter beam spots. The equivalent peak currents are ~5 to 8 kA/cm^2. Results from pulsed helium ion beam experiments will be reported at the conference.

References

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