Production of Oxygen Ions through the Laser Ablation of Alumina

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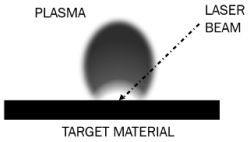
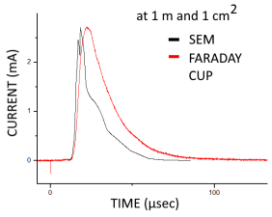
ABSTRACT

Laser ablation using a solid oxide compound material makes the ion production of gaseous elements possible. Aluminum and alumina targets were used in the laser ion source and was operated for laser power densities 2.0 to 4.3 $\times 10^8$ W/cm^2. Ion signals showed the presence of mainly Al, O and C for both aluminum and alumina targets. For the aluminum target, singly charged aluminum ions dominated the ion population in the plasma pulse with other ions and higher charge state aluminum ions stay below 30%. Meanwhile, large amounts of singly charged oxygen and aluminum ions were detected for the alumina target with the current due to the singly charged oxygen ions occupying 60% of the total beam current.

INTRODUCTION

Laser ablation of solid materials have been intensively studied in the fields of materials science and accelerator physics. Multiply charged ions are generated through a simple configuration with plasma parameters dependent on the laser irradiation conditions.





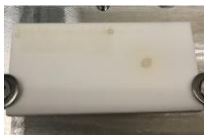
The assumption for the one-dimensional plasma propagation from a point source is described using the relation, $T \propto L$ and $I_{peak} \propto L^{-3}$, where L is the drift length, T is the ion beam pulse width, and I for the peak current. This allows the ion energy distributions to be analyzed in temporal profiles and also permit the scaling and estimation of the beam current measurements.

LASER ION SOURCE

The laser ion source utilized a Nd:YAG pulsed laser operated in the low power regime to produce the ions from the aluminum and alumina targets.

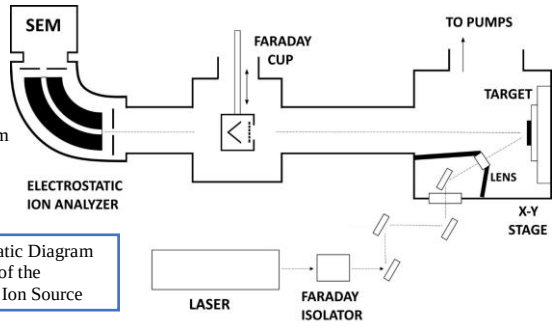
Operational parameters for the Laser Induced Plasma	
Laser Power Densities (W/cm^2)	2 - 4.3 × 10^8
Wavelength (nm)	1064
Pulsewidth (nm)	6
Laser spot area (cm^2)	0.17
Angle of Incidence	30°
Target material	Aluminum(99%) Alumina(96%)

ALUMINUM



ALUMINA

The mass separated ions were analyzed through the electrostatic ion analyzer to estimate the charge state distribution in a single plasma pulse.

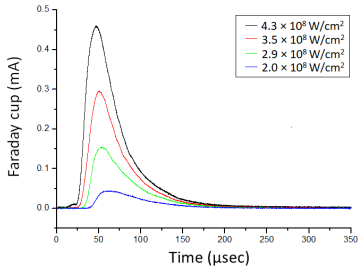


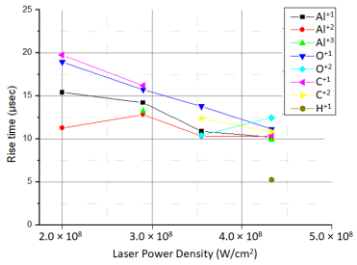
D_{FC} = 2.4 m
D_{EIA} = 3.86 m

Schematic Diagram of the Laser Ion Source

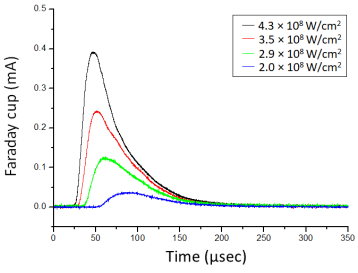
RESULTS AND DISCUSSION

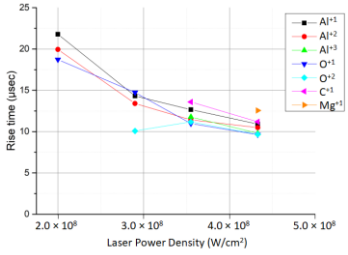
ALUMINUM



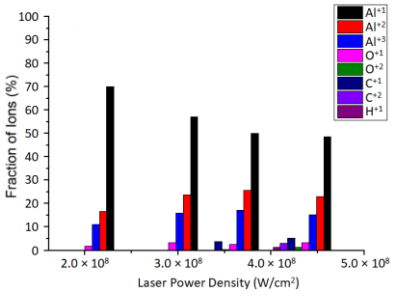


ALUMINA





To investigate the oxygen ion production from an alumina laser target, measurements were compared to an aluminum laser target with the same laser irradiation conditions.



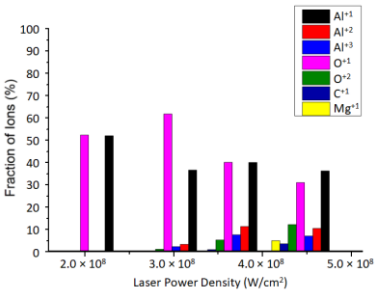
ALUMINUM

Al^{+1} dominates the pulse at 70% for the laser power density of 2.0×10^8 W/cm^2.

Al^{+2} and Al^{+3} maintained around 20% even at higher laser power densities.

ALUMINA

Produces fair amounts of singly charged aluminum as well as oxygen ions taking up half of the ion population for the laser power density of 2.0×10^8 W/cm^2



SUMMARY

The laser ion source was operated using alumina and aluminum targets in the low laser energy regime. For the aluminum target, the high percentage of singly charged aluminum ions for a plasma pulse was observed and goes down to 50 % upon increasing the laser power density where other ion species such as carbon and oxygen were ionized. The ion population in the plasma produced from the alumina target have a large amount of singly charged oxygen and aluminum ions. Since a high percentage of oxygen ions was produced from the alumina target, this suggests that alumina is a possible solid source of oxygen ions.

REFERENCES

M. Okamura, et.al., Rev. Sci. Instrum. 79, 02B314 (2008).
K. Kondo, et. al., Rev. Sci, Instrum. 81, 02B716 (2010).
J. G. Alessi, Rev. Sci. Instrum. 81, 02A509 (2010).
H. Y. Zhao, et. al., Rev. Sci. Instrum. 85, 02B910 (2014).