COMPARING VISUAL AND EUV SPECTRA FROM LASER-PRODUCED PLASMAS USING Nd:YAG AND FIBER LASERS

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Introduction

The goal of this of this experiment was to create laser-produced plasmas using Nd:YAG and fiber lasers aimed at tin (Sn) and lithium fluoride (LiF) targets. The plasmas were analyzed both in air and in vacuum utilizing the visible and extreme ultraviolet (EUV) spectrometers.

CR Model:

Calculating Power:

$$P = \frac{E}{t} = \frac{1.1\,J}{7.2\,ns} = 1.5\times10^{8}\,W$$

Area:

$$A\pi^2 = \pi(80\times10^{-6})^2 = (2.01\times10^{-8}m^2)\times10^4 = 2.01\times10^{-4}cm^2$$

Power Density:

$$\Phi = \frac{P}{A} = 7.46\times10^{11}\,\frac{W}{cm^2}$$

Electron Temperature:

$$T_e(eV) = (5.2\times10^{-6})\cdot A^{\frac{1}{5}}\cdot(\lambda_l{}^2\cdot\Phi)^{\frac{3}{5}}$$
$$T_e(eV) = 1.79\times10^{2}\,eV$$

Methods

Equipment:

Nd:YAG Laser:

- Pulse Duration 180ps
- Energy up to 380mJ
- Wavelength 1064nm
- Classification 4

Yb Pulsed Fiber Laser:

- Pulse Duration 6 ns
- Power Up to 31 W
- Wavelength up to 1075 nm
- Classification 4

Ocean Optics HR4000 High-Resolution Spectrometer:

- Focal Length 101.6 mm
- Spectral Range 200-1100 nm

Jenoptik EUV Spectrometer:

- Focal Length 0.25 m
- Spectral Range 8 to 18 nm
- Grating no. 1 1200 grooves/mm
- Grating no. 2 2400 grooves/mm
- TE cooled CCD Camera 2048 x 2048 pixels

Safety

Required gear for operation:

- Interlocks
- Goggles (for appropriate wavelengths

Results

Part I: Acquiring spectra from plasmas at Sn and LiF targets using the Ocean Optics Spectrometer in air and in vacuum – Nd:YAG Laser
Part II: Acquiring data using Jenoptik EUV Spectrometer in air and in vacuum – Nd:YAG Laser.
Part III: Attempting to acquire data with Ocean Optics Spectrometer – Fibre Laser.

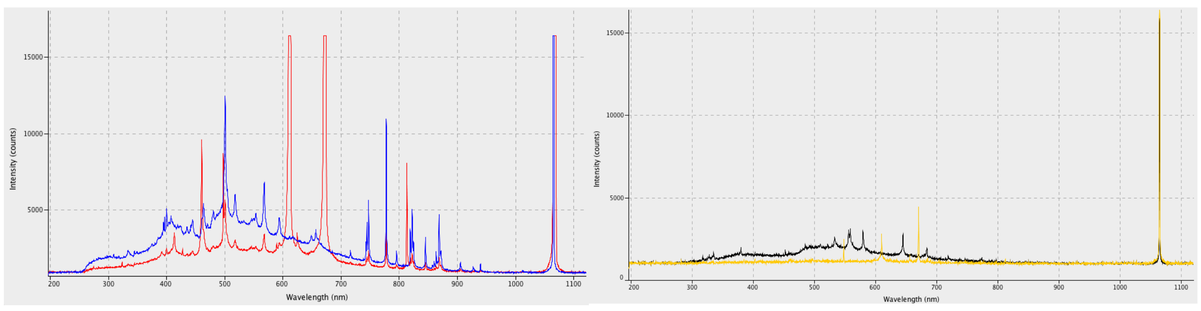


Figure 1: **(a)** Overlay of spectra of plasmas in air formed on Sn (blue) and LiF (red) targets. By comparing the wavelength peak values of each spectra to existing N.I.S.T. values, the presence of Sn and H for the Sn target, which accounts for the data being collected in air. The results from the LiF target showed a greater presence of Li ions than F ions **(b)** The second overlay compares spectra of plasmas in vacuum formed on same Sn (black) and LiF (gold) targets. Although the peaks lack the intensity found in the graphs in Figure 1(a), they still show the presence of the respective ions. This discrepancy may be due to a shift in the position of the spectrometer probe during the pumping down of the vacuum chamber.

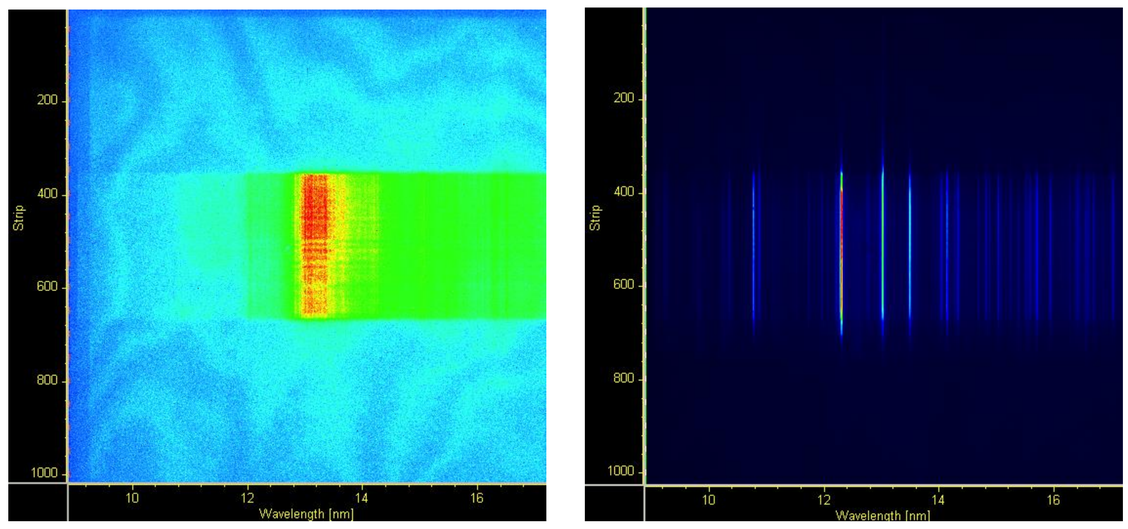
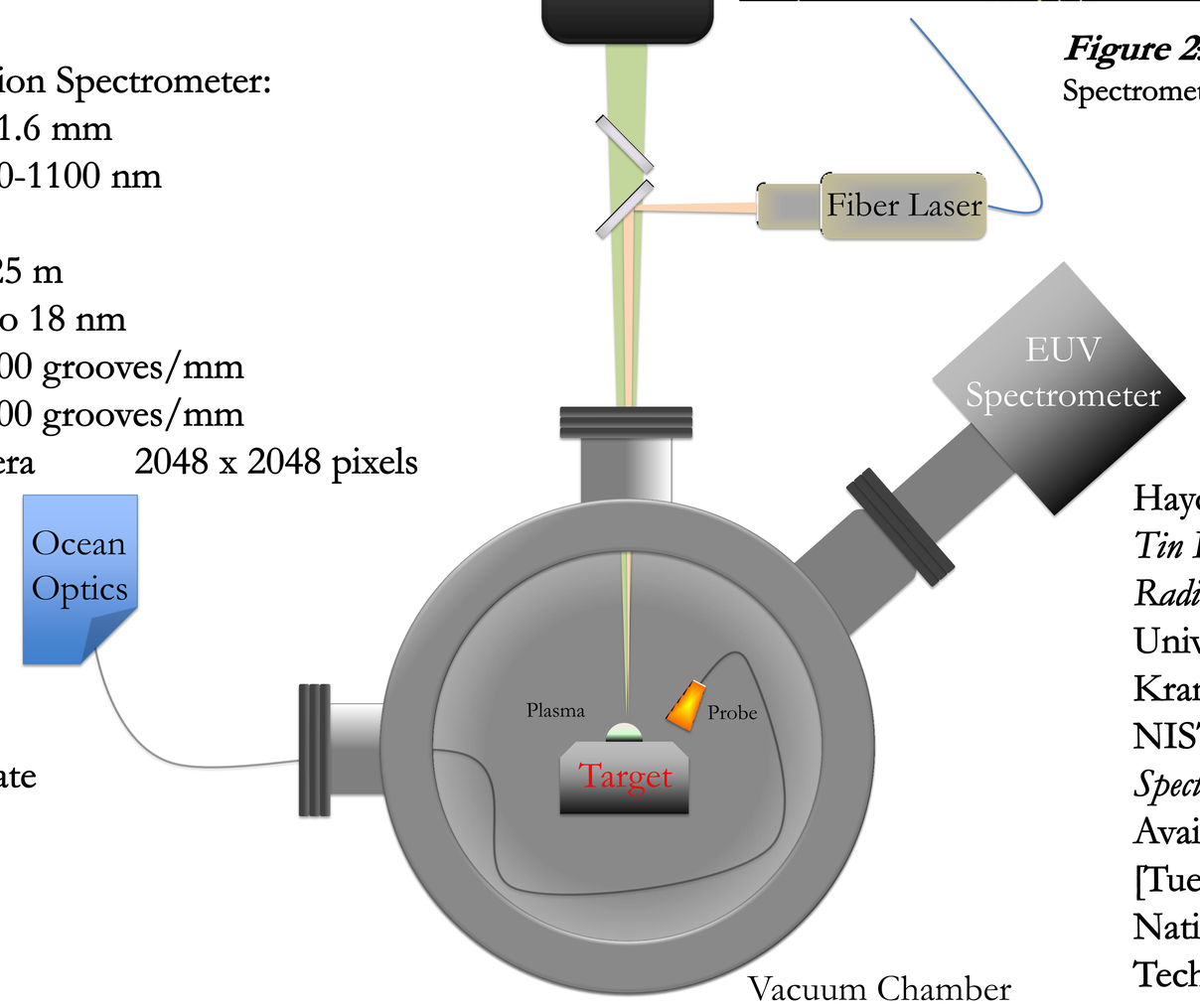


Figure 2: Spectra acquired using the Jenoptik EUV Spectrometer for the **(a)** Sn and **(b)** LiF targets.



References

Hayden, Patrick. (2004) *An Investigation of Tin Based Laser Produced Plasmas as a Source of Radiation at 13.5 nm.* Published PhD Thesis. University College Dublin.

Kramida, A., Ralchenko, Yu., Reader, J. and NIST ASD Team (2013). *NIST Atomic Spectra Database* (version 5.1), [Online]. Available: http://physics.nist.gov/asd [Tuesday, 29 Apr-2014 11:28:32 EDT]. National Institute of Standards and Technology, Gaithersburg, MD.

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