Out-of-band Spectroscopy of the Tin Droplet Target

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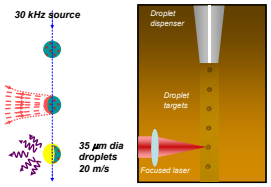
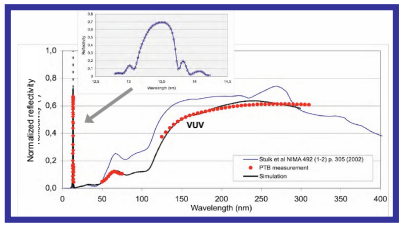
The LPL tin doped micro-droplet laser plasma EUV source

Mass-limited target

- Mass of tin within droplet limited to approximately 10^{13} atoms per droplet.
- Droplet technology minimizes target debris, with a fully ionized target at the end laser pulse
- High frequency source matched to high repetition rate laser



Extended Mo/Si mirror reflectivity measurement



- Complete spectral information of the tin droplet target for spectral purity assessment
- Out of Band metrology for the different wavelength regions are being completed.
- Atomic physics codes predictions are used to identify spectral features.

http://www.rijnh.nl/n2/Bijkerk101105SWSpubsympv2.pdf

LPL tin doped droplet EUV source development facility

Target Chambers

Metrology chamber

Debris chamber

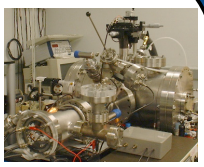
Lasers

Custom built, precision Q-switched, Nd:YAG laser, 11.5 ns pulse, 1064 nm, 1-2 Hz, 1.7J max energy

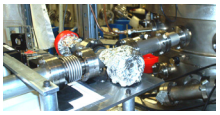
Spectra-Physics, 1064 nm, 100 Hz, Max. 300 mJ, 10 ns

Target dispenser

Droplet target Diameter: 30-50 mm



Spectroscopic Instrumentation



In-band: 5 nm – 20 nm

2 Flat-field Spectrometers (FFS)

Off-Band: 1 nm - 30 nm

Transmission Grating Spectrometer (TGS)

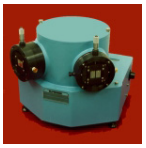
Out-of-Band: 30 nm - 1200 nm

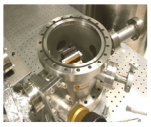
FFS with long wavelength range grating

McPherson Seya-Namioka design based scanning monochromator/spectrometer

Visible/IR grating spectrometer (EG&G)

Ocean Optics LIBS 2000

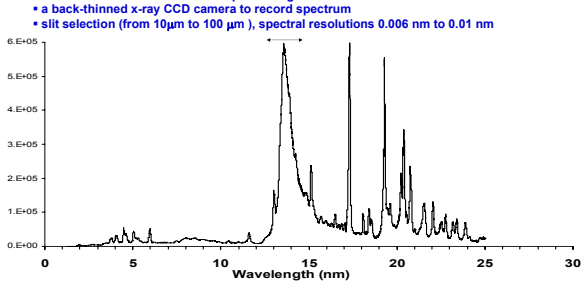




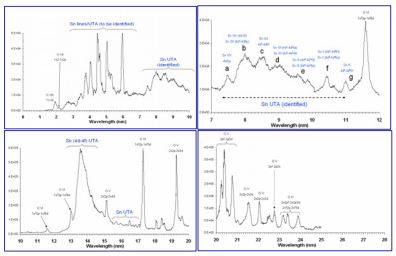
Near-Band spectral measurements

Transmission grating spectrograph

- 10,000 lines/mm SiN transmission grating, transmission 50%.
- filter selection allows choice of spectral region
- a back-thinned x-ray CCD camera to record spectrum
- slit selection (from 10µm to 100 µm), spectral resolutions 0.006 nm to 0.01 nm



Spectra shown is obtained for the optimum CE irradiance condition of the tin droplet laser plasma, near at intensity of 1 x 10^{11} W/cm²

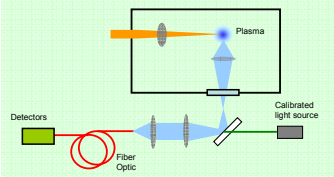


TGS Sn Droplet deconvolved Spectrum in the near band region from 0 - 28nm is shown.

Lines originating from tin and Oxygen transitions are identified

VUV/Visible/Near-IR Spectrograph

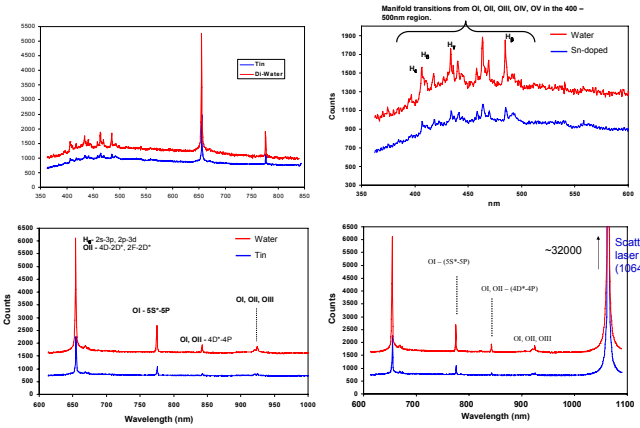
Experimental setup



Digital Triple Grating Spectrograph: three gratings of different resolution

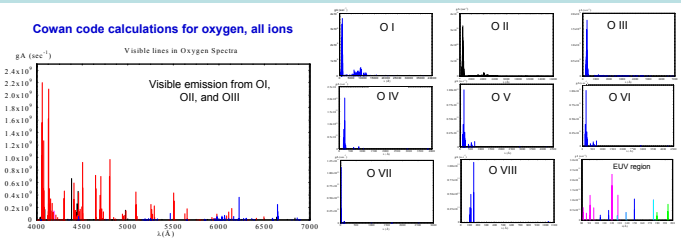
Data collected for Sn-doped droplets at conditions optimum for high conversion efficiency. For comparison spectra were obtained for water droplets under the same irradiation conditions.

For direct calculation of the energy, a fast photodiode was used. The detector was calibrated using laser light source of known energy.

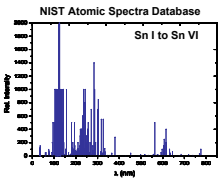


The spectral signature obtained from both targets are exactly the same. Peaks are stronger for water droplets, as expected. In the tin-doped target, all of the emission in the visible region is the result of hydrogen and oxygen transitions.

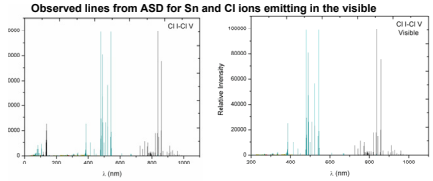
Cowan code calculations for oxygen, all ions



NIST Atomic Spectra Database

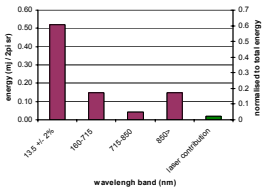


Observed lines from ASD for Sn and CI ions emitting in the visible



Energy Measurements

Measurements of the UCF source completed by the FOM team



FOM FC2 team
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Summary

Precision spectroscopy coupled with hydrodynamic, radiation and atomic physics code calculations, for a quantitative description of emission from tin-doped micro-droplet source.

Inferences obtained from spectral data of tin-based targets have dramatically improved our EUV source performance.

High resolution spectral data in the different wavelength regions have been obtained and being interpreted.

Out of band energy measurements to calibrate new spectral data, as well as to determine tin droplet source spectral purity are being completed.

Acknowledgements

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