NewLambda Technologies

Recent Progress on High-Brightness Source Collector Module for EUV Mask Metrology

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NewLambda Technologies

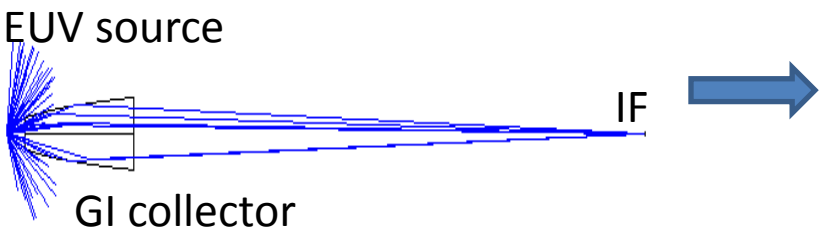
- Spin out from UCD School of Physics, Ireland
- Developing VUV, EUV and Soft X-ray sources
- Applications
  - Metrology
  - Table-top tuneable beamline
  - Microscopy

Metrology Source Considerations

Tool Requirements*		
Metrology Tool	Etendue	Brightness
AIMS	$5x10^{-4}$ mm^2sr	30-100 W/mm^2sr
Mask Blank	$4x10^{-3}$ mm^2sr	> 80 W/mm^2sr
Patterned Mask	$1.5x10^{-2}$ mm^2sr	> 40 W/mm^2sr

Choices for etendue matching:

- Demagnify large source – photon loss for fixed etendue
- Magnify small source - higher photon collection
  - higher brightness for given input power



Magnifying ellipsoid (x8)
Placed < 20 mm from EUV Source
Etendue ≥ 10^{-4} mm^2sr
High Brightness

Mask Metrology SoCoMo Status

Parameter	Industry Target Value*		
	AIMS	Blank	Pattern
Brightness (W/mm^2sr)	30-100	>80	>40
Etendue (mm^2sr)	5e-4	4e-3	1.5e-2
Position Stability (of FWHM**)**	3%	3%	3%
Size Stability	3%	3%	3%
Energy Stability	<3%	<3%	<3%-
Homogeneity	<5%	<5%	<5%
Operating time	100	100	100

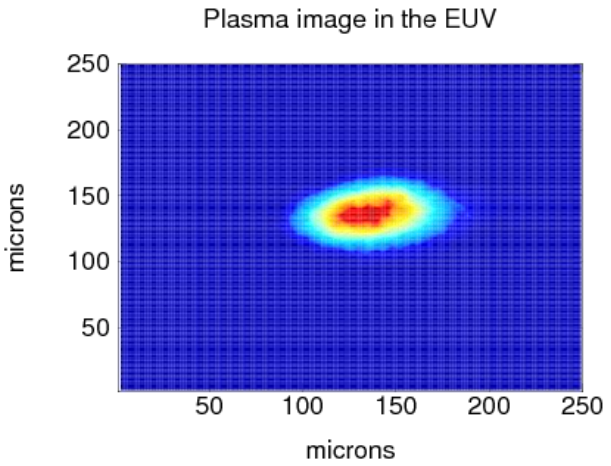
* EUVL Symposium, 2011

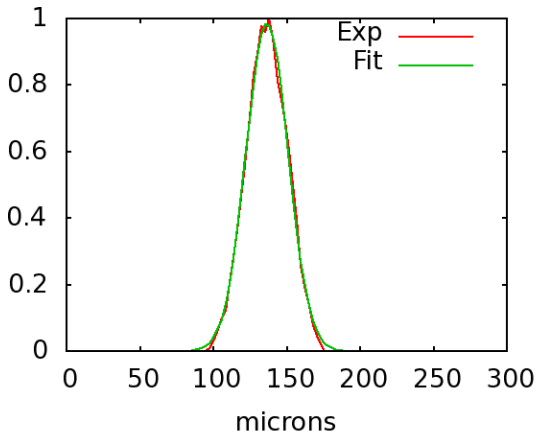
NLT Source

- LPP (Nd:YAG 125W, 25 mJ per pulse, 5 kHz)
- Proprietary liquid metal mixture as target
- Current status:
  - >200 hours total operation (since Nov. 2011)
  - Brightness = 80 W/mm^{2}sr
    - (Brightness calculated using the Carl Zeiss method)
  - 24 hours continuous
  - Self-healing collector
  - Roadmap to >500 W/mm^{2}sr, 100 hours continuous

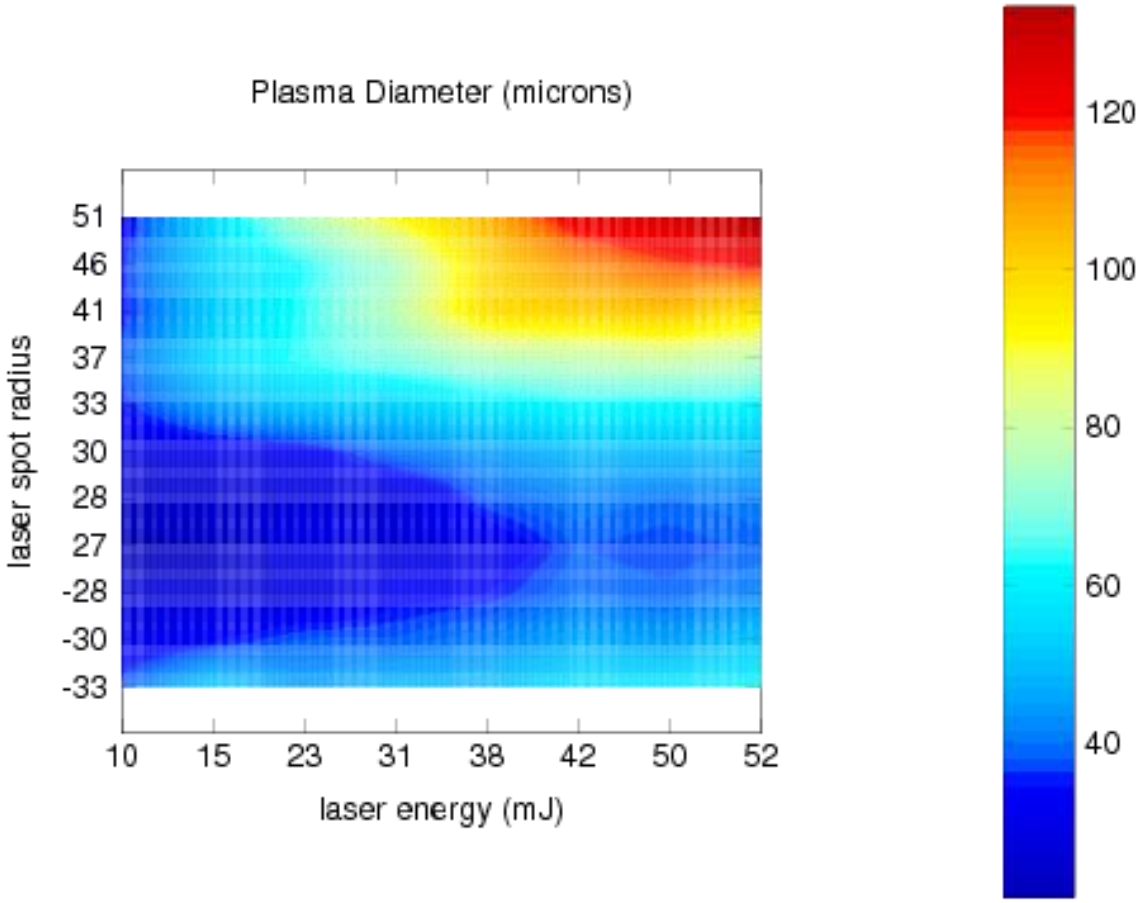
Source Imaging

- Imaged using multilayer concave mirror
- 10 shots per frame
- 34 x 55 micron spot measured
- Gaussian fit



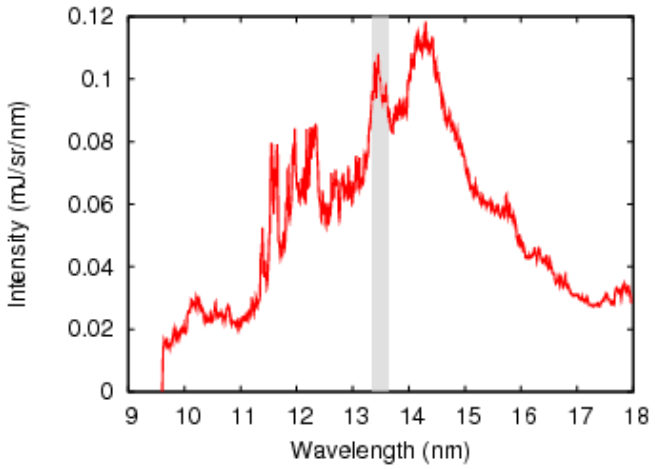


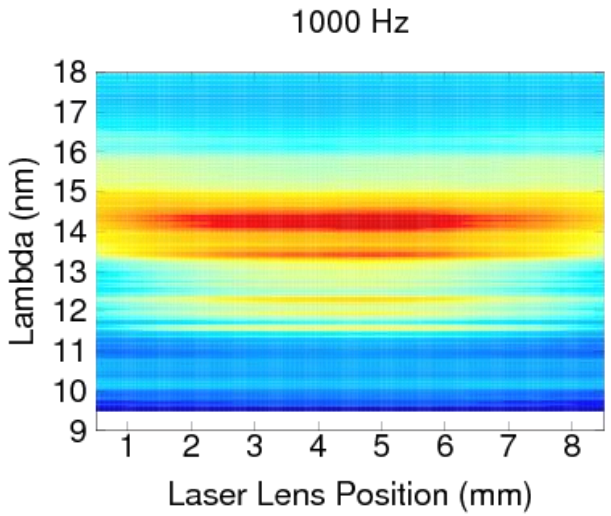
Source Imaging



Source Spectra

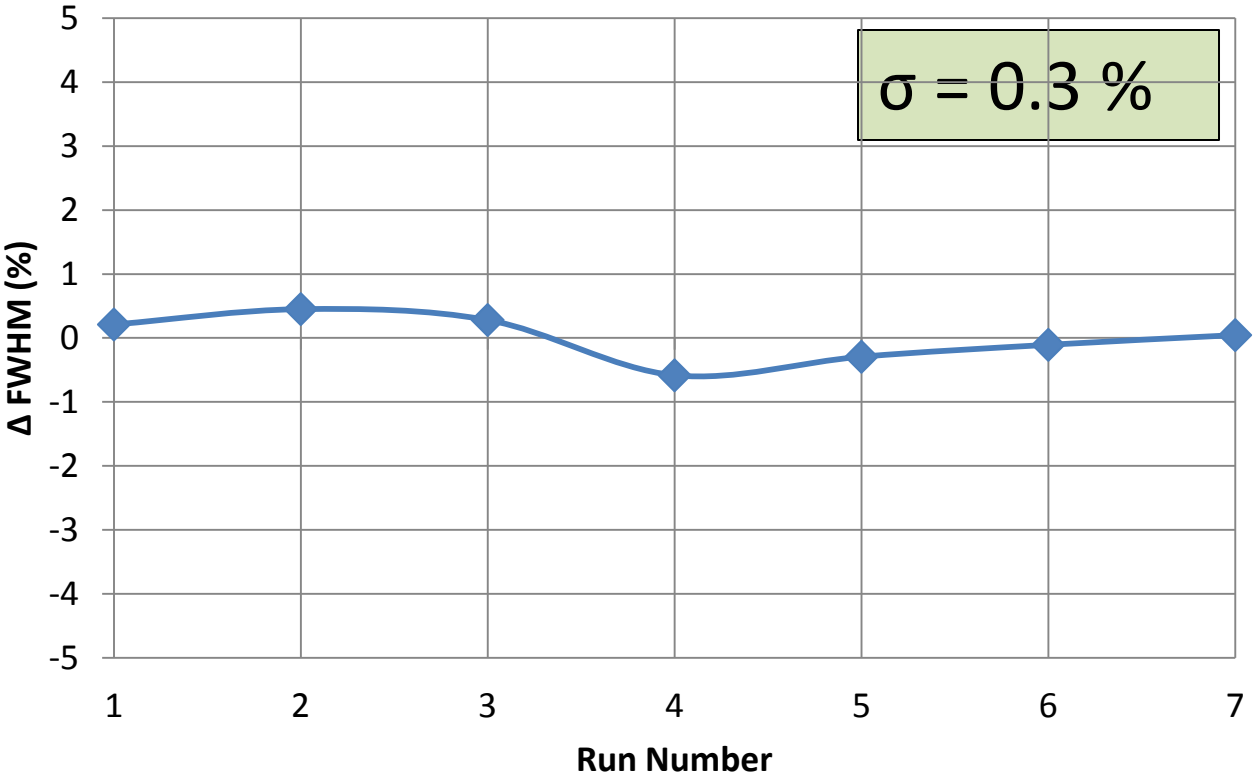
- Nd:YAG, 17 mJ per pulse, 1 kHz
- Viewed at 45°
- CE > 1% measured



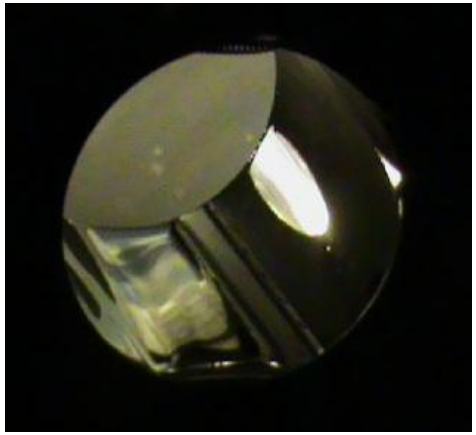


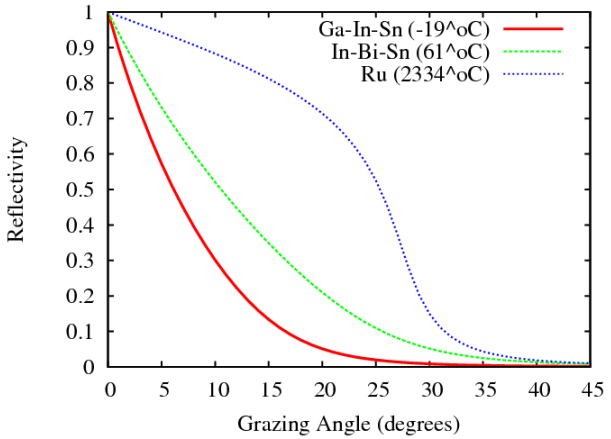
Stability - Source Position

Imaged with 50 µm pinhole



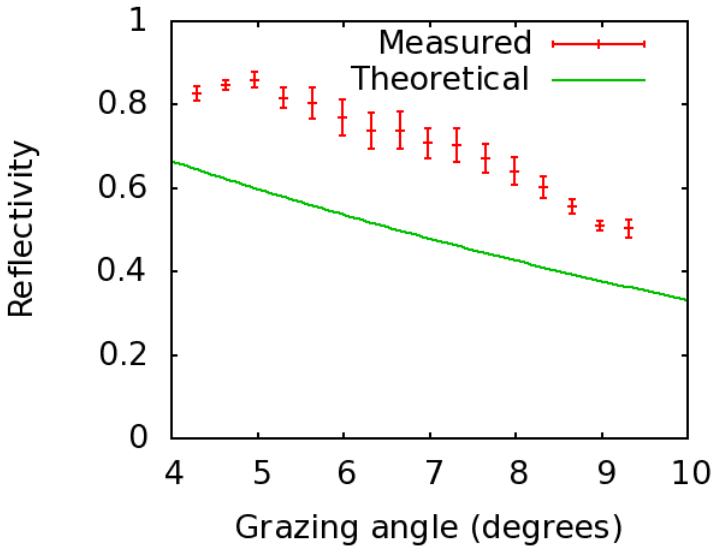
The Liquid Metal Collector



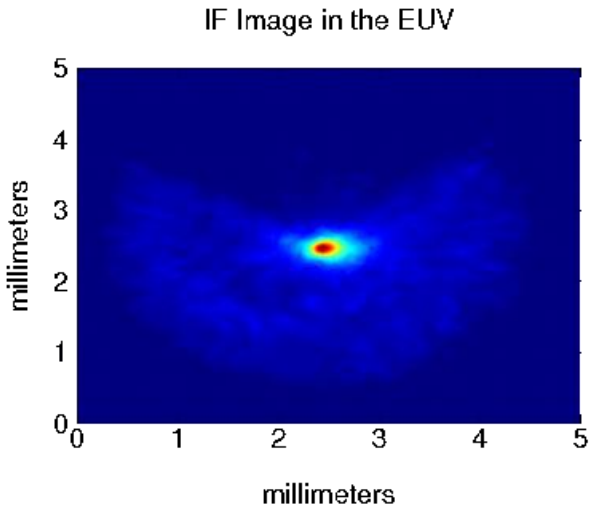


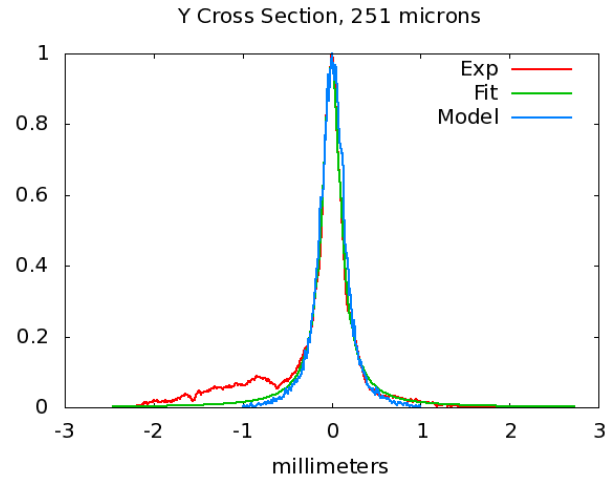
Collector design example:
Tin-based coating
Ellipsoid Shape
Length = 100 mm
Large Diameter = 40 mm
Predicted Collection ~ 3%

Optimising:
Collection efficiency
IF brightness

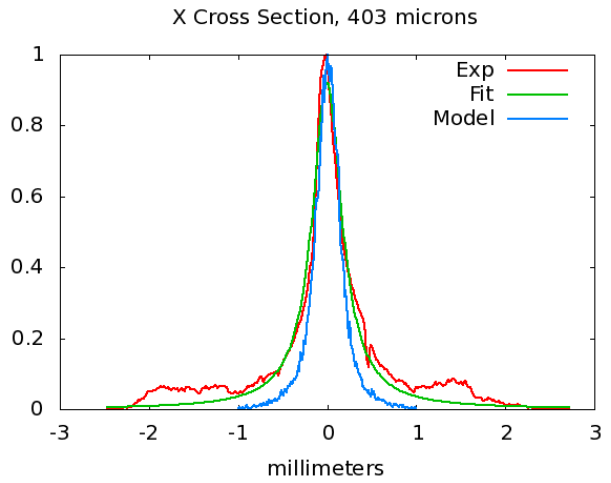


Intermediate Focus Imaging



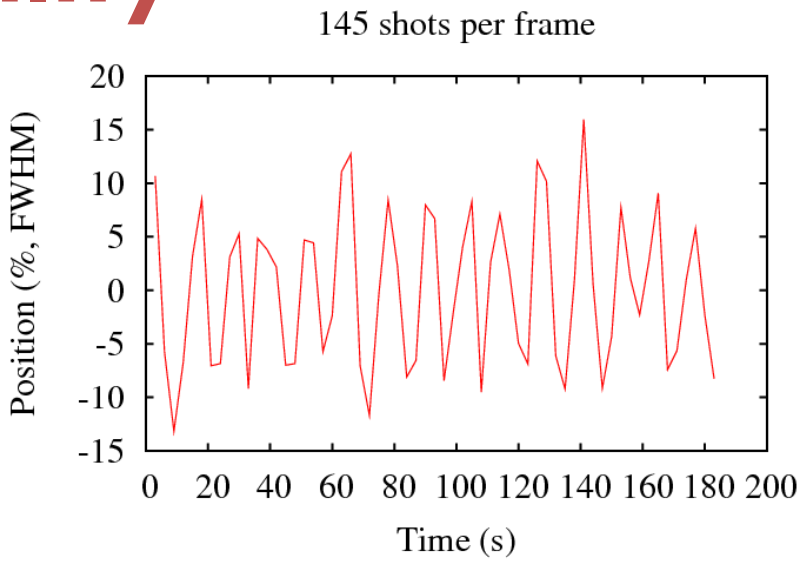


- Single Shot Imaging
- Lorentzian fit
- IF spot size 250 x 400 microns

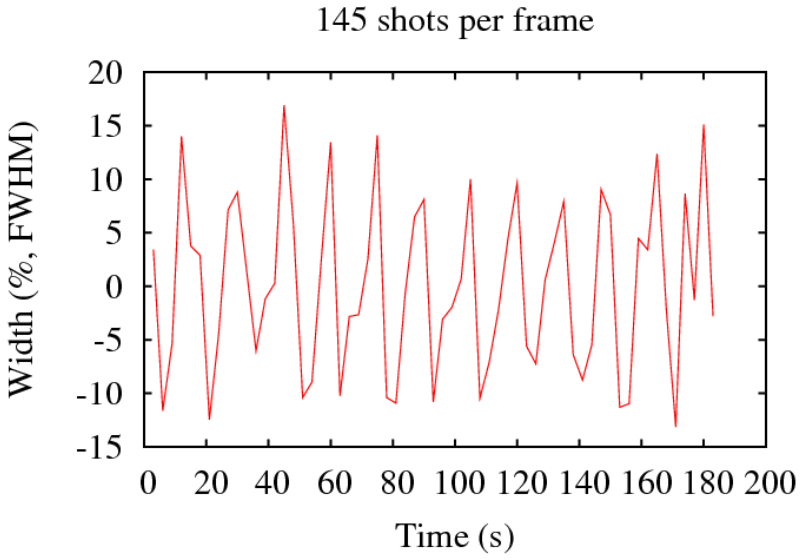


IF Stability

Position
- Measured σ = 7%
- Required σ = 3%



Size
- Measured σ = 8%
- Required σ = 3%



NLT SoCoMo

- High Brightness LPP
- Clean IF
- Stand Alone Unit
- 1 m x 1 m x 1.2 m
- Multiple parameter monitoring

Mask Metrology SoCoMo Status

Parameter	Industry Target Value			NewLambda
	AIMS	Blank	Pattern	Current Prototype
Brightness (W/mm^2sr)	30-100	>80	>40	80
Etendue (mm^2sr)	5e-4	4e-3	1.5e-2	5e-4
Positional Stability	3%	3%	3%	7%
Size Stability	3%	3%	3%	8%
Energy Stability	<3%	<3%	<3%-	9%
Homogeneity	<5%	<5%	<5%	7.5%
Operating time	100	100	100	>200 total 24 continuous

Future Plans

- Upgrade Laser to 300 W
- Improve source stability
- Optimising Liquid Metal recipe, (CE & Reflectivity)
- Extend Lifetime operation

Acknowledgements

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Thank you for listening