Monitoring EUV and DUV spectral emission ratios of a high power EUVL source

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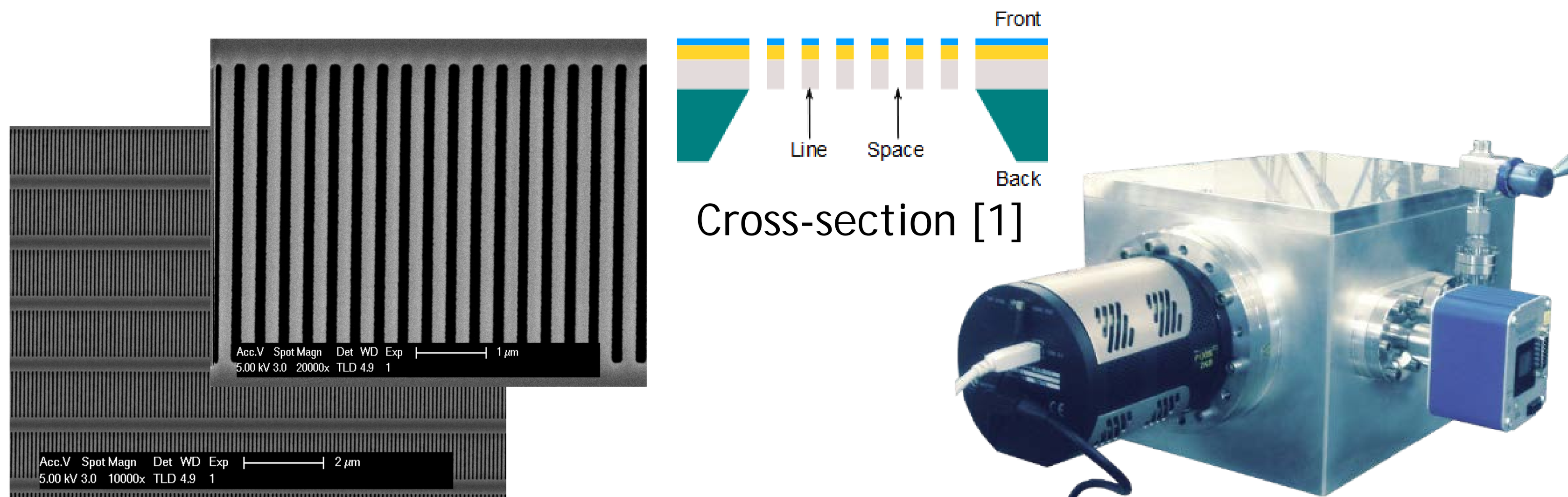
Motivation

- EUVL source plasma emission spectrum is relevant for scanner performance
  - In-band EUV range (13.5 nm ±1%) is needed for ensuring optimal plasma emission and influences imaging performance via coating angular and spectral dependencies
  - DUV range (130-400 nm) can cause parasitic heating of optical components and contrast loss in photoresist patterning
- Comprehensive spectral characterization with a compact broadband spectrometer based on transmission gratings
- Spectral comparison at various source operating conditions

Compact High-Resolution Spectrometer for VIS, DUV, EUV

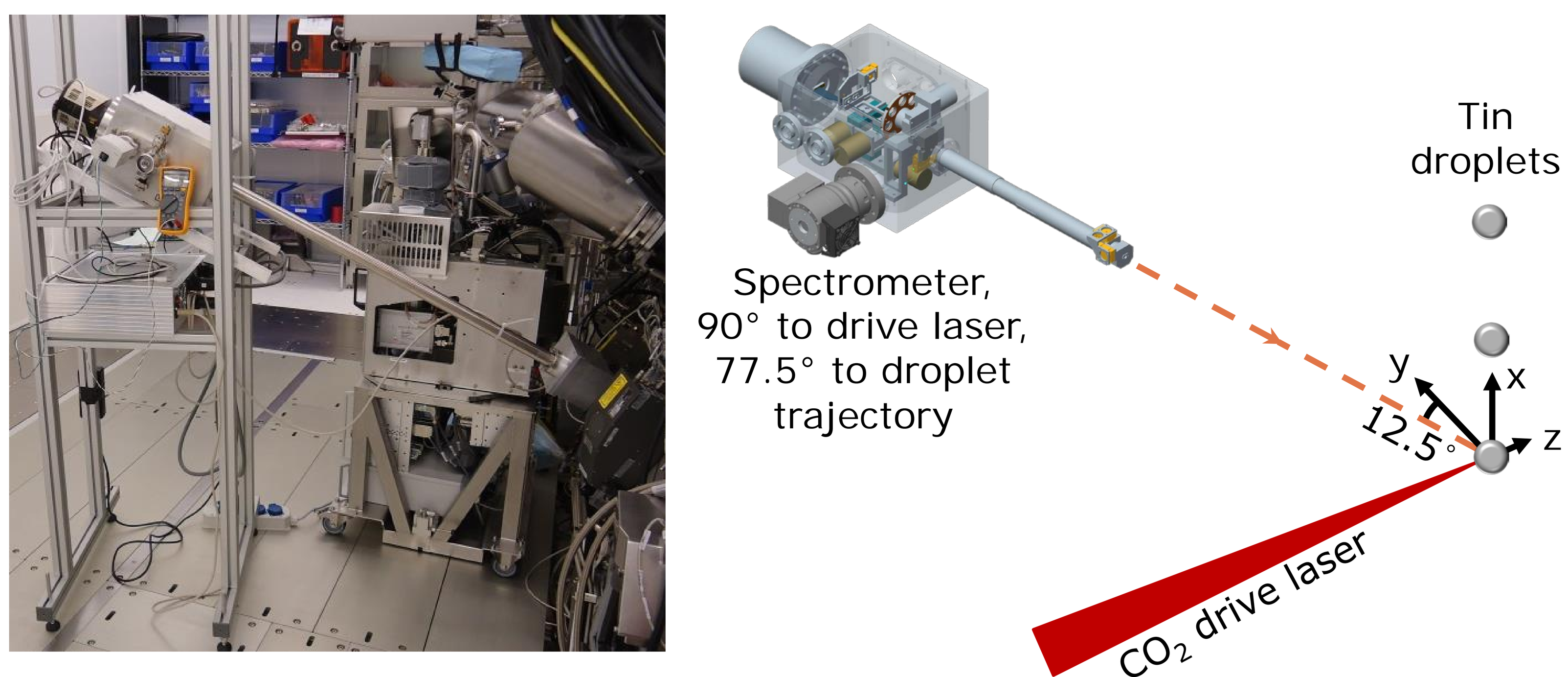
- Grating matrix with free-standing transmission gratings
  - Lines densities from 500 lines/mm up to 10.000 lines/mm
- Diffraction efficiency in the first order ≈ 10%
- Flat diffraction efficiency curve from 10 nm to 100 nm
- Reproducible fabrication of gratings by proprietary NIL process

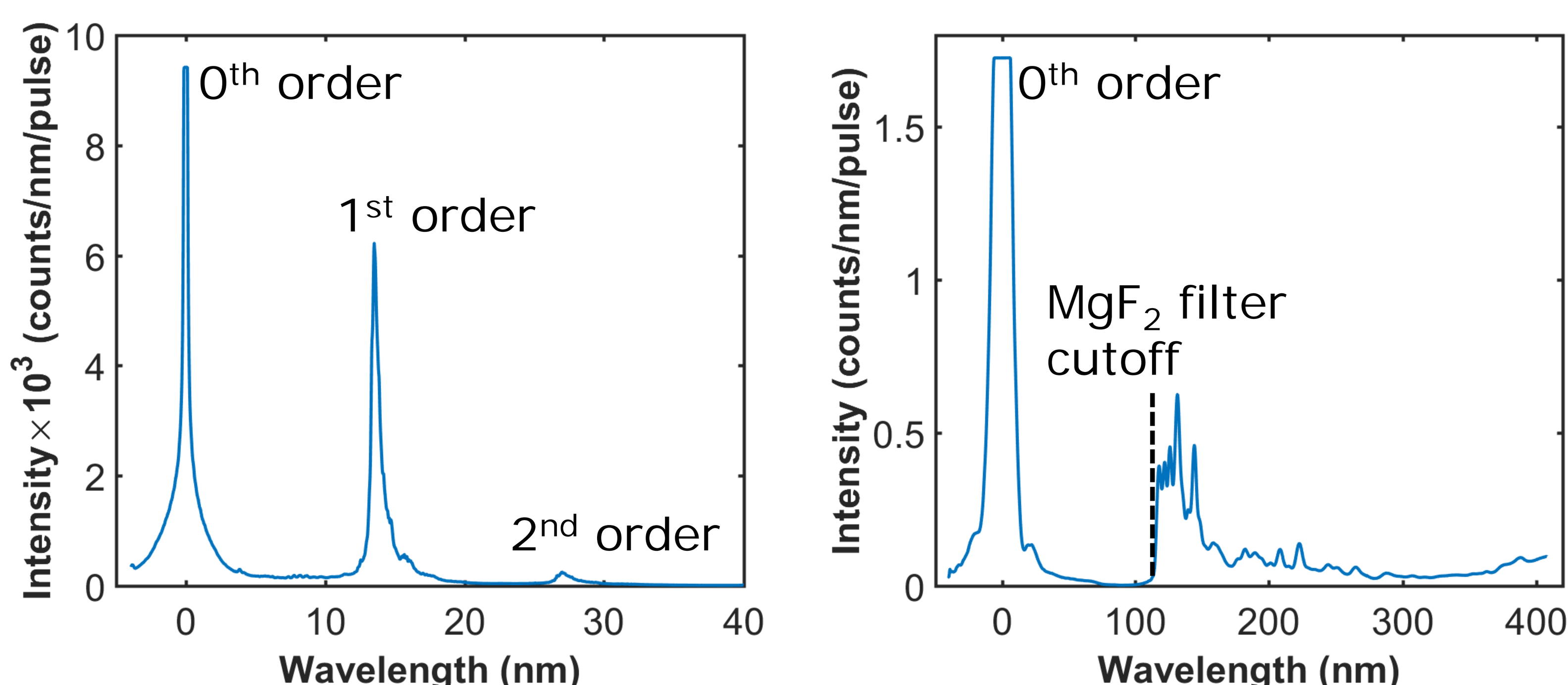


Cross-section [1]

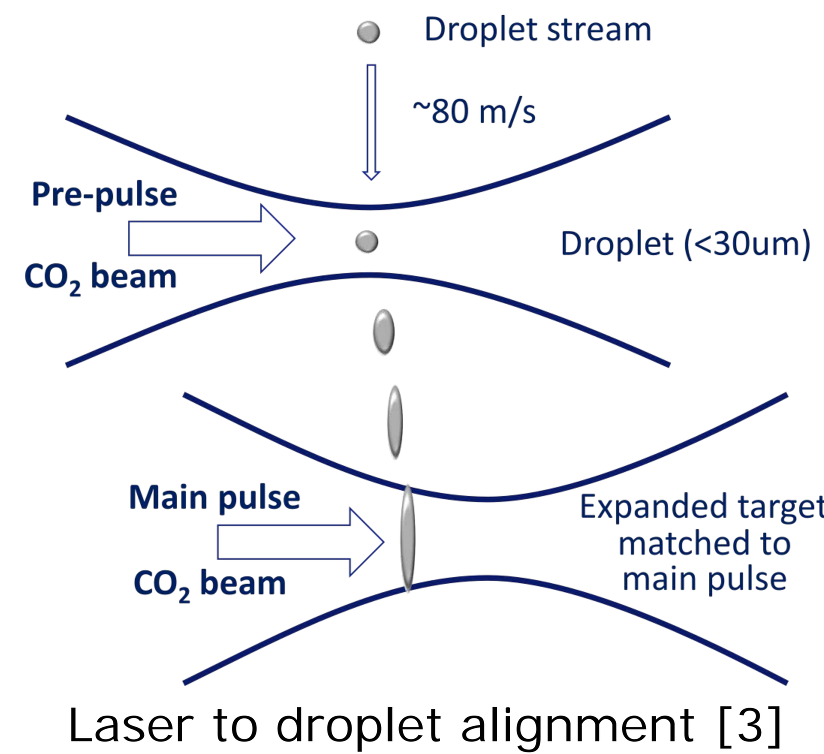
- High spectral resolution: 0.1 nm at 13.5 nm wavelength [2]
- Broad spectral coverage: 5 to 800 nm
- Fast switching between high resolution or wide spectrum
- Flat-field spectrum and higher order suppression by filters
- Easy alignment:
  - Computer-controlled positioning of components
  - GUI to control the optics and record/process spectrum

Measurement Setup





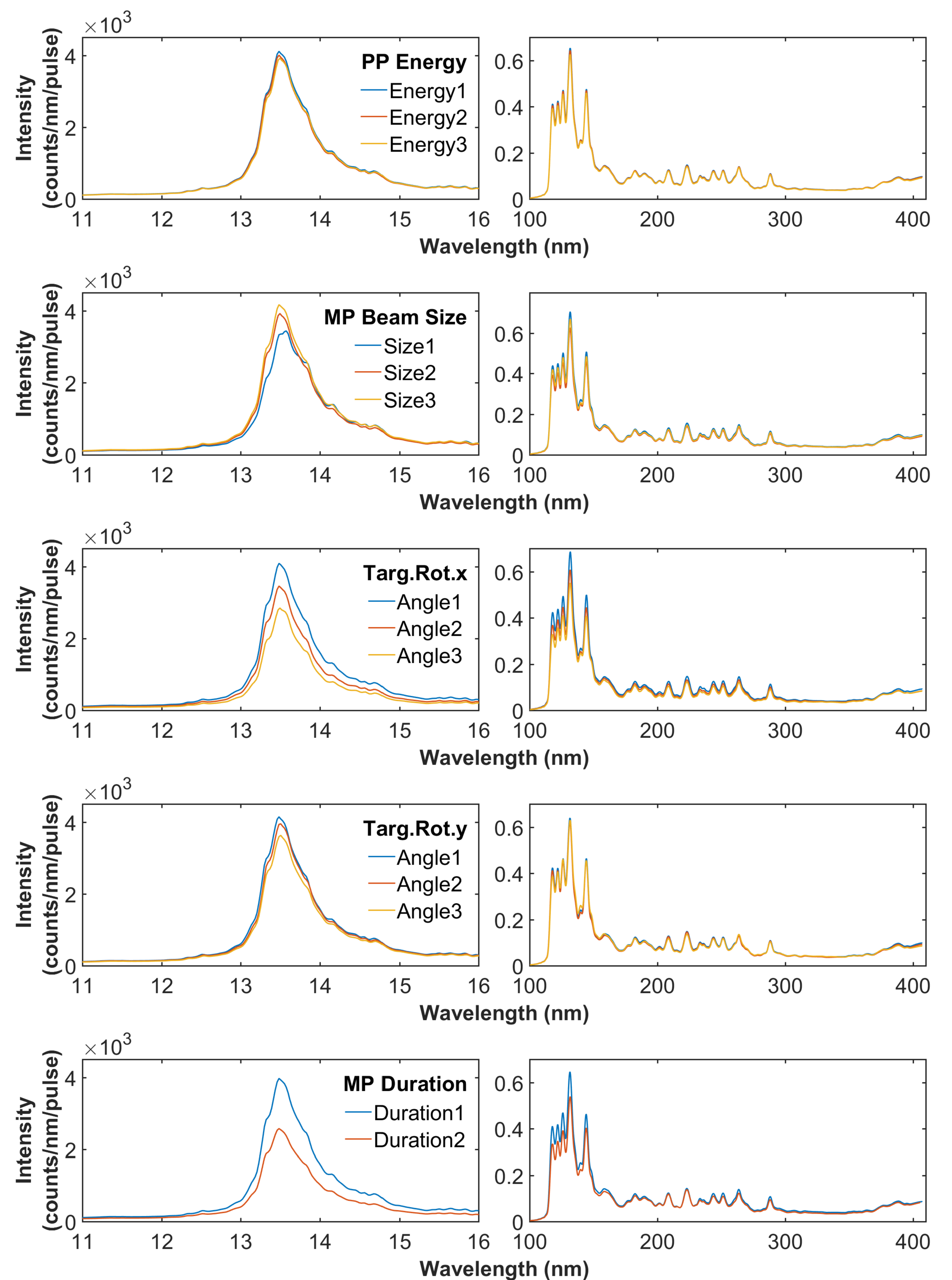
Measurement Results



Laser to droplet alignment [3]

- MgF_2 filter cutoff (~116 nm) is lower than shortest DUV range wavelength (130 nm), ensuring full DUV coverage.

Scanned parameters
- PP Energy
- MP beam size
- Target rotation around x-axis
- Target rotation around y-axis
- MP duration



Conclusions and outlook

- Developed spectrometer can measure EUV, DUV and VIS spectra at nominal operation conditions of EUVL sources
- EUV and DUV spectra shows strong dependency on the operating conditions of the EUVL source
- Trends in EUV and DUV energies can be followed by the spectrometer to optimize the source operation conditions for higher EUV and lower DUV energies
- Next: Angular dependence of the spectrum measurements
  Correlating in resist metrology with spectral measurements

[1] M. Bayraktar, et.al. *NEVAC Blad*, vol. **54**, no. 1, pp. 14-19 (2016).
[2] S.J. Goh, et.al. *Opt. Express.*, vol. **23**, no. 4, pp. 4421-4434 (2015).
[3] I. Fomenkov, *EUV Source Workshop*, Dublin, Ireland (2017).

This work has been enabled by the FOM Valorization Prize 2011, awarded to Fred Bijkerk and NanoNextNL Valorization Grant awarded to Muharrem Bayraktar in 2015.

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