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

M. Bayraktar1*, F. Liu2, H.M.J. Bastiaens3, C. Bruineman4, B. Vratzov5, and F. Bijkerk1
1Industrial Focus Group XUV Optics, MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands
2Source Performance and Plasma Technology Group, ASML, Veldhoven, The Netherlands
3Laser Physics and Nonlinear Optics, MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands
4Scientec Engineering, The Netherlands, 5NT&D - Nanotechnology and Devices, Germany  
*_m.bayraktar@utwente.nl

Motivation

- EUV 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

Measurement Setup

- High spectral resolution: 0.1 nm at 13.5 nm wavelength [2]
- Broad spectral coverage: 5 to 800 nm
- 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 Results

- MgF2 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

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.

References: