MOPA Prepulse LPP Light Source Development for HVM

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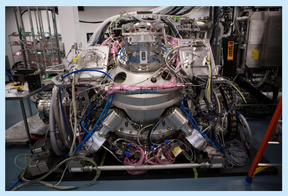
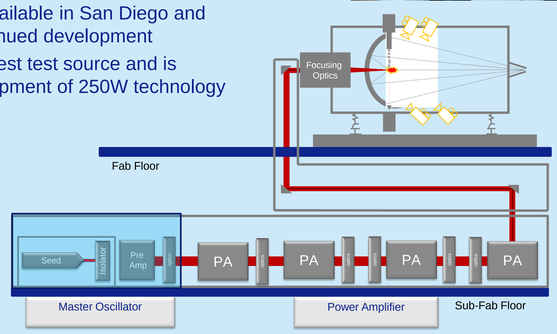
1 LASER PRODUCED PLASMA SOURCE

NXE:3300B and NXE:3350 LPP Sources



Cymer 4, 250W development test source for NXE:33x0 program

- Test sources are available in San Diego and Veldhoven for continued development
- Cymer 4 is the newest test source and is dedicated to development of 250W technology

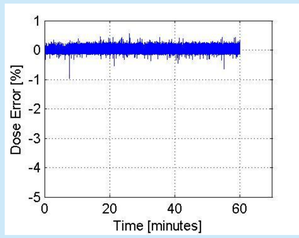


Three major subsystems of source architecture: Drive Laser (including seed laser), Beam Transport System (BTS) and Focusing System, Source Vessel (with Collector, Droplet Generator and Metrology)

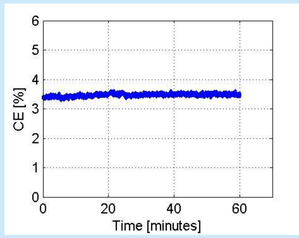
2 80W POWER ON NXE:3300B

MOPA Prepulse Demonstration

Stable dose controlled operation (1 hour)



Dose Stability >0.5% 3σ

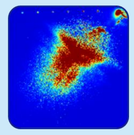


Conversion Efficiency >3%

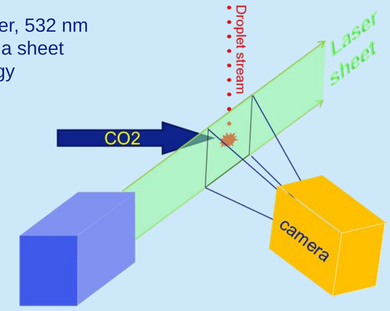
3 NEW DEBRIS METROLOGY

Plasma Imaging Velocimetry (PIV)

- 200 mJ pulsed laser, 532 nm
- Laser shaped into a sheet
- Dark-field metrology
- sCMOS camera



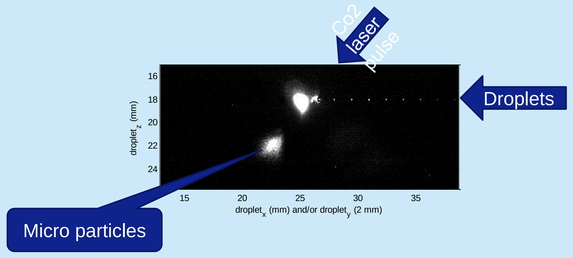
- Tin debris is illuminated

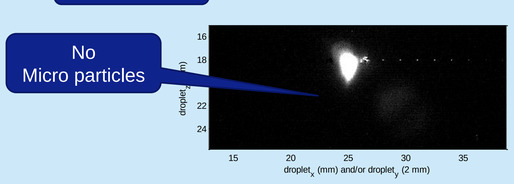


PIV laser

4 MICRO PARTICLE DEBRIS FREE OPERATION

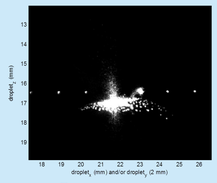
Plasma optimized for less debris



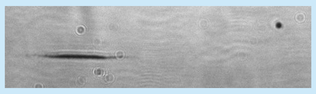


Optimized targets and irradiation can be used to fully eliminate micro particles by complete vaporization

Scatterography more sensitive than shadowgraphy



Scatterogram



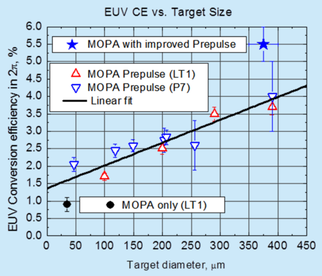
Shadowgram

PIV setup illuminates small microparticles not seen in shadowgram

5 MOPA PREPULSE – HIGH CONVERSION EFFICIENCY

MOPA Prepulse technologies demonstrated CE >5% on lab setup at low duty cycle

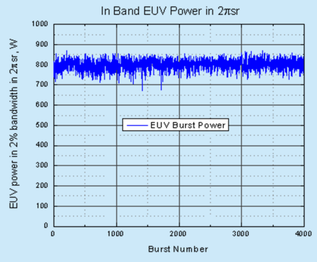
CE VS. TARGET SIZE



CE is maximized when the target diameter is optimized with the beam size

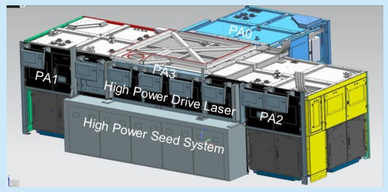
MAXIMUM POWER DEMONSTRATED

800W EUV in 2πsr corresponds to ~200 W at IF



EUV Power in 2% bandwidth 2π sr, measured by side sensors on LT1 at low duty cycle

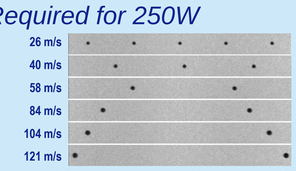
HPDL with HPSS



New high power drive laser with new high power seed system for 250W configuration For high duty cycle operation in 2015

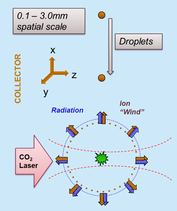
6 HIGH SPEED DROPLETS

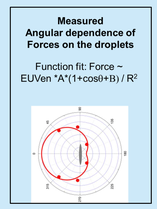
Required for 250W



Images of tin droplets at 80 kHz and at different applied pressures
Images taken at a distance of 200 mm from the nozzle

Forces on droplets drive the need for higher momentum / higher speed droplets at higher powers

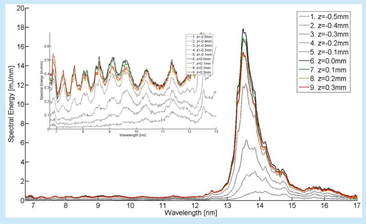


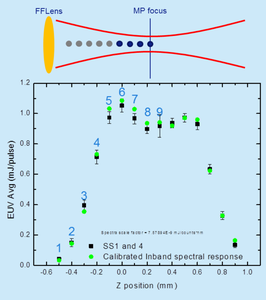


7 EUV CE OPTIMIZATION

Confirmed by spectra measurements

Spectra through the main pulse focus



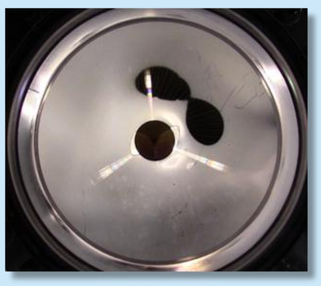


Spectra measurements show that 13.5 nm radiation is maximized without overheating of plasma, confirmed by radiation in 7-10 nm range

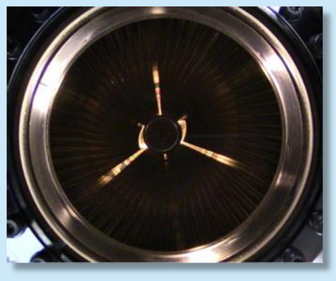
8 IN-SITU COLLECTOR CLEANING

Tin removal with hydrogen based cleaning system

Reduced COO Increased Availability

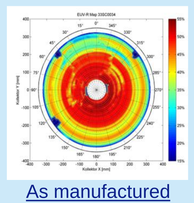


NXE:3300B Collector with tin deposited during EUV operation was put into a cleaning test stand for evaluation of the cleaning process

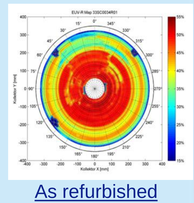


Collector after cleaning in the test stand with the product configuration, all of the tin is removed

Reflectivity Comparison



As manufactured

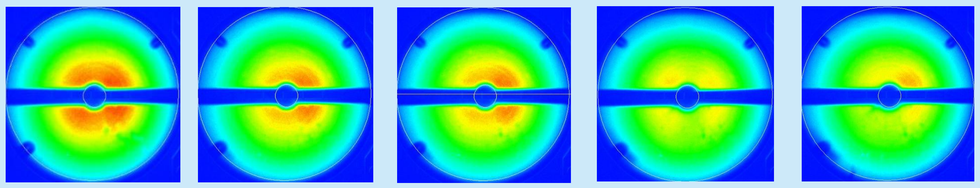


As refurbished

Comparison of reflectivity between new and cleaned Collectors shows reflectivity is fully restored after cleaning

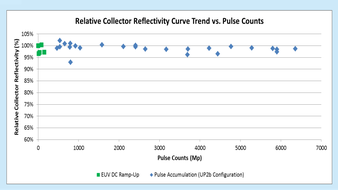
9 NXE:3300B COLLECTOR PROTECTION

Collector protection technology proves effective, extendable to >100 Giga pulses



Initial image | 1.58 Gp | 2.41 Gp | 4.78 Gp | 6.36 Gp

- New configuration improves source availability
- Data collected at 40W



10 SUMMARY

- Multiple NXE:3300B LPP sources for development are available
- 80W power demonstrated on NXE:3300B stand alone source
- 200W EUV measured using MOPA Prepulse, >5% CE demonstrated in lab at low duty cycle
- High speed droplets for EUV power scaling have been demonstrated
- New micro particle debris diagnostic provides insight on how to optimize for less debris
- Spectral measurements to maximize EUV CE
- In-situ collector cleaning developed to lower COO and increase availability
- MOPA Prepulse collector lifetime extrapolates to >100 Giga pulses

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ASML

2014 EUVL Symposium, Washington DC

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