# Laser Produced Plasma Light-source for EUVL

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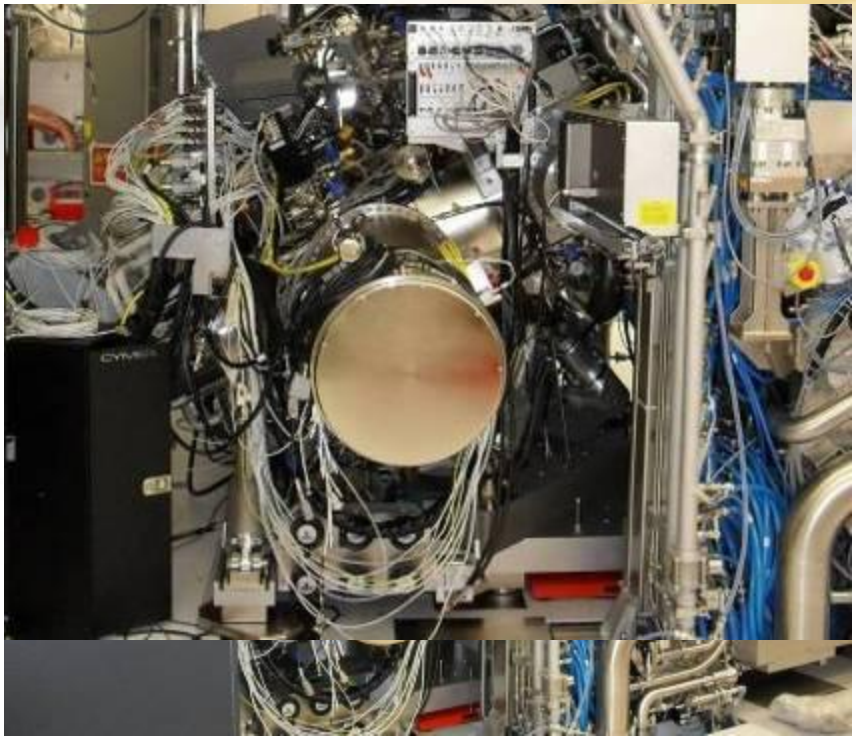
CYMER

Leading the Light Generation.

# Outline

- **HVM I Sources at Chipmaker Fabs**
  - Six source shipped, four at fabs making wafers
- **Power and Dose Stability**
  - Current and upgraded configurations
- **EUV Collector Reflectivity and Lifetime**
  - Volume production of collectors
- **Droplet Generation**
  - Droplet Generator Capability
- **Far Field Test Tool (FFTT)**
  - Measurement capabilities
- **Out of Band Radiation**
  - HVM I source measurements
- **IF Protection**
  - HVM I source measurements
- **Summary**

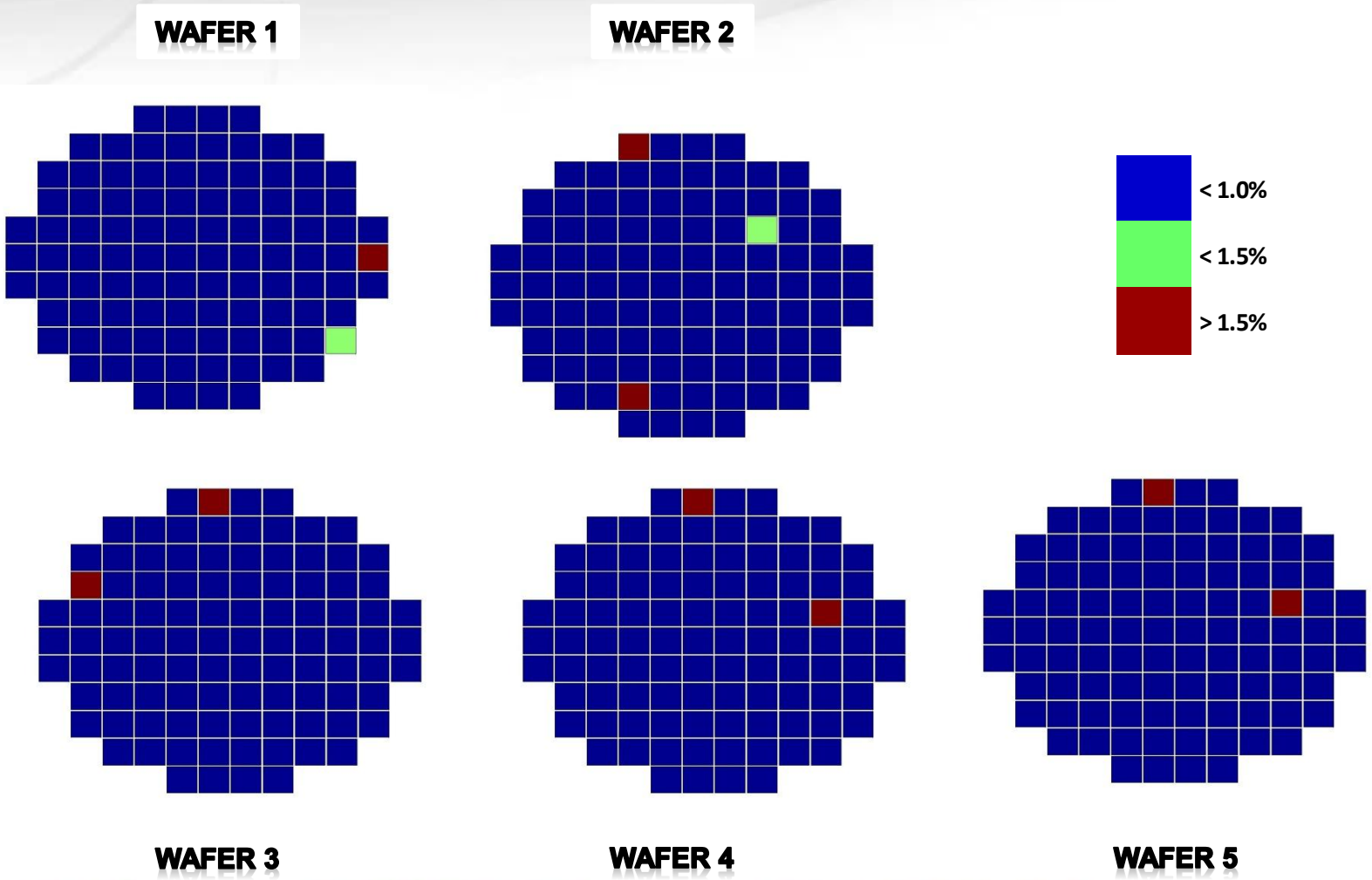
# Cymer LPP Sources are Operational at Chipmaker Fabs



- Six HVM I sources shipped to customers
- Four HVM I source operational at Fabs
- Two additional HVM I sources are operational in San Diego
- HVM II sources in planning and procurement

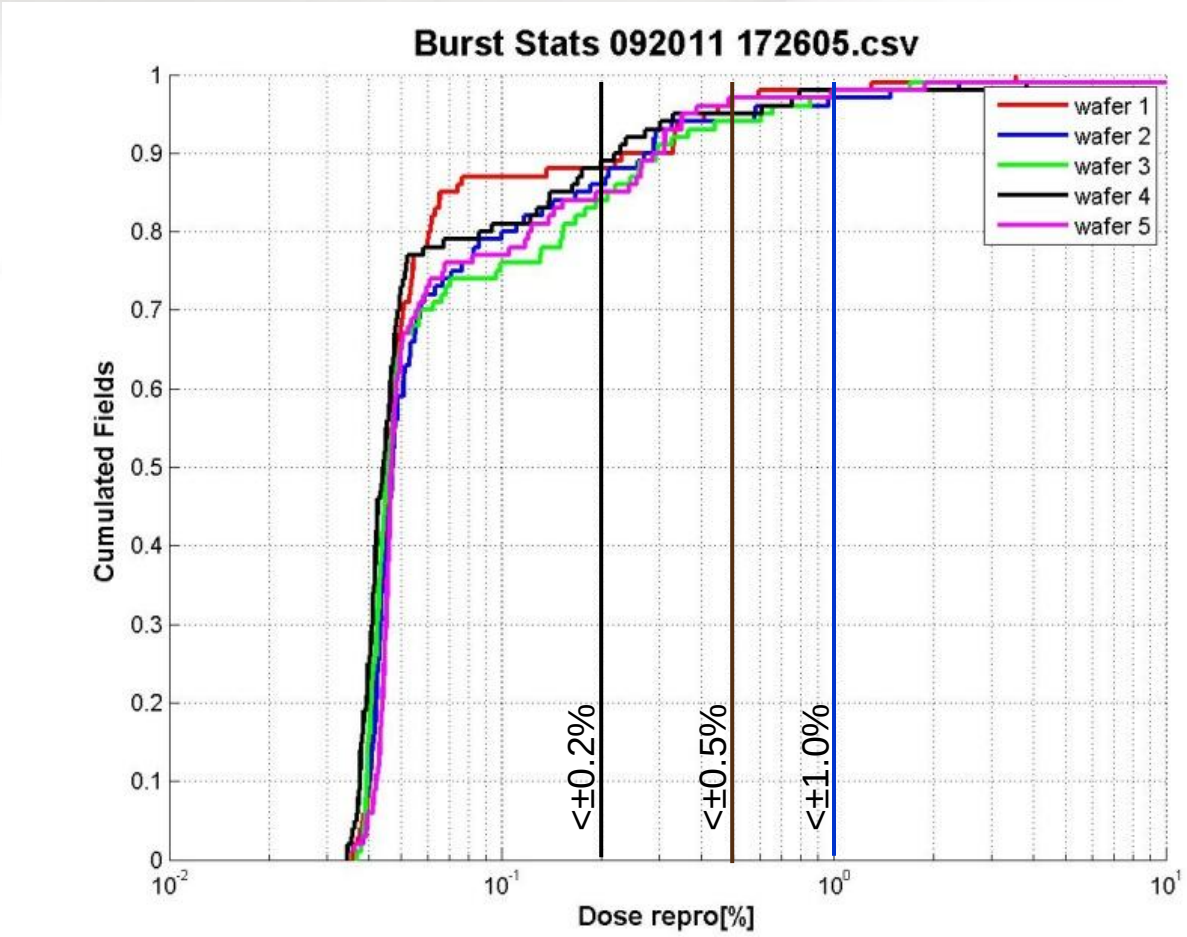
# ~19W Average Exposure Power at 90% Duty Cycle on HVM I Source

*Dose Stability by Die over Five Wafers*

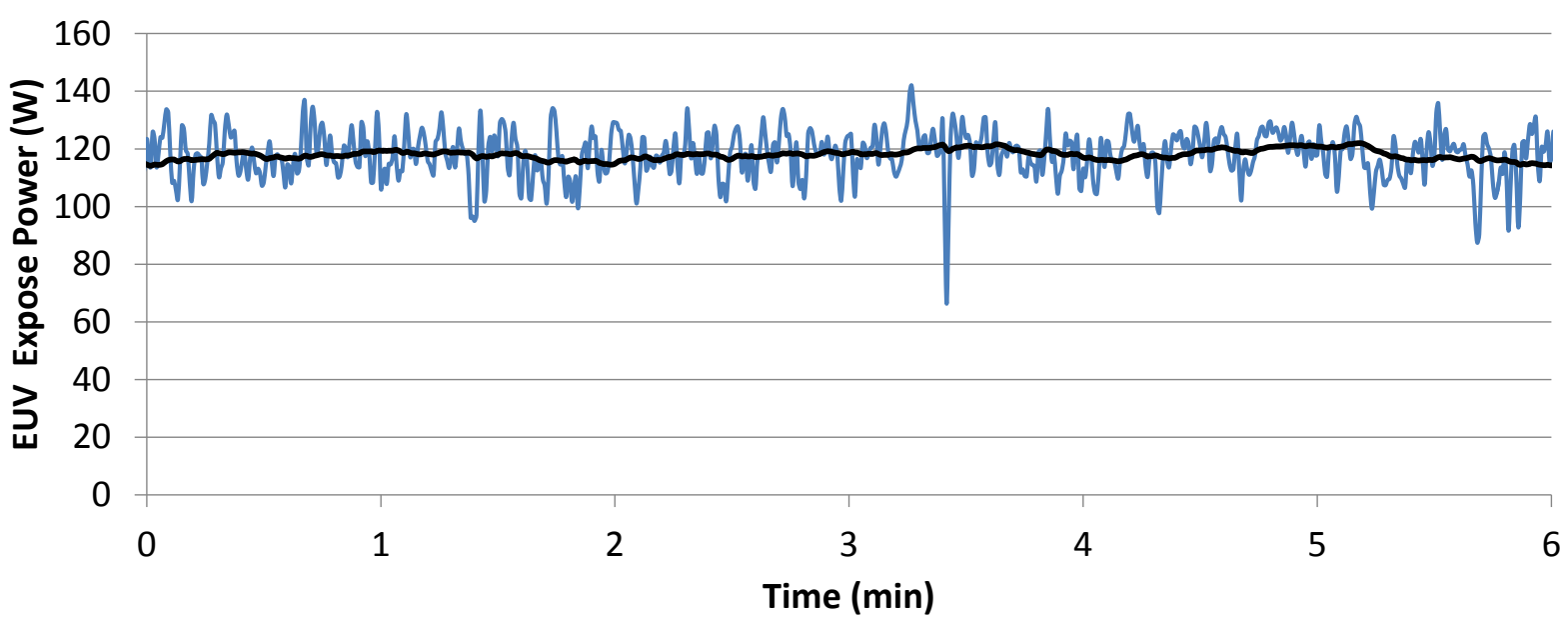


# Dose Reproducibility Distribution

*19W Average Exposure Power on HVM I Source*



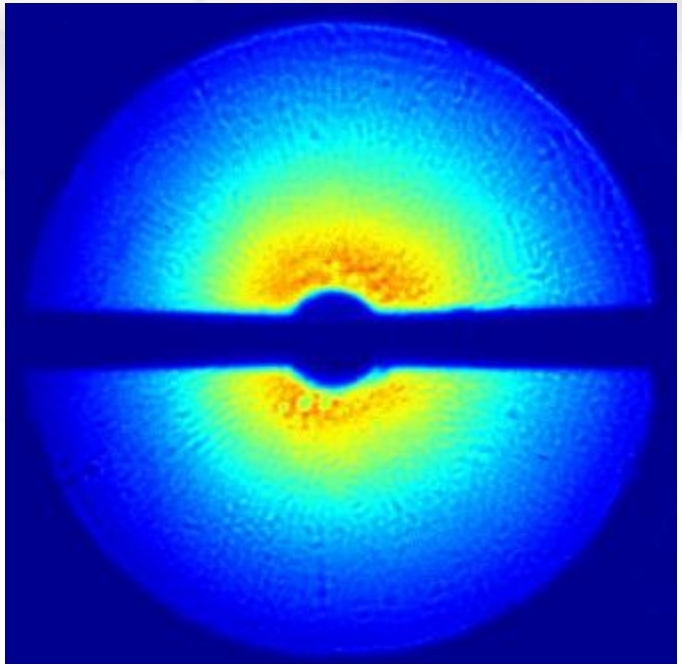
# >100W Clean Exposure Power with Prepulse on LT1



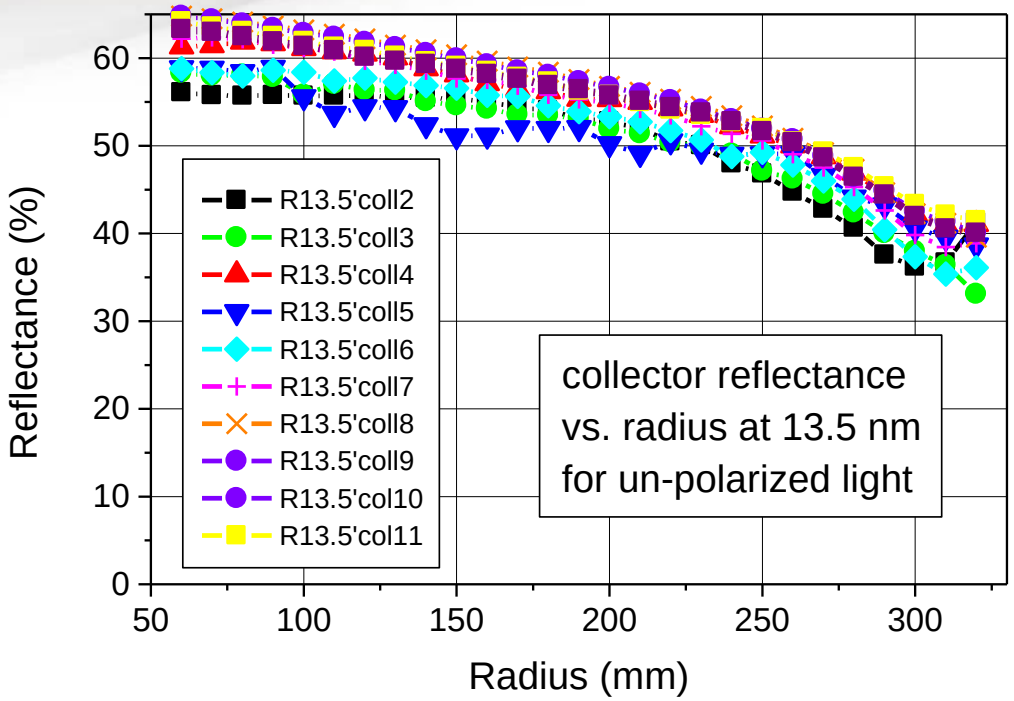

Low duty cycle operation without a collector

# 5sr Collector Reflectivity Measurements

*Average reflectivity >50%*



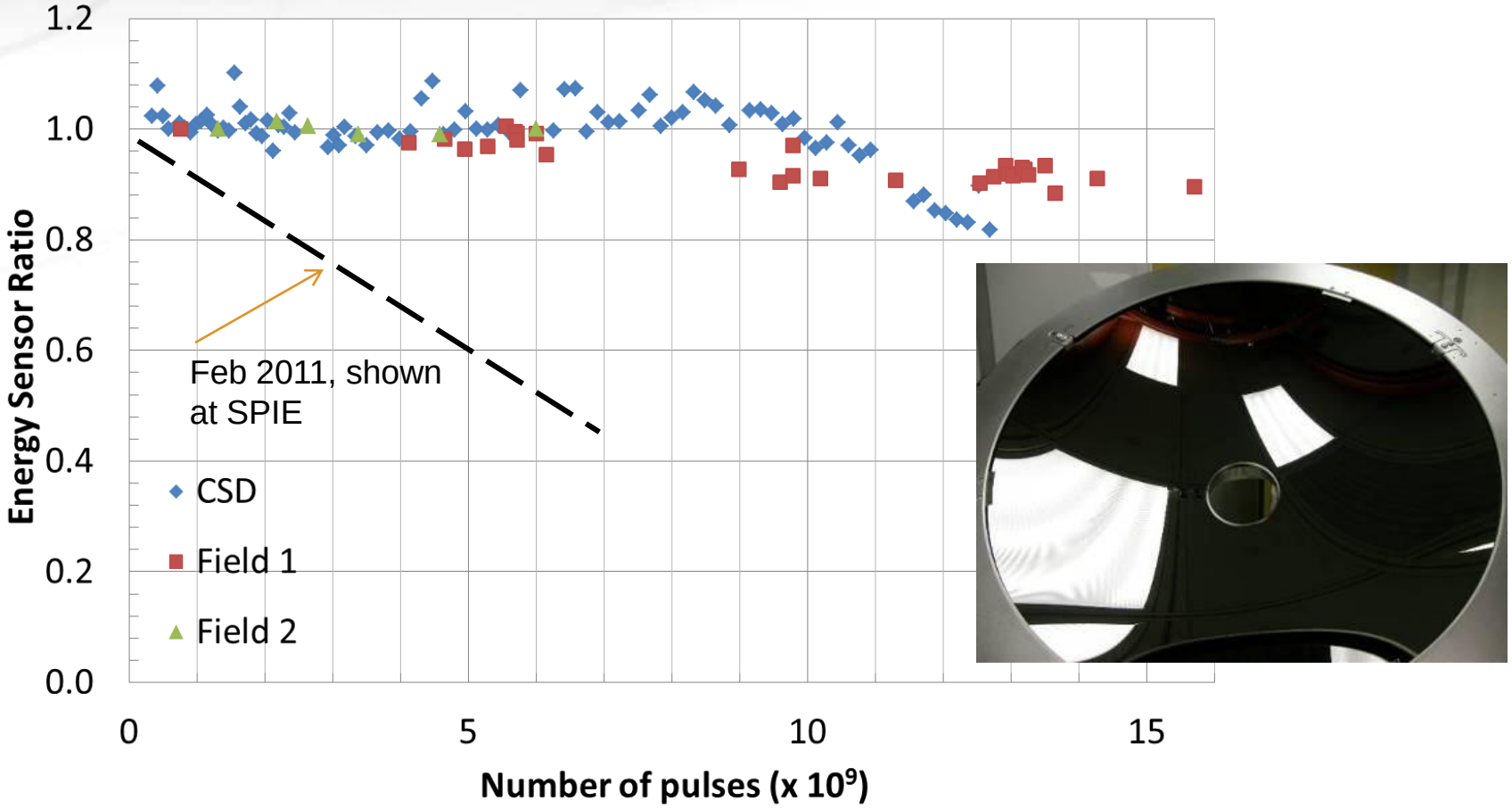
**Far Field EUV Intensity**




- **52.1% average area-weighted reflectivity reached at 13.5 nm**
  - Collector reflectivity measured at PTB using synchrotron radiation
  - Reflectivity for un-polarized light determined from data measured with s-polarized light

# Collector Lifetime Significantly Improved since SPIE (> *16 Billion Pulses lifetime in the Field)*

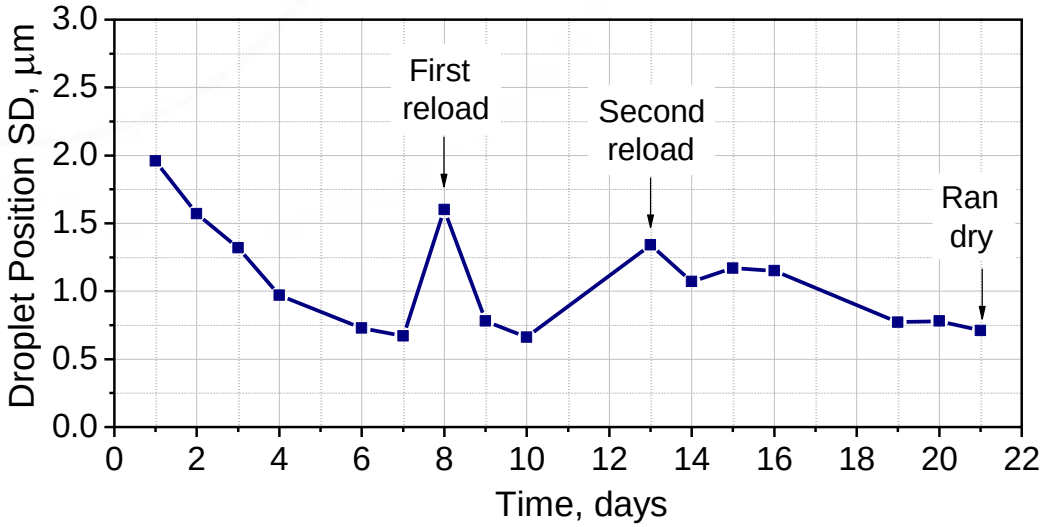
- Improvements confirmed at CSD and in the field
- Solutions in place to go to 30 billion pulses



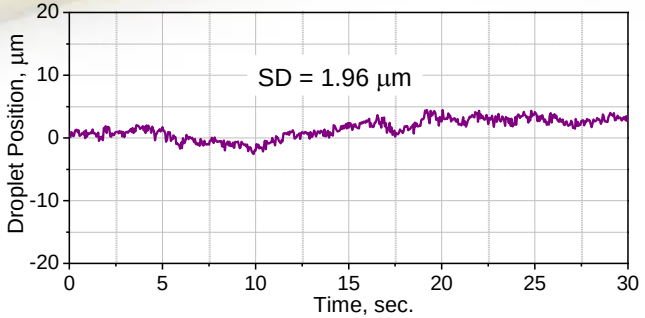
# Droplet Generator: Long Term Droplet Stability over 21 days

**Standard deviation of the position stability of tin droplets measured over a period of 21 days**

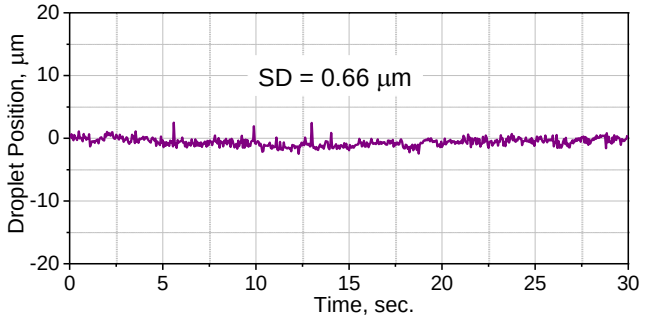
**Droplet generator was stopped for short time and refilled with tin twice during this test**



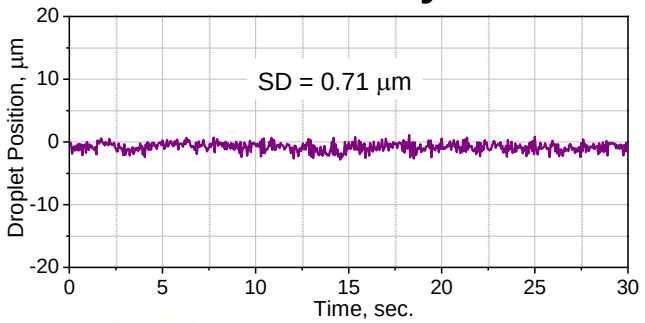

**1st day**




**10th day**




**21st day**

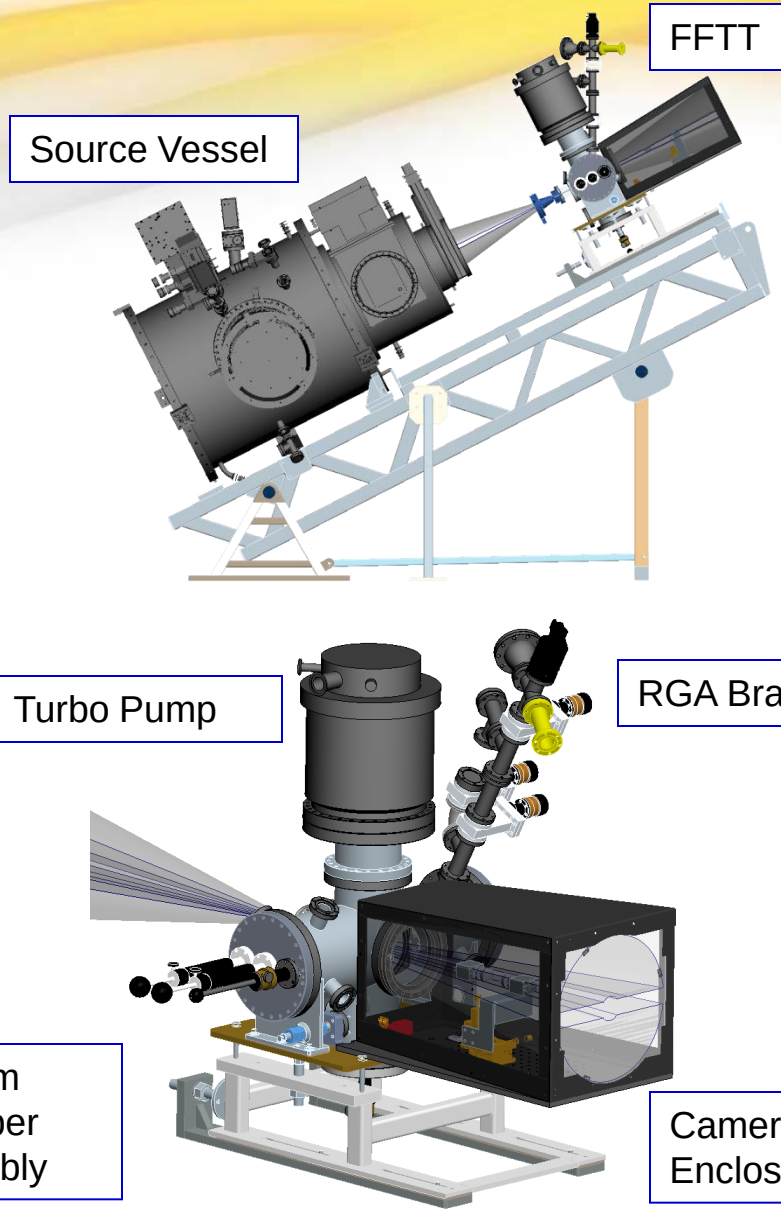


# Far Field Test Tool (FFTT)

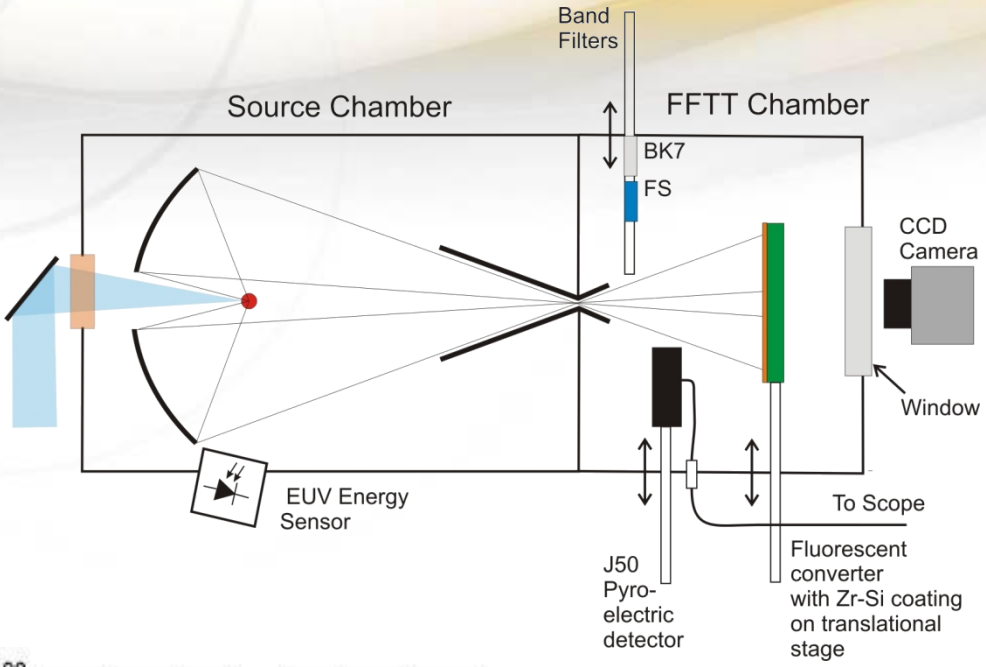
*For source qualification*

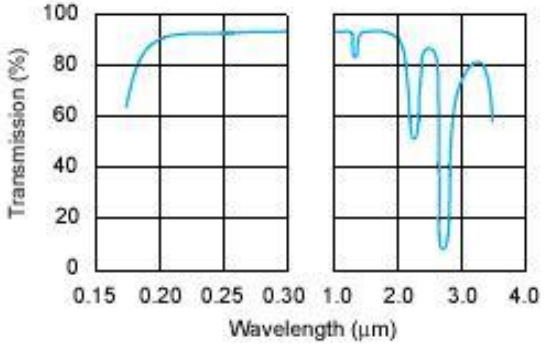
FFTT Capabilities

- EUV collector images
- EUV uniformity
- In Band EUV power after IF
- Collector Image in visible light at 1m from IF
- OOB after IF
- Flow-Pressure test
- Suppression test
- Simulate feedback signal to plasma position control (visible light image)
- SPF test

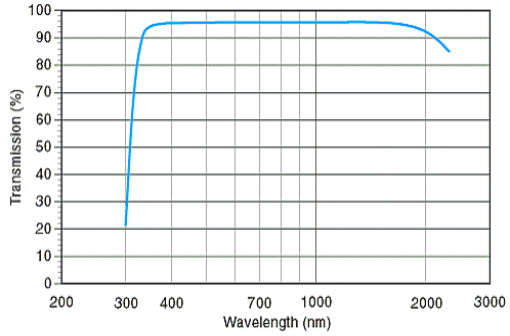


# FFTT Configuration for OOB Measurements



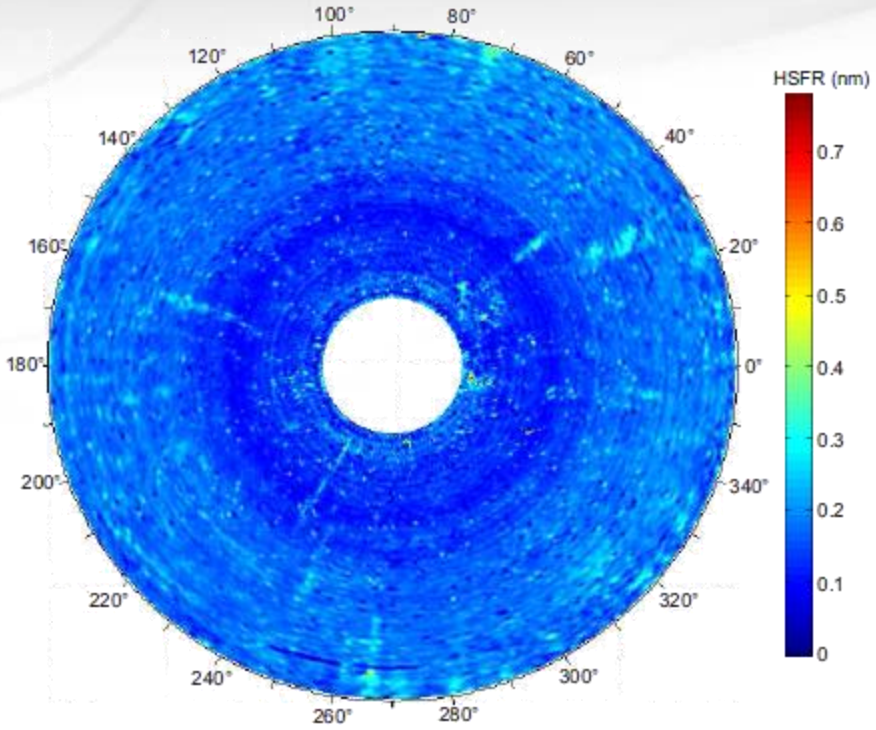

Fused Silica:
Band from 200nm to ~3μm
Thickness 6.4mm

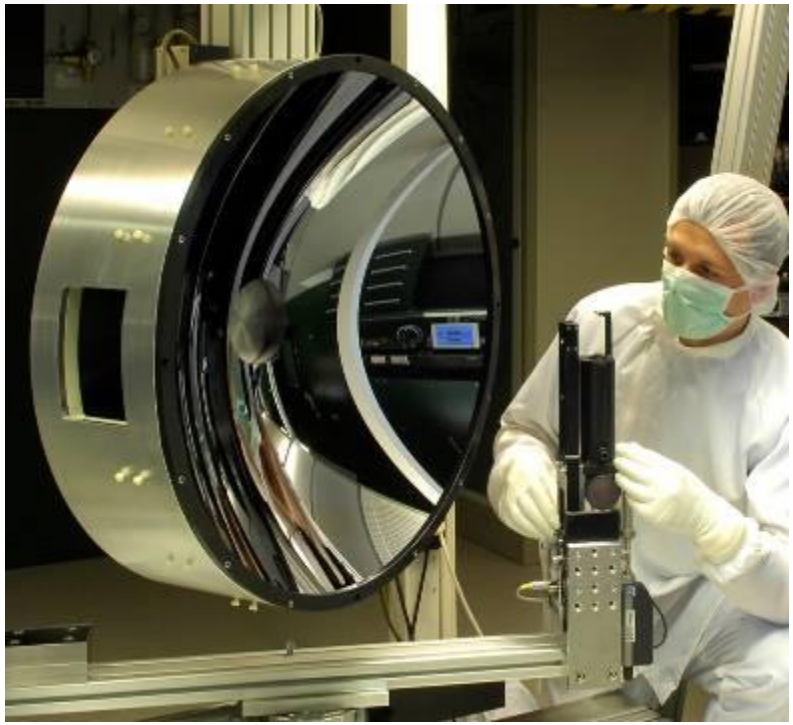



BK7:
Band from 350nm to ~2μm
Thickness 6.4mm

- Measurements for Visible UV and IR bands
- Band Filters (Fused Silica or BK7) were placed in front of J50 pyroelectric detector
- Operation at 1ms bursts, low DC (5Hz)
- FFTT was aligned with Fluorescent Converter. Images were taken before and after the test for verifying the alignment

# Collector HSF Roughness Map Derived from
*Laser Scatterometry Data*



HSFR mapping of collector surface based on angle-resolved scatterometry at 442 nm

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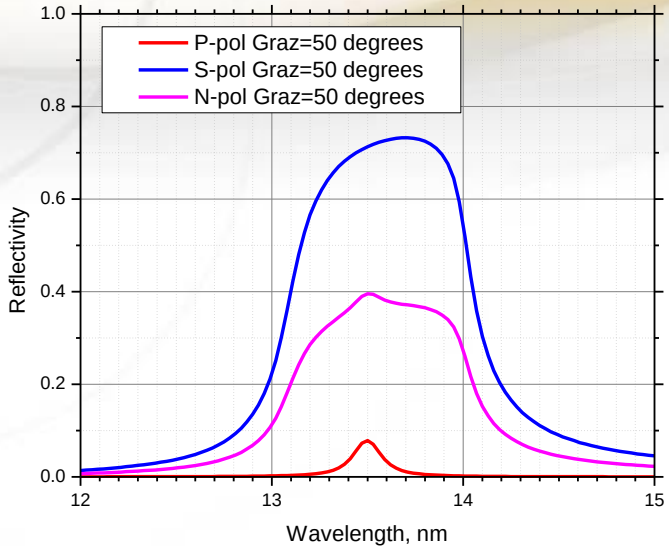
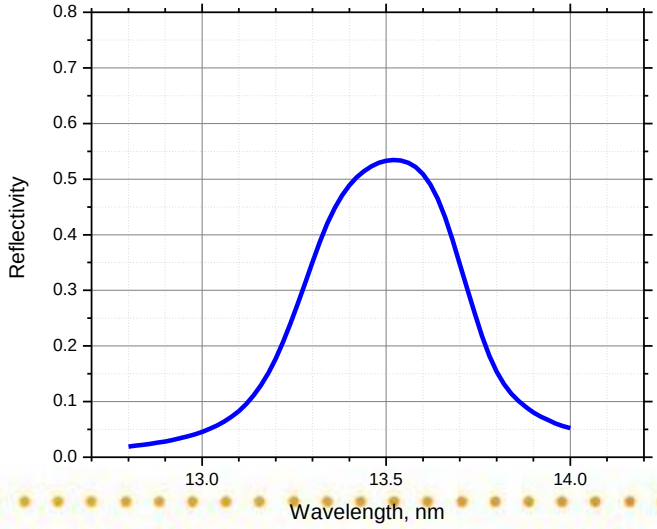
# Collector EUV Reflectivity and EUV OOB

Collector Reflectivity Model




Average Collector Reflectivity Curve



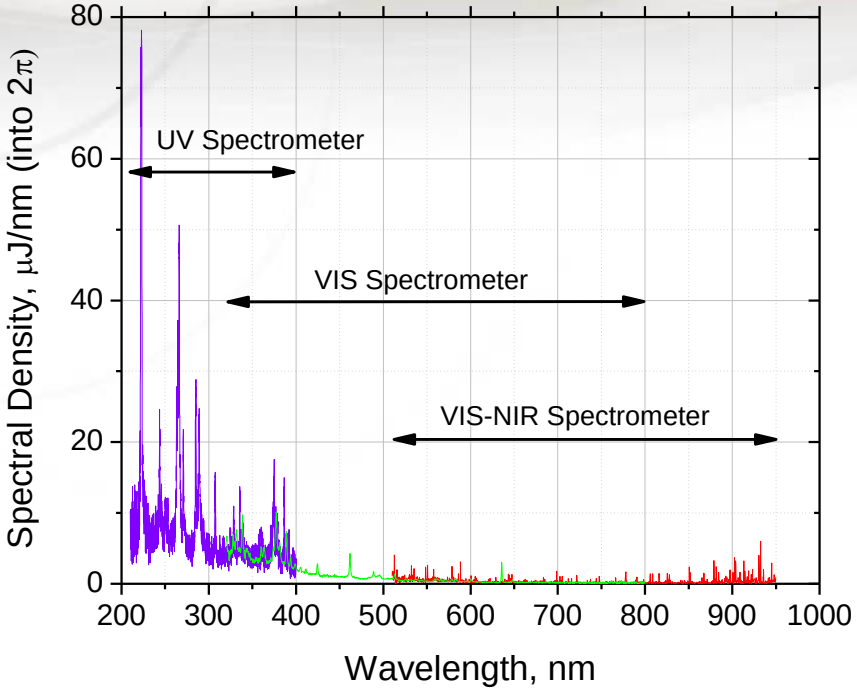

- Collector reflectivity was measured for S-polarization for 28 radial points on 4 azimuthal angles
- A reflectivity model was developed and verified for prediction of P-reflectivity curve from the measured S-curve
- Average reflectivity curve was calculated as follows:

$$R_{average}(\lambda) = \frac{\int_{\beta_{min}}^{\beta_{max}} [0.5R_S(\beta,\lambda) + 0.5R_P(\beta,\lambda)]\sin(\beta)d\beta}{\int_{\beta_{min}}^{\beta_{max}} \sin(\beta)d\beta}$$

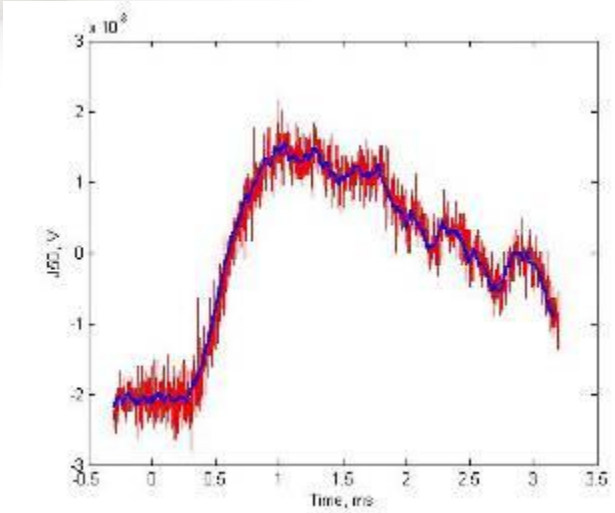
- Average reflectivity curve shows good matching with the requirements:
  - $\lambda_{center}$=13.486±0.007nm
  - $\lambda_{peak}$ =13.522±0.007nm
  - FWHM=0.481nm
  - $OOB_{EUV}$<(0.481-0.27)/0.27=78%

# OOB Measurement Results

**UV and VIS spectra of CO2-Sn LPP**




**J50 waveform with FS filter**

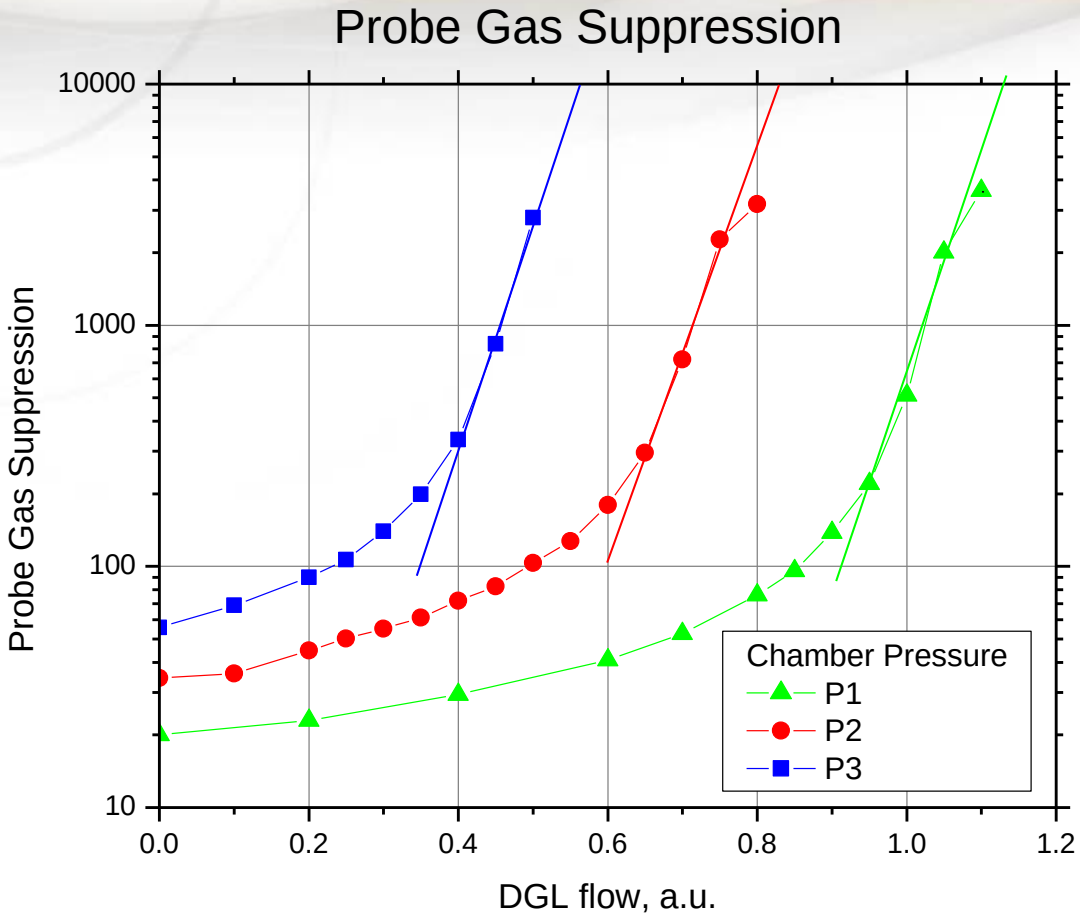



**Energy was referenced to EUV energy measured by side sensor**

| Band | Measurement results |
|---|---|
| EUV OOB, 10-35nm | FWHM calculated for reflectivity curve |
| DUV, 35-115nm | All radiation Absorbed by H2 |
| UV+Visible+NIR, 200nm-3μm, (FS filter) | 6-8% of In-Band EUV |
| UV, 200-310nm, (FS-BK7) | ~1% of In-Band EUV |

# IF Protection for Source-Scanner Interface

*Protection from Contaminations*




- Probe gas (Ar) was flown into the EUV chamber along with buffer gas for characterization of contamination protection by IFP
- Partial pressure of the probe gas was measured behind IFP with differentially pumped calibrated RGA
- Maximum suppression measurement was limited by background noise of RGA

- Fitting the suppression with exponential function provides extrapolation to nominal value of IFP flow. Predicted suppression for probe gas exceeds 13 orders of magnitude

# Summary

- Eight HVM I sources built, six shipped to customers, two sources being used in San Diego for EUV power upgrades and collector protection testing.
- HVM II source architecture for ASML NXE 3300B scanners is complete, modules are on order and first integration is planned in Q1 2012.
- 20W clean average exposure power will be available by year end for chipmaker installations.
- 50W validation on a HVM I source is in process to qualify upgrade 1, with plan for chipmaker upgrade by Q2 2012.
- >100W exposure power (low duty cycle) demonstrated on LT1.
- Significant collector lifetime improvements implemented in the field, currently to 16 billion pulses, with plan for 30 billion in early 2012.
- Far Field Test Tool (FFTT) developed for source qualification; including FF images, OoB, and IF suppression testing.